Voluntary inhibition of reflex: Effects of consistent meditative practice

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ABSTRACT

The present study investigated the effects of meditative practices on the regulation of autonomic function. 74 subjects (38 women; 36 men) comprised from a range of experienced and non-experienced meditators, engaged in a series of psychophysiological tasks designed to generate specific autonomic states. Regression analyses revealed that experienced meditators, as predicted, displayed greater suppression of myocardial reactivity during a highly reflexive and stressful task. Meditative practice also predicted a rise in electrodermal activity during a relaxation task, contrary to expectations. These results support the concept that meditative practices may alter aspects of autonomic function. Further, these results inform an emerging mind-body paradigm and illustrate the potential consequences of meditative practices in specific disease states and prevention.

Dedication

First and foremost, I thank my beautiful and wonder parents, Jim and Cyndi Pardikes. Without their efforts and love I have accomplished nothing. Next, I must thank all my colleagues at Virginia Tech. Your guidance and skepticism have vastly improved my trade. Lastly, I must acknowledge all the people in my life that have passed through me, each of us altering the other's path.

"When the spirit controls the body, the body obeys; when the body overrules the spirit, the spirit is exhausted. Although intelligence is useful, it needs to be returned to the spirit. This is called the great harmony."

Translated from "Huainanzi"
Anonymous

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1.0 - Introduction

The impetus of action has been a common question in the human psyche; its constancy speaks to the inherent difficulty in discerning its nature. The difficulties in tracing the origins of action are further amplified with the addition of conscious processes and behaviors. Human actions, must therefore, be considered complex actions, resulting from the interplay of both involuntary and voluntary responses to stimuli. Complex actions, as implied, can be categorized into two theoretical constituents; voluntary and involuntary, with each source occupying the opposite poles on a continuum of action. (Prochazka, Clarac, Loeb, Rothwell, & Wolpaw, 2000).

Autonomic functions are the result of both forms of action and represent a nexus between voluntary and involuntary motivations (Janig, 2006). I attempted to explore the dynamic nature of action in my master's project by indexing voluntary and involuntary actions through autonomic behaviors. This study was grounded in the concept that the autonomic nervous system (ANS) employs inherent mechanisms that allow for the intentional inhibition of reflex. The results supported the notion that a general population could inhibit reflexive motivations in favor of intentional motivations (Pardikes, 2008; Pardikes & Friedman, 2010).

The present study extends these findings into the realm of meditation. Conceptions of autonomic action are further explored by investigating the possible consequences of meditative practices on autonomic behavior. It was hypothesized that meditative practices can be considered an autonomic exercise that strengthens the ability to intentionally inhibit autonomic reflexes. An international project was formulated to test this hypothesis. American and Taiwanese participants, with varying degrees of meditative experience, engaged in a battery of psychophysiological tasks designed to test their abilities to inhibit reflexive autonomic actions. Results demonstrate that meditation may alter normative autonomic responses, with implications for understanding meditative practices and their potential consequences.

The present paper begins by reviewing current understandings of meditative practices, including descriptions of what constitutes meditation and their psychophysiological consequences. Next, properties of the autonomic nervous system are discussed, emphasizing the integration of voluntary and involuntary motivations. A clearer understanding of meditative practices and the autonomic nervous system allows a theoretical model of meditation and its effects on autonomic functions to be proposed. A review of previous studies regarding meditation and inhibition is then presented, followed by the specific hypotheses of the study. The experimental methods, results and a discussion of the significance of the findings makeup the final sections of the paper.

1.1 - Reflexive vs. Intentional Action

Prior to proceeding, it is necessary to define two terms that have already been invoked, *voluntary* and *reflexive* action. Despite their ubiquity, there is extensive philosophical and empirical uncertainty around the definitions and structures of voluntary and involuntary action. As a consequence of their nebulous nature, there is no clear distinction between reflexive and intentional responses. Generally, volition is understood as a conscious, intentional, goal directed action, and for the purpose of this study will be considered cortical in origin (Barbas & Zikopoulos, 2007; Brass & Haggard, 2007; Carver & Scheier, 2001; Critchley, Melmed, Featherstone, Mathias & Dolan, 2002; James, 1890; Kuhl & Beckmann, 1994; Tolman, 1932). Reflexes, in contrast, are usually conceived as immediate unconscious, involuntary responses and are ascribed a non-cortical (sub-cortical/brainstem/peripheral) origin (Head, 1921; Jackson, 1850:1958; James, 1890; Thayer, 2006; Sherrington, 1906). These definitions will be used for the current study, but the author recognizes that reflexive and volitional actions are highly mutable and to some degree interchangeable (For a discussion, see Prochazka et al., 2000).

1.2 - Meditative Practices

The benefits of meditation are now well recognized in western science. Consistent meditative practice appears to cultivate general psychological and physiological health (Austin, 1999; Baer, 2003; Bishop, 2002; Davidson et al., 2003; Grossman, Niemann, Schmidt, & Walach, 2004; Hankey, 2006; Lutz, Dunne & Davi-dson, 2007; Mayer, 1999; Moore & Malinowski 2009; Raub, 2002; Rubia, 2009; Sancier, 1999). Despite the increased interest and benefits, the most basic mechanisms and effects of meditative practices are not well understood (Brown, Ryan & Crewell, 2007; Lutz et al., 2007; Moore & Malinowski, 2009). Understanding the specific processes of meditative practices will prove beneficial to future health practices and contribute to the basic knowledge of the autonomic nervous system.

The ancient traditions of meditational philosophies and methodologies are a diverse group of psychophysiological practices designed to promote general health and cognitive regulation (Austin, 1999; Lutz et al., 2007; Rubia, 2009). The term *meditation* conjures images of silently sitting yogis, and Zen monks. However, meditation can also be characterized by more active states like *Hatha Yoga* and *Taiji* and may even include such nontraditional activities as jogging or painting (Kabat-Zinn, 1998). Meditation, by definition, is a diverse and nebulous concept, and there is considerable disagreement over what techniques or activities should be considered meditation (Lutz et al., 2007). Activities such as ritual dances and other religious exercises, assuming a spiritual component, are often placed under the rubric (West, 1987). However, the generic application of the term meditation to such a wide variety of practices may trivialize the practices, and blur their specific effects (Lutz, et al., 2007).

The vast array of meditative practices, the specific neural networks employed by the diverse techniques and the subjective experiences associated with particular methods have made the study of meditation difficult. As a result, most studies have employed a limited set of meditative practices in an effort isolate possible differences (see Lutz, et al., 2007 for review). However, such limitation also ignores the common factors and psychophysiological consequences found across all meditative practices (Lutz et al., 2007; Newberg & Inversen, 2003, Yu 1990).

Within all traditional practices there is tremendous variability, but it appears as if all meditative processes share common features. First, it is assumed that each technique elicits a predictable and distinctive state, identifiable via physiological and/or cognitive events or features. Second, these induced states are reportedly gradual but improve over time, such that an experienced meditator should have enhanced physical and cognitive features in comparison to a novice meditator (Lutz et al., 2007). Finally, all meditative practices and states employ specific corporeal, respiratory and mental strategies to attain these physiological and cognitive states (Yu, 1990). It is variations of these three components that give rise to the assortment of specific meditative practices.

Techniques can first be divided between kinetically dynamic or static methods. Practitioners commonly employ either slow and relaxed movements (e.g. *taiji* & *hatha yoga*) or static positions (e.g. *kneeling Zen meditation* & the *lotus position*) to assist in achieving and maintaining proper meditative states. Equally important is the role of respiration. Generally, techniques employs slow, deep abdominal breathing, but faster respiration rates as well as thoracic breathing can also be used in specific techniques (e.g. Benson, Malhorta, Goldman, Jacobs & Hopkins, 1990; Peng et al., 2004). Finally, all meditative disciplines stress the role of mind and the ability to control mental processes. Proper psychological states are most easily characterized as the intense application of focus or complete lack of focus, often referred to as *mindfulness* (i.e. mindful awareness). Mindful awareness is called by many names but is perhaps best conceptualized as strict attention to the present moment (Bishop et al., 2004; Cahn & Polich, 2006; Kabat-Zinn, 1998; Lutz et al., 2007; Newberg & Iversen, 2003; Rubia, 2009). The attainment of mindfulness is facilitated by two commonly conceived strategies: *concentration* and/or *introspection*.

Concentrative techniques require the practitioner to focus on a single object, concept, event or phrase (e.g. *mantra* repetition). Introspective meditation, conversely, necessitates an empty and free flowing mind. Practitioners allow thoughts to come and go without reaction or attachment (e.g. *Zen* & *mindfulness based stress reduction*) (Cahn & Polich, 2006; Lutz, Brefczyski-Lewis, Johnstone & Davidson, 2008; Rubia, 2009). Both concentrative and introspective techniques are common in all major contemplative traditions (e.g. *Taoism*, *Buddhism*, and *Vedic* practices). Finally, concentrative techniques usually serve as an initial method of training with introspective results becoming the default in advanced meditators (Goleman, 1977; Lutz et al., 2008).

The outcomes of meditational practices are numerous and varied as meditation alters many aspects of cognition and physiology. Despite this variety, all meditative practices appear to employ common central and autonomic structures, evidenced by neuroelectric, neuroimaging and behavioral studies. These neurophysiological effects are considered to be responsible for many of the specific and general effects associated with meditation.

Short-term physiological effects

The act of meditation is associated with acute (*in situ*) physiological changes. It is the common consensus that meditation generates a quiescent or hypometabolic state[1]. Decreases in heart rate (Kuo, Ho & Lin, 2003), blood pressure (Lee, Kim, Huh, Ryu & Chung, 2000), respiration rate (Arambula, Peper, Kawakami & Gibney, 2001; Travis & Wallace, 1999), oxygen consumption (Benson et al., 1990), electrodermal activity (Travis & Wallace, 1999) and increases in heart rate variability (HRV) (Cysarz & Bussion, 2005; Lehrer, Sasaki & Saito, 1999; Lu & Kuo, 2003; Travis & Wallace, 1999) all imply reductions in metabolic functions.

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[1] Metabolically active states can also be associated with meditative states (e.g. Benson et al, 1990; Lutz, Greischar, Perlman & Davidson, 2009; Newberg & Iversen, 2003; Peng et al., 2004).

Cerebral activity also demonstrates acute changes during meditation. Meditation tends to increase activity in the frontal, parietal, cingulate and insular cortices (particularly the dorsolateral prefrontal and anterior cingulate cortices), the hippocampus and the thalamus (e.g. Austin, 1999; Lazar et al., 2000; Lou, et al., 1999; Newberg, Alavi, Baime, Pourdehnad, Santanna & Aquili, 2001). Increased *alpha* (8-12 Hz) *& theta* (4-7 Hz) activity in anterior and parietal regions (e.g. Arambula et al., 2001; Kubota et al., 2001; Lee, Bae, Ryu, Sohn, Kim & Chung, 1997) and increased *gamma* (≥30 Hz) synchrony between frontoparietal regions are also common findings (e.g. Lutz, Greischar, Rawlings, Ricard & Davidson, 2004). However, cerebral activation during meditation is complex. Brefczynski-Lewis, Lutz, Schaefer, Levinson & Davidson (2007) for example, found that less experienced meditators (defined as 19,000 hours of experience) displayed greater activity in the same network of brain regions, typically involved in sustained attention, than more experienced meditators (defined as 44,000 hours of experience) during a meditative session.

Long-term physiological effects

Meditational practices are also associated with long term (trait) physiological changes, though fewer empirical inquires have been conducted. Long-term practitioners have demonstrated changes in cardiovascular, immune, and biochemical markers. Advanced meditators have displayed greater levels of HRV (Lu & Kuo, 2003; Ng & Tsang, 2009), white blood cells (Lee, Huh, Jeong, Lee, Ryu, Park et al., 2003),antibody titers induced via an influenza vaccine administered to subjects (Davidson et al., 2003) and lymphocytes (Lee, Huh, Jeong, Lee, Ryu, Park et al., 2003) and decreased resting levels of total cholesterol, heart rate and blood pressure (Dillbeck & Orme-Johnson, 1987; Hankey, 2006; Ng & Tsang, 2009; Rainforth, Schneider, Nidich, Gaylord-King, Salerno & Anderson, 2007) at baseline.

Meditation has also been associated with cerebral plasticity. Davidson et al. (2003) reported relative increased resting alpha activation of anterior regions for subjects completing an eight-week mindfulness training session versus a control group. Lazar, Kerr, Wasserman, Gray et al. (2005) found cortical thickening of the right anterior insular cortex (relative to an age matched control group). Holzel et al., (2007) reported experts to display larger inferior temporal gyrus, right anterior insular and right hippocampus volumes. And Luders, Lepore, Toga & Gaser (2009) found larger volumes of the right hippocampus and right orbitofrontal cortex in advanced meditators compared to controls.

Psychological attributes

The psychological effects that result from meditation are also vital to understanding its properties. A diverse range of psychological constructs including sensory perception, emotion, creativity and motivation have been linked to meditative practices. Meditation has been shown to generate improvements (short and long-term) in executive function (Brefczynski-Lewis et al., 2007; Chan & Woollacott, 2007; Valentine & Sweet, 1999), positive affect (Davidson et al., 2003), creativity (Krampen, 1997), image stabilization (Carter, Presti, Callistemon, Ungerer, Liu & Pettigrew, 2005), sensory acuity (Clements & Milstein, 1977), self-actualization (Gelderloos, Hermans, Ahlscrom & Jacoby, 1990), and the ability to reduce acute and chronic anxiety (Lee et al., 1997; Miller, Fletcher & Kabat-Zinn, 1995).

Meditational practices appear to have widespread and beneficial psychophysiological manifestations. The present project attempts to link the psychophysiological effects of meditation to changes in the ANS. The subsequent section describes various fundamental properties of the ANS. A further understanding of autonomic function will help illuminate the mechanisms and outcome of meditational practices.

1.3 - The Autonomic Nervous System

The ANS is a complex network that plays a crucial role in biological regulation. It integrates peripheral, hormonal, and central nervous system (CNS) activity in an arrangement that affords system-wide response, organization, and selection at the organismic level (Thayer & Friedman, 2004). The ANS is the entire system of neurons that controls visceral organs, effectors in the skin and the cardiovascular system via direct and indirect communication. All ANS functions are related to adjusting activities of tissues and organs so that they operate at levels that are most favorable to current psychophysiological states (Furness, 2006).

The complexity of autonomic activity has, however, often been oversimplified when defined with terms such as ‘stable’, ‘dichotomous’, and ‘reflexive’ (e.g. Cannon, 1939; Bernard, 1878, Langley, 1921). In contrast, contemporary views depict the ANS as a highly evolved system that moderates an organism’s actions and environmental fitness and represents a nexus between conscious and non-conscious experience (e.g. Thayer & Lane, 2009).

Homeostasis

Autonomic function has long been theorized to organize homeostatic adjustments (Bernard, 1878: Cannon, 1939; Langley, 1921). Homeostasis is commonly understood to imply a high level of normative stability ('steady-state') in physiological variables. While this notion is not incorrect, it is incomplete. A key to a system's viability is flexible responding, which suggests a high level of variability in physiological indices when observed over time. This concept has been represented by terms such as *heterostasis* (Davis, 1958), *allostasis* (Sterling & Eyer, 1988), *homeorhesis* (Stallone & Stunkard, 1991), and *rheostasis* (Mrosovsky, 1990). Current autonomic models propose a more dynamic view of homeostasis than was depicted in classical models. Change and variability, rather than rigid stability, are argued to be the essential features of healthy autonomic function. Variability affords an organism the ability to adjust multiple autonomic functions to achieve optimal autonomic-cognitive states, matched to fluid internal and external millieus (Gatlin, 1972; Glass, 2001; Globus & Arpaia, 1994; Goldberger, 1990; Thayer & Friedman, 2004; Thayer & Lane, 2009).

Sympathetic and Parasympathetic Integration

Traditionally, the ANS is divided into two discrete branches: the sympathetic (SNS) and the parasympathetic nervous systems (PNS)[2]. Autonomic behavior is then generally the result of the combined actions of the SNS and PNS. This anatomical and functional division of the autonomic subsystems creates a misleading impression of the SNS and PNS as reciprocal polar opposites (Bernston, Cacioppo, & Quigley, 1991, 1993). However, the SNS and PNS are best characterized as synchronous and synergistic; they operate in tandem, almost never independently (Koizumi, Kollai & Terui, 1986; Paton, Boscan, Pickering & Nalivaiko, 2005). The activation of both sympathetic and parasympathetic systems simultaneously is referred to as *coactivation* (Berntson, Cacioppo & Quigley, 1991, 1993). Coactivation enables an organism to generate diffuse, local and highly variable autonomic states (Paton et al., 2005; Uijtdehaage & Thayer, 2000; Furness, 2006).

