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# Mindfulness-Based Stress Reduction: Impact on the Acoustic Startle Response

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# Mindfulness-Based Stress Reduction: Impact on the Acoustic Startle Response

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## ABSTRACT

Previous research has demonstrated that the magnitude and duration of the acoustic startle response can be modulated by a number of psychological factors. Mindfulness meditation, being a form of mental training known to produce benefits in affect and attention regulation as well as other domains, may modulate factors of the acoustic startle response. The present study investigated participants' skin conductance responses to an acoustic startle stimulus before and after an 8-week Mindfulness-Based Stress Reduction (MBSR) course, and paired this assessment with self-reported trait mindfulness and positive and negative affect. There was significant startle habituation across the intervention, but no between-groups differences on startle magnitude. Self-report measurement yielded significant increases in negative affect for the control group, and significant increases in trait mindfulness for the MBSR group, but this did not relate to changes in startle magnitude. Importantly, it was found that MBSR participants tended to be significantly more likely than controls to report mindful breathing at the post-intervention startle trial. Although startle magnitude was not significantly affected by MBSR enrollment, behavior during the startle trial may have been significantly affected.

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# INTRODUCTION

In the last few decades there has been an emergence of research on the practice and clinical application of mindfulness (Grossman, 2011). As described by Jon Kabat-Zinn (2003), mindfulness is non-judgmental attention directed toward present moment experiences. The appearance of literature on mindfulness has been associated with the development of a basic mindfulness course known as Mindfulness-based Stress Reduction (MBSR), which is an 8-10 week group program that employs mindfulness techniques to alleviate the harmful effects of stress by increasing awareness of moment-to-moment experience (Grossman et al., 2003). Research on the benefits of mindfulness practice has shown that it can positively influence factors of physical health, emotional wellbeing, and cognitive skills, and it can also improve symptoms in several clinical populations, including patients with generalized anxiety disorder (GAD) and depression (Hölzel et al., 2011). Yet despite many advances in this field, much of this research has dealt with self-report measures of mindfulness and symptomatology, and less of it has dealt with physiological or behavioral measures. This being so, there is a demand for more objective assessments of mindfulness practice and its associated effects (Levinson et al., 2014).

## *The Startle Response*

One tool that may be useful in the assessment of mindfulness is the acoustic startle response. The startle response is considered an aversive or defensive sympathetic nervous system reflex that serves to protect an organism from potential threat or injury and to prime a behavioral response to a possible threat (Hillman, Hsiao-Wecksler & Rosengren, 2005). The "acoustic" startle response in particular is the startle response as elicited by a loud noise with rapid onset and short (~100 ms) duration, and it is characterized by several typical physiological and somatic changes in the recipient. These include increased conductivity of the muscles surrounding the eye (i.e. the eye-blink startle response), a spike in skin conductance (SC) and in heart rate, and a set of stereotypical muscular and facial behaviors (Lang, Bradley & Cuthbert, 1990). Over the last few decades, the acoustic startle response has been used as a reliable measure of autonomic nervous system activity since it has a variety of relatively objective measurable physiological signs (Blumenthal et al., 2005).

The earliest research on the human startle response is often credited to Landis & Hunt (1939), who studied the behavioral aspects of the response in various populations and under different experimental conditions. Their well-known study, titled *The Startle Pattern* (1939), used a high-speed film camera to capture subjects' immediate facial and postural reactions to a gunshot stimulus fired in close vicinity. They noted many typical involuntary behaviors, the most immediate being blinking of the eyes, followed by others such as forward head movement, contracted facial expression, raising of shoulders, and contraction of the abdomen; they also observed what they termed "secondary behaviors", which were a more variable set of responses that came after the immediate involuntary response and included facial expressions of amusement, surprise, and disgust among others.

Although Landis and Hunt (1939) were keen to classify the startle response as a reflex, their study spawned a controversy, as others sought to classify it as an emotion. In an effort to help settle this controversy, Ekman et al. (1985) conducted a study to see in which ways participants' startle responses could be compared and contrasted with a typical emotional expression, such as fear or surprise. The researchers found that the startle response resembled emotion in the uniformity of its associated facial behaviors. In addition, startle's brief latency and duration resembled that of surprise, although it was briefer in duration than surprise. They also found four differences that set it apart from all other emotions: it is extremely easy to elicit, it is shown reliably as each subject's initial response, it cannot be completely inhibited, and it cannot be simulated with the correct latency. Thus, the researchers concluded that this was enough evidence to suppose that the startle response was not an emotion per se.

Following Ekman et al.'s (1985) conclusion that startle is not itself an emotion, Lang, Bradley & Cuthbert (1990) gathered findings from startle studies and proposed that the startle is actually a useful tool in the *study of* emotion. Evidence from startle studies had shown repeatedly that the magnitude of the startle response is affected by an organism's emotional state at the time of the response. For example, studies that displayed foreground stimuli such as pleasant, neutral, or aversive images at the time of startle administration repeatedly found that startle eye-blink magnitudes were highest for unpleasant images and progressively lower for neutral and pleasant images. Findings consistently supported the notion that the startle response is modulated by the valence, or attractiveness/repulsiveness, of ongoing affective responses. Lang, Bradley & Cuthbert (1990) also made clear the utility of the startle response in the study of psychopathological distortions of emotion and in the analysis of anxiety-disordered patients. Many other researchers have also cited it as a useful tool in the study of emotion and behavior in general (e.g. Lang et al. [1990], Koch [1999], Grillon [2008]), given its non-zero baseline that can be enhanced or attenuated under different emotional and cognitive conditions. Since mindfulness practice has been purported to have an array of emotional and cognitive effects, these effects of mindfulness may leave a trace in the realm of startle behavior.

The neurological underpinnings for the acoustic startle response and its modification have been extensively researched in recent years. The response begins with the input of an abrupt noise stimulus with an intensity of greater than 80 db. It is primarily mediated by a pathway in the lower brainstem, and mainly consists of connections between the auditory nerve, the ventral cochlear nucleus, the dorsal nucleus of the lateral lemniscus, the caudal pontine reticular nucleus (PnC), spinal interneurons, and spinal motor neurons. Most important of these, as Koch (1999) points out, is the PnC, which is considered the main hub of the acoustic startle response and receives the auditory evoked excitatory input from various brainstem nuclei. The PnC then sends that information to motor neurons that initiate the behavioral reflex (Koch, 1999). The brainstem has already been shown to be affected by mindfulness training, as we will see later on (Singleton et al., 2014).

Neural circuitry occurring in higher order from the brainstem is thought to be responsible for the modification (i.e. enhancement or attenuation) of the startle response. The amygdala, for example, plays an important role in fear and anxiety and also in the aversive character of the startle response, since aversive stimuli such as loud and abrupt noises activate this region and lead to an amplification of the response. Research has also demonstrated a role of the anterior cingulate cortex in the processing of startle stimuli (Pissiota et al., 2003). The findings of top-down startle modification are important to the present study because such top-down processes may be affected by mindfulness training.

Apart from being studied in normal human subjects and in animals, the startle response has also yielded abnormalities in clinical populations. Different effects of attenuation and enhancement of the response can be found for different disorders. Patrick (1993) reported on a series of startle studies that demonstrated insights into the emotions of psychopaths. When presented with unpleasant photographs the psychopath would not show the startle enhancement trend, and when shown pleasant images the psychopath would not show the startle attenuation trend. Evidence has also repeatedly shown that individuals with post-traumatic stress disorder (PTSD) have exaggerated startle responses, which is actually a diagnostic criterion for PTSD in the DSM (e.g. Butler et al., 1990; Jovanovic, 2009). Additional findings have shown exaggerated startle trends for other anxiety disorders such as panic disorder and generalized anxiety disorder (Grillon, 2008). There is also evidence of startle reflex normalization after the reduction of anxiety symptoms through cognitive-behavioral therapy (Bakker et al., 2011), so it has already been shown that startle can be modified through mental training.

*Mindfulness Practice*

The practice of mindfulness, which historically dates back 2000 years to ancient Buddhism, has in the last few decades made an emergence as a topic in psychological literature (Grossman, 2011). The practice itself involves bringing an “attentional stance” characterized by openness and curiosity to all aspects of experience. Common forms of mindfulness/meditation practice are: sitting meditation, in which a person chooses an object of attention (usually the breath) and continually restores attention on that object whenever the mind wanders, walking meditation, in which one attends to the sensations of walking, and intentionally becoming aware of phenomena occurring in the environment such as sights and sounds, etc. (Baer, 2003).

