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Effect of CRM on Neurobiology via EEG and Biofeedback

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LOMA LINDA UNIVERSITY
School of Behavioral Health
in conjunction with the
Department of Psychology

Effect of CRM on Neurobiology via EEG and Biofeedback

by

Sophia Truong

A Project submitted in partial satisfaction of
the requirements for the degree
Doctor of Psychology

September 2022

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Each person whose signature appears below certifies that this doctoral project in his/her opinion is adequate, in scope and quality, as a doctoral project for the degree Doctor of Philosophy.

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ACKNOWLEDGEMENTS

I would like to express my deepest gratitude to Drs. Brenner and Arechiga who provided me tremendous advice and direction throughout this doctoral project. Dr. Brenner, thank you for meticulously reading over and editing my paper, as well as preparing me well for my defense. Dr. Arechiga, thank you for inspiring me to love the CRM model and for helping me feel the “shift” for the first time. I truly believe simple wellness skills can go a long way in emotional well-being.

I would also like to give a shout out to my family, who has loved and supported me since day one on pursuing my dream career. I hope to make you all proud! To my Loma Linda friends, thank you for being my rocks. I cherish our relationship so much more than beyond colleagues, but lifelong friends. I love you all!

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ABBREVIATIONS

CRM	Community Resiliency Model
EEG	Electroencephalogram
MBSR	Mindfulness Based Stress Reduction
HEP	Heart Evoked Potential
TAU	Treatment As Usual
MBCT	Mindfulness Based Cognitive Therapy
DMN	Default Mode Network
HRV	Heart Rate Variability
LLD	Late Life Depression
GSR	Galvanic Skin Response

ABSTRACT OF THE DOCTORAL PROJECT

Effect of Community Resiliency on Neurobiology via EEG and Biofeedback

by

Sophia Truong

Doctor of Psychology, Department of Psychology
Loma Linda University, September 2022
Dr. Adam Arechiga, Chairperson

We reviewed the literature on mindfulness and its effects on psychological functioning. EEG studies have shown that different approaches to meditation, including MBSR, guided imagery, etc. have been associated with better interoception, increases in left frontal activity, and better stress regulation. These findings were used to create a study protocol that utilizes a somatically based intervention, the Community Resiliency Model (CRM) to decrease test taking anxiety in graduate school students.

CHAPTER ONE

MINDFULNESS AND EEG LITERATURE REVIEW

The term mindfulness can be defined as bringing one's full awareness to internal and external experiences during the present moment and engaging in an attitude of non-judgment and openness to the current experience (Bishop et al., 2004; K. W. Brown & Ryan, 2003; Kabat-Zinn, 1994). Mindfulness practices encompasses different forms meditative practices, including Mindfulness-based stress reduction (MBSR) and imagery. Mindfulness-based stress reduction (MBSR) is a structured psychoeducational program that incorporates mindful meditation, yoga, and deep breathing and is intended to help practitioners live in the current moment by being receptive to their thoughts, emotions, and sensations (Moynihan et al, 2013). Imagery refers to a technique of creating images in the mind and is used to elicit mental perceptual experiences by focusing on different sensations (e.g. auditory, visual, tactile). One of the uses of imagery is to formulate a positive change-goal by picturing their ideal life (Arbuthnott et al., 2001) or to regulate their nervous system by imagining a soothing image (Miller, 2015). Some forms of imagery are "guided" meaning an individual takes an active role to guide another to imagine particular experiences (Greenberg, Watson, & Lietaer, 1998; Heaps & Nash, 2001). For the purposes for this paper, the terms MBSR, meditation, and imagery are used in contexts that illustrate similar definitions, all of which allude to the idea of being mindful, or paying attention to the sensory details in order to stay in the present moment.

Many studies have found that MBSR has beneficial effects on psychological functioning. MBSR is associated with increases in working memory, attention, and

executive control (Moynihan et al., 2012). Working memory is one's capability to mentally manipulate and sustain information without becoming distracted by unrelated information. It was observed in one study that subjects trained in mindfulness had significantly better working memory than subjects not trained in mindfulness. In the same study, the mindfulness group had a significantly lower reaction time ($p < .05$) when asked to complete the Trails Making Test Parts A and B, neuropsychological assessment that measures executive functioning. These findings indicate that mindfulness allows for improved sustained attention (Chambers et al., 2008).

Attention refers to concentration and awareness on task-related stimuli and the exclusion of other, potentially distracting stimuli. In a study conducted by Jha et al. (2007), outcome measures assessing alertness, orientation, and conflict monitoring (i.e. subsystems of attention) were compared between participants who engaged in an eight-week MBSR program, participants who engaged in a one-month intensive MSBR retreat, and participants that were in a control group who were naïve in meditation and received no further meditation training. Alertness refers to vigilance and being in a state of preparedness, orienting refers to limited attention to arbitrary inputs, and conflict monitoring refers to the capability to prioritize competing tasks and responses. Shortly after the mindfulness trainings, it was found that the group who engaged in the eight-week MBSR program showed significant improvements in orientation compared to the other groups. Furthermore, the participants who were in the one-month intensive program showed improvements in alertness, specifically improvements in detecting exogenous stimuli compared to the other groups. Lastly, the groups did not show differences in conflict monitoring after the mindfulness trainings. These results suggest that MBSR

helps improve different subcomponents of attention, which all contribute to greater cognitive functioning. Furthermore, in a different study conducted by Chambers et al. (2008), MBSR practice in younger adult populations was shown to be associated with decreases in reaction time in the Internal Switching Task, a measure that indicates improved sustained attention. This finding suggests that mindfulness results in increased functional attention in tests of cognitive performance.