[2] The *enteric* nervous system, contained within the walls of digestive organs, is also a historically recognized autonomic division (Furness, 2006; Langley, 1921).

Volitional and Reflexive Integration

Autonomic activity has also been generally assumed to be autonomous, non-conscious, or beyond volitional control (Cannon, 1939; Langley, 1921). However, in addition to reflexive action, the ANS appears to take considerable instruction from cortical (volitional) centers, as is held by many contemporary models of ANS-CNS integration (e.g., Benarroch, 1993, 1997; Damasio, 1998; Devinsky, Morrell, & Vogt, 1995; Thayer & Lane, 2000, 2002). Although aspects of these models vary, they are consistent in the view that afferent and efferent information are functionally integrated to promote system-wide sensitivity and response (e.g.,visceromotor, neuroendocrine and behavioral) range. The models also tend to incorporate common structures, such as the anterior cingulate, insular, and ventromedial prefrontal cortices, the central nucleus of the amygdala, the paraventricular and related nuclei of the hypothalamus, the periaquaductal grey matter, the parabrachial nucleus, the nucleus of the solitary tract, the nucleus ambiguus, the ventromedial medulla, and the medullary tegmental field. These structures serve as the hub of autonomic activity, allowing the integration and dissemination of conscious and non-conscious information to the entire system.

The ANS is a dynamic and complex network. It generates distinct and diffuse actions and is under both conscious and reflexive control. In short, the ANS is essential to complex organisms, evolved to control most of an organism's actions and environmental fitness. With the importance of the ANS, it is no wonder that autonomic functions would be integral to meditational practices and their effects. But how does meditation alter autonomic function? Meditation could strengthen the theorized hierarchical organization of the ANS.

1.4 - Hierarchical Organization of Autonomic Function

The ANS is a reciprocal and continuous system. However, the ANS also displays hierarchical characteristics. Is has been suggested that the phylogenetic development of autonomic function generated a system which favors complex (i.e. volitional) over less complex (i.e. reflexive) events (Jackson, 1958; Lovallo, 2005; Porges, 2007). All organisms must constantly adjust behaviors to a dynamic environment. As the complexity of organisms increases, so does the variability of action. The most basic actions, ubiquitous in life, are done to regulate local events. Cells and organized units of cells (i.e. organs) have intrinsic regulation mechanisms which allow autonomous reflexivity to minimal environmental demands (Janig, 2006). However, greater fluctuation of environmental conditions quickly exhausts the capabilities of local reflexes.

Organisms must rely on incoming information from more global systems to adjust to more complex demands. These global states rely on autonomic and endocrine responses which can be initiated by the direct and indirect actions of specific nuclei and structures in the brain (e.g. medulla, mesencephalon & telencephalon) which operate in an ascending order of control. Such behavior is indicative of a hierarchy and predicts that higher (e.g. volitional) autonomic actions, within a range of conditions, have the ability to suppress lower (reflexive) autonomic actions (Lovallo, 2005; Porges, 2007).

The organizational relationship between voluntary and involuntary autonomic functions is vital to understanding how complex organisms operate. Central-peripheral integration models, as the name implies, employ both voluntary and reflexive actions as components of autonomic behavior (Benarroch, 1997; Devinsky, Morrell, & Vogt, 1995; Thayer & Lane, 2000, 2002; Thayer & Friedman, 2002, 2004). These models necessitate the integration of implicit and explicit motivations (hormonal, peripheral and central nervous system actions) into a hierarchical arrangement that affords system-wide, variable and precise responding. The hierarchical organization of autonomic function can give an advantage when confronting environmental situations. Multiple responses, via volitional action to specific and general conditions allow an animal to react with various behaviors to various conditions (Davidson, 2000; Dempster, 1991; Lovallo, 2005; Thayer, 2006).

Autonomic function via inhibition. Healthy autonomic systems appear to exhibit tonic activity of both sympathetic and parasympathetic branches, with both direct and indirect pathways linking the anterior cortex to autonomic afferent & efferent circuits (Barbas, Saha, Rempel-Clower & Ghashghaei, 2003; Barbas & Zikopoulos, 2007; Levy, 1990; Nagai, Critchley, Featherstone, Trimble & Dolan, 2004; Raichle et. al., 2001, Rempel-Clower, 2007; Shekhar, Sajdyk, Gelhert & Rainnie, 2003; Ter Hosrt & Postema, 1997). Anatomical and functional evidence suggests that the modulation of autonomic activity is further, asymmetrical (Cechetto & Shoemaker, 2009; Craig, 2005; Foster, Drago, Ferguson & Harrison, 2008). At the cortical level, autonomic regulation appears to involve frontal, temporal and parietal regions (i.e. anterior cingulate, insular, dorsolateral prefrontal, orbitofrontal cortices) and the parasympathetic and sympathetic systems may be lateralized to the left and right hemispheres, respectively. (e.g. Craig, 2005, Critchley, et al., 2003; Foster et al., 2008; Oppenheimer, 1992; Wittling, Block, Genzel & Schweiger, 1998; Wittling, Block, Schweiger & Genzel, 1998).

The interhemispheric, intrahemispheric and cortical-subcortical characteristics of parasympathetic and sympathetic regulation, however, garner considerable debate. Researchers have postulated that the right anterior cortex is the primary hemisphere involved in the parasympathetic inhibition of subcortical sympathetic activity (Ahern, Sollers, Lane, Labiner, Herring & Weinand, 2001; Meyer, Strittmatter, Fischer, Georg & Schmitz, 2004; Thayer & Lane, 2000; 2009, Thayer & Brosschot, 2005); others posit that left anterior cortical regions exhibit the greatest degree of parasympathetic regulation (Craig, 2005; Wittling, Block, Genzel & Schweiger, 1998; Oppenheimer, 1992). The asymmetrical representation of cerebral autonomic regulation not only exists along the lateral dimension, but also in relation to anterior and posterior activation. Models that incorporate that view, assign the same left-right distinction of parasympathetic-sympathetic regulation, but also place greater emphasis on anterior inhibition and posterior activation of each system (Foster & Harrison, 2006; Foster, et al., 2008). Lateralization of autonomic function is clearly an important topic in this line of research. However, the methods employed in the present study did not allow for conclusions regarding lateralization to be drawn, and as such, the topic will not be discussed further.

Regardless of the specific lateral assignment of cerebral function, much of autonomic regulation appears to involve inhibitory processes; this is especially true in respect to parasympathetic regulation. Many autonomic functions, particularly cardiac function, appear to be under the tonic inhibitory control of the vagus (nucleus ambiguus) nerve (Levy, 1990; Nagai et al., 2004; Porges, 2007; Raichle et. al., 2001; Ter Horst, 1997; Thayer & Lane, 2000) which appears to take considerable instruction from cortical areas (Ahern et al., 2001; Porges, 2007; Ter Horst & Postema, 1997).

One method of cortical parasympathetic control appears to involve sub-cortical inhibition. Anterior cortical areas, including the orbitofrontal and medial prefrontal cortex may tonically inhibit the amygdala via pathways to intercalated GABAergic neurons in the amygdala (Barbas et al., 2003; Shekhar et al., 2003). This path is important because the central nucleus of the amygdala is one of the major efferent sources of ANS and endocrine responses and affects a multitude of autonomic structures (Veening, Swanson & Sawchenko, 1984). Thus, activation of the central nucleus, via prefrontal disinhibition, may lead to cascade of increased sympathetic activity and decreased parasympathetic activity (Thayer & Lane, 2009).

The parasympathetic system appears to regulate sympathetic activity via tonic inhibitory control of the anterior cortical regions (Cechetto & Shoemaker, 2009; Craig, 2005; Demaree & Harrison, 1996; Davidson, 2000; Foster et al., 2008; Thayer & Lane, 2009). The tonic regulation of sympathetic activity is also supported by the deactivation of anterior networks. When the prefrontal cortex (no lateral differences were stated in these studies) is taken “off-line,” sympathetic activity increases (Lutz, Greischar, Perlman & Davidson, 2009; Nagai et al., 2004; Raichle et al., 2001). Frontal parasympathetic inhibition may allow a greater variety of autonomic response and help protect the system from the maladaptive behaviors (i.e. stress) that result from an overactive sympathetic system (Porges, 2007; Thayer & Friedman, 2004). The importance of cortical inhibition is further instantiated by the variety of psychopathological and specific disease states that result from a general loss of top-down control. Attentional disorders, emotion regulation problems, pathological anxiety (Derryberry & Tucker, 1992; Gorenstein & Newman, 1980; Friedman, 2007; Porges, 1976; Posner, 1990; Thayer & Brosschot, 2005;), incontinence (Baig & Wexner, 2000) and Tourette Syndrome (Orth, Amann, Robertson, & Rothwell, 2005; Serrien, Orth, Evans, Lees, & Brown, 2005) all evidence some loss of frontal control resulting in the deregulation of reflexive action and maladaptive states (Head, 1921; Jacobsen, 1936; Porges, 1976; Wolpe, 1961).

Inhibition is the primary principle in a hierarchical model of autonomic function. The volitional act of inhibiting reflexive or habitual action in the promotion of long range goals is a key aspect of complexity and provides insight into the organization and development of complex nervous systems (Baddeley, 1986; Jacobsen, 1936; Luria, 1966; Porges, 2007; Thayer & Brosschot, 2005). The overall importance of autonomic regulation and its key role in meditative practices suggest a link between the two. The following section depicts the vital relationship between meditation and ANS regulation.

1.5 - Meditation as Cortical Control of Autonomic Action

Based on the information presented, anterior inhibition, via parasympathetic activity, facilitates adaptive and healthy behaviors. An efficient parasympathetic system, with the ability to suppress or allow sympathetic behavior, generates greater behavioral and autonomic control which in turn leads to greater overall health. I proposes that meditative practices enhance the same central-peripheral circuits discussed above.

Previous research has sought to conceptualize the consequences of meditative practices in various fashions. However, the mechanisms and processes indicative of meditation are not yet verified or fully understood. One theory suggests that meditational techniques lead to enhanced interoception and proprioception. Enhanced awareness is therefore thought to be responsible for greater autonomic and cognitive control (Kabat-Zinn, 1990; Kornfield, 1996; Nairn, 2000). However, empirical investigations have not supported this hypothesis (Khalsa,et al., 2008; Nielsen & Kaszniak, 2006). Enhanced interoception and proprioception are most likely attributes of meditational practices, but the absence of empirical support suggests that some other mechanism may be more prominent in creating the displayed effects of meditation.

Alternatively, meditation may be best characterized as an autonomic exercise that leads to increased parasympathetic regulation of autonomic function. Meditation may be beneficial to health because such practices alter autonomic function and control, not necessarily the awareness of somatic events. In this view, meditational practices should therefore engage the frontocortical circuits which enhance the efficacy and control of the parasympathetic system. This process is argued to generate greater autonomic and cognitive control, increased tonic parasympathetic activity and overall improved psychophysiological health. Indeed, the parasympathetic and intentional components of meditation have been identified with brain imaging, neurochemical, and behavioral data.

The acute and consistent physiological outcomes of meditation generally support the concept that meditation increases tonic parasympathetic activity while decreasing tonic sympathetic activity (e.g. Ng & Tsang, 2009, Newberg & Iversen, 2003). The reported increase of activity in the anterior cortex (e.g. dorolateral, anterior cingulate), hippocampal, and thalamic structures during meditation suggests that meditation employs intentional, inhibitory, attentional and autonomic neural-networks (Brefczynski-Lewis et al., 2007; Dempster, 1991; Diamond, 1988; Herzog, et al., 1990; Lazar et al., 2000; Luders et al., 2009; Newberg, et al., 2001; Posner, 1990; Vogt, 1992). The role of the anterior cortex is further illustrated by the increased levels of γ-aminobutyric acid (GABA) during meditation (Elias, Guich & Wilson, 2000). GABA release would result in the inhibition of the thalamus, amygdala and other structures, effectively lowering the occurrence of distracting stimuli and sympathetic activity (Newberg & Iversen, 2003; Thayer & Lane, 2009). Behaviorally, practiced meditators are better at sustained attention than non-meditators and as meditative experience increases so does their ability to sustain volitional attention (Chan & Woollacott, 2007; Slagter et al., 2007; Valentine & Sweet, 1999).

Meditation is best considered an attentional-autonomic task which necessitates the sustained attention of autonomic control and often actively suppresses reflexive states: One learns to gain control over reflexive autonomic patterns via meditative techniques.[3] Thus, well-practiced meditators should display an enhanced ability to voluntarily control autonomic functions.

Evidence also supports this claim; expert meditators have displayed extraordinary control of autonomic function. This was first empirically studied in the 1930's as psychophysiologists journeyed to India to study advanced Yogis. Physiological data were collected while Yogis remained buried in earthen pits for upwards of nine days. During these experiments, metabolic rate was severely depressed, so much that on occasion no electrocardial activity could be detected (Kothari, Bordia & Gupta, 1973a). Conversely, advanced meditators can also display abilities that dramatically increase body temperature and metabolism during a Tibetan practice called *G-Tum-mo yoga* (Benson, et al., 1982; Benson, et al., 1990). The list of strange anomalous behavior continues regarding abilities to completely block pain perception (Peper et al., 2006; Kakigi et al., 2005) and alter *inotropic* (myocardial contractility strength) activity (Kothari, Bordia & Gupta, 1973b). Advanced meditators provide intriguing subjects by which to test the parameters of volitional inhibition and help extend the empirical understanding of the meditative process.

1.6 - Previous studies

Numerous studies have investigated the psychophysiological effects of meditative practices, but very little research has approached the question of autonomic control and meditation from the present perspective. A few experiments have approximated the proposed study by focusing on the ability of non-meditators and meditators to inhibit reflexive actions. Experienced meditators and non-experienced meditators alike have demonstrated an ability to

[3] Anyone ever having attempted to meditate understands that the maintenance of specific physical (e.g. deep, slow abdominal breathing) and mental states (e.g. *"clearing the mind"*) is absolutely necessary, and for novices, absolutely impossible to do for any substantial length of time.

suppress reflexive actions (e.g. Brass & Haggard, 2007; Carter et al., 2005; Chan & Woollacott, 2007; Curtis & D'Esposito, 2003; Pardikes & Friedman, 2010; Peper et al., 2006; Reeves & Shapiro, 1982; Wolpe, 1961).

Experiments which induced autonomic coactivation (e.g. Friedman & Santucci, 2003; Friedman & Thayer, 1998; Friedman et al., 1993; Pardikes & Friedman, 2010; Uijidehaage & Thayer, 2000) and operantly conditioned autonomic responses (e.g. Reeves & Shapiro, 1982; Weipert, Shaprio & Suter, 1986) using non-meditators are also a close analog to the present study. Shapiro and colleagues investigated the active (voluntary) inhibition of autonomic reflex in series of biofeedback studies (Reeves & Shapiro, 1982; Sirota, Schwartz, Shapiro, 1974; Victor, Mainardi, & Shapiro, 1978; Victor, Weipert & Shapiro, 1984; Weipert, Shaprio & Suter, 1986). Much of the biofeedback work has demonstrated that autonomic functions, like heart rate and blood pressure, can be mitigated or increased via volitional faculties, especially when subjects are allowed to view accurate levels of the autonomic activity they are instructed to alter (Reeves & Shapiro, 1982, Shapiro, 1977).

Several studies are of particular interest to the present experiment. Victor, Weipert & Shapiro (1984) & Weipert, Shapiro & Suter (1986) asked subjects to increase heart period and lower blood pressure during *orthostatic stress* (changing from a seated position to a standing position). Biofeedback training showed no enhancement of autonomic control compared to pre-training levels. However, Reeves and Shaprio (1982) found that subjects after biofeedback training were able to lower and increase heart rate during a *cold pressor* (submerging a limb in cold water) task compared to other control groups.