Operationalizing mindfulness and defining its core components has been a prominent topic in recent publications. One of the main proponents of mindfulness research is Dr. Jon Kabat-Zinn, who wrote an oft-cited definition for mindfulness: “Paying attention in a particular way: on purpose, in the moment, and nonjudgmentally” (Kabat-Zinn, 1994), and this definition has been expounded on and tested in later publications. Hölzel et al. (2011) suggested that mindfulness works through a few different components: attention regulation, body awareness, emotion regulation (which includes reappraisal, exposure, extinction, and reconsolidation), and a change in perspective on self. Bishop et al. (2004) also postulated a two-component model of mindfulness that involves the self-regulation of attention such that it is maintained on one's immediate experience, and an orientation towards that experience characterized by curiosity, openness and acceptance. Black (2011) states that, overall, scientific definitions of mindfulness share the notion of a general receptiveness to and engagement with the present moment.

Dr. Jon Kabat-Zinn also founded the most frequently cited form of mindfulness training, called the Mindfulness-based Stress Reduction (MBSR) program (Baer, 2003). MBSR is a secular group-based intervention that usually takes place across an eight week period. Participants in the course meet once a week for 2 to 2 ½ hours, and there is also an optional all day retreat after the six or seventh week of the course. Certain core elements have become standard for the weekly MBSR sessions, including body-scan exercises that involve bringing awareness to and relaxing each region of the body, awareness of breathing, yoga, and the practice of sitting meditation. MBSR groups usually consist of 10 to 30 members and are lead by one or two instructors. Overall, the goal of the intervention is to teach participants mindfulness techniques as an approach to stress reduction and increasing emotional wellbeing by fostering an open attitude towards each moment (de Vibe, 2010).

Since its conception, the MBSR course has proven to be a useful model for the study of the mechanisms of mindfulness practice and its associated effects on the practitioner. A meta-analysis by Grossman et al. (2003) assessed the results from 20 different studies dealing with health-related changes occurring from standardized MBSR interventions. Included were studies with various patient populations such as those with chronic pain, fibromyalgia, cancer, anxiety disorders, and depression. Overall, both controlled and uncontrolled studies showed highly significant effect sizes of approximately 0.5 on standardized mental health measures including quality of life, anxiety, depression, and other affect-related scales. They also showed improvements in physical well-being measures including medical symptoms, sensory pain, and physical impairment. The researchers concluded that the results of these studies supported the utility of MBSR as a clinical and nonclinical intervention. Of importance to the present study is that the data presented in the meta-analysis were all self-report-based, and the researchers cite the need for objective measurements *in addition to* self-report indices.

The neural mechanisms underlying some of these changes in self-reported experience have only recently been investigated. Holzel et al. (2011) conducted an MRI study of a group of 16 MBSR participants and 17 wait-list controls to examine MBSR-related brain changes. Included was a self-report Five-Facet Mindfulness Questionnaire (FFMQ; Baer et al., 2006) that was used to assess trait mindfulness at both pre- and post-intervention. Along with an increase in total FFMQ scores, MRI data showed volumetric increases in the brainstem, left hippocampus, posterior cingulate cortex, the temporo-parietal junction, the amygdala, and the cerebellum in the MBSR group compared to the controls. The researchers inferred from these results that participation in MBSR is associated with increases in gray matter concentration in brain regions involved in learning and memory, emotion regulation, self-referential processing, and perspective taking.

A follow-up study by Singleton et al. (2014) investigated the effect of an MBSR intervention on brainstem gray matter concentration and its association with changes in self-reported psychological well-being, and found a significantly positive correlation. Taken together, the results from Hölzel et al. (2011) and Singleton et al. (2014) add greater validity to the self-report data analyzed by Grossman et al. (2003) and further demonstrate the power of short-term training in mindfulness practice. They also point to a potential overlap in the brain regions (e.g. brainstem & amygdala) affected by mindfulness practice and those implicated in startle behavior and modification.

Goldin & Gross (2010) studied the effect that MBSR had on brain-behavior indices of emotional reactivity and regulation in patients with social anxiety disorder (SAD). The researchers employed a "Regulation of Negative Self-Beliefs Task" in which participants were placed in an fMRI machine before and after the MBSR intervention and were exposed to a variety of self-critical personal beliefs (e.g. "I am ashamed of my shyness", "People always judge me", etc.). When instructed to shift attention to the breath ("breath-focused attention") versus counting backwards from 168 ("distraction-focused attention"), it was found that the breath-focused attention condition led to decreased negative emotion experience and reduced amygdala activity in response to the self-critical statements. This relates to the present study because amygdala activation in particular is known to be involved in startle enhancement (Koch, 1999). Attenuation of amygdala activity through mindful breathing in a non-clinical sample may be associated with a reduction in startle magnitude. Prior studies have also suggested other effects of mindful breathing, such as reduced reactivity to ruminative thinking (Feldman, Greeson & Senville, 2010), lower depression ratings (Burg & Michalak, 2011), and diminished perceived pain intensity and unpleasantness during slow breathing (Zautra et al., 2010).

*Mindfulness Practice and the Startle Response*

At present, a great deal of the research on mindfulness has relied primarily on self-report measures, which naturally invites a greater degree of subjectivist error. This is an issue in mindfulness research in particular because people are often not able to accurately rate their performance on certain measures such as mindful awareness, nonjudgment, mindful observation, etc. (Grossman, 2011). There is a crucial importance of contributing objectively measurable phenomena to the study of mindfulness if the research is going to be given greater validity (Grossman, 2011; Levinson et al., 2014). As Lang et al. (1990) points out, use of the acoustic startle response has its strength in measuring an obligatory reflex that is modulated by attentional, cognitive, and emotional states. Furthermore, it has been suggested that the reflexive nature of the startle response makes it less prone to intentional control and more resistant to demand characteristics than self-report (Grillon, 2008). Thus, the acoustic startle response may be of use in the study of mindfulness because it presents a more reliable method of inferring changes in psychological and emotional variables than does mere self-report. Therefore, it may provide a relatively objective measurable dimension of mindfulness outcomes. Combining startle measurement with self-report measurement may also yield interesting objective-to-subjective relationships.

Thus far, it appears that Levenson, Ekman & Ricard (2012) have published the only peer-reviewed study that combined the acoustic startle response with mindfulness meditation experience. The researchers studied a single meditator with 40 years of meditation experience under four different startle conditions in which a countdown from 10 signaled the impending 115-db, 100-ms acoustic startle stimulus. The four conditions were: 1) Open presence meditation: The meditator was instructed to enter into a meditative state of openness, without a particular object of focus, but simply aware of the environment and all passing phenomena, 2) Focused meditation: the meditator was instructed to enter into a meditative state focusing on a single detail in the surrounding environment, 3) Distraction:

The meditator was instructed to think in detail about a particular event in the past, and 4) Unanticipated startle: the startle stimulus was presented without countdown or instructions and the meditator was not in a meditative or distracted state. The physiological measurements the researchers used were heart rate, finger pulse amplitude, skin conductance level, and general somatic activity, and the behavioral measurements involved a high-speed camera recording of the participant's face.

The researchers found that the participant's startle magnitude in the unanticipated condition did not differ from those of historical controls. However, both kinds of meditation produced physiological and facial responses that were smaller than in the distraction condition, and open presence meditation produced smaller responses than focused meditation. The researchers interpreted the lack of a difference between the meditator's unanticipated startle response and that of the controls as a sign that his extensive meditation experience did not penetrate into the low-level brainstem circuitry that mediates the startle response. However, the effect of meditative states on the startle response was interpreted as evidence that meditation, as a state, is powerful enough to exert top-down attenuation of the response. Importantly, the results from Levenson et al. (2012) lack generalizability since it was a case study of a single expert meditator. The researchers cited the need to conduct research on the startle response and meditation in a greater population, including those with less experience. In order to draw effective conclusions about meditation and the startle response, more data on this subject would be needed from more meditators with varying levels of experience.

### *The Present Study*

The present study recruited participants from an MBSR course, and implemented an interventional design to assess changes in startle magnitude, self-reported affect and trait mindfulness across the 8-week intervention period. Subjects filled out the Five Facet Mindfulness Questionnaire (FFMQ; Baer et al., 2006) and the Positive and Negative Affect Schedule (PANAS; Watson, Clark & Tellegen, 1988) and underwent a 2-minute acoustic startle trial at both pre- and post-intervention (T1 and T2, respectively). The MBSR protocol provided a scientifically tested and standardized way of teaching participants mindfulness methods. The course was organized by the researcher, funded partially by the Office of Religious and Spiritual Life and launched at the school in January 2015. Short-term practitioners were chosen primarily because startle responses have not yet been studied in this population, and there was a possibility that startle measurement could be a useful contribution to the array of mindfulness outcome assessments.

The main aim of this thesis was to use the startle response as a way of assessing mindfulness outcomes, given that mindfulness may influence certain variables (e.g. emotional state, attention regulation) that tend to modulate the startle response. A secondary aim was to pair startle measurement with self-report assessments of mindfulness and affect in order to examine potential objective-to-subjective relationships. A third aim was to examine if participants engaged in mindful breathing behavior during the startle trial, and to see if this related to reductions in startle magnitude. Considering mindful breathing was shown to reduce activity in the amygdala in one sample (Goldin & Gross, 2010), and that amygdala activation leads to enhanced startle responses (Koch, 1999), mindful breathing behavior may lead to reduced startle magnitudes.