Executive functioning refers to a higher-level thinking that includes the capability to reason, plan, control, and regulate oneself in order to achieve a goal. It was suggested that MBSR helps improve visual and executive control among older adults (Moynihan, 2013) along with younger and middle-aged adults (Chambers et al, 2008; Jha et al., 2007; Jha et al., 2010). In Jha and colleagues' 2010 study, two military cohorts were recruited before a high-stress pre-deployment interval. One group was provided an eight-week mindfulness training—and were asked to log their out-of-class formal mindfulness practice time, and the other group was not. Outcome measures assessed both groups' working memory capability (WMC) and results found that although WMC decreased over time for those who had low hours of mindfulness practice outside of the training, WMC increased over time for those who had high hours of practice. Higher mindfulness practice time was also associated with lower negative affect and higher positive affect. These findings highlight that sufficient time of mindfulness practice can protect against cognitive impairments associated with high-stress context.

There has been evidence to suggest that guided imagery is effective for a variety goals (D. Arbuthnott & Arbuthnott, 1987; Edwards, 1989; Foote, 1996; Kundendorf, 1990; Martin & Williams, 1990; Meichenbaum, 1978; A. Richardson, 1994). In the

context of health psychology, some of the benefits of imagery include quickening of the rate of recovery from serious illnesses and surgery (Carey & Burish, 1988; Hall, 1984, 1990; Hall & Kvarnes, 1991; Holden-Lund, 1988; Manyande et al., 1995; Sheikh & Kunzendorf, 1984), alleviating health related stress and infectious illnesses (Baum, Herberman, & Cohen, 1996; Hall, 1990; Jasnoski & Kugler, 1987; Olnes, Culbert, & Uden, 1989; Schneider, Smith, Minning, Whitcher, & Hermanson, 1990; Watson & Marvell, 1992), and managing chronic pain (Marino, Gwynn, & Spanos, 1989; Turk, Meichenbaum, & Genest, 1983). In the context of psychotherapy, imagery has been shown to help with stress (Aylwin, 1988; Hammer, 1996), anxiety disorders such as phobias (Stampfl & Levis, 1967; Wolpe, 1973) and panic attacks (Der & Lewington, 1990), post-traumatic stress disorder (Kuch, Swinson, & Kirby, 1985), and eating disorders such as bulimia nervosa (Esplen, Garfinkel, Olmsted, Gallop, & Kennedy, 1998).

Overall, the benefits of MBSR include the opportunity for a greater working memory, attention, and executive functioning (Moynihan et al., 2013), along with mitigating physical, psychosomatic, and psychiatric disorders (Grossman et al., 2014). The benefits of imagery include helping one explore their emotional theme and to work toward their change goal (Arbuthnott et al., 2001)

EEG as a Neurobiological Measure

Over the years, electroencephalograms (EEG) have been a method used to measure the neurophysiological changes that occur in meditation.

Electroencephalography (EEG) refers to the process by which electrical brain activity is

recorded from the scalp. The EEG method was first discovered in the 1920s by Hans Berger and has advanced tremendously over the decades. It is currently one of the most common techniques for measuring brain activity as it is relatively less intrusive, less costly, and more widely accessible compared to other neuroimaging techniques.

EEG measures the electrical signal of large populations of neurons. Electrical activity within the brain can come from two sources: action potentials and postsynaptic potentials. Action potentials refer to the electrochemical occurrences that transmit from the cell body to the axon terminals where neurotransmitters are fired. Postsynaptic potentials refer to the process in which neurotransmitters binds to the postsynaptic cell. When this binding occurs, ion channels open and close, and it generates a graded electrical potential throughout the cell membrane. Scalp-recorded EEGs collect all the electrical activity coming from the postsynaptic cell rather than the action potential due to the rapid timing of the action potential and the physical makeup of the axons. Because neurons are firing within microseconds, action potentials from different axons will ultimately cancel out, leaving a minute amount of electricity to capture. In other words, the electrical activity flowing into one axon will almost be instantaneous to the activity flowing out of the axon, thus cancelling each other out. On the other hand, postsynaptic potentials are mostly bound in the dendrites and cell bodies and occurs immediately, compared to action potentials that take time to travel down the axon. This allows the postsynaptic potentials to summate compared to cancelling out, which subsequently allows the voltage changes to have larger amplitudes and can be recorded at the surface of the scalp. Hence, EEG recordings typically use the electrical signals coming from the postsynaptic potentials (Jones and Amodio, 2012).

Heart Evoked Potential

Event related potentials (ERP) refer to post-synaptic electrical activity in response to external stimuli or events (Blackwood and Muir, 1990), which may be in the forms of motor, sensory, or cognitive events (Couto, 2015). Heart evoked potentials (HEP) refer to a similar concept, however, the stimuli is the individual's heartbeat. HEP are different from ERP because cortical activation is triggered by internal body signals, rather than external stimulus locked markers (Pollatos et al., 2007a). The HEP is a cortical correlate of interoceptive afferents to the cortex (Pollatos and Schandry, 2004) related to behavioral performance.

The understanding of the communication between the brain and visceral organs is still at rudimentary stages. For instance, it had been assumed that sensory input from the gut to the brain was transmitted via hormones. However, recent research suggested that there are epithelial cells that activates the vagal nerve, thus highlighting that there is a specific neural pathway that reveals the direction communication between the gut and brain (Kaelberer et al., 2018). Similarly, though there is limited research on the pathways between the heart and brain, we know that the brain communicates with internal organs through two mechanism, the neural mechanism (e.g. autonomic nervous system) or the chemical mechanisms (e.g. endocrine system, immune system, etc.) Tallon-Baudry et al. (2018) identified several potential pathways which includes: 1) the baroreceptors and the carotid arteries, 2) cardiac afferent neurons at the heart wall, 3) somatosensory mapping through the skin, and 4) neurovascular coupling in the cortex.

The current literature suggests that there is a link between cardiac interception and emotional responses (Wiens, 2005). For example, in Weins' (2000) study, when students

were exposed to film clips that projected different emotions, individuals who were able to detect their own heartbeat (without physically feeling their pulse) reported experiencing more intense emotions than individuals who had poor detection of their heartbeat (Wiens, 2000). Research indicates that emotional feelings are intensified by the physical state of the body (Garfinkel and Critchley, 2013). Because the interoceptive-emotional networks share the same neural system (Feinstein et al., 2013; Lane et al., 2009), the heartbeat is one of the key sources of interoceptive signals related to emotion.