Other studies have explored the inhibitory effects of meditation, but those experiments have primary focused on cerebral activation. Specifically, past studies have investigated phenomena like the habituation to auditory startle or orienting responses (Brefczynski-Lewis, et al., 2007; Banquet, 1973; Becker & Shapiro, 1981; Cahn & Polich, 2009; Deikman, 1966; Heide, 1986; Kasamatsu & Hirai, 1966; Lehrer, Schoicket, Carrington & Woolfolk, 1980; Wallace, 1970). The findings are mixed regarding such reflexes, but imply that meditation may significantly alter auditory reflexes at the cerebral level.

Studies investigating visual attention reflexes, such as perceptual rivalry and photic stimulation, have also tested the contribution of meditative practice to cognitive/reflexive regulation (Carter et al., 2005; Slagter et al., 2007; Williams & West, 1975). Results demonstrate the ability for advanced meditators to significantly alter the normal attentional processes and fluctuations in conscious states induced by binocular rivalry and motion-induced blindness.

Of the most interest are studies that illustrate extraordinary autonomic inhibitory action among expert meditators (Anand, Chhina & Singh, 1961; Benson et al., 1982; Benson et al., 1990; Das & Gastaut, 1955; Kakigi et al., 2005; Kothari, Bordia & Gupta, 1973a; Kothari, Bordia & Gupta, 1973b; Peper et al., 2006; Wenger & Bagchi, 1961). These experiments have demonstrated incredible autonomic regulation (e.g. raising body temperature, decreases of cardiac responses, inhibition of the cerebral markers of pain perception). However, the majority of experiments investigating the physiological components of meditation and inhibition lack large sample sizes, control groups and often reveal conflicting results.

Using a similar concept and procedures, Pardikes & Friedman (2010) used a coactivation paradigm to explore the issue of reflexive and volitional autonomic action. In this study, subjects were instructed to engage in reflexive and volitional tasks simultaneously with no feedback of their performance. Autonomic responses demonstrated the tendency for activity elicited by an intentional task to dominate the activity elicited by the reflexive task. Specifically, subjects were able to inhibit the sympathetic reactivity of placing the hand in cold water (10-15°C) by simultaneously engaging in guided relaxation, and inhibit the parasympathetic reflex of cooling the trigeminal nerve (“facial cooling”; 0-2°C) by simultaneously performing mental arithmetic. Further, this effect was displayed in a large, randomly selected college student sample of both genders, which provides evidence of inhibitory abilities in subjects with little or no meditative experience or practice.

1.7 - The Present Study

Following the described central-peripheral model and past studies, a putative relationship between autonomic function and meditation emerges. Meditation is an autonomic exercise which strengthens the capabilities of the anterior cortex to regulate autonomic action. The proposed effects of meditation were investigated by recording the autonomic activity of experienced and non-experienced meditators during a battery of behavioral tasks, some which generated opposing autonomic activity via volitional and reflexive sources. Experienced meditators were predicted to exhibit greater volitional control of autonomic reflex than less experienced meditators.

Autonomic Variables

Autonomic activity was measured via two interrelated autonomic systems: *Cardiorespiratory* (interconnected autonomic system coordinating cardiac and respiratory behaviors) and *integumentary* (autonomic system that coordinates the activity of the hair, skin and nails).

Heart rate variability. The oscillation of heart period is called heart rate variability (HRV) and is produced by autonomic sources generated via psychological and physiological factors (Berntson et al., 1997). These patterns of cardiac activity are mediated through sympathetic (beta-adrenergic) and parasympathetic (nicotinic) neurons that innervate the heart at the sino-artrial node. It is the interplay between the two autonomic divisions which creates the complex patterns of the heart rate time series (Saul, 1990). HRV was derived from the temporal period between myocardial contraction (inter-beat intervals) to generate the root mean square of successive differences (RMSSD) and spectral analyses (Bianchi et al. 1991; Kleiger, Stein, Bosner, & Rottman, 1995). Spectral analyses derived from fast Fourier transform (FFT) were used to formulate two measures: absolute low frequency (LF) and high frequency (HF) power.

RMSSD. The square root of the mean squared successive heart period differences is a metric representing the average inter-beat intervals for immediate successive heart periods. The dependence upon a small window of *chronotropic* activity (temporal characteristics of myocardial activity) filters out slower temporal patterns, isolating respiratory sinus arrhythmia (Berntson, Quigley & Lozano, 2007). RMSSD is also highly correlated with frequency domain measures of cardiac vagal control (Friedman, Allen, Christie & Santucci, 2002)

High frequency. HF is typically defined as heart period oscillations spanning from 0.15 Hz to 0.4 Hz (9-24 breaths/minute) and is also generally considered the respiratory component of HRV. However, respiratory components of HRV may extend below 0.15 Hz and above 1Hz in developmental stages and various behaviors (e.g. exercise, sleep, meditation) (Peng et al., 1999, Peng et al., 2004; Saul, 1990). HF is generally attributed to vagal (nucleus ambiguus) activity via telencheplonic structures (Bertson et al., 1997; Neff, 2003; Porges, 2007; Saul, 1990).

Low frequency. LF is typically labeled as frequencies occurring between 0.04 and 0.15 Hz. The most prominent oscillation is called the Mayer wave, and is directed by baroreflex heart rate modulation occurring approximately every 10 seconds (Cohen & Taylor, 2002; Mayer, 1877). LF is sometimes attributed to sympathetic activity as events that increase sympathetic activity tend to increase LF (e.g. Friedman, Thayer, & Tyrrell, 1996; Pardikes & Friedman, 2010). However, debate continues as evidence for both sympathetic and parasympathetic activity in the LF has been found and the issue remains unresolved (Dellinger, Taylor, & Porges, 1987; Eckberg, 1997; Parati, Mancia, Di Rienzo, & Castiglioni, 2006; Porges, 2007).

Heart rate. The mean heart rate (HR) is the product of both sympathetic and parasympathetic functions as well as intrinsic mechanisms (Saul, 1990; Levy, 1990).

Electrodermal activity (EDA). The skin has a natural degree of conductance, measured in microsiemens mediated by the ionic properties of sweat. As sweat ducts are excited, skin conductance is increased; this is referred to as skin conductance level and will be labeled electrodermal activity. The sweat ducts are under the direct control of sympathetic cholinergic pathways. EDA is generally used as an index of arousal (Dawson, Schell & Filion, 2007).

Respiratory rate (RR). Respiration is regulated by complex feedback loops and represents mixed autonomic influence. Both the vagus and glossopharyngeal cranial nerves play roles in respiratory regulation (Hlastala & Berger, 1996).

Tasks and Experimental Predictions

The experimental tasks were chosen due to the general autonomic activity they elicit (sympathetic/parasympathetic) and the primary source from which the activity is generated (volition/reflexive). The following hypotheses were generated for the present study.

Baseline (pre-task). Increased meditational experience was predicted to be positively correlated with increased parasympathetic activity during baseline readings (Wu & Lo, 2008). High frequency (HF) and root mean square of successive differences (RMSSD) were predicted to increase and skin conductance levels (EDA), heart rate (HR), low frequency and respiratory rates (RR) were predicted to decrease with greater meditational experience.

Isolated volitional sympathetic task. *Silent mental arithmetic* involves performing mental calculations, and can be considered a volitional sympathetic task. Mental arithmetic requires the allocation of significant processing resources and produces increases in sympathetic activity (Hedman & Nordlander, 1988; Pike, Smith, Hauger, & Nicassio, 1997; Willemsen, Ring, McKeever, & Carroll, 2000). Increased meditational experience was predicted to generate greater vagal withdraw, enhancing sympathetic activity as evidenced by decreased HF and RMSSD and increased RR, HR and EDA (Calkins, Graziano & Keane, 2007).

Isolated Volitional parasympathetic task. *Mental relaxation,* a task which involves self guided relaxation, is a voluntary parasympathetic task. Mental relaxation is shown to elicit parasympathetic activity (Kaushik, Mahajan, & Rajesh, 2006; Sebastiani, Simoni, Gemignani, Ghelarducci, & Santarcangelo, 2005; Terathongkum & Pickler 2004; Uijidehaage & Thayer, 2000). Increased meditational experience was predicted to generate increased parasympathetic activity evidenced by increased HF and RMSSD and decreased RR, HR and EDA (Brefczynski-Lewis et al., 2007; Wu & Lo, 2008).

Isolated reflexive sympathetic task. The *hand cold pressor* is a reflexive sympathetic task, and involves placing a limb in cold water. The cold pressor increases α-adrenergic activity, nociception and efferent sympathetic activity (Kregel, Seals & Callister, 1992; Peckerman et al., 1994; Wirch, Wolfe, Weissgerber, & Davies, 2006). Increased meditative experience was predicted to generate less sympathetic reaction and greater vagal activity (increases in HF, RMSSD and decreases in HR) in experienced meditators. This prediction was based on possibility that the cold pressor reflex might be confounded by psychological processes associated with pain (e.g. Peckerman et al., 1994). Subjects could actively inhibit reflexive tasks in the absence of specific instruction to do so in an attempt to cope with the discomfort generated by the task.

Isolated reflexive parasympathetic task. *Supine posture* is a reflexive task, defined by lying down with the face up. Supine position elicits diffuse parasympathetic activation associated with decreased blood pressure, respiratory activity, and myocardial activation (Knepp & Friedman, 2008; Levy, 1984; Paton, Boscan, Pickering, & Naliviako, 2005). No prediction was made regarding meditational experience and autonomic reactivity to supine posture.

Dual tasks. Two isolated tasks were performed simultaneously to generate two coactivated tasks.

Dual reflexive parasympathetic & volitional sympathetic task. Supine posture (reflexive-parasympathetic) was paired with *mental arithmetic* (volitional-sympathetic). Meditational experience was hypothesized to be positively correlated to increased sympathetic activity evidenced by decreased HF and RMSSD and increased RR, HR, LF and EDA (Pardikes & Friedman, 2010).

Dual reflexive sympathetic & volitional parasympathetic task. Hand cold pressor (reflexive-sympathetic) was paired with *mental relaxation* (volitional-parasympathetic). Meditational experience was hypothesized to be positively correlated to increased parasympathetic activity evidenced by increased HF and RMSSD and decreased RR, HR, LF and EDA (Pardikes & Friedman, 2010; Reeves & Shapiro, 1982).

2.0 - Method

2.1 - Subjects

74 subjects were recruited from the Virginia (N = 37) and Taiwan (N = 37) areas. Gender was evenly matched (36 men, 38 women), but more men were recruited from the U.S.A. (13 women, 24 men) and more women from Taiwan (25 women, 12 men). Subjects ranged in age from 18-82 years (Mean (M) = 44.42 Standard Deviation (SD) = 14.86). There was a significant difference in age between Taiwanese and American groups ($t(73) = 25.55$, $p < 0.001$; U.S.A.: M = 40.86, SD = 14.3; Taiwan: M = 47.79, SD = 14.96). Subjects reported an average of 10.38 years (SD = 11.8 yrs) of meditational experience, an average of 41.7 minutes/day practicing meditation (SD = 55.8 min/day) and an average of 5.4 hours/week of practicing meditation (SD = 7.2). There was no significant difference between the Taiwanese or American groups for reported meditational experience or between genders and meditational experience. However, the difference between men and women regarding years of meditative practice was marginally significant (Men: N = 36, M = 13.0, SD = 14.23; Women: N = 38, M = 7.908, SD = 8.46; $t(72) = -1.883$, $p = 0.068$) (Figure 1).

Subjects were also asked to describe their meditative techniques. Based on these descriptions the author created tentative meditational groups (N = 18 Vedic/Buddhist, N = 6 *Qigong/Taiqi*, N = 12 Seated Buddhist Sutra Reading, N = 21 Introspective-non descript), N = 16 Non-meditators). Any potential participant reporting a history of severe psychiatric or physiological disease was excluded from participation as were daily cigarette smokers.

2.2 - Apparatus and Materials

Electrocardiogram (ECG), electrodermal activity (EDA) and respiratory patterns were recorded using the BIOPAC MP36 system (BIOPAC Systems Inc, Goleta, CA). Three thoracic (modified Lead II configuration) electrodes were used to record ECG. Two electrodes placed on the medial phalange of the left index and middle fingers were used to record EDA. Physiological signals were conducted through disposable, pre-gelled stress-testing electrodes. ECG attachment sites were prepared using 70% isopropyl alcohol. Respiratory variables were collected by a strain gauge at the thoracic level. All electrophysical signals were collected by BIOPAC AcqKnowledge software (BIOPAC Systems Inc, Goleta, CA).

Health questionnaire. A questionnaire, designed by the Mind-Body Lab, to gauge the subject's health history and Body Mass Index (BMI) was given during a screening process (Appendix A).

Meditational history questionnarie. A brief questionnaire designed to assess the subject's meditational history and specific practice (Appendix B). Subject's were asked to estimate the number of years they had practiced meditation (Med Years), amount of time (min) they practiced meditation every day (Med Day), the amount of time (hours) they practiced meditaiton per week (Med Week) and describe their meditative practices.

University of Houston non-exercise test. This scale measures the functional aerobic capacity of a subject (VO2peak) without exercise testing (Jackson et al., 1990) (Appendix C). Aerobic fitness levels have been shown to affect cardiovascular measures (Rossy & Thayer, 1998).

Depression anxiety stress scale (DASS). The DASS 21 (DASS 21 is comprosed of 21 questions as opposed to the standard 42 questions) is a set of three self-report scales designed to measure the negative emotional states of depression, anxiety and stress (Lovibond & Lovibond, 1995) (Appendix D). Depression, anxiety and stress have been shown to alter cardiovascular activity (Lyonfields, Borkovec, & Thayer, 1995; Thayer, Friedman, & Borkovec, 1996; Thayer & Lane, 2000). DASS scores were calculated by summing the responses of each specific corresponding question (i.e. question designed to assess depression, anxeity or stress) and then multiplying the sum by two to approximate the DASS 42.

Stroop color and word test. Subjects were presented with a series of color words or symbols displayed in color ink and asked to verbalize their responses according to perceptual or semantic cues (Golden, 1978) (Appendix E). Subjects were instructed to verbalize the "color of the word" the "written word" or the "color of a non-word," then immediately strike the space bar on a standard keyboard. Twenty *baseline* and forty *experimental* (twenty *semantic* and twenty *incongruent* were presented randomly) trials were conducted. Trials were administered in rapid succession with subsequent trials initiating upon the completion of the preceding trial. Instructions and data collection (reaction times) were performed on E-Prime software. The

Stroop test is designed to assess the subject's inhibitory control and appears to measure anterior cingulate & prefrontal cortical function (Pardo, Pardo, Janer & Raichle, 1990; Vendrell et al., 1995). Taiwanese subjects were not administered the test due to the incompatibility of computer software.

Valence, activation and concentration scale. Measurements of valence and activation were assessed via a self reported fourteen-item questionnaire (Likert scale: 1-7). Scales served as a manipulation check for the tasks (Christie & Friedman, 2004). (Appendix F). Following isolated *mental relaxation* and *cold pressor* tasks and the dual *mental relaxation-cold pressor* task, subjects were asked to describe how they attempted to relax and cope with the discomfort of the *cold pressor* (Appendix G). Taiwanese subjects were not administered the post-task scales (valence and activation) due to the incompatibility of computer software but were asked to describe their experience and coping strategies.

Laterality questionnaire. In an effort to gain a more reliable estimate of the laterality preferences, a laterality questionnaire was administered (Coren, Porac & Duncan, 1979) (Appendix H). Subjects responded to a series of questions regarding their lateral preferences. Actions with right dominance were scored as a 1, left dominance -1 and ambidextrous preference 0. Scores were then totaled to produce an overall lateral preference. Increasing positive scores indicate a right lateral preference. Increasing negative scores indicate a left lateral preference.

Toronto mindfulness questionnaire. The lack of a simple linear relationship between each specific meditational technique and the duration of practice needed to cultivate proper mental states necessitates another metric of meditational experience. The Toronto Mindfulness Scale (TMS) may provide another variable by which to measure a subject's meditational abilities (Appendix I). The TMS is purported to measure an attentional quality characterized by a curious, open, accepting awareness of experience including bodily sensations, thoughts, or emotions. The items of Factor 1 (Curiosity) reflect an attitude of wanting to learn more about one's experiences. The items of Factor 2 (Decenteredness) reflect a shift from identifying personally with thoughts and feelings to relating to one's experience in a wider field of awareness (Teasdale et al., 2002). TMS scores are positively correlated to defined factors. Taiwanese subjects did not complete the TMS because of the difficulty in translating the questionnaire.