Self-reported mindfulness, as measured by the FFMQ (Baer et al., 2006) was included to examine if there was, in general, a relationship between how mindful a person perceives him/herself to be and the size of the startle response. If such a relationship exists, then there would be more evidence that startle can be a useful tool in mindfulness research since it may be resistant to the demand characteristics of which the FFMQ is vulnerable. The Positive and Negative Affect Schedule (Watson, Clark & Tellegen, 1988) was included to examine if changes in self-perceived affect due to the intervention were related to changes in startle magnitude. If so, this would mean that the subjective changes in affect had an objectively measurable component to substantiate them. Lastly, the findings from the present study may also have clinical relevance towards the use of mindfulness techniques in treating anxiety disorders that classically show exaggerated startle responses.

*Hypotheses*

1. There will be no pre-intervention (T1) significant differences on any of the measures employed between MBSR and control groups.
2. Startle magnitude will decrease for both groups across the intervention period, but this decrease will be significantly greater for the MBSR group
3. For the MBSR group, FFMQ and positive affect scores will increase significantly, and negative affect scores will decrease significantly.
4. Participants who report mindful breathing during the T2 startle trial will demonstrate a significantly lower startle magnitude at T2 than those who report doing otherwise.

# METHODS

*Course structure*

In order to facilitate recruitment of participants, the researcher organized an 8-week Mindfulness-Based Stress Reduction program at Union College, open to faculty, staff, and students. Enrollment in the full course was $100 for all participants. An extra $1000 dollars in funding for the course was acquired from the Office of Religious and Spiritual Life, and was paid directly to the course teachers; two experienced mindfulness teachers from Solid Ground Center for a Balanced Life in Albany were recruited to lead the course according to the standard MBSR protocol. The course was included as a Wellness Center offering during winter term at the school and was advertised through fliers posted around campus and through campus-wide emails. The class meetings each lasted two hours and were held every Wednesday night for eight weeks. An optional six-hour mindfulness retreat was held at the Kelly Adirondack Center on February 21st, after the sixth class meeting.

*Participants*

All participants filled out a screening form provided by the course teachers to ensure there would be no significant liabilities upon enrollment. 20 out of 23 signups were allowed to enroll in the course, and the remaining three were asked to participate as waitlist controls for the experiment. None of the 20 participants dropped the course across the 8-week period. Of the 20 enrollees, 11 (6 female, 5 male; Mean age = 41.27) voluntarily participated in the thesis experiment and formed the experimental group. They were each assigned a study ID number that was given to them by email. This was to be written on all of their practice logs and forms from the study. The control group consisted of eight participants (All female: Mean age = 25.63), two of which were from the course waitlist, and the remaining six of which were recruited from a meditation event in the Fall and expressed interest in MBSR but did not enroll in the course. Of the 11 MBSR group participants, two participated in the six-hour retreat.

*Procedure*

The study utilized an interventional design with the primary independent variable being enrollment in the MBSR course and the dependent variables being PANAS scores, FFMQ scores, and skin conductance responses to the startle stimulus. All experimental participants were brought into the lab at the beginning of the MBSR course, either before or after the first class, but before the second class. The control group was invited to participate after all experimental group participants underwent the T1 procedure. The procedure was the same for both groups.

A sound level meter was used to calibrate the startle sound to 110 ± 1 dB prior to each participant's arrival. At T1, all participants arrived at the lab and signed informed consent. They were then instructed to fill out a brief questionnaire that contained demographic questions as well as questions about mindfulness meditation experience. Following this, they filled out the PANAS (Watson, Clark & Tellegen, 1988) and were then instructed to wash their hands so that clean contact could be made with the skin conductance electrodes. The electrodes were then attached to the index and middle fingers of the non-dominant hand and a one-minute baseline skin conductance recording was initiated as participants filled out the FFMQ. Once this was done, participants were read aloud the following script:

> "In a few moments you will see a figure appear on this monitor and it will stay on the screen for two minutes. At some point in those two minutes you will hear a loud noise but you will not know exactly when this will occur.

> Just relax and keep your gaze on the center of the figure for the two minutes it is there and remain seated until I come get you."

A two-minute recording of skin conductance data was then initiated, the startle video was played, and the experimenter left the room and closed the door. The startle sound was emitted from a Line 6™ amplifier located directly behind the participants. Once the trial was over, the experimenter reentered the room, removed the electrodes, and $3 payment or ¼ psychology out-of-class credit was offered. Participants were instructed not to reveal any information about the experiment to others until March 14th, 2015, when data collection would be complete.

T2 data collection for the experimental group occurred during the final week of the MBSR class. Once all of this data was collected, the control group's data was collected. The T2 procedure was mostly identical to T1 with a few exceptions that will be reviewed shortly. Upon arriving the participants were given the option of reviewing their informed consent (all of them declined) and were then informed that the procedure would be mostly the same as the last visit. The T2 Brief Questionnaire asked participants if they attended the optional mindfulness retreat, how many MBSR classes they missed, and how much they felt they benefitted as a result of taking the MBSR course. At the end of their lab visits, participants were verbally asked if they found themselves using any mindfulness techniques during the two-minute startle trial, and if so what they did specifically. Their answers were recorded in writing on the front of their T2 brief questionnaires. Following this, they were given a debriefing form, allowed to ask any questions they had, and given payment or credit. They were reminded not to discuss the experiment with others until data collection was complete, and then were allowed to leave.

*Materials and Measures*

*Neulog™ GSR Logger Sensor NUL-217*: This device was used to acquire skin conductance readings in real-time for both baseline and startle trials. The GSR Logger Sensor contained two electrodes with Velcro straps used to attach them to participants' fingers.

*USB-200 Module*: This device was connected to the GSR module and was used to feed data to the laptop used for data collection.

*BAFX Products™ Digital Sound Level Meter*: Sound level meter that measured decibels and was used to calibrate the startle sound prior to lab visits.

*Line 6™ Amplifier*: 75-watt amplifier that emitted the startle sound at a loud enough level to elicit a strong startle response.

*Startle Video*: The video that was shown to participants during the two-minute startle trial showed six different configurations of annuli organized around a cross and was coded using MATLAB with help from a peer. Configurations cycled every 10 seconds. At the 55-second mark a 100-ms, 110 dB burst of white noise was played through the amplifier.

*Practice logs*: All MBSR group participants were given practice logs each week to record the number of minutes spent each day doing the prescribed mindfulness exercises. These were collected by the experimenter at the beginning or end of each of the class meetings.

*T1 and T2 Questionnaires* (Appendices 2 & 3): These brief questionnaires were the first questionnaires filled out at the beginning of the T1 and T2 visits, respectively. Both asked for demographic information (i.e. name, age, sex). The T1 form asked for information about prior mindfulness experience (e.g. perceived mindfulness experience on a 5-point Likert-type scale, and years of practice on a 7-point Likert-type scale ranging from no experience to 5+ years of experience) and the T2 form asked for information about experience with the MBSR course (i.e. classes missed, retreat attendance, perceived benefit from enrolling).

*PANAS* (Watson et al. 1988) (Appendix 4): This affect scale consists of 20 different items and has participants rate on a 5-point Likert-type scale (1=Very slightly or not at all, 5=Extremely) the degree to which they have been feeling a certain emotion, such as “Interested”, “Guilty”, and “Determined”, over the past week.

*FFMQ* (Baer et al. 2006) (Appendix 5): This mindfulness questionnaire contains 39 different statements that are intended to measure five different sub-constructs of mindfulness, namely Non-judge, Observe, Describe, Act with Awareness, and Non-react. Participants rate on a 5-point Likert-type scale (1=Never or rarely true, 5=Very often or always true) statements such as “I disapprove of myself when I have irrational ideas”, “My natural tendency is to put experiences into words”, and “I pay attention to sounds, such as clocks ticking, birds chirping, or cars passing.”

*Statistical Analyses*: Skin conductance data were collected using Neulog software, and magnitude was acquired using Ledalab software for MATLAB (Benedek & Kaernbach, 2010). An adaptive smoother was applied to each dataset, and then a continuous decomposition analysis (CDA) was performed to separate phasic and tonic components of the skin conductance curve. The startle response window was defined as the first five seconds after the startle event within each participant’s skin conductance dataset. Startle magnitude was calculated as the area under the phasic curve within that five-second response window. These data as well as those from the FFMQ, PANAS, and brief questionnaires were then entered into and analyzed using IBM SPSS Statistics 20.