In Gentsch and colleague's 2018 study, HEP was measured among 19 participants after being shown images of different emotional facial expressions, that of which some expressions were expected, and some were unexpected. The researchers also manipulated the emotional valence by alternating or repeating the emotional content. Results showed that HEP amplitude changes were modulated by the prediction--or expectancy of the emotional content, such that expected negative faces lead to decreases in HEP amplitude. Neutral expected faces did not have a significant effect. These results suggest that affective predictions along with their respective bodily sensory state can affect cardiac interoceptive responses. Furthermore, the researchers found that the repetition of the visual stimuli affected the affective effects, suggesting that there is a top-down exteroceptive influence on the interoception.

In Petzschner and colleague's 2018 study of 19 healthy males, participants were asked to focus their attention to their heartbeats (interoceptive attention) or a sound stimulus (exteroceptive attention) for 20 seconds. Participants were presented with a visual symbol of a heart on a computer screen which indicated the participant to focus on their heartbeat. After a 20 second interval, participants were presented with a visual

symbol of headphones on the computer screen which indicated the participant to focus on the auditory stimulus. Results showed that the HEP amplitude was significantly higher during interoception than compared to exteroception at the right side channels (C4 and CP4) during the time window of 520 to 580 ms (with the peak at 575 ms). This study suggests that shifting attentional focus from external to internal stimuli can change patterns of brain wave activity.

Several other studies have also used HEP amplitude as a measurement for good versus poor heartbeat perceivers (Katkin, Cestaro, & Weitkunat, 1991b; Montoya, Schandry, & Muller, 1993; Pollatos, Kirsch, & Schandry, 2005; Pollatos & Schandry, 2004; Schandry, Sparrer, & Weitkunat, 1986). A majority of these studies found that keener awareness of one's heartbeat (or 'good heartbeat perception') was associated with higher HEP amplitude during interoceptive conditions (Pollatos et al., 2005; Pollatos & Schandry, 2004; Schandry, Sparrer, & Weitkunat, 1986). Studies of heartbeat detection should be interpreted with caution; most studies measuring heart rate perception often have limitations of confounding variables that may not accurately represent interoception. For example, many studies have asked their participants to count their heartbeats aloud (Montoya, Schandry, Müller, et al. 1993*; Pollatos et al. 2005b*; Pollatos & Schandry 2004b*; Schandry, Sparrer, & Weitkunat 1986*; Terhaar et al. 2012) or tap on a computer keyboard to their perceived heartbeat (Canales-Johnson et al. 2015*; Garcia-Cordero et al. 2016*; García-Cordero et al. 2017*; Melloni et al. 2013; Sedeño et al. 2014**; Yoris et al. 2015, 2018). The auditory and tactile component of these tasks may not reflect pure interoception, as participants may be attuned to the other sensory components. More studies should focus on pure interoception without distraction from

external stimuli.

Frontal Lobe Asymmetry

Frontal brain asymmetry refers to the nonsymmetrical responses of the left and right hemispheres of the brain, particularly in the frontal regions (Watford & Stafford, 2015). Researchers have suggested that through electrophysiology (i.e. EEG), greater left frontal activity is related to greater experiences of positive emotions (Davidson et al., 1990) and curiosity of new experiences (Takahashi et al., 2005). There is a considerable amount of literature that support the approach/withdrawal model of frontal EEG alpha asymmetry, motivation, and emotion. (Davidson, 1993, 1998; for review, see Coan & Allen, in press). The approach/withdrawal model hypothesizes that frontal brain activity is associated with approach or withdrawal tendencies. More specifically, greater left frontal activity is associated with behavioral activation, appetitive behaviors (Moynihan et al., 2013), and attributes of reacting to positive stimuli (Coan, Allen, & Harmon-Jones, 2001); whereas greater right frontal activity is associated with withdrawal, depressive states (Moynihan et al., 2013), and attributes of reacting more intensely to negative stimuli (Tomarken, Davidson, & Henriques, 1990; Wheeler, Davidson, & Tomarken, 1993).

Studies have shown differences in frontal brain activation when engaged in MBSR. In one study by Moynihan and colleagues (2013), alpha from the left hemisphere was measured among participants who engaged in an eight-week MBSR training and were compared to participants who received no MBSR training. Left hemispheric alpha activity was measured at baseline, 8 weeks, and 32 weeks. At baseline measure, there

were no significant differences in left alpha activation among the two groups, suggesting there were not any pre-existing group differences. It was found immediately following the intervention (at 8 weeks), there was a significant increase from baseline level in left hemisphere alpha among participants who were in the MBSR group compared to the control group ($p = .03$). At 8 weeks, the control group also showed increases in right hemisphere activation. Comparing baseline scores to 32 weeks post intervention scores, there were no significant differences in left alpha activation, however, the control group displayed significantly greater right alpha activation ($p = .02$).

These findings were similar to Barnhofer et al.'s (2007) findings with depressed, suicidal patients. Specifically, Barnhofer looked at the effects of MBCT (mindfulness-based cognitive therapy) on frontal activation among individuals who had a prior history of suicidal depression. Groups were randomly assigned to either a MBCT intervention group or a TAU (treatment as usual) group. EEG activity was recorded at baseline and after the 8-week program. Results found that the TAU group displayed significant decreases in left frontal activity, while the MBCT displayed no significant differences. These findings suggest that MBCT among high-risk suicidal patients can help maintain a balanced pattern of brain activation.

In 2011, Moyer et al. found similar results of significant greater left frontal activity from meditation ($p < .001$), however, this study focused on measuring asymmetric activity while meditating, rather than after meditating, which may have produced enhanced group differences. Again, clinical implications for these findings include that left frontal activation is associated with approach tendencies.