3.0 - Procedure

Potential participants first completed health and meditational history questionnaires online or upon arrival to the laboratory (This questionnaire was designed to screen subjects and assess meditational experience, age, gender and BMI characteristics). Qualified subjects were then asked to complete the study in a laboratory setting in the Mind-Body Laboratory at Virginia Tech (Blacksburg, VA), Satchidananda Ashram (Buckingham county, VA), Bhavana Theravada Buddhist Monastery (High View, WV) and Taipei Veterans General Hospital (Taipei, Taiwan). Subjects were demarcated into two groups: data collected in Taiwan and in the U.S.A. in an effort to detect any possible differences in subsequent statistical analyses (defined as *group* in statistical analyses). At each location, quiet and isolated rooms were selected to house the experiments. Subjects were instructed to refrain from caffeine and alcohol at least twelve hours prior to the experiment and to avoid eating and rigorous exercise at least one hour before the experiment. Upon arrival, subjects were first attached to physiological recording equipment to attain some degree of the acclimation to the equipment. Next, subjects performed the Stroop color and word test and Toronto Mindfulness scale (American subjects only), then completed the DASS and Houston non-exercise scales.

After completing pre-experimental tests, subjects were sequentially assigned one of four possible task orders (Appendix J) in which all six tasks were performed. Each experimental task lasted three-minutes and was preceded by a three-minute pre-task and followed by a three-minute post-task. After the post-task, American subjects were asked to rate valence and activation levels for each trial (Appendix F). Following the isolated supine, relaxation and cold pressor tasks, subjects were asked to describe their experience to the experimenter (Appendix G).

All questionnaires and experimental trials were run on a laptop computer for American subjects. A laptop computer administered the experimental trials while questionnaires were administered on paper for Taiwanese subjects. The entire experiment took approximately 90 minutes to complete. All subjects gave informed consent, and all procedures were approved by the Institutional Review Board at Virginia Tech or the Taipei Veterans General Hospital Institutional Review Board.

3.1 - Tasks

All tasks, except the supine posture, were performed in a seated position. Subjects performed all tasks in isolation. Prior to each task, an experimenter would enter the room to prepare and instruct the subject on their impending assignment. Once assured of the subject's comprehension and willingness to perform the task, the experimenter initiated the trial and left the room. Subjects were instructed to minimize all their movements during the tasks.

Supine. In preparation of the supine posture, American subjects were assisted in changing from an upright seated position to lying on the floor face up. Taiwanese subjects were assisted in changing from a seated position to lying in an adjacent hospital bed. Once the subject was positioned, the recording period began.

Hand cold pressor. For the hand cold pressor task, subjects were instructed to submerge their left hand in cold water (0-3° C) up to the wrist. The subjects were asked to keep their hand fully submerged for the entire trial. The recording period began once the hand was fully submerged. Following the trial, subjects were asked if they had been able to keep their hand fully submerged for the entire length of the trial. Any subjects that reported an inability to maintain the task were disqualified from the task analysis. Immediately following the trial, the experimenter dried the hand of the subject with a towel and the recovery period began.

Mental arithmetic. Silent mental arithmetic instructed the subjects to silently count backwards by 7 starting from 3000. Experimenter performed the first three calculations to assist in the subject's comprehension of the task. Subjects were explicitly asked to do all the calculations mentally, without the aid of speaking or using their hands. In an effort to ensure adherence to the task, experimenter emphasized the subject's need to perform the task as quickly and accurately as possible and subjects were asked to repeat the final number they calculated at the end of the trial.

Mental relaxation. Mental relaxation task instructed the subjects to simply close their eyes and relax. No instructions were given regarding breathing, and no specific mental goal was articulated except maximal attention to relaxation.

Dual tasks. Two isolated tasks were performed simultaneously to generate the cold pressor-mental relaxation and supine posture-mental arithmetic tasks. Each dual task followed the same protocol as the isolated tasks.

Pre and post tasks. The pre-task and post-task conditions (i.e., task baseline and recovery periods) required subjects to view a series of neutral pictures in an attempt to standardize autonomic levels providing accurate reactivity levels ("Vanilla Baseline;" see Jennings, Kamarck, Stewart, Eddy & Johnson, 1992). Pictures were selected from the International Affective Picture System (Lang, Bradley, & Cuthbert, 2008) and scored an average valence level of 5.16 (1= strong negative affect, 9= strong positive affect 4.5= neutral) and an average arousal rating of 2.7 (1=no arousal, 9= most arousal). Pictures were presented randomly in 10 second increments.

3.2 - Data Reduction

Measures were analyzed via AcqKnowledge (BIOPAC Systems Inc, Goleta, USA) and Kubios HRV (University of Kuopio, FI) softwares. The ECG signal from was digitized at 1,000 Hz. ECG measurements were filtered using a modified Pan and Tompkins algorithm: ECG data are normalized to 1 whereby the peak amplitude of the highest R-wave represents 1. Inter-beat-intervals were measured as time (ms) between R spikes. All electrophysiological tracings and measures were visually scanned and corrected for artifacts. Ectopic heart beats were removed from the analysis & a piecewise cubic spline interpolation method was used to correct artificial IBI measures. Power spectral analyses were conducted using a FFT based Welch's periodogram method. The high frequency (HF) band was limited to 0.15–0.4 Hz. The low frequency (LF) band was limited to 0.04-0.15 Hz. The integrals within the frequency bands served as the absolute spectral density.

Signals from respiration and skin conductance transducers were digitized at 200 Hz. Respiration rates were visually scanned and counted with each full respiratory cycle counting as a breath. The number of breaths calculated over each three-minute task was then divided by 180 to generate the rate of respiration per second (Hz). 66.5 Hz low pass and 0.05 high pass filters were applied to EDA signals to cancel any possible electrical interference, signal drift and other non-electrodermal activity present in the signal. Average EDA level (EDA mean) defined as the average EDA level, and maximum minimum EDA (EDA MaxMin), defined as the minimum level subtracted from the maximum level, were derived from the EDA measures of each trial.

Statistics were conducted on both baseline measurements and "reactivity" (task – baseline) measures. Individual autonomic measurements exhibiting levels greater than three standard deviations were excluded from the statistical analyses to eliminate outliers. Recovery data were not considered in the analyses. Variables were checked for normality and corrected if needed using a natural log transformation. Each variable was averaged across each three-minute trial. Subjects that were unable to perform the entire duration of a given task (i.e. cold pressor tasks) were excluded from that specific analysis. All statistical analyses used an alpha level of .05 to detect significance levels.

4.0 - Results

4.1 - Baseline Findings

MANOVAs were first conducted on baseline physiological variables (HR, RMSSD, LF, HF, RR, EDAmean, EDAMaxMin), defined as dependent variables, to determine any significant differences between gender, group and task (defined as independent variables). Subject age was assigned as a covariate in the model. Baseline levels were determined to be different for gender ($F(15, 398) = 6.009$, $p < 0.001$), group ($F(15, 398) = 16.929$ (Wilk's Lambda), $p < 0.001$) and their interaction term ($F(15, 398) = 5.148$ (Wilk's Lambda), $p < 0.001$). No significant differences were found between baseline tasks or any additional interaction terms. Baselines measured were then averaged together to generate a more simple MANOVA model using gender and group as the independent variables, average physiological baseline levels as the dependent variables and age as a covariate. Both gender ($F(7, 60) = 2.40$ (Wilk's Lambda), $p = 0.031$) and group ($F(7, 60) = 5.827$ (Wilk's Lambda), $p < 0.001$) were found to be different for average baseline measures but their interaction term was not.

Independent sample t-tests were performed to detect which autonomic variables differed between groups and genders at baseline. T-tests performed on group differences revealed *low* frequency power ($t(70) = 3.272$, $p = 0.002$), respiration rate ($t(70) = -4.627$, $p < 0.001$), EDA mean ($t(70) = 4.945$, $p < 0.001$) and EDA MaxMin ($t(69) = 3.496$, $p = 0.001$) to differ. Descriptive statistics reveal that the American group registered higher levels of low frequency power, EDA mean and EDA MaxMin, and lower levels of respiration rate at baseline (see Table 1).[4] T-tests performed on gender differences also revealed low frequency power ($t(70) = -3.452$, $p = 0.001$), respiration rate ($t(70) = 2.715$, $p = 0.008$) and EDA mean ($t(70) = -2.904$, $p = 0.005$) to differ. Descriptives revealed men to display greater levels of low frequency power and EDA mean, and lower respiration rates than women at baseline (see Table 1). These results may reflect the shared influences of both gender and group.

[4] The differences observed for raw electrodermal activity between ethnicities may have been due to calibration issues.

Averaged physiological baseline measures were also analyzed via bivariate Pearson correlations to determine the relationship among continuous variables. All significant relationships are shown in Table 2. Of particular interest are the following correlations. Age demonstrated the greatest number of significant correlations, correlating positively with all measures of meditational experience, laterality and TMS decenteredness and negatively with HRV (RMSSD, LF and HF), depression, anxiety, stress, and EDA MaxMin. TMS decenteredness displayed a significant negative correlation with depression and TMS curiosity displayed a significant negative correlation with RMSSD. Finally, meditational experience, as measured by years of practice, was positively correlated with TMS (decentered) and EDA mean and negatively correlated with Houston scores, depression, anxiety and stress.

In an effort to explore the influence of years of meditative experience on EDA mean baseline levels, a series of singular linear regression analyses were conducted. Averaged EDA mean served as the dependent variable, age, group, gender, Houston score, DASS scores, TMS (decentered) score and years of practice were entered individually as independent variables. Analyses demonstrated that the majority of the observed variance of EDA mean was due to group (ethnic) differences. Meditative experience alone did not predict a significant amount of the observed EDA mean variance.

Raw baseline scores were also correlated within gender to detect any possible relationships between meditational experience and physiological measures. Women displayed no significant correlations for meditational experience. Men only displayed a positive correlation between meditational practice/day and EDA mean ($N = 36$, $r = 0.36$, p .= 0.031). A hierarchical linear regression analysis was performed defining EDA mean as the dependent variable. Age, group, respiration rate and practice/day were defined as the independent variables and entered into the regression equation in the respective order. Results demonstrate group, (Standardized β coefficient = -0.319; R^2 change=0.136, F change (1, 33) = 5.216, $p = 0.029$), respiration rate (Standardized β coefficient = -0.293; R^2 change = 0.127, F change (1, 32) = 5.531, $p = 0.025$) and practice/day (Standardized β coefficient = 0.398; R^2 change = 0.128, F change (1, 31) = 6.559, $p = 0.016$) to all equally contribute to the observed variance of EDA mean. The final regression model is significant (Mean Square (MS) = 54.016, F (4, 31) = 5.033, $p = 0.003$) and accounts for 39.4% of the observed variance.

4.2 - Task, Group and Gender Differences

A MANOVA was performed using physiological reactivity to task (HR, RMSSD, LF, HF, RR, EDA mean, EDA MaxMin) as the dependent variables and gender, group and task as the independent variables. Task (F(35, 1668.251) = 9.292 (Wilk's Lambda), p < 0.001) and group (F(7, 396) = 5.063 (Wilk's Lambda), p < 0.001) both registered significant main effects on the reactivity scores but gender was not found to be significant for task reactivity. The task by group (F(35, 1668.251) = 2.178 (Wilk's Lambda), p < 0.001) and group by gender (F(35, 1668.251) = 2.031 (Wilk's Lambda), p = 0.05) interaction terms also displayed significant effects on physiological reactivity.

The interaction effect between group and task was further explored by creating 12 new variables (Group x Task Interaction) which represented all group by task pairings. American subjects were labeled as a 1 in the one's place and Taiwanese subjects were labeled 2. The six tasks (1-6) were demarcated to the ten's place to create 12 pairings (11, 12, 13, 14, 15, 16, 21, 22, 23, 24, 25 & 26). A multivariate test was again performed using physiological reactivity scores as the dependent variables and the Group x Task Interaction as the independent variable. Bonferroni correction post-hoc tests were performed to determine which group x task pairings differed from each other (see Table 3). Contrast tests illustrate a complex interaction among autonomic, ethnic and experimental manipulations. Generally, all tasks can be distinguished by their physiological responses in varying degrees. Heart rate and respiration rate displayed the greatest number of significant differences among autonomic variables and high frequency power was the only autonomic variable to display no differences for task x group interaction. Interaction term descriptive statistics were also generated (see Table 4).

In an effort to clarify the Group x Task Interaction term, t-tests were conducted on group main effects and Bonferroni correction post-hoc tests were performed on task main effects. T-tests between groups revealed heart rate (t(433) = -2.299, p = 0.022), EDA mean (t(432) = -3.727, p < 0.001) and EDA MaxMin (t(432) = -2.75, p = 0.006) significantly differed, with Taiwanese subjects displaying greater reactivity [HR: American (N = 37, M = -0.574, SD = 6.16), Taiwanese (N = 37, M = 0.742, SD = 5.771); EDA mean: American (N = 37, M = 0.202, SD = 1.919), Taiwanese (N = 37, M = 0.552, SD = 1.753); EDA MaxMin: American (N = 37, M = 0.317, SD = 2.766), Taiwanese (N = 37, M = 0.668, SD = 2.04)] across all tasks in comparison to Americans.

Task contrast tests again reveal heart rate and respiration rate to display the greatest number of significant differences between tasks and high frequency power to evidence no distinction between tasks (see Table 5). The specific distinctions among tasks vary among physiological variables. Effect sizes (Glass's Delta) were generated to help discern some of the autonomic patterns elicited by the tasks (see Table 6 & Figure 2). Supine produced small increases in RMSSD and HF and small decreases in HR, LF, and RR. Cold pressor generated a medium increase in HR and a small increase in HF and EDA measures. Arithmetic produced a medium increase in RR and a medium decrease in LF, small increases in HR and EDA mean and a small decrease in RMSSD. Relaxation elicited a medium decrease in RR but had little effect on any other variables. Cold pressor-relaxation produced a medium decrease in RR and small increases in RMSSD and HF. Supine-arithmetic generated medium increases in RMSSD, HF and RR and elicited small decreases in HR and LF. Delta task descriptive statistics were also generated for reference (see Table 7).

The group by gender interaction effects were explored by creating 4 new variables (Group x Gender Interaction) which represented all group by gender pairings. American subjects were again labeled with a 1 and Taiwanese subjects a 2 in the one's place, women were then labeled as 0 and men as 1 in the ten's place to generate the 4 interaction terms: American women (10), American men (11), Taiwanese women (20) and Taiwanese men (21). Bonferroni correction post-hoc tests were performed on the interaction means to reveal only EDA measures to differ among the groups (Table 8). EDA mean displayed only American and Taiwanese women to differ across all tasks and EDA MaxMin showed American women to differ from all other groups. Descriptive statistics exhibit American women to have the smallest EDA mean reaction to tasks and greater levels of maximum to minimum EDA during baseline relative to tasks (see Table 9).

4.3 - Manipulation Check

Multivariate tests were performed on valence and activation responses to tasks. Valence and activation responses were defined as dependent variables, task and gender were defined as independent variables. Analyses reveal significant main effects for task ($F(70, 799.167) = 3.91$ (Wilk's Lambda), $p < 0.001$) and gender ($F(14, 167) = 3.837$ (Wilk's Lambda), $p < 0.001$) but not for their interaction term. Bonferroni post-hoc correction tests were conducted on tasks demonstrating negative valence and elevated activation to generally define arithmetic and cold pressor tasks. Positive valence and inactivity generally defined supine and relaxation tasks and dual tasks displayed intermediate rankings (see Tables 10 & 11). Independent sample T-tests were conducted with valence and activation scores considered dependent variables and gender as the grouping variable. T-tests display gender ratings for both "Bad" [$t(190) = -2.034$, $p = 0.043$; Men: (N=36, M = 1.99, SD = 1.503), Women: (N = 38, M = 1.58,SD = 1.031)] and "Pleasant" [$t(190) = -2.793$, $p = 0.006$; Men: (N = 36, M = 4.5, SD = 1.962), Women: (N = 38, M = 3.69, SD = 1.889)] to be significantly different, with men scoring the tasks higher for both responses.