# RESULTS

All 19 participants that enrolled in the study successfully completed T1 and T2 trials. Independent samples T-tests did not reveal any significant differences between MBSR and control groups in perceived mindfulness experience, $t(17) = 1.774$, $p = .094$, reported amount of prior mindfulness experience, $t(17) = 1.458$, $p = .163$, or mean age, $t(17) = 2.001$, $p = .062$, although there were trends suggestive of differences. Of the 11 MBSR participants, nine successfully recorded their average practice minutes across the intervention. Average practice minutes for these participants in all the different exercises (*not* including the two-hour class every Wednesday) amounted to 142 minutes per week, and 20 minutes per day. Within-groups measures are represented in **Table 1**.

Independent samples T-tests revealed that there was no significant difference in startle magnitudes between MBSR and control groups at either T1, $t(14) = -1.348$, $p = .199$, or T2, $t(16) = -1.515$, $p = .149$. A repeated measures ANOVA yielded a statistically significant effect of time on startle magnitude, $F(1,13) = 5.628$, $p = .034$. However, there was no statistically significant interaction between MBSR enrollment and time on startle magnitude, $F(1, 13) = .673$, $p = .427$. Furthermore, paired samples T-tests that were conducted separately for each group did not reveal any significant differences in startle magnitude across the intervention, MBSR group: $t(7) = 1.285$, $p = .240$; Control group: $t(6) = 1.951$, $p = .099$. These data are shown in **Figure 1**.

Different results were acquired when the independent variable was defined as whether or not participants reported “breathing” or “other” during the T2 startle trial. The “breathing” group was defined as anyone who reported mindfully breathing at T2, *excluding* participants who reported only breathing *after* the T2 startle stimulus. The percentage of participants who reported “breathing” or “other” significantly differed by participation in MBSR or control groups, $c^2(1, N=19)=4.968$, $p = .026$, such that MBSR participants tended to be more likely to fall into the “breathing” group than the controls. A repeated measures ANOVA was conducted on startle magnitude for the “breathing” and “other” groups, and there was no statistically significant effect of time on startle magnitude, $F(1,13) = 4.417$, $p = .056$, nor was there a significant group-by-time interaction, $F(1,13) = 1.090$, $p = .315$. Separate paired samples T-tests were conducted on the effect of time across the intervention for the “breathing” and “other” groups individually. There was no significant effect of time on startle magnitude for the “breathing” group, $t(5) = .582$, $p = .588$, but there was a significant reduction in startle magnitude across time for the “other” group, $t(8) = 2.843$, $p = .022$. Two independent samples t-tests were conducted on startle magnitude between the “breathing” and “other” groups at T1 and T2. There was no significant difference in startle magnitudes between groups at either T1, $t(14) = .525$, $p = .608$, or at T2, $t(16) = .350$, $p = .753$. These data are represented in **Figure 2**.

A repeated measures ANOVA was conducted on FFMQ scores across the intervention for the MBSR and control groups. There was a significant main effect of time, $F(1,1\ 7) = 15.741$, $p = .001$, and a significant interaction, $F(1, 17) = 7.752$, $p = .013$. Paired samples T-tests were conducted on FFMQ totals across the intervention for MBSR and control groups. There was a significant increase in FFMQ scores for the MBSR group, $t(10) = -4.697$, $p = .001$, but not for the control group, $t(7) = -.946$, $p = .376$. Independent samples T-tests did not yield significant differences in total FFMQ scores between MBSR and control groups at T1, $t(17) = -1.407$, $p = .177$, or at T2, $t(17) = .136$, $p = .894$. These data are displayed in **Figure 3**.

A repeated measures ANOVA was conducted on positive affect scores across the intervention for the MBSR and control groups. There was no significant effect of time, $F(1, 17) = 4.283$, $p = .054$, and no significant interaction, $F(1, 17) = .004$, $p = .949$. Paired samples T-tests did not yield significant differences in positive affect scores across the intervention for either MBSR, $t(10) = -1.429$, $p = .183$, or for controls, $t(7) = -1.799$, $p = .115$. Independent samples T-tests did not reveal any significant differences in positive affect scores between MBSR and control groups at either T1, $t(17) = .074$, $p = .942$, or at T2, $t(17) = .194$, $p = .849$. These data are displayed in **Figure 4**.

A repeated measures ANOVA yielded no significant effect of time on negative affect scores across the intervention, $F(1,17) = 2.929$, $p = .105$, but did reveal a significant interaction between time and MBSR enrollment, $F(1,17) = 5.741$, $p = .028$. Paired samples T-tests yielded a significant increase in negative affect scores across the intervention for the control group, $t(7) = -3.424$, $p = .011$, but no significant difference for the MBSR group, $t(10) = .469$, $p = .649$. Independent samples T-tests revealed a significant difference in negative affect scores between MBSR and control groups at T1, $t(17) = 2.261$, $p = .037$, but not at T2, $t(17) = -1.239$, $p = .232$. These data are displayed in **Figure 5**.

## DISCUSSION

The main purpose of this study was to assess whether mindfulness-based stress reduction training could produce an impact on the acoustic startle response as measured by skin conductance response, and if this impact could be linked to changes in PANAS and FFMQ self-report variables across the intervention. As predicted, startle magnitudes measured by skin conductance response declined for both the MBSR and the control group across the 8-week MBSR intervention period. This result was most likely due to habituation to the startle stimulus and to the startle trial in general. Also as predicted, there was no significant difference between groups in startle magnitude at T1, however the MBSR group appeared to have non-significantly lower startle magnitudes at both time points. Nevertheless, there was no significant difference between-groups in startle habituation across T1 & T2, therefore it cannot be concluded from this study that the MBSR intervention successfully yielded an effect on the acoustic startle response.

There are several different interpretations of these main results. First, it is possible that habituation at T2 generated a floor effect, whereby it became difficult to discern differences in magnitude that may have been influenced by the MBSR enrollment variable. This would mean that the habituation effect at T2 was far stronger than the effect that mindfulness training would have had on the startle response, and so it oversaturated the results at T2. Second, the small sample size and subsequently low statistical power could have made small differences impossible to detect. This will need to be corrected by greater enrollment in future research. Third, and perhaps most importantly, eight weeks of introductory mindfulness practice may simply not be enough to make a noticeable difference in the low-level, immediate reaction that is the startle response. Instead it might take more practice to internalize mindfulness skills to the point of affecting visceral defensive behavior.

This last point is perhaps most interesting because it recalls the findings from Hölzel et al. (2011) and Singleton et al. (2014) that point to significant increases in regional gray matter after an MBSR intervention. In particular, both of these studies found significant changes in the volume of various regions in the brainstem, which is the general site of startle behavior (Koch, 1999). Although the PnC (the main site within the brainstem that mediates startle) was not directly included in the findings from Hölzel et al. (2011) and

Singleton et al. (2014), other regions that are apparently related to startle behavior were included. For example, the locus coeruleus was one of the areas in which both of those studies found volumetric increases, and one lesion study of the locus coeruleus in rats found that the rats consistently exhibited reduced startle responses afterwards (Adams & Geyer, 1981). Accordingly, in a human subject with a higher volume locus coeruleus one might expect to see a corresponding change in startle functioning. On the contrary, participants in the present study may not have experienced the same regional brain volume increases as in Hölzel et al. (2011) and Singleton et al. (2014), and these increases do not necessarily entail changes in startle magnitude. Therefore only further research on the neural overlap between startle and mindfulness may illuminate this matter. In general, the startle magnitude results suggest that the startle response may not be a good outcome measure for short-term practitioners, and this is an important finding for guiding future research.

Self-report scores at T1 were indicative of poorer self-perceived mindfulness and higher self-perceived negative affect for the MBSR group compared to the controls, however this difference was only significant for negative affect scores. Nevertheless these trends indicate a population difference that was present at T1. It is logical that participants with higher self-perceived negative affect would be likely to enroll in the MBSR course, since there may be a greater perceived need for a “stress-reducing” intervention in these participants. Additionally, only two of the ‘waitlist’ controls were recruited from the MBSR waitlist, and the other six were participants who had expressed interest in the MBSR course but did not sign up for various reasons. Those who did not sign up may have experienced less of a perceived need to undergo 8-weeks of mindfulness training, as evidenced by lower negative affect and higher initial FFMQ totals. These T1 differences were potentially confounding and suggest that there was a population skew that invited greater experimental error.

The MBSR group's self-report scores showed trends that were indicative of steadier affect and improved mindfulness skills across the intervention, but these trends were not present for the control group. The only significant self-report trend the control group showed was a significant increase in negative affect across the intervention, whereas the MBSR group showed a non-significant reduction in negative affect scores. One explanation for this result may be that the control group underwent their second lab visit during the tenth week of the trimester while the MBSR group underwent theirs during the ninth week. Given that the tenth week is just before exams, the control group may have been more stressed and thus may self-reported greater negative affect. However, limitations aside, this finding may also suggest that MBSR helped the participants to buffer against the negative affect that comes with higher stress at the end of the trimester. That they did not increase in negative affect but instead showed a slight decrease might suggest that MBSR positively affected some aspect of resilience.