In 2015, Watford and Stafford conducted a study where 70 undergraduate students were shown either a 15-minute video of a mindfulness intervention or a neutral video. Following this, participants were given a positive or negative emotion induction. Those in the mindfulness group self-reported higher levels of mindfulness and awareness of their emotions, and demonstrated greater left frontal activity and greater heart rate variability. The participants indicated that they had higher emotional awareness regardless of whether they were shown the positive or negative emotion induction, and higher negative affect when they were shown the negative emotion indication. This finding has important clinical implications such that people may feel more dysregulated towards the beginning stages of mindfulness meditation, and that negative emotions may be intensified if one is paying attention to the negative sensations.

In 2003, Davidson and colleagues studied the effects of mindfulness on brain and immune function among healthy employees in a work environment. EEG brain activity was measured at baseline, immediately after an eight-week mindfulness intervention, and four months post intervention among 41 participants (meditation group $n = 25$; control group $n = 16$). All participants were given an influenza vaccine at the end of the intervention. Results found that there were significant increases in the left-side anterior activity in the meditation group compared to the control group. Furthermore, significant increases of antibodies levels to the influenza vaccine were noted among the participants in the mindfulness group compared to the control group. These findings further suggest the benefits of mindfulness on brain, along with new findings on the benefits of mindfulness on immune function.

Power

The concentration, or magnitude of synchronized EEG activity, within a specific frequency band is defined as power (Tarullo et al., 2011). Power in higher frequencies bands are indicative of a state of alertness and quicker processing. Power in lower frequencies bands are indicative of hypoactivation and sleep (Marshall et al., 2004). Meditation has been shown to affect the frequency bands of theta and alpha activity. Alpha activity refers to rhythmic, oscillatory brain activity of 8 to 12 Hz, and has been shown to be associated with relaxation and calmness. Theta activity occurs between 4 to 8 Hz and is associated with drowsiness, daydreams, or internally generated images (Corrs, 2011).

It has been found that alpha and theta bands are modulated by different cognitive tasks (Bastiaansen et al., 2008; Sederberg et al., 2003; Sternberg et al., 1996) and mental imagery. Theta synchronization and lower alpha desynchronization have been shown to be correlated with episodic memory and attentional tasks (Klimesch et al., 1997a; Klimesch et al., 1997b). Upper alpha desynchronization have been shown to be activated during semantic memory tasks. Theta activation may reflect the occurrence of working memory and alpha activation may reflect the recalling of long-term memories to short term memory.

In 2010, Cavallaro and colleagues examined the modulating variables that determined differences in the alpha and theta band amplitude during guided visual and somesthetic imagery. Results showed that individuals who are both highly susceptible (High group) and lowly susceptible (Low group) to hypnotization reported greater vividness and lower effort for guided imagery compared to somesthetic imagery. EEG

patterns showed that the High group displayed more alpha desynchronization along with different activation during the two types of imagery. The Low group displayed segregated alpha and theta desynchronization and there was no difference in activation during the two types of imagery. The results indicate that cognitive mechanisms responsible for different levels of susceptibility to hypnotization are responsible for similar subjective experiences when guided through visual and somesthetic imagery for both the High and Low groups.

In 2016, Bing-Canar and colleagues examined the effects of mindful breathing on alpha power. The researchers assigned an audio exercise in mindful breathing to the participants and later had the participants complete a Stroop task (which measures selective attention), while brain activity was recorded via EEG. The ERAS (Error Related Alpha Suppression) index was used to measure the level of mental engagement following an error compared to a correct response. The researchers found that participants who practiced the mindful breathing showed increases in alpha power during the exercise and enhanced ERAS after the Stroop test, suggesting that mindful breathing practitioners were more alert of their errors. These results support the literature that mindfulness increases attentional awareness on cognitive tasks.

In Afranas and Golocheikine's (2001) study, coherence among alpha, delta, and theta bands were estimated at anterior and midline regions, along with prefrontal and posterior regions of the left prefrontal cortex. These brain regions were used to characterize meditative states, specifically the state of a *blissful experience*. Results suggest that only theta coherence was sensitive to meditative practices, and that there was

a positive correlation between blissful experience and theta power. Results also indicated that there was no correlation among the alpha powers.

In Overton's 2004 study, correlations among vividness of guided imageries and EEG theta power were investigated for potential relationships. This study included 18 individuals who were measured at three different time points: before, during, and after the guided imagery task, all of which were 3-minute intervals. Results indicated that vividness of the imagery was correlated with frontal midline theta power during the first measurement (before the guided imagery) with $R = .89857$ and the second measurement (during the guided imagery) with $R = .8837$. These results suggest that the brain regions associated with the production of frontal midline theta power are active when creating vivid mental images.

In Cahn and Polich's 2006 meta-analysis, results showed that alpha power increases during meditation, and this amount of alpha power is stronger at rest in meditators compared with nonmeditators, suggesting that meditation can impact both state and trait-like changes. These studies also support the finding that meditation results in theta power increases, specifically in the frontal midline regions during meditation. This region is also an area of activation for sustained attention in certain non-meditative studies.

Cahn and Polich's meta-analysis also found contradicting results in regard to alpha power. These studies suggest there is an absence of alpha power increase and sometimes even decreases in alpha in meditative practices. These specific studies looked at a variety of meditative practices (from Tantric yoga to Zen and Transcendental Meditation), rather than MBSR per se, suggesting that different types of meditation may

result in different types of brain wave changes. It is interesting that particular forms of meditation affect alpha power in different regions of the brain. For instance, one study showed that that Qigong meditators showed an increase in alpha power in the frontal cortex, and a decrease in alpha power in the occipital cortex (J. Z. Zhang, Li, & He, 1988). The inconsistent alpha changes that are selective to particular brain regions may be a reason as to why there are contradicting findings.

Coherence

Coherence refers to a statistic that determines the synchronicity of EEG activity within or across specific frequency bands, recorded at two different sites (Bowyer, 2016). In other words, it is used to determine if two separate areas of the brain are producing signals that are statistically correlated—or coherent. Coherence is the most common measure to determine brain pattern synchronicity. It is measured by quantifying frequency and amplitude signals within a frequency band and is then compared to different brain regions. Coherence values range from a value of zero to one. If the signals from the two different brain areas are identical, the coherence value is one. Conversely, if the signals are unrelated, the coherence value will approach zero.