4.4 - Effects of Meditational Experience on Tasks

Bivariate Pearson correlations and hierarchical linear regression models were used to detect the possible effects of meditational experience on physiological reactivity to tasks. Correlations between non-physiological (age, meditational experience, BMI, Houston scores, laterality scores, DASS scores, TMS scores and Stroop scores) and physiological reactivity (HR, RMSSD, LF, HF, RR, EDA mean and EDA MaxMin) were first performed for every task in isolation. Any significant correlations between meditational experience and physiological reactivity were then subjected to hierarchical regression modeling. Significant physiological variables were entered as the dependent variable. Generally, age, group, gender, respiration rate and appropriate meditational experience metric were entered into the regression equation in a respective stepwise order as the independent variables unless otherwise noted. Any possible contribution of gender to physiological reactivity was further investigated by isolating women or men and running the same sequence of analyses.

Supine. Correlations revealed both respiration rate and EDA mean to display significant correlations with meditational experience (see Table 12). Regression analyses were performed with respiration rate as the dependent variable and age, group, stress score and meditational experience (years) as the independent variables. Analyses revealed age and group, but not meditational experience, to account for significant amounts of observed variance in respiration rate (non sig.). Regressions were also performed with EDA mean as the dependent variable. Average meditative practice/day was the only variable to account for a significant amount of the observed variance of EDA mean (Standardized β coefficient = -0.244; R^2 change = 0.052, F change$(1, 67) = 4.054$, $p = 0.048$). Analyses within genders suggest that men accounted for the bulk of the relationship between meditational experience and EDA mean. Men displayed a marginally significant negative correlation between EDA mean and meditative practice/day (N = 36, r = -.32, p = 0.057) but women showed no significant relationships between physiological reactivity and meditative practice.

Cold pressor. Correlations demonstrated meditational experience (years) to correlate negatively with change in heart rate and EDA mean during the cold pressor task (Table 13). Hierarchical regression analyses were performed with heart rate as the dependent variable. Meditative experience was the only variable to account for a significant amount of observed variance (Standardized β coefficient = -0.312; R^2change = 0.07, F change(1, 58) = 5.017, p = 0.029). Data were divided into men and women to explore possible gender effects. Correlations on women reveal no significant correlations between meditational experience and physiological reactivity to the task. Correlations, performed on men only, reveal a significant negative correlation for meditational years (N = 34, r = -.490, p = 0.003) and a significant positive correlation for Houston scores (N = 31, r = .392, p = 0.029) with heart rate reactivity. Regressions were performed with heart rate as the dependent variable and age, group, Houston scores, respiration rate and meditational years as the independent variables. Only Houston scores (Standardized β coefficient = 0.187; R^2 change=0.142, F change(1, 27) = 4.682, p = 0.039) and meditational years (Standardized β coefficient = -0.57; R^2 change = 0.195, F change(1, 25) = 7.974, p = 0.009) accounted for a significant amount of variance, but meditative experience accounts for more variance. Years of practice accounts for nearly 28% of the observed variance (single linear regression) in heart rate change during the cold pressor task. Scatterplots, plotting heart rate reactivity and meditational years for both men and women clearly reveal the relationships (Figure 3).

Possible interaction effects between gender and meditational experience were explored by multiplying the centered meditational experience (years) by gender (women = 0, men = 1) to create an interaction variable (Cohen, Cohen, West & Aiken, 2003). Hierarchical regressions were performed with heart rate as the dependent variable. Gender, centered meditational experience (years) and the interaction term were entered respectively into the model and categorized as independent variables. Analyses revealed that meditational experience (F change(1, 61) = 9.372, p = 0.003) is significantly contributing to the observed variance but the interaction term is not. This analysis suggests no significant interaction between years of practice and gender.

Mental arithmetic. Correlation analyses revealed no significant relationships between physiological variables and meditational experience during mental arithmetic. Correlations within genders also revealed no significant relationships between meditational experience and physiological reactivity.

Mental relaxation. Correlation analyses revealed change in heart rate during relaxation to have a significant positive relationship to age, meditative practice/day and both TMS components and a significant negative correlation to anxiety and stress (Table 14). Regression analyses, however, demonstrated that the majority of the observed variance of heart rate is accounted for by age, not meditational experience (non sig.).

Correlations within women reveal no significant relationships between meditative practice and physiological reactivity. Correlations within men revealed a significant positive relationship between meditational years and EDA mean (N = 36, r = .35, p = 0.037). Subsequent regression analyses revealed years of practice as the only variable to account for a significant amount of the observed variance of EDA mean (Standardized β coefficient = 0.469; R^2 change = 0.14, F change(1, 33) = 5.158, p = 0.03).

Possible interaction effects between gender and meditational experience were again explored through a hierarchical regression analysis performed with EDA mean as the dependent variable and gender, centered meditational experience (years) and their interaction term entered as independent variables in a stepwise order respectively. Analysis reveals that meditative experience (F change(1, 70) = 7.036, p = 0.01) is significantly contributing to the observed variance but the interaction term is not. The analysis suggests no significant interaction between years of practice and gender.

Cold pressor-mental-relaxation. Correlations revealed no significant relationships between meditative practice and physiological reactivity. Data were demarcated by gender and correlations were again conducted. Women revealed no significant correlations between physiological reactivity and meditational experience. Analyses of men reveal a significant negative correlation between meditational years and heart rate (N = 35, r = -.417, p = 0.013). Regression analyses demonstrate that the only significant amount of the observed variance of heart rate change is explained by meditational years (Standardized β coefficient=-0.597; R^2

change = 0.237, *F* change(1, 29) = 9.798, *p* = 0.004) in men. Heart rate change and years of practice were again plotted against each other for both women and men to illustrate the differences between the two genders. (Figure 4)

Possible interaction effects between gender and meditational experience were again explored through a hierarchical regression analysis performed with heart rate as the dependent variable and gender, centered meditational experience (years) and their interaction term entered as independent variables in a stepwise order respectively. Analysis reveals that meditative experience (*F* change(1, 66) = 4.768, *p* = 0.033) is significantly contributing to the observed variance but the interaction term is not. The analysis suggests no significant interaction between years of practice and gender.

Supine-mental arithmetic. Correlations demonstrated no significant relationship between meditational experience and physiological reactivity during the supine-arithmetic task. Correlations within gender similarly demonstrated no significant relationships.

Stroop color and word test. Increased meditational experience was originally predicted to generate reductions in habitual responding to the task as measured by faster reaction times for incongruent pairings (Wenk-Sormaz, 2005). No significant relationship between Stroop scores and meditational experience was detected.

5.0 - Discussion

Meditative practices were defined as autonomic exercises and predicted to strengthen anterior control of autonomic function. Results from the present study exhibited complex relationships among autonomic function, ethnicity, gender and experimental manipulation. However, the data give at least partial support for the proposed hypothesis. A discussion of these results follows. The experimental outcomes in reference to non-meditative and meditative factors will be discussed first, with each hypothesis being addressed. The interpreted significance of the most salient findings will be discussed next, followed by the limitations and future directions of the study.

5.1 - Experimental Outcomes

The autonomic effects of the tasks, independent of meditative experience will be addressed first. Task effects illustrate autonomic reactivity for the entire population and provide a comparison for meditative effects. Next, the effects of meditative experience on tasks will be discussed. Regression analyses reveal that meditative experience significantly altered autonomic activity during three of the recorded trials.

Findings regarding non-meditative variables. MANOVAs revealed significant differences among genders, ethnicities, tasks and their interactions, independent of meditative variables. The relationships among these variables are complex and difficult to interpret. The strongest autonomic effects were generated by the tasks and ethnic groups. Importantly, gender did not generate a significant effect on group behaviors, except in concert with ethnic differences. Further, ethnic group did not alter the influence of meditative experience on heart rate or EDA mean reactivity during the cold pressor and isolated relaxation tasks. In an effort to simplify the relationship between meditative experience and autonomic reactivity to tasks, only the main task effects and effect sizes of the isolated cold pressor, isolated relaxation, cold pressor-relaxation, and supine arithmetic tasks will be discussed below.

Cold-pressor. Group means displayed a simultaneous rise in HF, HR and EDA measures during the isolated cold pressor task. The fluctuations in HR and EDA suggest the influence of sympathetic activation and are consistent with past studies (e.g. Peckerman et al., 1994, Qiao, Vaeroy, & Morkrid, 1991).

Relaxation. The isolated relaxation task displayed the least autonomic reactivity of the tasks, with the instruction to relax only producing a decrease in RR. The lack of reactivity is most likely due to the close similarity of the baseline and relaxation tasks.

Cold pressor-relaxation. Cold pressor-relaxation displayed increases in RMSSD, HF and decreases in RR. The addition of relaxation instructions to the cold pressor task, appears to have partially mitigated some of the sympathetic effects of the cold pressor. Decreases in the reactivity of HR and RR, and increase in RMSSD, relative to the isolated cold pressor, support increased parasympathetic reactivity to the dual tasks. However, no autonomic indices significantly differed between the isolated cold pressor and the dual cold pressor-relaxation tasks. Pardikes & Friedman (2010) reported decreased HR and increased RMSSD and HF reactivity during a cold pressor-relaxation task; however, the temperature of the cold pressor was kept between 10-15 ˚C.

Supine-arithmetic. The dual supine-arithmetic task produced increases in RMSSD, HF and RR and decreases in HR and LF. Arithmetic appears to have had little influence on the supine task except increasing RR. Overall, the task displayed autonomic behavior indicative of parasympathetic activation. No dual supine-arithmetic tasks, to the author's knowledge, have been previously performed. Studies which have combined tasks like "facial cooling" (cooling the trigeminal nerve to elicit bradycardia, a parasympathetic reflex) and a mental stressor (e.g. mental arithmetic or a shock avoidance task) can be considered analogs of the present manipulation. Such studies have often reported combination tasks to demonstrate intermediate autonomic effects, represented by suppressed sympathetic and parasympathetic markers (e.g. Friedman, Thayer & Tyrell, 1996; Uijtdehaage &Thayer, 2000).

Autonomic complexity of cold pressor tasks. Task manipulation produced results more or less in line with past studies. However, the simultaneous increases in HR, RMSSD, LF, HF and EDA mean during both cold pressor tasks are puzzling. This pattern of behavior displays evidence of both sympathetic (increased HR and EDA mean) and parasympathetic activity (increased RMSSD and HF). This may be a sign of the complexity (conscious and non-conscious influence) inherent in the cold pressor task and autonomic function (i.e. coactivation). In addition, the mixed results speak to the complexity of autonomic indices during complex psychophysiological tasks and calls for the inclusion of multiple indices (Friedman et al. 2002; Jauregui-Renaud et al., 2001; Thayer & Friedman, 2000).

Meditational influence on tasks. Meditative practice was predicted to influence the autonomic patterns of the subjects. There appears to be partial support for this hypothesis, especially among men.

***Baseline*.** Increased meditational experience was predicted to be positively correlated with increased parasympathetic activity during baseline readings (Wu & Lo, 2008). A minimal but significant meditative effect was detected for men during the baseline task. However, it was contrary to the predicted autonomic behavior. The average time spent practicing meditation per day was positively correlated with EDA mean, an index of sympathetic arousal. Meditative experience accounts for nearly 13% of the observed variance of EDA mean during baseline (multiple regression model). However, group (negative correlation) and respiration rate (negative correlation) account for equal amounts of the variance observed in EDA mean.

The distinction between Americans and Taiwanese could be one of the primary factors contributing to the detected autonomic patterns. T-tests showed Americans to displayed greater levels of EDA mean and lower levels of respiration frequency during baseline recordings.

Correlations display that same relationship, but t-tests did not demonstrate a significant difference between the groups for average meditative practice/day.

The lack of difference between the groups regarding meditative practice/day and the significant contribution of practice to the regression model suggests that meditative experience may be affecting EDA behavior at baseline, independent of group effects. However, the metric of meditative practice minutes/day may be problematic. The distribution of practice per/day is greatly skewed toward minimal practice, with two individuals reporting more than three standard deviations above the mean (240 min/day & 300 min/day). Inspection of the data revealed that these individuals were generating the slope of the regression model during baseline tasks. If these individuals are removed from the analysis, the trends go away and the relationships between EDA mean and practice/day are no longer significant. Greater numbers of meditators practicing more than 2 hours a day are needed to further explore this finding.

Isolated reflexive parasympathetic task. No prediction was made regarding the supine posture manipulation. However, meditational experience, as measured by practice/day, displayed a significant inverse relationship with EDA mean. As meditative practice/day increased, EDA mean decreased. This relationship suggests that the amount of meditation/day helps to decrease one index of sympathetic reactivity during a highly parasympathetic task. Further, this effect was strongest in men, though the effect was not significant in an isolated population. However, as stated, the metric of meditative practice/day may be problematic. Inspection of the data again revealed that the same individuals were generating the slope of the regression model during the supine task. Once again, if these individuals are removed from the analysis, the trends go away and the relationships between EDA mean and practice/day are no longer significant. Greater numbers of meditators practicing more than 2 hours a day are needed to further explore this finding.

That said, supine is a specific meditative or relaxation posture and often employed to compare the anti-stress effect of a meditative and non-meditative behavior in empirical studies (e.g. Sharma, Mahajan & Sarma, 2007). It logically follows that the supine posture could elicit greater parasympathetic activity in advanced meditators. But meditators, to the author’s knowledge, have never been shown to generate less EDA activity during a supine task then non-meditators.

Isolated reflexive sympathetic task. Increased meditative experience was predicted to generate less sympathetic reaction and greater vagal activity in experienced meditators during the cold pressor task. This prediction was based on the conception that the cold pressor would be confounded by psychological processes, especially in advanced meditators. Evidence implies that advanced meditators tend to naturally generate meditative states, which could have mitigated the sympathetic responses of the task (Lutz et al., 2007). This effect appears to have occurred. Meditative practice was significantly predictive of heart rate changes in response to the task with experienced meditators generating less change and even producing decreases in cardiac response compared to baseline levels. However, this effect was only observed in men.

Isolated volitional sympathetic task. Increased meditational experience was predicted to generate greater vagal withdrawal, enhancing sympathetic activity when faced with a stressful task (Calkins, Graziano & Keane, 2007). Meditational experience, however, did not significantly affect physiological reactivity to mental arithmetic.

Isolated volitional parasympathetic task. Increased meditational experience was predicted to generate increased parasympathetic activity during the relaxation task (Brefczynski-Lewis et al., 2007; Wu & Lo, 2008). Often, experiments investigating the psychophysiological outcomes of meditative practice investigate *in situ* effects. The mental relaxation task is the closest approximation of the meditative process in this experiment. In the subpopulation of men, years of practice demonstrated a significant positive correlation with EDA mean. Hence as experience went up, so did a cholinergic sympathetic response, generally associated with arousal. The observed autonomic behavior suggests meditative practice produced an increase in sympathetic activity during a task that is somewhat analogous to actual meditation. The effects of meditational experience on the relaxation task, like baseline measures, are puzzling: The autonomic indices affected by meditative experience are counter to what was predicted.

Dual reflexive parasympathetic & volitional sympathetic task. Meditational experience was hypothesized to be positively correlated with increased sympathetic activity during the supine-arithmetic task (Pardikes & Friedman, 2010). Meditational experience evidenced no significant effects on the physiological reaction to the task. It was argued that meditation increases anterior regulation of autonomic function. Thus, the withdrawal of parasympathetic inhibition was predicted to be as efficient as the activation of parasympathetic inhibition. It is possible that the supine posture was too powerful of a reflexive task. Weipert et al. (1986)

demonstrated a similar effect when they instructed subjects to inhibit the sympathetic responses of orthostatic stress via biofeedback. Subjects were unable to significantly depress the cardiovascular sympathetic reflexes elicited by standing. Additional explanations, regarding this finding, will be discussed in a subsequent section.

Dual reflexive sympathetic & volitional parasympathetic task. Meditational experience was hypothesized to be positively correlated with increased parasympathetic activity during the cold pressor-relaxation task (Pardikes & Friedman, 2010; Reeves & Shapiro, 1982). Meditation was able to predict heart rate reactivity, but the relationship was not as strong as the relationship observed during the isolated cold pressor task. Overall, subjects displayed a mitigated increase in heart rate compared to the isolated cold pressor task (change was not significant). The ability for the whole group to buffer the sympathetic effects of the cold pressor task with a mental parasympathetic task replicates previous work and supports a hierarchical model of autonomic function (e.g. Reeves & Shapiro, 1982; Pardikes & Friedman, 2010).