Positive affect scores in general increased across the intervention, but this was not technically significant for either of the groups. This was an expected result for the MBSR group but not for the control group. Nevertheless, the lack of a difference between groups makes it difficult to draw any conclusions about MSBR and positive affect. Increases in the MBSR group's FFMQ scores are a common result of the MBSR intervention (e.g. Baer, Carmody & Hunsinger, 2012; Robins et al., 2011; Bränström et al., 2010), so this finding was expected for the present study. One aim of this study was to examine if changes in the startle response related to changes in self-reported affect and self-reported mindfulness skills; however, this analysis was not carried out since there was no significant difference in startle magnitudes at any point between the two groups. Therefore it cannot be concluded from this study that changes in the startle response correlated in any way to changes in self-report scores resulting from the MBSR intervention.

A different startle magnitude result was discovered when groups were defined as whether they reported breathing or otherwise during the startle trial. The “other” group tended to have higher startle magnitudes at T1 and then a significant reduction in startle magnitude by T2, whereas the “breathing” group had lower T1 startle magnitudes but no significant reduction at T2. It is not known how many of these participants would have reported breathing at T1 had they been asked, so it is not clear if the lower T1 magnitudes in this group was due to mindful breathing. If so, this may have confirmed the hypothesis that mindfully breathing would be associated with a reduced startle magnitude. However, due to the potentially overwhelming effect of habituation and other factors this reduction may not have been detectable at T2, and only further research examining mindful breathing and startle behavior could help illuminate this.

One related important finding from this study was that MBSR participants were significantly more likely to report mindfully breathing at T2 than controls. Once again, it cannot be known whether this result was caused by the intervention in itself. Nor can it be known if this result was specific to the startle trial in particular; for example, it may have been the result of participants sitting silently in a chair for two minutes, which may have cued sitting meditation behavior. However, I hypothesize that this result was at least partially specific to the startle trial, or elements of the startle trial; being placed in an uncertain situation in which a loud noise can sound at any moment will likely produce some degree of apprehension, and the breath can serve was a way of calming and anchoring oneself during the trial. In addition, I also assert that the difference in the number of participants from either group reporting mindful breathing was indeed an effect of the intervention. The participants in the MBSR group had trained over eight weeks in several techniques that use the breath as a tool for reducing stress. It is therefore not surprising that they would revert to the breath when placed in a situation that was potentially stressful in the moment. A greater implication of this is that the MBSR course may have brought about a behavioral difference in how participants related to stressful situations.

*Strengths*

Given the significance of the self-report findings and the general non-significance of the between groups startle magnitude findings, there remains the question of whether or not the improvement in MBSR self-report scores were merely due to demand characteristics. As Grossman (2011) and Levinson et al. (2014) suggest, it is not yet clear if self-reported mindfulness questionnaires are accurately judging mindfulness skills per se, considering there is no “gold standard” for measuring mindfulness and very few (if any) behavioral measurements of mindfulness have been developed. Yet, many researchers thus far (e.g. Baer, Carmody & Hunsinger, 2012; Robins et al., 2011; Bränström et al., 2010) appear to be relying heavily on subjective (i.e. self-report) variables for making claims about the potentials of mindfulness and the benefits of participants. The principle strength of this study, therefore, was in its attempt to add a relatively objective physiological/behavioral outcome measure to the study of mindfulness interventions. The startle response was chosen because it is resistant to intentional control and demand characteristics (Grillon, 2008) and can be affected by a number of psychological factors that may also be influenced by mindfulness training (e.g. emotional functioning). This study also had the strength of questioning participants about their behavior during the startle trial. The results found from this aspect of the study opened up avenues for further research, which will be reviewed shortly.

*Limitations*

The study design brought a number of significant limitations. Firstly, the idea of doing an interventional measure on the startle response was likely to yield a large effect of habituation, but it was not anticipated until after the fact that this effect might actually overwhelm the potential effect of mindfulness training. The startle intervention also introduced a number of potential extraneous variables. For example, if the MBSR group demonstrated significantly smaller startle responses post-intervention, it is possible that this effect could be mediated by how mindfulness affects habituation, preparation, dealing with the uncertainty, and other effects. The intervention design might not have been necessary in assessing how mindfulness affects the startle response, and may have actually negatively affected the results. However it was thought to be worthwhile because it could have suggested a causal role of mindfulness in altering the startle response.

There were also a number of population issues with the sample. Although there weren't technically significant differences on demographic measures between the MBSR and control groups, there were prominent trends that suggested the groups were not evenly distributed. For example, there was a large difference in mean age, a difference in sex distribution between groups, and also differences in perceived amount of mindfulness experience. Another population issue was that the controls were not "true" waitlist controls. Only two were from the MBSR program's waitlist and the other six were recruited because they had expressed interest in enrolling in the MBSR course at a meditation event during the fall trimester, but ultimately did not enroll. That they had decided not to enroll in the course already indicated another difference between the two groups.

There was also difficulty with the experimental procedure itself. Firstly, this experiment incorporated a "dynamic" fixation cross, and it was thought that this might be a better way to control the attention of participants during the startle trial. However, this may have introduced a problem because there were spikes in skin conductance every ten seconds whenever the fixation image changed. It (IT IT IT IT!) may have been wiser to avoid this and incorporate a static fixation cross, without attempting to unnecessarily exert more control over the participants' attention. Furthermore, and perhaps one of the greatest drawbacks of this study, was that it lacked a "time-locked" startle stimulus. This means that the beginning of the skin conductance recording was not synchronized with the beginning of the startle video, so the startle event could not be precisely located on the skin conductance output. Instead the startle event had to be manually defined within each dataset, thus subjecting the data to possible biases and introducing a greater degree of experimental error.

This study only reported startle magnitudes, but did not report other aspects of the response, such as rise time, latency, or recovery time, which may indeed be influenced by mindfulness practice. A paper by Desbordes et al. (2013) suggested that the development of "equanimity", which they define as "an even-minded mental state or dispositional tendency toward all experiences or objects, regardless of their origin or their affective valence (pleasant, unpleasant, or neutral)", arises through the development of mindfulness practice. Furthermore, they suggested that a marker of equanimity might be a normal initial startle response followed by a markedly quicker recovery time. This theory suggests that perhaps the present study would have benefited from more detailed reports of startle physiology, i.e. reports that included information about latency period, rise time, and recovery time of the startle response. However, given the lack of time-locking between the startle video and the skin conductance recording, this was not possible.

*Future Directions*

Future research in this area should correct for population differences between groups, use a larger sample size, and also incorporate true waitlist controls that still retained the intention to enroll in the MBSR course. Apart from correcting for these and the other limitations listed in the previous section, it may be useful to include the State-Trait Anxiety Inventory (Spielberger, 2010) in the battery of self-report questionnaires administered at each visit. This is because state and trait anxiety levels are apparently closely linked to exaggerated startle behavior (Grillon, 2008), and would likely reduce after an MBSR intervention (Hazlett-Stevens, 2012). There has also been a more recently developed questionnaire called the "Intolerance of Uncertainty Scale" that may be usefully applied to the study of mindfulness and the startle response. Intolerance of uncertainty has been defined as the degree to which an individual tends to consider the possibility of an impending negative event as unacceptable, and high levels of self-reported intolerance of uncertainty have been linked to anxiety disorders (Carleton, Norton & Asmundson, 2006). Intolerance of uncertainty has also been shown to be associated with increased physiological responses to probabilistically uncertain aversive events (Nelson & Shankman, 2011). However, there has yet to be research focusing on the relationship between intolerance of uncertainty and mindfulness training, so this would be an important future direction as well.

It may also be useful to have participants more extensively rate and describe their subjective experience of the startle trial itself, to see if this would present information that may guide other research endeavors. Although the startle response may be physiologically the same for practitioners with mindfulness experience compared to controls, practitioners may have subjective information about the startle that indicates a difference in how they felt they were able to relate with the startle trial. For example, the present study succeeded in finding a behavioral difference between MBSR and control groups based on whether they reported mindful breathing during the trial, but this was not a physiologically detected difference. More extensive questioning after the startle trial is warranted, particularly about the emotional aspect of participants' experiences.

Lastly, it would be useful to conduct research on what types of situations cue reported mindful behavior, such as mindful breathing, particularly during stressful events. Since a major question in the literature deals with the question of behavioral measurement of mindfulness, one area of study that may guide further research would be to investigate the behavior of experienced practitioners during, for example, a pain stimulus trial. Although neuroimaging research has found differences in brain activity during these sorts of pain trials (e.g. Zeidan et al., 2011), it would be worthwhile to investigate if there are particular behaviors that are associated as well. If, for example, mindful breathing is cued more frequently during pain trials compared to control trials, then this may present behavioral evidence of a change in how practitioners relate with aversive events.