There are numerous studies that suggest an alpha and theta range coherence among intra and interhemispheric regions during meditation. (Aftanas & Golocheikine, 2001; Badawi, Wallace, Orme-Johnson, & Rouzere, 1984; Dillbeck & Bronson, 1981; Faber, Lehmann, Gianotti, Kaelin, & Pascual-Marqui, 2004; Farrow & Hebert, 1982; Gaylord, Orme-Johnson, & Travis, 1989; Hebert & Tan, 2004; Travis, 2001; Travis & Pearson, 1999; Travis & Wallace, 1999, Dillbeck & Vesely, 1986; Orme-Johnson & Haynes).

In Fingelkurts and colleagues' (2016) study of 15 healthy individuals, the researchers investigated the association between meditation and synchronicity of the brain's DMN (default mode network). The DMN is a network that involves a few different cortical and subcortical structures, including the following: 1) the frontal area which controls the first-person perspective and the sense of control, 2) the posterior right area which controls the sense of self as a localized entity, thought related to emotions, and autobiographical memories, and 3) the posterior left area which controls the experience of thinking about oneself. Fingelkurts and colleagues state that these three areas of the DMN make up a complex selfhood. This study suggested that experienced meditators had increased synchronization in frontal regions and decreased synchronization in the left and right posterior regions. In addition, this study noted that experienced meditators already had structural brain changes at the baseline condition, where participants were at a resting state compared to those who do not meditate, suggesting again that meditation can have long-term, trait-like benefits.

In Yang and colleagues' 2009 study, EEG coherence was measured and analyzed among three visual mental imagery tasks: 1) mentally imagining jogging along the walls of a gymnasium and pressed a button when they imagine themselves reaching a corner (jogging imagery task), 2) thinking about and memorizing a one digit number, pressing a button five times, and recalling the digits sequentially after pressing the button again (digit imagery task), and 3) pressing a button (button pressing task). Results showed that theta power was significantly higher in the parietal and frontal lobes during the digit memory and jogging imagery tasks. There were almost no differences in coherence during the digit imagery and button pressing tasks. Coherence was significantly higher between regions that were far further apart on the scalp, particularly between the frontal and parieto-occipital areas, along with interhemispheric regions during the jogging imagery task. These findings indicate that

increases in theta power during the jogging imagery tasks reflects the ability to manipulate internal information. These findings also indicate that long-range theta coherence plays a critical role in forming the neural mechanisms required for mental navigation.

Heart Rate Variability

Heart rate variability (HRV) is a well validated measure of autonomic health (Brown et al., 2018; Hillebrand et al., 2013). HRV is a physiological marker of the person's ability to regulate the stress response (Shearer, 2016). In Shearer's (2016) study, the researchers found that people who practiced MBSR showed significantly higher level of HRV, suggesting that these individuals were able to regulate the stress response during a stress situation that mimicked strenuous situations of students in a study environment.

In a randomized controlled trial study conducted by Zwan and colleagues (2015), 76 participants were randomly assigned into the following groups for stress reduction: 1) physical activity (consisted of intensive exercise), mindfulness meditation (consisted of guided mindful meditation) and heart rate variability biofeedback (consisted of slow breathing while hooked to a heart rate variability biofeedback device). The aim of this study was to examine the efficacy of these three groups on stress and stress related symptoms. The participants underwent psychoeducation and an introduction to their respective intervention technique and were assigned to practice it for five weeks at home. Outcome measures included the Dutch version of the Depression Anxiety Stress Scales (DASS; De Beurs et al. 2001; Lovibond and Lovibond 1995), Pittsburgh Sleep Quality Index (PSQI; Buysse et al. 1989), and Scales of Psychological Well-being (SPW; van Dierendonck 2004; Ryff and Keyes 1995). Overall, these interventions improved the participant's stress, anxiety, depression, sleep, and well-being. There

was no significant between-intervention effect, suggesting that the three groups (physical activity, mindfulness meditation, and heart rate variability biofeedback) were equally effective in reducing stress and its' related symptoms.

It was suggested in Ionson and colleagues' 2019 study that there is a relationship between late-life depression (LLD), or a depression that is typically associated with a relatively later age of onset and cardiovascular disease. This relationship may be mediated by damage in the automatic control of the heart (Brown et al., 2018) as indicated by the HRV. In a 2018 meta-analysis, several studies suggested that people with LLD have lower frequency HRV (Brown et al., 2018).

In May and colleagues' 2016 study, a sample of 124 participants partook in a short (15 minutes) mindfulness inducing intervention. The purpose of this study was to investigate the relationship between mindfulness and cardiovascular autonomic modulation, as measured by heart rate variability and blood pressure variability. Results suggested that the mindfulness intervention had a strong positive effect on cardiovascular functioning. Specifically, there were decreases in cardiac sympathovagal tone, vasomotor tone, vascular resistance, and ventricular workload, suggesting that mindfulness and cardiovascular functioning are correlated.

Respiration Rate

Respiration rate refers to the rate at which breathing occurs. In a study with 20 experienced and non-experienced meditators, 10 experienced meditators were asked to relax for five minutes, meditate for 20 minutes, and relax again for five minutes (Holmes et al., 1983) The other 10 non-experienced meditators were asked to relax for 5 minutes,

rest for 20 minutes, and then relax for 5 minutes. Results showed that there was an association between meditation and reduced respiration rate among both groups. Interestingly, results showed no evidence of lower respiration rate among people who meditated compared to those who rested. This evidence suggests that there may be similar biological manifestations between a mindful state and a restful state.

In another study with forty male undergraduates, the participants were assigned to one of four groups, including 1) the control group, 2) deactivation demand group, 3) neutral demand group, and 4) activation demand group (Malec and Sipperlle, 1977). The control group was told to “just sit there” during the treatment period, while the latter three groups watched a videotape of a Zen meditator demonstrating how to count breaths. Following the exercise demonstration, the Zen meditator role-modeled and suggested three different outcomes, including a relaxed outcome, no specific outcome, and an aroused outcome, for each of the respective groups. Results showed that for the groups who practiced meditation, respiration rate initially decreased followed by a gradual decline during the treatment period. These results show that meditation may produce minute physiological changes among people who practice meditation.