Regardless of the differences between the two cold pressor tasks, years of practice was again the best predictor of heart rate reactivity for men during the cold pressor-relaxation task. This finding is in partial support of the hypothesis that meditation enables the suppression of reflexive action. The observed heart rate changes and absence of other significant autonomic behaviors during the cold pressor tasks also suggests that meditators may have been reflexively inhibiting sympathetic responses via some intrinsic cardiac and/or psychological mechanisms.

5.2 - Significance of findings

Autonomic activity and function are complex processes. Overall, the administered psychophysiological tasks elicited autonomic behaviors predicted by past research, but meditative experience was able to predict specific autonomic reactivity to three tasks. The next section will further describe the most interesting and salient nuances of these findings.

Differences between supine-arithmetic and cold pressor tasks. The cold pressor tasks and supine-arithmetic were the crux of the entire experiment, predicted to display the regulatory properties of meditative practices. Although supine-arithmetic did not show the predicted effects, meditative practice was the strongest predictor of heart rate reactivity during both cold pressor tasks. Why did supine-arithmetic not display the same properties as the cold-pressor relaxation procedure? The cold pressor tasks may have been more apropos for exploring the predicted autonomic hierarchy and the influence of meditative practices on autonomic functions. Meditators may have been more motivated to inhibit the stressful effects of the cold pressor and better practiced at inhibiting stressful and distracting stimuli.

First, the act of inhibiting the stressful effects associated with the cold pressor may have been more salient to the subjects than performing mental arithmetic while lying down. Although some subjects appeared agitated by the arithmetic tasks, many more subjects were clearly distraught by placing their hand in ice water. Subjects also appeared to take the cold pressor task as more of a challenge than the arithmetic task. Future experiments might detect the predicted meditational influence on anterior regulation during a psychological stressor if a more salient challenge (greater pressure to perform well) was employed. Next, meditative practices rarely attempt to increase sympathetic activity. Instead, meditation commonly employs increased parasympathetic activity and necessitates the inhibition of distracting stimuli preventing increased parasympathetic activity (the cold pressor is an excellent example of such a distraction). The cold pressor tasks, in this regard, better approximated the natural behaviors associated with meditation than did the supine-arithmetic task.

Differences between the cold pressor tasks. The properties of meditation and the organization of autonomic function may also be one component of why meditative practice was less predictive of heart rate reactivity during the cold pressor-relaxation task compared to the isolated cold pressor task. As argued, autonomic regulation is postulated to be one of the primary components of meditative practices and these practices commonly employ increased parasympathetic activity and necessitate the suppression of distracting stimuli preventing increased parasympathetic activity. So, it is plausible that advanced meditators were naturally suppressing the stressful effects of the cold pressor even when not asked to. A related plausible influence is demand characteristics. Meditators might have recognized the underlying motivations of the experiment, and actively attempted to suppress or enhance autonomic activities to meet the perceived desires of the experimenter (e.g. Rosenthal, 2002).

In addition, the ability to regulate autonomic function is arguably an intrinsic feature of a healthy autonomic nervous system. The decrease of the predictive power of the meditational experience for the dual task may reflect the pervasive abilities of healthy autonomic regulation independent of meditative influence. Hence, less experienced or non-meditators were able partially suppress the stressful effects of the cold pressor when they were instructed to do so.

A portion of the cold pressor-relaxation task results could also have been due to practice effects. The order of tasks always assigned the isolated cold pressor task before the cold pressor-relaxation task. Thus, some of the sympathetic suppression observed during the cold pressor-relaxation task could be an artifact of task order.

Gender differences. The effects of meditational experience on autonomic regulation were almost entirely present in men only. However, the lack of detected interaction effects between gender and meditational experience imply that gender was not responsible for the observed results. Rather, the discrepancy may be due to the lack of experienced women meditators. T-tests showed that the meditational experience of men and women were marginally different, and men averaged more years of experience. It is predicted that similar autonomic effects could be detected in women if more advanced meditators were studied. The only instance of meditative effects found in both men and women occurred with the supine task. However, as stated, women alone did not register a significant correlation between EDA mean and practice/day may be a problematic variable (in addition, both of the outliers discussed previously were men).

The gender differences, with regard to the cold pressor tasks, might alternatively be the explained via pain tolerance. Perhaps the cold pressor task was perceived as less painful to men and generated less of a sympathetic response in them. Past research supports gender differences in response to noxious stimuli, with women displaying greater sensitivity to pain (Berkley 1997; Fillingim, 2000; Riley, Robinson, Wise, Myers & Fillingim, 1998). Conversely, past studies, which have investigated meditative practice and pain tolerance, have found greater pain tolerance in meditators, but no gender differences (Grant & Rainville, 2009; Kingston, Chadwick, Meron & Skinner, 2007). However, these studies were not designed to investigate gender and pain sensitivity. Grant and Rainville only tested 5 women and 8 men and Kingston et al., did not even include men in their sample population. Further research is needed to clarify the detected genders differences found in the present study.

Intrinsic heart rate changes. Heart rate reactivity was the most salient variable with respect to predicted autonomic behavior. It is curious, however, to find significant heart rate changes in the absence of other significant autonomic changes. Despite the lack of significant consensus among the autonomic variables, the observed variance of heart rate reactivity is illustrating some aspect of the relationship between meditational experience and autonomic output. It is plausible that the behavior of cardiac reactivity is occurring independent of direct autonomic control. A possible account of this phenomenon is demonstrated in the reported effects of regular exercise on heart rate. Studies have found higher resting bradycardia, the result of lower intrinsic heart rate, among consistent exercisers (Bonaduce et al., 1998; de Geus et al., 1996; Goedhart et al., 2008, Katona et al., 1982; Kingwell et al., 1992; Uusitalo, Tahvanainen, Uusitalo, & Rusko, 1996) and worriers to exhibit an increased resting heart rate, independent of other autonomic markers (Knepp & Friedman, 2008). How and why this effect occurs is unclear. It is speculated that the lower intrinsic heart rate may be due to changes in myocardial pacemaker tissue or cell metabolism (Katona et al., 1982). Perhaps a similar myocardial process is occurring in consistent meditators.

Previous studies have reported meditators to have lower resting heart rates than controls (e.g. Delmonte 1984; Dillbeck & Orme-Johnson, 1987). Heart rate changes, however, were not detected in the resting (i.e. baseline) heart rates of meditators for the present study. Instead, meditators displayed decreased heart rate response to a highly reflexive stressor task. Additionally, the limited number of physiological measures (cardiorespiratory and electrodermal responses) limits autonomic information. Autonomic changes could have been occurring outside of detection. Further exploration of this experimental paradigm is needed to clarify the evidenced cardiac changes during a stressful task of advanced meditators in the absence of other autonomic changes.

Years of meditative practice. Years of practice and average practice time per day, though strongly correlated, appeared to provide different information on the specific effects of meditation that were tested. However, the strongest predictor of autonomic reactivity for the experiment was reported meditative years, influencing the relaxation, cold pressor and cold pressor-relaxation tasks. This result suggests that the observed regulation of heart rate during the cold pressor tasks and regulation of EDA mean during relaxation are not detected in novice meditators and may develop over time. Often the most extraordinary reported effects of meditation are only found in advanced meditators (e.g. Anand, Chhina & Singh, 1961; Benson et al., 1982; Carter et al., 2005).

Increased EDA during relaxation task. The counterintuitive results of the relaxation task necessitate further inquiry. One possible explanation, involves “intrinsic” or “default mode” brain systems in meditators. Default networks are diffuse but consistent systems of cortical and sub-cortical structures that exhibit activity during 'restful' states but decrease in activation with the introduction of goal-directed behaviors (Raichle & Snyder, 2007). The functionality and specific structures involved in default networks are debated. However, the posterior cingulate, ventral medial prefrontal , dorsal medial, precuneus and lateral temporal cortices and the hippocampi are often indicated as structures that help maintain the default state of potentiality (Esposito et al., 2006; Nagai et al., 2004; Raichle & Snyder, 2007; Raichle et al., 2001)

Notably, default mode activity has also been reported to increase sympathetic activity (Nagai et al., 2004), and there is evidence that spontaneous thoughts (Mason et al., 2007) and meditation may also deactivate goal-directed cerebral regions in advanced meditators (Brefcyznski-Lewis et al., 2007; Guo & Pagnoni, 2008). It is possible that experienced meditators were participating in an introspective of form meditation during the relaxation task, while less experienced and non-meditators were distracted or actively trying to relax. Introspective techniques allow spontaneous thoughts to come and go without attaching any reference and were previously defined as the eventual default meditative method for advanced meditators. Further support may be found in a recent study by Lutz et al. (2009); they reported expert meditators to demonstrate increased heart rate and skin conductance relative to controls during a *compassion meditative* session independent of other autonomic change (Compassion meditation employs both introspective and concentrative techniques. Subjects are instructed to focus on feelings of altruistic love or compassion without attaching any reference to those thoughts). The authors attributed this finding as support of prevalent non-parasympathetic mechanisms involved in the meditative process.

5.3 - Limitations and Future Directions

The methodology and theory behind the present study is innovative, with the potential to contribute to the current understanding of autonomic and meditative processes. Regardless, numerous improvements must be implemented to confirm, clarify and enhance the current findings.

Limitations. The nature and circumstances of this research introduced factors into the data set that could not be controlled and the conceived limitations of the study need to be acknowledged. The project required finding subjects from the full range of meditational experience, the most difficult to find being very advanced subjects. The necessity of finding advanced subjects generated the need to collect data from a diverse population, which may have diluted some of the effects of meditation on autonomic function. Specific limitations of the study consist of the inclusion of different ethnic groups, meditative styles, multiple experimental sites, a large range of age among subjects and possibly both genders. Multiple experimental sites further handicapped the study by excluding more than three autonomic variables and a broader picture of autonomic behavior. Perhaps the largest limitation of the study is the absence of blood pressure measures, as the most salient physiological response to the cold pressor task is evidenced in blood pressure modulation (Peckerman et al., 1994). Alterations of the experimental protocol along these lines would help elucidate the described effects of meditation.

Future directions. There are some specific questions which arise from the current study and should be addressed in future studies investigating the effects of meditative practices on autonomic function. First, does gender alter the effects of meditation on autonomic control? More advanced women meditators are needed to clarify this finding. Second, the cold pressor task may include too many psychological contaminants. It may be best for future studies to employ some other reflexively stressful task. Heat stimulation could limit psychological contaminants, and provide a better alternative to cold pressor (Grant & Rainville, 2009). Cognitive reflexes or distractions, such as listening to a conversation while attempting to meditate, could also test the effects for meditative practices to foster attentional and autonomic regulation (Wallace, 1970). In addition, a better rating of the subject's discomfort or pain should also be employed in any future investigations. Third, the counterintuitive finding regarding EDA mean during the relaxation task must be further explored. The reported increase of EDA in other studies encourages more inquiries. Finally, future studies could profit from employing longitudinal and idiodynamic designs. Longitudinal approaches would allow the modulations of autonomic and cognitive functions to be tracked over an extended period of time in a number of individuals. Idiodynamics approaches permit a more concentrated study of individuals (with varying levels of meditative experience) across multiple situations (Friedman & Santucci, 2003). Both designs allow for greater control of meditative experience.

6.0 - Conclusion

The connection between meditative practices and autonomic functions illustrates the unity of the voluntary and involuntary actions. Human beings, as animals, are primarily creatures of habit, but humans and some non-human animals can actively disrupt some of these reflexive states and possibly form new behavioral patterns. However, old habits die hard, and many disease states could have some impetus in an inability to disrupt deleterious reflexive states. Meditative states are argued to help in the volitional regulation of reflexes and generate salubrious health effects. Meditation, in this context, can be viewed as an exercise that enhances the anterior cortical control of autonomic action. The present study tested this notion by performing specific volitional and reflexive autonomic evoking tasks on a full range of experienced and non-experienced meditators. Meditative experience was hypothesized to alter autonomic states, experienced meditators evidencing greater overall parasympathetic activity and autonomic output indicative of the volitional tasks during dual tasks.

Analyses are mixed in their conclusions. Some predictions were realized, but most were not and still other findings are opposite to what was predicted. In respect to meditative experience, analyses revealed significant relationships between years of practice and heart rate reactivity during both cold pressor tasks and EDA mean reactivity during the relaxation task. These effects were however, only found in the sub population of men. It is hypothesized that women did not demonstrate a similar effect because of lack of experienced meditators.

The present study represents an experimental analysis of meditation via volitional regulation of autonomic states, exploring the parameters and potential of volitional autonomic activity. Decreased heart rates, as demonstrated by advanced meditators during the cold pressor tasks, are argued to support the hypothetical relationship between meditative practices and autonomic regulation. However, further inquires are needed to gain a better understanding of autonomic and meditative functions. Specific questions include the presence of significant heart rate changes in the absence of significant autonomic change, the exclusion of women from significant findings, the process of parasympathetic engagement vs. disengagement and the counterintuitive relationship between meditative experience and EDA during relaxation. This and future work will continue to contribute to mind-body conceptions of health and illustrate the potential consequences of meditative practices in specific disease states and prevention.

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Appendix A

Health Status Questionnaire

It is necessary for us to obtain a very brief medical history in order to determine if you are eligible for participation in the study. It is very important that you be completely honest. This information will be kept strictly confidential.

What is your age, height, weight, and gender?
Age: _____ years
Height: _____ feet or cm
Weight: _____ lbs. or kg
Gender: ___M ___F
Handedness: do you consider yourself
Right handed__, Left handed__, Both__

Since birth, have you ever been hospitalized or had any major medical problems?
___ Yes ___ No
If Yes, briefly explain:

Have you ever experienced a concussion or lost consciousness due to a blow to the head?
___ Yes ___ No
If Yes, briefly explain:

Have you ever had problems that required your seeing a counselor, psychologist, or psychiatrist?
___ Yes ___ No
If Yes, briefly explain:

Do you use tobacco products of any kind?
___ Yes ___ No
If Yes, describe what kind how often/much:

Do you currently have or have you ever had any of the following?
___ Yes ___ No …..Strong reaction to cold weather
___ Yes ___ No …..Circulatory problems
___ Yes ___ No …..Tissue disease
___ Yes ___ No …..Skin disorders (other than facial acne)
___ Yes ___ No …..Arthritis
___ Yes ___ No …..Asthma
___ Yes ___ No …..Lung problems
___ Yes ___ No …..Cardiovascular disorder/disease
___ Yes ___ No …..Diabetes
___ Yes ___ No …..Hypoglycemia
___ Yes ___ No …..Hypertension (high blood pressure)
___ Yes ___ No …..Hypotension (low blood pressure)
___ Yes ___ No …..Hepatitis
___ Yes ___ No …..Neurological problems
___ Yes ___ No …..Epilepsy or seizures
___ Yes ___ No …..Brain disorder
___ Yes ___ No …..Stroke
If you responded Yes to any of the above conditions, briefly explain:

Have you ever been diagnosed as having:
___ Yes ___ No …..Learning deficiency or disorder
___ Yes ___ No …..Reading deficiency or disorder
___ Yes ___ No …..Attention deficit disorder
___ Yes ___ No …..Attention deficit hyperactivity disorder;

List any over-the-counter or prescription medications you are currently taking:

List any other medical conditions that you have or have had in the past:

Appendix B

Meditational History Questionnaire

How many years have you practiced meditation?

On average, how many minutes do you practice meditation per day?

On average, how many hours do you practice meditation per week?

What type of meditative practice do you perform?

Appendix C

University of Houston Non-Exercise Test

Choose the number below that corresponds with the best description of your GENERAL LEVEL of physical activity during the PREVIOUS MONTH. Circle select ONE NUMBER out of the eight possible choices.

0 Avoid walking or exertion (e.g., always use elevator, drive whenever
possible instead of walking).

1 Walk for pleasure, routinely use stairs, occasionally exercise
sufficiently to cause heavy breathing or perspiration.

Participate regularly in recreation or work requiring modest physical activity such as golf, horseback riding, calisthenics, table tennis, weight lifting, yard work, etc.

2 10 to 60 minutes per week

3 Over one hour week

Participate regularly in heavy physical exercise such as running, swimming, cycling, tennis, or similar aerobic activity.