*Conclusion*

Despite significant limitations in a variety of domains, eight weeks of mindfulness practice may not be enough to significantly affect the startle response. The question remains, therefore, as to whether the self-report findings reported above were simply due to demand characteristics. Additionally, the fact that MBSR participants reported a higher incidence of mindful breathing during the startle trial may suggest a difference in how they dealt with the uncertainty and apprehension that may have resulted from the startle trial. As the mindfulness literature is right now, it is becoming more and more important that we incorporate a wider and deeper array of behavioral and physiological tasks and paradigms that measure outcome differences in practitioners vs. controls.

Although this study did not find differences in startle functioning for the practitioners, physiological measurement of the startle response in these populations may be worthy of further research because it may present a relatively foolproof way of assessing functional differences. In particular, for example, the startle response may be useful in adding an objective dimension to self-reported changes in anxiety that follow from mindfulness training. It could then be applied to clinical research with patients that have anxiety-based disorders, and therefore help to establish whether or not mindfulness training is truly a viable option in the treatment of such conditions. More generally, the startle response represents one of the many potential tools that are emerging for the purpose of raising the scientific standards placed on mindfulness research.

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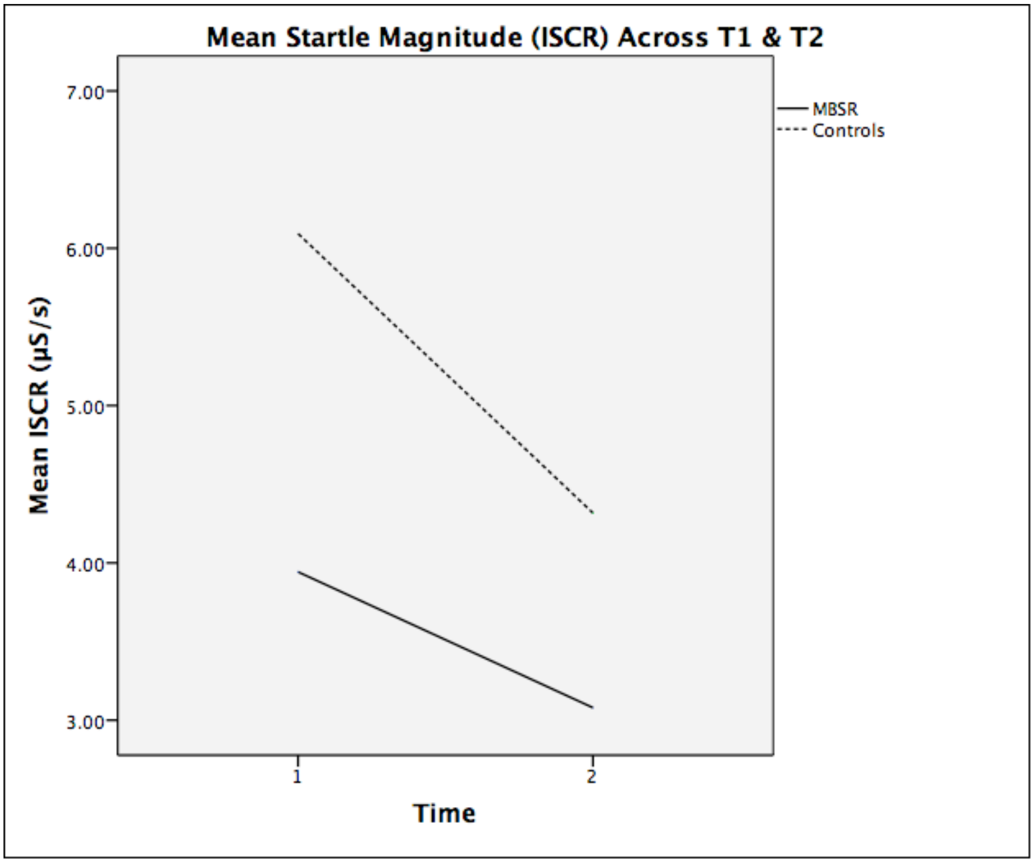
TABLES & FIGURES

**Table 1**. Within-groups comparisons of pre- and post-intervention measures

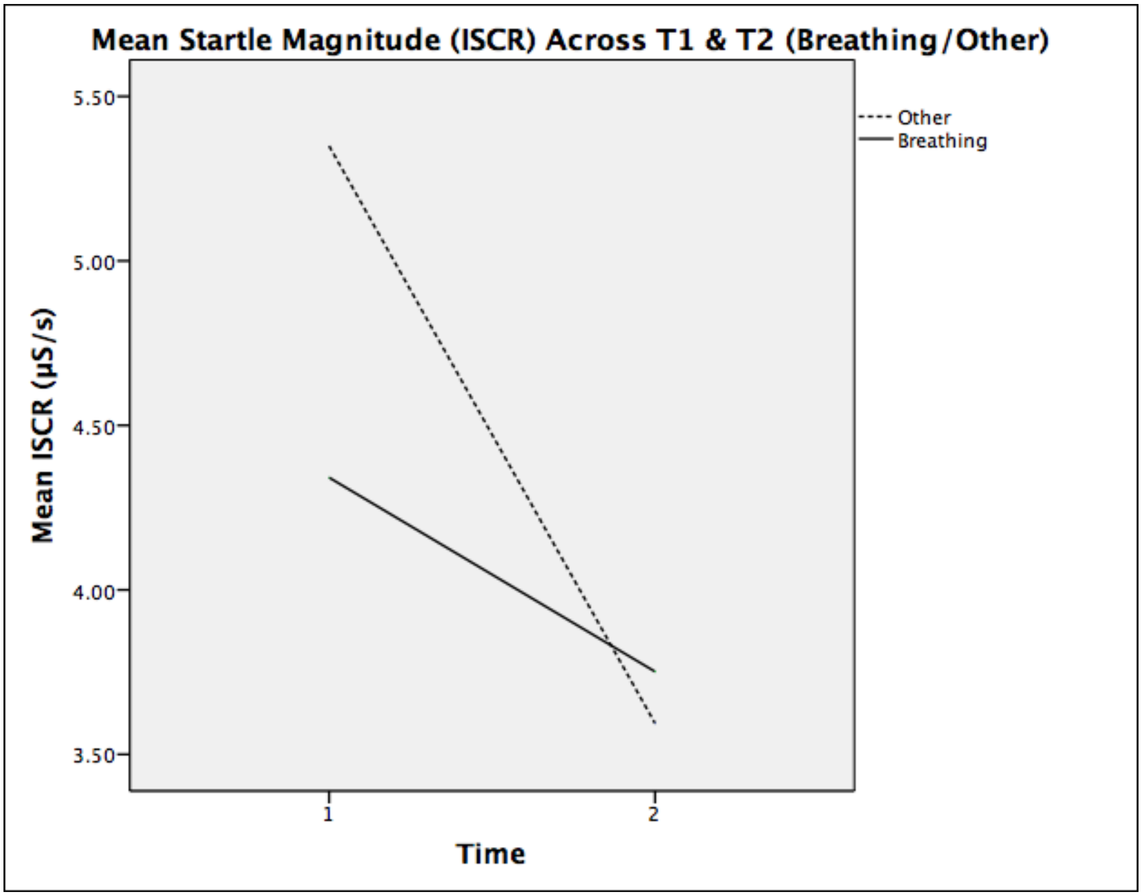
| | Measure | PRE | | POST | | t-test |
|---|---|---|---|---|---|---|
| | | mean | SD | mean | SD | |
| MBSR Group | FFMQ Total | 115.09 | 25.43 | 133.64 | 25.43 | $t(10) = -4.697, p = .001$ |
| | Positive Affect | 28.45 | 7.20 | 32.18 | 5.10 | $t(10) = -1.429, p = .183$ |
| | Negative Affect | 22.27 | 4.519 | 21.27 | 5.14 | $t(10) = .469, p = .649$ |
| | Startle Magnitude ($\mu$S/s) | 3.94 | 2.15 | 3.08 | 1.12 | $t(7) = 1.285, p = .240$ |
| Control Group | FFMQ Total | 129.12 | 13.97 | 132.38 | 13.33 | $t(7) = -.946, p = .376$ |
| | Positive Affect | 28.25 | 3.37 | 31.75 | 4.33 | $t(7) = -1.799, p = .115$ |
| | Negative Affect | 18.13 | 2.949 | 24.13 | 4.67 | $t(7) = -3.424, p = .011$ |
| | Startle Magnitude ($\mu$S/s) | 6.09 | 2.71 | 4.32 | 2.46 | $t(6) = 1.951, p = .099$ |