Other studies have opposing results that suggest that there is no significant difference in respiration rate among people who meditate. In a study conducted by Cauthen and Prymak (1977), physiological reaction including respiration rate was assessed among five groups of seven subjects each. The three meditation groups comprised of expert meditators (with an average of five years of meditation), median meditators (with an average of 14 months of meditation), and novice meditators (with an average of 7 days of meditation). The two relaxation groups were instructed to practice

relaxing five days prior to the study and viewed a videotape on instructions and demonstrations for relaxation. The results showed that there were no significant changes in respiration rate attributable to meditation or relaxation.

Due to contrary results of the relationship between meditating and respiration rate, further research needs to be conducted in order to assess if the possible effect of meditation on the physiological response of respiration rate, especially controlling for variables of the relaxed state.

Galvanic Skin Response

Galvanic skin response (GSR) refers to a change in electrical properties of the skin in response to stimuli that evokes arousal (Das and Anand, 2012). It is an electrodermal response, which is a function of the human body that is associated with the sweat gland activity. When the body experiences increased stress levels (i.e. arousal of the sympathetic nervous system), changes in the electrical resistance of the skin are detected by the GSR sensors. Different levels of sweat activity are then a measure of psychological or physiological arousal. Specifically, the higher the GSR value, the lower the stress response.

Studies have also found a relationship between relaxation and high skin resistance. For instance, Shashi's 2011 study results suggested that GSR increases during meditation, specifically while "Om" chanting. In the same study, the participant reported that after the meditation, they felt more alert and relaxed. Additionally, Delius and Kellerova, 1971 also found evidence that mental reciting of "Om" increased alertness. The "Om" meditative practice has been around since the ancient and medieval time, and

recent studies wanted to further research if this exercise still had a positive effect on physiological stress.

In Das and Anand's 2012 study of 20 female participants, the practice of daily prayer and "Om" meditation for half an hour for one month had an effect on GSR. In this study, the "Om" meditation refers to a deep meditative practice where an individual imagines their own God, concentrates on the background prayer music, and recites the mantra "Om." This technique incorporates deep breathing exercises along with the use of visual imagery, as one would picture him/herself in a state of happiness. The results showed that there was a statistically significant increase in GSR values after the intervention (** $p < .01$) The results of this study suggest that meditative practices can contribute to psychophysiological relaxation.

In another 2019 study by Hicks and colleagues, the researchers were interested in dispositional mindfulness and perceived stress. "Dispositional mindfulness" refers to the quality or trait of an individual whom has high inherent mindfulness (Baer, 2011). The study included 59 participants whom self-reported their dispositional mindfulness and perceived levels of stress. Recordings of GSR were collected during a 15 minute resting state. Results from hierarchical regressions showed that there was a significant relationship between greater dispositional mindfulness and less perceived stress, along with lower resting state physiological stress (i.e. sweat). This study provides further evidence that meditation/mindfulness can help with autonomic arousal, and adds novel evidence that high dispositional mindfulness is associated with lower physiological stress.

CHAPTER TWO

SUMMARY OF MEASURES

This study will measure heart rate variability (HRV) and the following EEG variables: frontal lobe asymmetry, power, coherence, and HEP. Frontal lobe asymmetry refers to the uneven activation between the left and right hemispheres of the brain. Greater left frontal activation has been shown to be associated with activity related to experiences of positive emotions (Davidson et al., 1990), curiosity of new experiences (Takahashi et al., 2005), behavioral activation, appetitive behaviors (Moynihan et al., 2013), and attributes of reacting to positive stimuli (Coan, Allen, & Harmon-Jones, 2001). Right frontal activation has been shown to be associated with withdrawal, depressive states (Moynihan), and attributes of reacting more intensely to negative stimuli (Tomarken, Davidson, & Henriques, 1990; Wheeler, Davidson, & Tomarken, 1993).

Power refers to the concentration or magnitude of the EEG activity within a specific frequency band (Tarullo et al., 2011). In the mindfulness and meditation literature, the two most prominent frequency bands are alpha and theta. Alpha power is associated with alertness and quicker processing, whereas theta is associated with hypoactivation, sleep (Marshall et al., 2004), daydreams, or internally generated images (Hamlin, 2018). Alpha and theta power has provided insight into levels of attentional awareness and cognitive processing.

Coherence is a measure of synchronization among different parts of the brain. Increased synchronization in the frontal areas of the brain are indicative of higher levels

of a first-person perspective and a sense of self control. Decreased synchronization in the left posterior region is indicative of the experience of thinking about oneself, and decreased synchronization in the right posterior region is indicative of sense of self as a localized entity, thought related to emotions, and autobiographical memories. Furthermore, greater coherence among the frontal-parieto-occipital regions and along the interhemispheric regions indicate the ability to manipulate internal information.

HRV is a measure of autonomic health (Brown et al., 2018; Hillebrand et al., 2013) that assesses an individual's ability to regulate their stress response (Shearer, 2016). Higher levels of HRV indicate greater abilities to regulate stress and lower levels indicate lessened abilities to regulate stress. Stress related symptoms are associated with a wide variety of physical and mental health concerns such as depression, anxiety, well-being, blood pressure, and cardiovascular functioning.

HEP refers to changes in neural activity in response to one's heartbeat. Higher levels of HEP amplitude indicate greater interoception (as compared to exteroception), which suggests the ability to shift focus from external to internal stimuli. Research indicates that the physical state of the body via interoception can intensify emotional feelings (Weins, 2000).

Biofeedback measures of respiration rate and GSR refer to the rate of which one breathes and the electrical conductance of skin in response to arousal, respectively. Lower rates of breathing indicate lower physiological arousal and stress. Higher levels of GSR indicate lower physiological arousal and stress.