4 Run or equivalent activity < 30 minutes per week.

5 Run or equivalent activity 30-60 minutes per week.

6 Run or equivalent activity 1-3 hours per week.

7 Run or equivalent activity > 3 hours per week.

Appendix D

Depression Anxiety Stress Scale

DASS21

Please read each statement and select a number 0, 1, 2 or 3 that indicates how much the statement applied to you *over the past week*. There are no right or wrong answers. Do not spend too much time on any statement.

The rating scale is as follows:

0 Did not apply to me at all
1 Applied to me to some degree, or some of the time
2 Applied to me to a considerable degree, or a good part of time
3 Applied to me very much, or most of the time

1	I found it hard to wind down	0	1	2	3
2	I was aware of dryness of my mouth	0	1	2	3
3	I couldn't seem to experience any positive feeling at all	0	1	2	3
4	I experienced breathing difficulty (e.g. excessively rapid breathing, breathlessness in the absence of physical exertion)	0	1	2	3
5	I found it difficult to work up the initiative to do things	0	1	2	3
6	I tended to over-react to situations	0	1	2	3
7	I experienced trembling (eg, in the hands)	0	1	2	3
8	I felt that I was using a lot of nervous energy	0	1	2	3
9	I was worried about situations in which I might panic and make a fool of myself	0	1	2	3
10	I felt that I had nothing to look forward to	0	1	2	3
11	I found myself getting agitated	0	1	2	3
12	I found it difficult to relax	0	1	2	3
13	I felt down-hearted and blue	0	1	2	3
14	I was intolerant of anything that kept me from getting on with what I was doing	0	1	2	3
15	I felt I was close to panic	0	1	2	3
16	I was unable to become enthusiastic about anything	0	1	2	3
17	I felt I wasn't worth much as a person	0	1	2	3
18	I felt that I was rather touchy	0	1	2	3
19	I was aware of the action of my heart in the absence of physical exertion (e.g., sense of heart rate increase, heart missing a beat)	0	1	2	3
20	I felt scared without any good reason	0	1	2	3
21	I felt that life was meaningless	0	1	2	3

Appendix E

Stroop Color and Word Test

Baseline condition:
Instructions: "Say the appropriate color aloud then press the space bar"
Example:
@@@@
@@@@
@@@@
@@@@

Experimental conditions:
Experimental condition will consist of twenty semantic and twenty incongruent trials randomly presented to minimize habitual responding.

Semantic trials
Instructions: "If a word in black ink is presented, say the written color"
Example:
yellow
green
blue
red

Incongruent trials
Instructions: "If a word in color ink is presented, say the color of the ink and not the written color"
Example:
red
green
blue
yellow

Appendix F

Valence and Activation Self-Report Scale

Choose the number on the scale that best describes how you felt during the task. If the word does not at all describe how you felt during the task, choose 1. If the word very accurately describes how you felt, choose 7 or an intermediate amount, choose 3, etc.

Good
Calm
Active
Unpleasant
Neutral
Excited
Negative
Relaxed
Passive
Positive
Agitated
Bad
Pleasant
Rate the intensity of what you felt

Appendix G

Post Task Questions

<u>Recorded on Experimental Run Sheet immediately following selected recovery sessions:</u>

What, if any, methods did you use to fully relax?

While (you were lying down/you had your hand in the water) what were you thinking?

Did you find the task (cold pressor) uncomfortable? Did you try to alleviate the tension?

If so, describe your methods.

Appendix H

Laterality Questionnaire

Select the appropriate number after each item:	***Right***	***Left***	***Both***
With which hand would you throw a ball to hit a target?	1	-1	0
With which hand do you draw?	1	-1	0
With which hand do you use an eraser on paper?	1	-1	0
With which hand do you remove the top card when dealing?	1	-1	0
With which foot do you kick a ball?	1	-1	0
If you wanted to pick up a pebble with your toes, which foot would you use?	1	-1	0
If you had to step up onto a chair, which foot would you place on the chair first?	1	-1	0
Which eye would you use to peep through a keyhole?	1	-1	0
If you had to look into a dark bottle to see how full it was, which eye would you use?	1	-1	0
Which eye would you use to sight down a rifle?	1	-1	0
If you wanted to listen to a conversation going on behind a closed door, which ear would you place against the door?	1	-1	0
If you wanted to listen to someone's heartbeat, which ear would you place against their chest?	1	-1	0
Into which ear would you place the earphone of a portable music player?	1	-1	0

Is your mother left or right hand dominant? ________
Is your father left or right hand dominant? _________

# of Right + # of Left = Total Score
_______ + _______ = _______

Appendix I

Toronto Mindfulness Scale

Instructions: We are interested in some of your daily experiences. Below is a list of things that people sometimes experience. Please read each statement and select one of the five choices: “not at all,” “a little,” “moderately,” “quite a bit,” and “very much.” Please indicate the extent to which you agree with each statement. In other words, how well does the statement describe what you tend to experienced on a daily basis.

Not at all	= 0
A little	= 1
Moderately	= 2
Quite a bit	= 3
Very much	= 4

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

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

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

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

5. I am curious to see what my mind is up to from moment to moment.

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

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

8. I am more invested in just watching my experiences as they arise, than in figuring out what they could mean.

9. I approach each experience by trying to accept it, no matter whether it is pleasant or unpleasant.

10. I remain curious about the nature of each experience as it arises.

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

12. I am curious about my reactions to things.

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

Scoring:
Key: All items were written in the positively keyed direction.
Factor 1 (Curiosity score): The following items are summed: 3, 5, 6, 10, 12, 13
Factor 2 (Decentering score): The following items are summed: 1, 2, 4, 7, 8, 9, 11

*Scale was modified to place questions in present tense rather than past tense.

Appendix J

Possible Task Orders

1. (Cold pressor, Supine), (Arithmetic, Relaxation), (Cold pressor-Relaxation, Supine-Arithmetic)

2. (Supine, Cold pressor), (Arithmetic, Relaxation), (Supine-Arithmetic, Cold pressor-Relaxation)

3. (Cold pressor, Supine), (Relaxation, Arithmetic), (Cold pressor-Relaxation, Supine-Arithmetic)

4. (Supine, Cold pressor), (Relaxation, Arithmetic), (Supine-Arithmetic, Cold pressor-Relaxation)

Isolated reflexive tasks were always performed first and dual tasks were always performed last.

Figure 1 - Reported Years of Practice by Gender: 0=Women; 1=Men

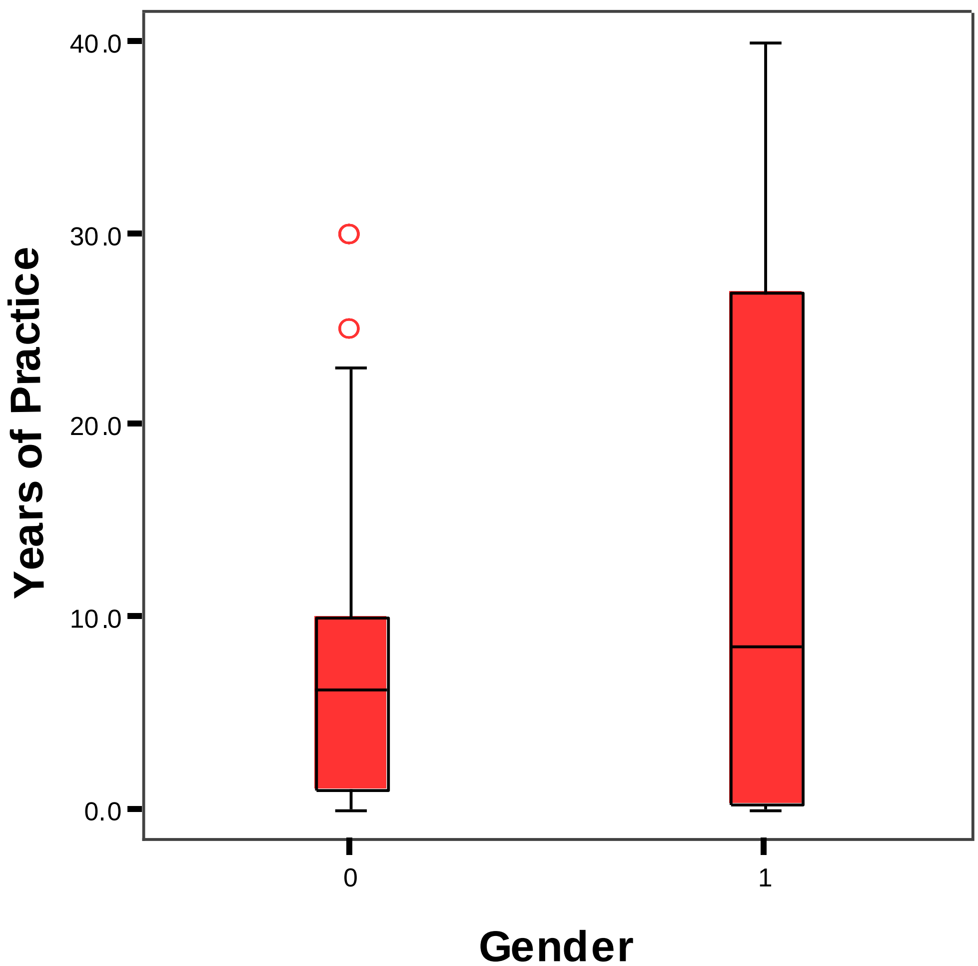


Figure 2 - Task Reactivity Effect Sizes

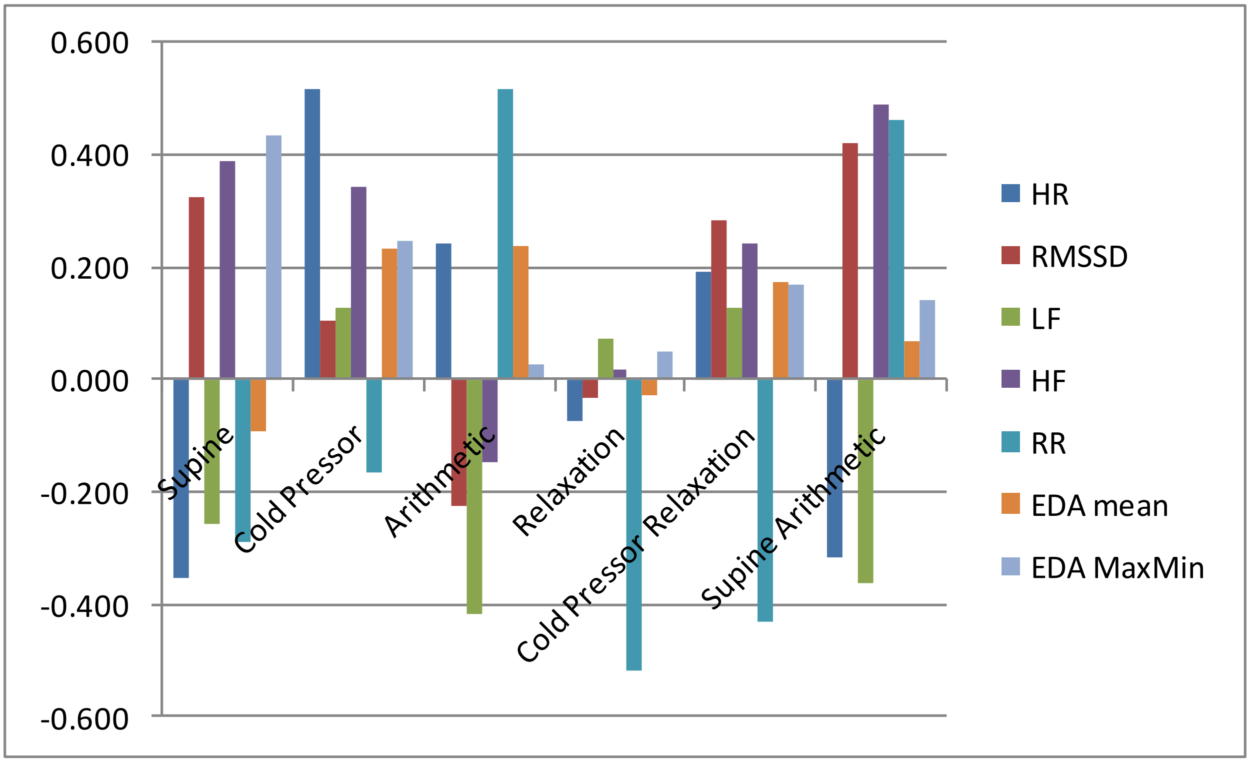
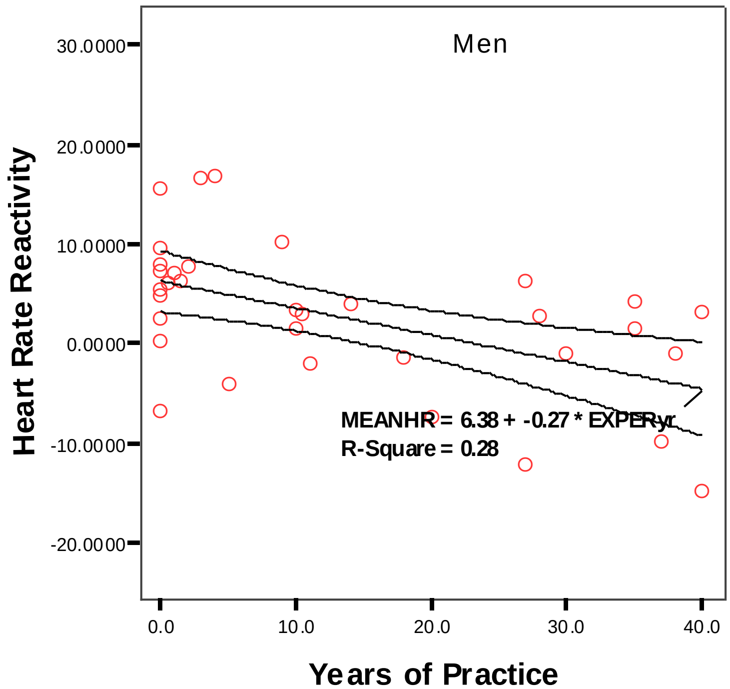


Figure 3 - Cold pressor Scatterplots (Years of Practice x Heart Rate Reactivity) Men & Women