**Figure 1**



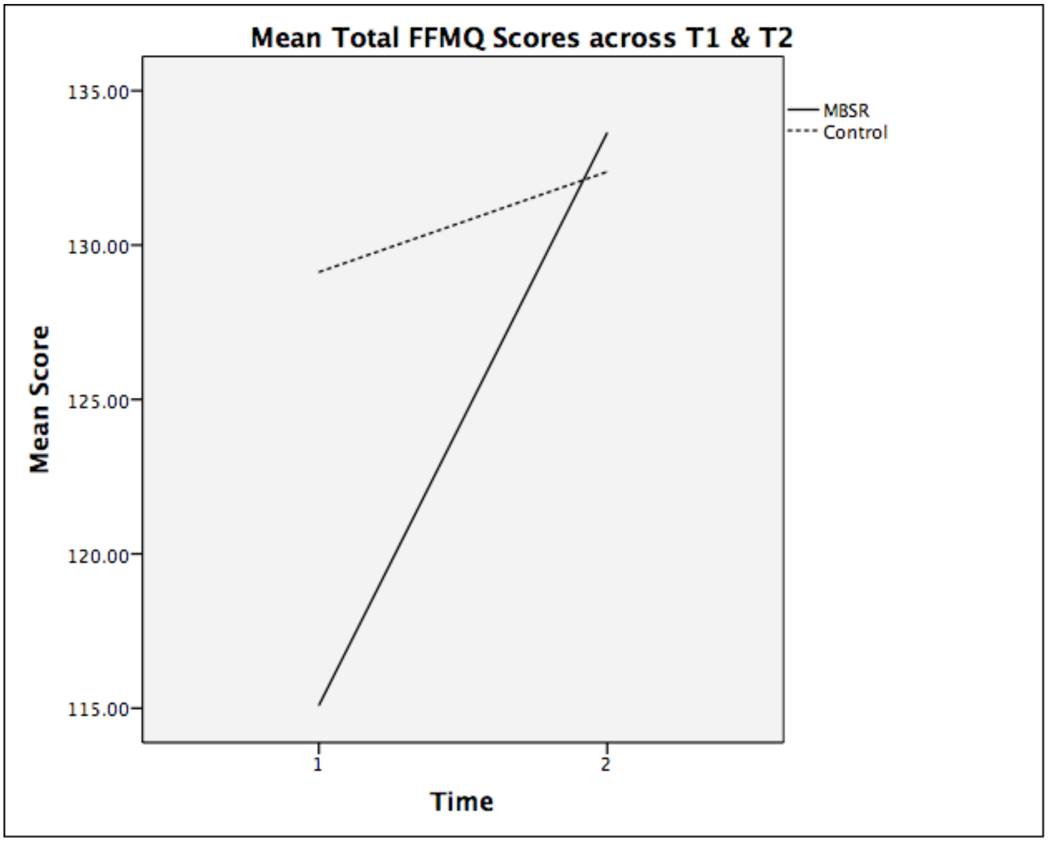

Independent samples T-tests revealed that there was no significant difference in startle magnitudes between MBSR and control groups at either T1, $t(14) = -1.348$, $p = .199$, or T2, $t(16) = -1.515$, $p = .149$. A repeated measures ANOVA yielded a statistically significant effect of time on startle magnitude, $F(1,13) = 5.628$, $p = .034$. However, there was no statistically significant interaction between MBSR enrollment and time on startle magnitude, $F(1, 13) = .673$, $p = .427$. Furthermore, paired samples T-tests that were conducted separately for each group did not reveal any significant differences in startle magnitude across the intervention, MBSR group: $t(7) = 1.285$, $p = .240$; Control group: $t(6) = 1.951$, $p = .099$.

**Figure 2**



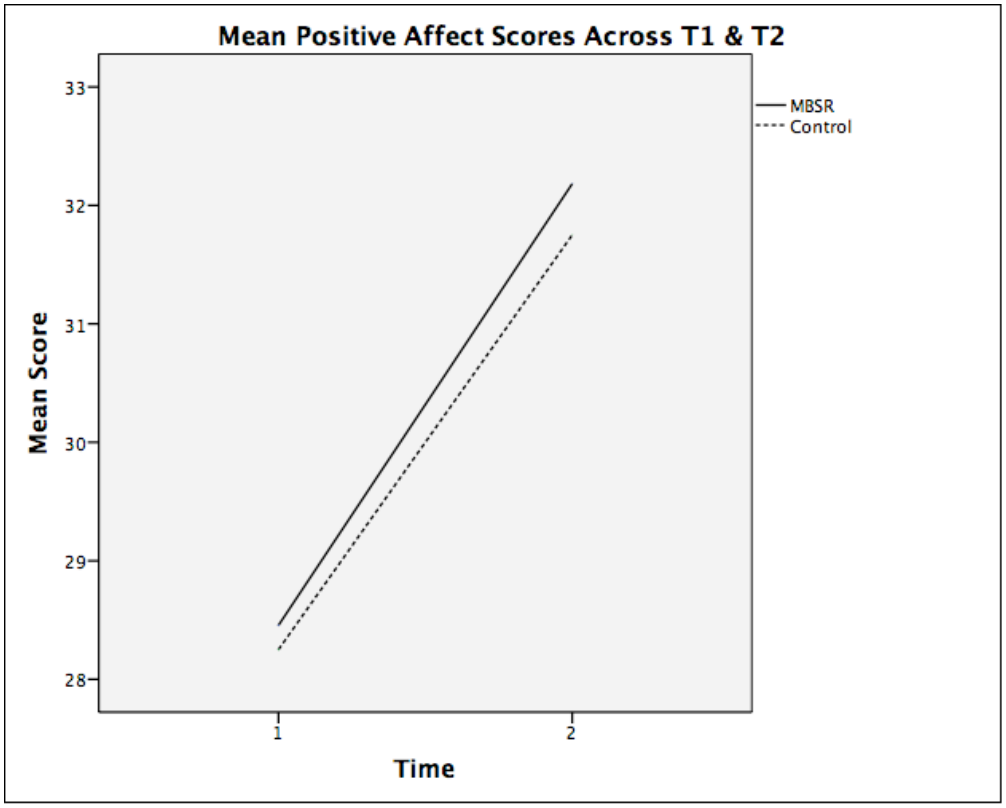

A repeated measures ANOVA was conducted on startle magnitude for the "breathing" and "other" groups, and there was no statistically significant effect of time on startle magnitude, $F(1,13) = 4.417$, $p = .056$, nor was there a significant group-by-time interaction, $F(1,13) = 1.090$, $p = .315$. Separate paired samples T-tests were conducted on the effect of time across the intervention for the "breathing" and "other" groups individually. There was no significant effect of time on startle magnitude for the "breathing" group, $t(5) = .582$, $p = .588$, but there was a significant reduction in startle magnitude across time for the "other" group, $t(8) = 2.843$, $p = .022$. Two independent samples t-tests were conducted on startle magnitude between the "breathing" and "other" groups at T1 and T2. There was no significant difference in startle magnitudes between groups at either T1, $t(14) = .525$, $p = .608$, or at T2, $t(16) = .350$, $p = .753$.