CHAPTER THREE

INTRODUCTION OF CRM

Community Resiliency Model (CRM), founded by Elaine Miller-Karas, LCSW, was created for the purpose of educating individuals about the biology and neurophysiology of trauma and resilience. Through the six basic wellness skills of: Tracking, Resourcing, Grounding, Gestures, Shift-and-Stay, and Help Now, individuals can reset and stabilize their autonomic nervous system. Practitioners of CRM learn how to read bodily sensations connected to their own well-being, which Elaine calls the “resilient zone.” Sensations related to relatively higher energy such as edgy, anger, irritability, mania, anxiety and panic, and pain are indicative of one being in the “High Zone.” Conversely, sensations related to relatively lower energy such as depression/sadness, isolation, exhaustion/fatigue, and numbness are indicative of one being in the “Low Zone.” Labeling sensations as “pleasant,” “neutral,” or “unpleasant” can help inform individuals where they are in the spectrum of zones and help guide them back to the resilient zone. It is important to note that CRM is a non-therapeutic approach. It is a practical model of self-regulation that anyone can learn and use.

Neurobiology of CRM

As human beings, we all share the same biological stress response. The autonomic nervous system is comprised of the sympathetic nervous system (fight or flight response) and the parasympathetic nervous system (rest and relax response). In the face of a threat or stress, our sympathetic nervous system gets activated and when it becomes too

activated, we begin the fight or flight mode. Over time, this survival instinct changes the way our brain processes information. In CRM, Elaine described these individuals as people who have “flipped their lids,” meaning that they are so dysregulated that they are not using their prefrontal cortex to think. Conditions like this include immense pressure, stress, or trauma. At its core, the CRM model is a nervous system hack where basic techniques help one engage the parasympathetic response which can help reregulate the mind and body.

Study Aim

The overall aim of this study is to investigate brain activity changes, via EEG and biofeedback measures, while undergoing Community Resiliency Model (CRM) procedures. CRM is a biologically based set of self-help skills aimed to help individuals who deal with stress and/or trauma. CRM is a technique that has been comparable to mindfulness and meditation; however, CRM is slightly different in that practitioners are paying attention to physical sensations (rather than thoughts and emotions) in the body and purposefully shifting their attention to pleasant or neutral areas within the body. Our study investigates whether CRM is an effective technique to regulate the autonomic nervous system. These results may be included in the repository of data necessary to establish CRM as an evidence-based technique that clinicians and civilians can easily and accessibly use. See Appendix A for the prospective study protocol utilizing CRM for graduate students with test taking anxiety.

Hypotheses

There are eight hypotheses. All hypotheses will be tested using a Repeated Measures T-test where phase represents the within subjects effect.

Hypothesis 1: CRM skills will be associated with greater left frontal alpha asymmetry compared to the resting state.

Hypothesis 2: CRM skills will be associated with greater alpha power and lower theta power compared to the resting state.

Hypothesis 3: CRM skills will be associated with greater coherence in the frontal lobes compared to the resting state.

Hypothesis 4: CRM skills will be associated with decreased synchronization in the posterior regions compared to the resting state.

Hypothesis 5: CRM skills will be associated with higher levels of HRV compared to the resting state.

Hypothesis 6: CRM skills will be associated with greater HEP amplitude compared to the resting state.

Hypothesis 7: CRM skills will be associated with lower levels of respiration state.

Hypothesis 8: CRM skills will be associated with greater GSR values.

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APPENDIX A

EEG and CRM Protocol

Overall Objectives:

1. To learn simple, biologically based skills to help graduate students with test-taking anxiety
2. To learn the three wellness skills of the Community Resiliency Model
3. To learn about interoception and how to self-regulate during high anxiety states

Consent and Data Collection

Prior to Meeting (15 minutes)

[The research team should arrive at the meeting location 30 minutes early to ensure that all equipment is set up and working adequately.]

Introduction and Consent (20 minutes)

[Read or paraphrase this section prior to distributing the consent forms]

Hi, my name is _____ and I am from the School of Behavioral Health. I would like to talk to you about the EEG and CRM research study.

The study I am presenting will examine the effectiveness of the Community Resiliency Model (CRM) in decreasing test taking anxiety. CRM is a set of wellness skills that will help you in managing your stress and maintaining resiliency.

This research study will take about 90 minutes total, all in one session. The session will consist of a brief overview of the study, obtaining your consent, setting up the EEG and biofeedback machine, and training you in CRM.

Your participation in the research portion of this program is completely voluntary. It will include the following:

- An electroencephalogram (EEG) and biofeedback machine will be used to measure your neural and physiological activity. An EEG cap with electrodes will be placed on your scalp and connected to the EEG machine. Another electrode will be placed on your wrist to measure heartbeat.
- You will be asked to think and talk about a specific time you experienced test-taking anxiety. This will evoke moderate activation of anxiety and stress during the session. If in any case where you experience a panic attack, a licensed clinical psychologist will be in the room to remediate the situation.
- You will learn the CRM skills of Tracking, Resourcing, and Grounding.

Confidentiality is essential in our research project; all identifiable information obtained as part of the research will only be reviewed by the research team and will be disclosed only with your permission or as required by law. Furthermore, no identifying information will be used in any written reports or publications from the results of this research. All data will be linked by assigned ID numbers rather than names and only the lead researchers will have access to the linking codes.

I will now distribute the informed consent forms and want to thank you for your consideration. If you do not want to participate in the research study, please let one of the research assistants know and leave your content form blank. Please let me know if you have any questions.

[Distribute and collect consent forms. Have research assistants review consent forms for completeness and attempt to collect any missing information prior to beginning data collection or the CRM training.]

EEG and Biofeedback Set-Up

The researchers will set up the EEG cap on the participant's scalp and add appropriate amounts of gel. The researchers will connect the EEG and biofeedback to the computers.

Introduction to CRM

“CRM is a set of biologically based wellness skills that can be used for self-care; it restores balance to the mind, body, and spirit. After stressful events, many of us get stuck in the High Zone, feeling anxious and uptight, or stuck in the Low Zone, feeling numb, disconnected, and exhausted. Some of us shift from High to Low Zone and no longer feel like our best self.”

“Like the rhythms of nature, our bodies have natural rhythms too. The nervous system is one of our natural rhythms. When the nervous system is in balance we feel like our best self. We make better decisions for ourselves, our family, and our community. This is called our Resilient Zone or our “ok zone. When we are in our Resilient Zone, it is easier to respond to life’s stresses. However, when you experience a distressing event, your body and mind go on alert. This is what we call being stuck in the High Zone. For example, our heart rate speeds up and our breathing becomes faster and shallower. The amping up of our nervous system helps us “fight-or-flight. Our bodies are designed to do this without thinking in order to survive. On the contrary, if the stressful situation lasts for too long, our bodies may crash into the Low Zone and you may feel numb, depressed, and tired.”

“Many of us experience the effects of stress because of the challenges at home, school, work, and our wider community. Sometimes the stress is just too much, and you may feel like you are not yourself. This means that your body’s natural balance is out of balance. The goal of CRM is to help you from being stuck in the High or Low Zone and get you back in the Resilient Zone. Through the use of the wellness skills, our goal is to help you ease your anxiety and nervousness around test-taking.”

Objectives:

1. To measure Baseline, Anxious, Grounding, and Resourcing stage
2. To elicit moderate anxiety from participant
3. To learn to read physiological sensations of the body and label it as pleasant, unpleasant, or neural (Tracking)
4. To learn the significance of building a resource to decrease anxiety (Resourcing)
5. To learn the significance of physical support of the immediate environment to decrease anxiety (Grounding)

The researcher will state the following at the corresponding stages:

BLOCK 1	Baseline	Anxious	Grounding	Baseline	Anxious	Resourcing
BLOCK 2	Baseline	Anxious	Ground	Baseline	Anxious	Resourcing

*30 seconds of recording at each stage

Baseline: “Please sit still and remain neutral for the next 30 seconds. We are measuring your baseline rates.”

Anxious: “Tell me about your test-taking anxiety. Can you imagine yourself right now as if you were about to take a test? What do you see, smell, hear, taste, touch? Is that anxiety small, medium, or large? Imagine yourself about to take a test. Hold this imagine in your head for the next 30 seconds.”

Grounding (With Tracking): “Tracking is a method of reading your nervous system. It is also known as interoception, which is the awareness of internal sensations (e.g., how do you know you are hungry?). Tracking means paying attention to the sensations in the body. Once you’ve identified an internal sensation, you will hear me asking you to label it as: pleasant, unpleasant, or neutral. Tracking will make more sense when we use it through the next skill, Grounding.”

“Grounding refers to bringing your attention to your body in the present moment by noticing how your body or part of your body is making contact with a surface. I want to invite you to find a comfortable position. As you find a comfortable position, notice how you are being supported by the chair and floor. As you bring your attention to the places of support, notice your breathing, heart rate, and your muscle relaxation. Notice especially any places inside that feel more relaxed, more pleasant or neutral. Next, bring attention to your back...lower body... thighs.. legs and notice how your feet are resting on the floor and how they are making contact with the ground. Bring your attention to sensations that are calming or neutral within your body. Take your time. As you bring your attention to neutral or comfortable sensations, notice your breathing, heart rate, muscle relaxation, etc. If you become aware of an uncomfortable or even painful sensation, shift your attention to places that feel better, more comfortable or

neutral. Notice the change. As a way to bring your practice of Grounding to a close slowly scan your body from head to toe, bringing attention to all the places inside that have changed in a more pleasant or neutral way since you started. Take your time. When you are ready, bring your awareness back to the room.”

“What sensations did you notice in your body? Was it pleasant, unpleasant, or neutral? Please Ground for the next 30 seconds without my guidance.”

Resourcing (With Tracking): *“A resource can be anything that helps you feel better. It can be a characteristic you like about yourself, a positive memory, a person, place, animal, spiritual guide, or anything that provides joy, peace, or calm. The resource is simply brought to mind and at least three details about the resource are remembered and then one’s attention is directed to the sensations that pleasant or neutral on the inside.”*

“What gives you strength, peace, and/or joy in your life? What are some more details about your resource? What smells, sounds, visual images are pleasing to you about the resource? As you describe your resource, bring attention to what is happening inside. Where in your body do you feel the sensations that are pleasing or neutral to you as you think about your resource? Take your time. Notice what is happening inside. Notice what is happening to your breath.. heart rate.. muscle relaxation. Bring awareness to the changes that are pleasant or neutral.”

“Do you notice any new feelings, thoughts, or beliefs? If there are, bring attention to the sensations connected to them. To end, bring your attention to your whole body and notice all the changes that have happened. Stay with that for a few moments. Know that you can return to this resource anytime you are bumped out of your Resilient Zone or you can select a new resource and repeat the exercise. Keep practicing Resourcing for the next 30 seconds without my guidance.”

**During the second round of Grounding and Resourcing, the CRM expert does not need to repeat the instructions. CRM expert will state “Please practice Grounding for the next 30 seconds” or “Please practice Resourcing for the next 30 seconds.”*

Closing

“Thank you for your participation in the EEG and CRM study. If you have any questions, comments, and/or concerns, feel free to contact either of us via email.”

The researchers will leave their email address for the participant.

Materials Needed

1. Informed Consent
2. Checklist of Stages (See Appendix)
3. Timer
4. Pen / Pencil

APPENDIX B
CHECKLIST

Note: EEG Expert will Record 30 Seconds of at Each Stage. A Timer is needed.

PARTICIPANT 1:

Block 1:

Baseline Anxious Grounding Baseline Anxious
Resourcing

Block 2:

Baseline Anxious Grounding Baseline Anxious
Resourcing

PARTICIPANT 2:

Block 1:

Baseline Anxious Resourcing Baseline Anxious
Grounding

Block 2:

Baseline Anxious Resourcing Baseline Anxious
Grounding