**Figure 3**



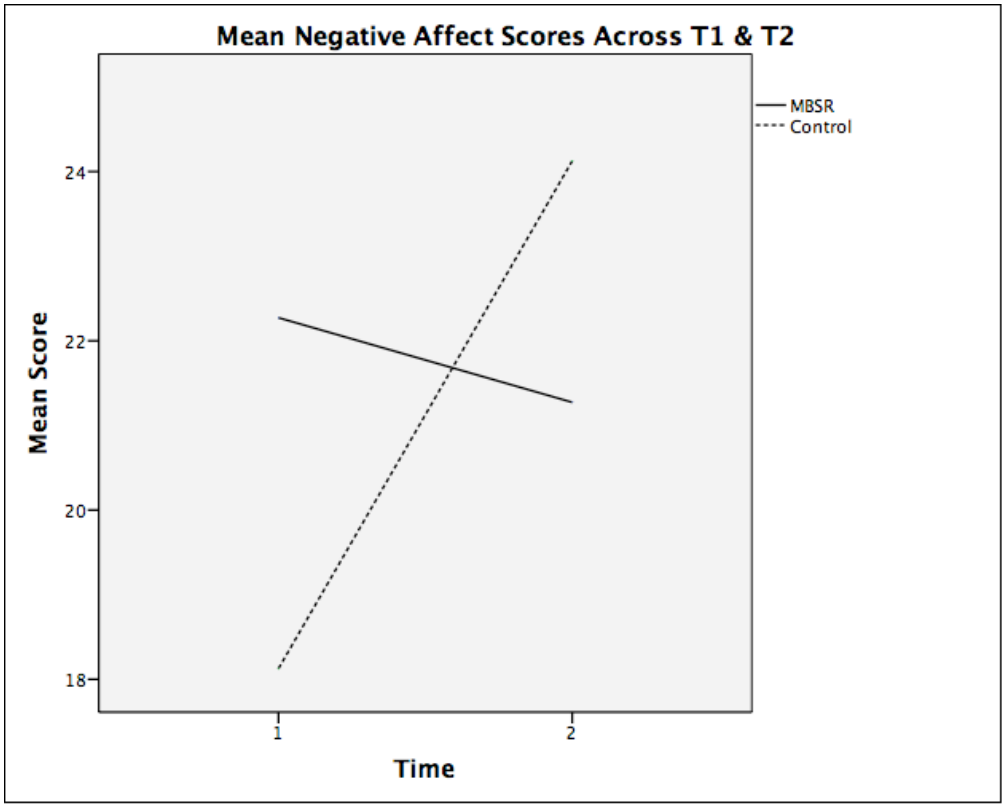

A repeated measures ANOVA was conducted on FFMQ scores across the intervention for the MBSR and control groups. There was a significant main effect of time, $F(1,1\ 7) = 15.741$, $p = .001$, and a significant interaction, $F(1, 17) = 7.752$, $p = .013$. Paired samples T-tests were conducted on FFMQ totals across the intervention for MBSR and control groups. There was a significant increase in FFMQ scores for the MBSR group, $t(10) = -4.697$, $p = .001$, but not for the control group, $t(7) = -.946$, $p = .376$. Independent samples T-tests did not yield significant differences in total FFMQ scores between MBSR and control groups at T1, $t(17) = -1.407$, $p = .177$, or at T2, $t(17) = .136$, $p = .894$.

**Figure 4**




A repeated measures ANOVA was conducted on positive affect scores across the intervention for the MBSR and control groups. There was no significant effect of time, $F(1, 17) = 4.283$, $p = .054$, and no significant interaction, $F(1, 17) = .004$, $p = .949$. Paired samples T-tests did not yield significant differences in positive affect scores across the intervention for either MBSR, $t(10) = -1.429$, $p = .183$, or for controls, $t(7) = -1.799$, $p = .115$. Independent samples T-tests did not reveal any significant differences in positive affect scores between MBSR and control groups at either T1, $t(17) = .074$, $p = .942$, or at T2, $t(17) = .194$, $p = .849$.

**Figure 5**




A repeated measures ANOVA yielded no significant effect of time on negative affect scores across the intervention, $F(1,17) = 2.929$, $p = .105$, but did reveal a significant interaction between time and MBSR enrollment, $F(1,17) = 5.741$, $p = .028$. Paired samples T-tests yielded a significant increase in negative affect scores across the intervention for the control group, $t(7) = -3.424$, $p = .011$, but no significant difference for the MBSR group, $t(10) = .469$, $p = .649$. Independent samples T-tests revealed a significant difference in negative affect scores between MBSR and control groups at T1, $t(17) = 2.261$, $p = .037$, but not at T2, $t(17) = -1.239$, $p = .232$.

Appendix 1

INFORMED CONSENT FORM

My name is Daniel Grossman, and I am a student at Union College in Schenectady, NY. I am inviting you to participate in a research study. Involvement in the study is voluntary, so you may choose to participate or not. A description of the study is written below.

I am interested in learning about how physiological activity and psychological well-being change after short-term training in mindfulness practice. Mindfulness practice is training in developing non-judgmental attention directed towards present moment experiences, and is hypothesized to result in many changes in how the practitioner relates and reacts to his/her experiences. First you will be asked to fill out a brief questionnaire, and then to complete two self-report scales. While filling out one of the scales, a baseline skin conductance reading will be obtained to measure your baseline nervous system activity. Following this, you will be asked to sit in a chair for two minutes and observe a figure on a computer monitor as another skin conductance reading is obtained. At some point during that period, you will be exposed to a sudden and loud, although harmless noise, but you will not know exactly when this loud noise will occur. The whole visit will take approximately 20 minutes. This study is interventional, meaning that you will be asked to come to the lab two times to undergo the same basic procedure. I will notify you when it is time to come in for your second visit.

The risks to you for participating in this study are temporary discomfort and surprise, due to the unexpected noise. These risks will be minimized by ensuring that the noise is safe and well below the harmful threshold of 140 decibels. If you no longer wish to continue, you have the right to withdraw from the study, without penalty, at any time.

Your responses will be held confidential. Your responses will be linked to a random ID number in a data file(s) retained by the researcher. Because you will be asked to come to the lab two times, the researcher will keep a list of IDs and names to ensure that your data from both times can be matched together; the list will be destroyed at the conclusion of the study. Thus, only de-identified data will be used in analyses and only aggregate/de-identified data will be reported in presentation or publication. If you are participating in the mindfulness-based stress reduction course, I will be collecting your weekly practice logs from the course teacher as part of my data analysis.

Even though all aspects of the study may not be explained to you beforehand (e.g. the entire purpose of the study), during the debriefing session you will be given additional information about the study and have the opportunity to ask questions.

By signing below, you indicate that you understand the information above, and that you wish to participate in this research study.

Participant Signature Printed Name Date

Appendix 2

## Questionnaire Form

Name: ___________________________________ Subject ID# (for researcher's use): ____

Age: ____________________

Sex (M/F): __________________

Are you enrolled in the Mindfulness-Based Stress Reduction class at Union? ____________

How many months/years of mindfulness meditation experience do you have? (Circle your choice):

0 = No experience

1 = less than 1 month

2 = 1 to 3 months

3 = 3 to 6 months

4 = 6 months to 1 year

5 = 1 year to 3 years

6 = 3 years to 5 years

7 = More than 5 years

Approximately how many times per week do you currently practice mindfulness meditation? _________________

How much mindfulness meditation experience do you perceive yourself to have? (Circle your choice):

1 = none

2 = a little

3 = some

4 = a lot

Appendix 3

# T2 Questionnaire Form

Name: ________________________________ Subject ID# (for researcher's use): ___________

Age: __________________

Sex (M/F): ________________

Are/were you enrolled in the Mindfulness-Based Stress Reduction class at Union (yes/no)?

___________

(If you answered no to this question, you may leave the questions below it blank)

Did you attend one of the day-long MBSR retreats (yes/no)? ____________

How many of the MBSR classes did you miss, if any? ____________

In general, to what extent do you feel you have benefited as a result of enrolling in the course?

(Circle your choice)

1 = not at all

2 = a little

3 = some

4 = a lot

5 = tremendously

Appendix 4

## PANAS

### Directions

This scale consists of a number of words that describe different feelings and emotions. Read each item and then circle the appropriate answer next to that word. Indicate to what extent you have felt this way <u>during the past week</u>.

Use the following scale to record your answers.

(1) = Very slightly or not at all (2) = A little (3) = Moderately (4) = Quite a bit (5) = Extremely

| | Very slightly or not at all | A little | Moderately | Quite a bit | Extremely |
|---|---|---|---|---|---|
| 1. Interested | 1 | 2 | 3 | 4 | 5 |
| 2. Distressed | 1 | 2 | 3 | 4 | 5 |
| 3. Excited | 1 | 2 | 3 | 4 | 5 |
| 4. Upset | 1 | 2 | 3 | 4 | 5 |
| 5. Strong | 1 | 2 | 3 | 4 | 5 |
| 6. Guilty | 1 | 2 | 3 | 4 | 5 |
| 7. Scared | 1 | 2 | 3 | 4 | 5 |
| 8. Hostile | 1 | 2 | 3 | 4 | 5 |
| 9. Enthusiastic | 1 | 2 | 3 | 4 | 5 |
| 10. Proud | 1 | 2 | 3 | 4 | 5 |
| 11. Irritable | 1 | 2 | 3 | 4 | 5 |
| 12. Alert | 1 | 2 | 3 | 4 | 5 |
| 13. Ashamed | 1 | 2 | 3 | 4 | 5 |
| 14. Inspired | 1 | 2 | 3 | 4 | 5 |
| 15. Nervous | 1 | 2 | 3 | 4 | 5 |
| 16. Determined | 1 | 2 | 3 | 4 | 5 |
| 17. Attentive | 1 | 2 | 3 | 4 | 5 |
| 18. Jittery | 1 | 2 | 3 | 4 | 5 |
| 19. Active | 1 | 2 | 3 | 4 | 5 |
| 20. Afraid | 1 | 2 | 3 | 4 | 5 |

Appendix 5

**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 (IT IT IT 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 (IT IT IT 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

**Scoring Information:**

Observe items:
1, 6, 11, 15, 20, 26, 31, 36

Describe items:
2, 7, 12R, 16R, 22R, 27, 32, 37

Act with Awareness items:
5R, 8R, 13R, 18R, 23R, 28R, 34R, 38R

Nonjudge items:
3R, 10R, 14R, 17R, 25R, 30R, 35R, 39R

Nonreact items:
4, 9, 19, 21, 24, 29, 33

**Reference:**

Baer, R. A., Smith, G. T., Hopkins, J., Krietemeyer, J., & Toney, L. (2006). Using self-report assessment methods to explore facets of mindfulness. *Assessment, 13*, 27-45.