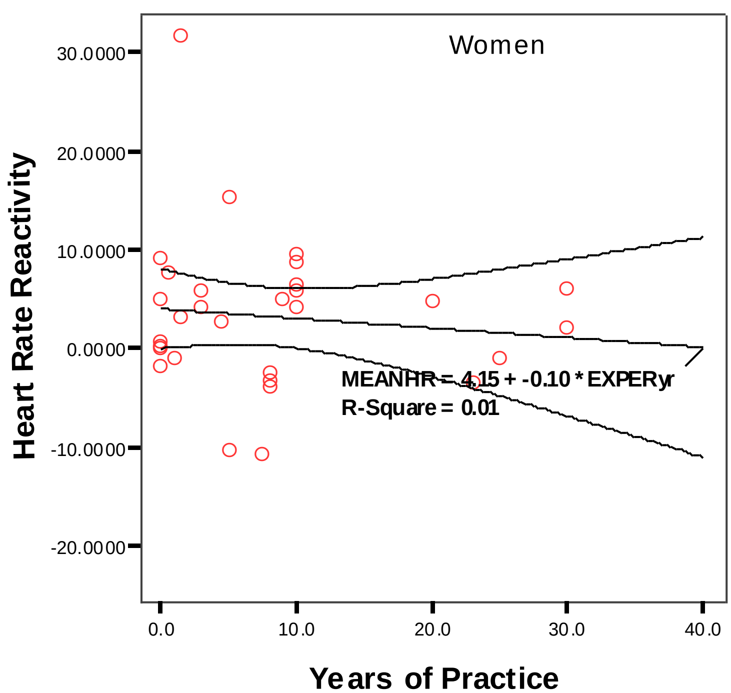
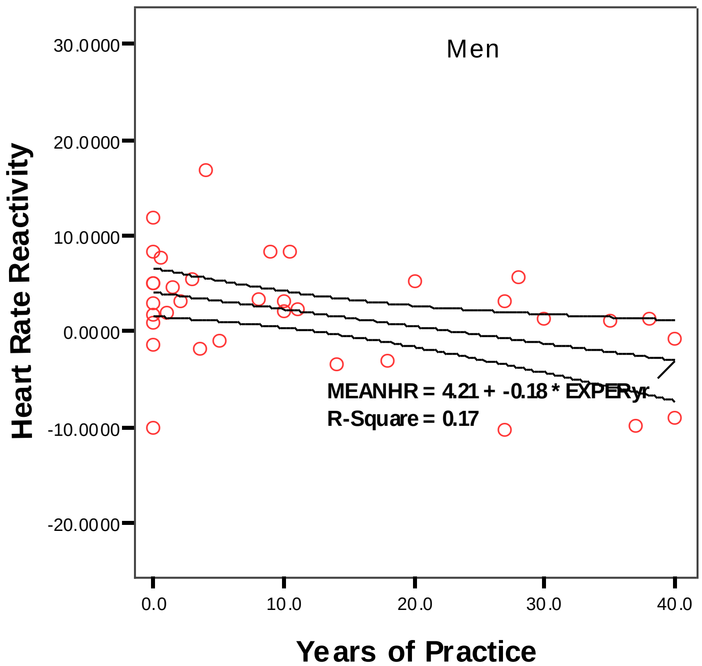
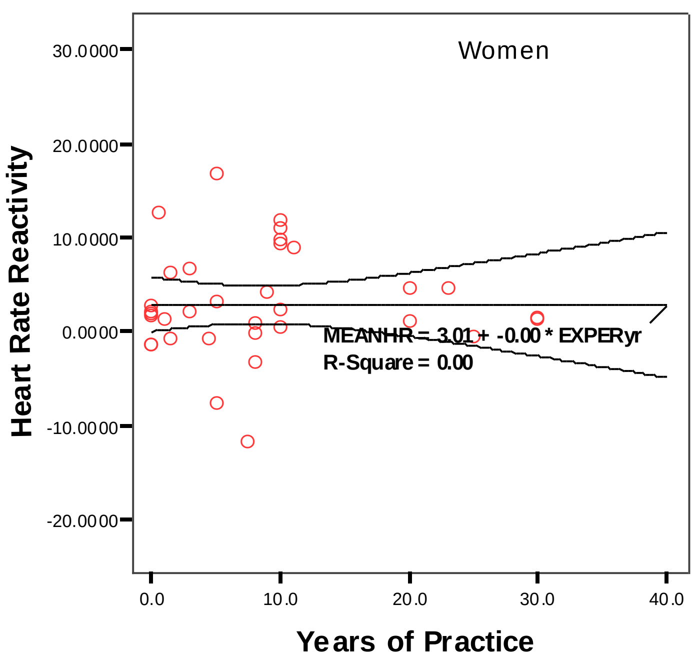


Figure 4: Cold pressor-Relaxation Scatterplots (Years of Practice x Heart Rate Reactivity) Men & Women





Tables

Legend: Med Day=Meditational experience (min/day); Med Year=Meditational experience (years); Med Week=Meditational experience (hrs/wk); BMI=Body Mass Index; TMS d=Toronto Mindfulness Scale (decentered); TMS c=Toronto Mindfulness Scale (curiosity); HR=heart rate; RMSSD=root mean square of successive differences; LF=absolute low frequency (fast Fourier transform analysis); HF=absolute high frequency (fast Fourier transform analysis); RR=respiration rate; EDA mean=average electrodermal activity level; EDA MaxMin=change from maximum to minimum electrodermal activity levels; S=Supine; CP=Cold Pressor; A=Mental Arithmetic; R=Mental Relaxation; CPR=Cold Pressor-Relaxation; SA=Supine Arithmetic

Correlation Tables

*Correlation is significant at the 0.05 level (2-tailed)

**Correlation is significant at the 0.01 level (2-tailed)

Table 1: Baseline Descriptives American vs. Taiwanese; Men vs. Women

		American	Taiwanese
LF	N	35	37
	Mean	2088.659	744.349
	Std. Deviation	2629.565	793.56
EDA mean	N	35	37
	Mean	7.167	3.797
	Std. Deviation	3.596	3.032
EDA MaxMin	N	34	37
	Mean	3.693	1.842
	Std. Deviation	3.136	2.129
RR	N	35	37
	Mean	0.191	0.257
	Std. Deviation	0.069	0.053
		Men	**Women**
LF	N	36	36
	Mean	1866.394	929.272
	Std. Deviation	2304.463	1590.998
EDA mean	N	36	36
	Mean	6.693	4.177
	Std. Deviation	3.96	2.987
RR	N	36	36
	Mean	0.204	0.246
	Std. Deviation	0.065	0.067

Table 2: Baseline Correlations

Correlations														
		Age	Houston	Med Day	Med Years	Med Week	BMI	Laterality	Depression	Anxiety	Stress	TMSd	TMSc	Stroop
Houston	Pearson Correlation	-0.228												
	Sig. (2-tailed)	0.062												
	N	68												
Med Day	Pearson Correlation	.273(*)	-0.224											
	Sig. (2-tailed)	0.020	0.066											
	N	72	68											
Med Year	Pearson Correlation	.414(**)	-.353(**)	.717(**)										
	Sig. (2-tailed)	0.000	0.003	0.000										
	N	72	68	72										
Med Week	Pearson Correlation	.344(**)	-.266(*)	.879(**)	.607(**)									
	Sig. (2-tailed)	0.003	0.028	0.000	0.000									
	N	72	68	72	72									
BMI	Pearson Correlation	0.186	0.181	-0.009	-0.051	0.041								
	Sig. (2-tailed)	0.117	0.139	0.94	0.671	0.735								
	N	72	68	72	72	72								
Laterality	Pearson Correlation	.285(*)	-0.131	0.056	-0.033	0.016	-0.002							
	Sig. (2-tailed)	0.020	0.312	0.657	0.794	0.899	0.989							
	N	66	62	66	66	66	66							
Depression	Pearson Correlation	-.292(*)	-0.031	-.271(*)	-.314(**)	-0.219	0.027	-0.179						
	Sig. (2-tailed)	0.015	0.808	0.025	0.009	0.071	0.824	0.149						
	N	69	65	69	69	69	69	66						
Anxiety	Pearson Correlation	-.294(*)	-0.088	-.256(*)	-.277(*)	-0.228	-0.114	-0.177	.553(**)					
	Sig. (2-tailed)	0.014	0.486	0.034	0.021	0.06	0.349	0.156	0.000					
	N	69	65	69	69	69	69	66	69					
Stress	Pearson Correlation	-.548(**)	0.079	-.374(**)	-.386(**)	-.392(**)	-0.183	-0.197	.704(**)	.506(**)				
	Sig. (2-tailed)	0.000	0.529	0.002	0.001	0.001	0.133	0.113	0.000	0.000				
	N	69	65	69	69	69	69	66	69	69				
TMSd	Pearson Correlation	.383(*)	-0.345	.431(**)	.380(*)	.391(*)	-0.278	0.157	-.361(*)	0.068	-0.315			
	Sig. (2-tailed)	0.023	0.058	0.010	0.024	0.020	0.106	0.391	0.028	0.691	0.058			
	N	35	31	35	35	35	35	32	37	37	37			
TMSc	Pearson Correlation	0.295	-0.218	0.172	0.227	0.13	-0.286	0.153	-0.235	0.131	-0.188	.716(**)		
	Sig. (2-tailed)	0.085	0.239	0.323	0.191	0.458	0.096	0.403	0.161	0.44	0.264	0.000		
	N	35	31	35	35	35	35	32	37	37	37	37		
Stroop	Pearson Correlation	0.272	-.387(*)	0.002	0.059	0.117	-0.205	0.009	-0.264	0.002	-0.128	0.168	0.061	
	Sig. (2-tailed)	0.131	0.042	0.989	0.747	0.524	0.261	0.962	0.131	0.992	0.471	0.344	0.733	
	N	32	28	32	32	32	32	29	34	34	34	34	34	
HR	Pearson Correlation	-0.194	0.002	-0.109	-0.13	-0.076	-0.156	0.161	0.197	-0.065	0.232	-0.109	0.128	-0.097
	Sig. (2-tailed)	0.103	0.987	0.361	0.277	0.524	0.190	0.196	0.104	0.596	0.056	0.534	0.465	0.596
	N	72	68	72	72	72	72	66	69	69	69	35	35	32
RMSSD	Pearson Correlation	-.441(**)	0	0.005	-0.05	-0.069	-0.027	-0.041	0.012	0.139	0.177	-0.059	-.359(*)	-.355(*)
	Sig. (2-tailed)	0.000	0.999	0.968	0.677	0.565	0.82	0.742	0.919	0.255	0.146	0.739	0.034	0.046
	N	72	68	72	72	72	72	66	69	69	69	35	35	32
LF	Pearson Correlation	-.543(**)	0.157	-0.018	-0.048	-0.135	-0.051	-0.128	-0.051	-0.117	0.132	-0.054	-0.303	-0.256
	Sig. (2-tailed)	0.000	0.202	0.883	0.689	0.258	0.668	0.306	0.678	0.337	0.28	0.756	0.076	0.157
	N	72	68	72	72	72	72	66	69	69	69	35	35	32
HF	Pearson Correlation	-.521(**)	-0.067	-0.051	-0.138	-0.098	-0.031	-0.035	0.121	.252(*)	.241(*)	-0.123	-0.306	-0.294
	Sig. (2-tailed)	0.000	0.590	0.673	0.248	0.412	0.794	0.783	0.324	0.037	0.046	0.481	0.074	0.102
	N	72	68	72	72	72	72	66	69	69	69	35	35	32
RR	Pearson Correlation	0.186	-0.078	-0.13	-0.151	-0.044	0.054	0.149	.245(*)	.256(*)	0.152	-0.143	0.047	0.039
	Sig. (2-tailed)	0.118	0.528	0.275	0.206	0.716	0.653	0.232	0.042	0.034	0.214	0.414	0.789	0.832
	N	72	68	72	72	72	72	66	69	69	69	35	35	32
EDA mean	Pearson Correlation	-0.171	0.207	0.172	.264(*)	0.077	0.162	-0.025	-0.198	-.270(*)	-0.051	-0.178	-0.237	-0.108
	Sig. (2-tailed)	0.152	0.090	0.149	0.025	0.523	0.175	0.838	0.097	0.023	0.674	0.292	0.158	0.543
	N	72	68	72	72	72	72	68	71	71	71	37	37	34
EDA MaxMin	Pearson Correlation	-.241(*)	0.176	0.128	0.166	0.028	0.076	-0.086	-0.064	-0.152	0.09	0.049	-0.149	-0.231
	Sig. (2-tailed)	0.043	0.151	0.287	0.166	0.818	0.531	0.488	0.599	0.210	0.461	0.776	0.387	0.195
	N	71	68	71	71	71	71	67	70	70	70	36	36	33

Table 3: Group x Task Interactions Bonferroni Post Hoc Analyses
Key: US=American group; TW=Taiwanes group
Only significant findings are displayed (p≤0.05)

Multiple Comparisons					
Bonferroni					
Dependent Variable	(I) GrpTaskINT	(J) GrpTaskINT	Mean Difference (I-J)	Std. Error	Sig.
RMSSD	**US S**	US A	.526731(*)	0.115	0.000
	US A	US S	-.526731(*)	0.115	0.000
		US SA	-.503123(*)	0.114	0.001
		TW S	-.438556(*)	0.113	0.008
		TW CP	-.680281(*)	0.114	0.000
		TW CPR	-.484823(*)	0.116	0.002
	US R	TW CP	-.482925(*)	0.113	0.002
	US SA	US A	.503123(*)	0.114	0.001
	TW S	US A	.438556(*)	0.113	0.008
	TW CP	US A	.680281(*)	0.114	0.000
		US R	.482925(*)	0.113	0.002
		TW A	.460500(*)	0.113	0.004
		TW R	.417147(*)	0.113	0.016
	TW A	TW CP	-.460500(*)	0.113	0.004
	TW R	TW CP	-.417147(*)	0.113	0.016
	TW CPR	US A	.484823(*)	0.116	0.002
LF	**US A**	US CPR	-.934803(*)	0.259	0.023
		TW CP	-1.535053(*)	0.254	0.000
		TW CPR	-1.010309(*)	0.257	0.007
	US CPR	US A	.934803(*)	0.259	0.023
		US SA	1.000334(*)	0.257	0.008
	US SA	US CPR	-1.000334(*)	0.257	0.008
		TW CP	-1.600583(*)	0.252	0.000
		TW CPR	-1.075839(*)	0.255	0.002
	TW S	TW CP	-1.182023(*)	0.250	0.000
	TW CP	US A	1.535053(*)	0.254	0.000
		US SA	1.600583(*)	0.252	0.000
		TW S	1.182023(*)	0.250	0.000
		TW A	1.391506(*)	0.252	0.000
		TW R	1.115134(*)	0.250	0.001
		TW SA	1.297676(*)	0.254	0.000
	TW A	TW CP	-1.391506(*)	0.252	0.000
		TW CPR	-.866762(*)	0.255	0.050
	TW R	TW CP	-1.115134(*)	0.250	0.001
	TW CPR	US A	1.010309(*)	0.257	0.007
		US SA	1.075839(*)	0.255	0.002
		TW A	.866762(*)	0.255	0.050
	TW SA	TW CP	-1.297676(*)	0.254	0.000
HF	**No sig. results**				

Multiple Comparisons					
Bonferroni					
Dependent Variable	(I) GrpTaskINT	(J) GrpTaskINT	Mean Difference (I-J)	Std. Error	Sig.
HR	**US S**	US CP	-10.095196(*)	1.265	0.000
		US A	-8.843571(*)	1.274	0.000
		US R	-6.404110(*)	1.265	0.000
		US CPR	-8.706584(*)	1.293	0.000
		TW S	-4.867712(*)	1.257	0.008
		TW CP	-7.738074(*)	1.265	0.000
		TW A	-9.292099(*)	1.265	0.000
		TW R	-5.567998(*)	1.257	0.001
		TW CPR	-9.493677(*)	1.283	0.000
		TW SA	-7.085794(*)	1.274	0.000
	US CP	US S	10.095196(*)	1.265	0.000
		US SA	8.005047(*)	1.256	0.000
		TW S	5.227484(*)	1.248	0.002
		TW R	4.527198(*)	1.248	0.021
	US A	US S	8.843571(*)	1.274	0.000
		US SA	6.753422(*)	1.265	0.000
	US R	US S	6.404110(*)	1.265	0.000
		US SA	4.313961(*)	1.256	0.043
	US CPR	US S	8.706584(*)	1.293	0.000
		US SA	6.616434(*)	1.284	0.000
	US SA	US CP	-8.005047(*)	1.256	0.000
		US A	-6.753422(*)	1.265	0.000
		US R	-4.313961(*)	1.256	0.043
		US CPR	-6.616434(*)	1.284	0.000
		TW CP	-5.647925(*)	1.256	0.001
		TW A	-7.201950(*)	1.256	0.000
		TW CPR	-7.403528(*)	1.275	0.000
		TW SA	-4.995645(*)	1.265	0.006
	TW S	US S	4.867712(*)	1.257	0.008
		US CP	-5.227484(*)	1.248	0.002
		TW A	-4.424387(*)	1.248	0.029
		TW CPR	-4.625965(*)	1.266	0.019
	TW CP	US S	7.738074(*)	1.265	0.000
		US SA	5.647925(*)	1.256	0.001
	TW A	US S	9.292099(*)	1.265	0.000
		US SA	7.201950(*)	1.256	0.000
		TW S	4.424387(*)	1.248	0.029
	TW R	US S	5.567998(*)	1.257	0.001
		US CP	-4.527198(*)	1.248	0.021
	TW CPR	US S	9.493677(*)	1.283	0.000
		US SA	7.403528(*)	1.275	0.000
		TW S	4.625965(*)	1.266	0.019
	TW SA	US S	7.085794(*)	1.274	0.000
		US SA	4.995645(*)	1.265	0.006

Multiple Comparisons					
Bonferroni					
Dependent Variable	(I) GrpTaskINT	(J) GrpTaskINT	Mean Difference (I-J)	Std. Error	Sig.
RR	**US S**	US A	-.064603(*)	0.014	0.000
		US SA	-.048477(*)	0.014	0.038
	US CP	US A	-.056019(*)	0.014	0.005
		US CPR	.051978(*)	0.014	0.018
	US A	US S	.064603(*)	0.014	0.000
		US CP	.056019(*)	0.014	0.005
		US R	.087037(*)	0.014	0.000
		US CPR	.107997(*)	0.014	0.000
		TW R	.072072(*)	0.014	0.000
		TW CPR	.076961(*)	0.014	0.000
	US R	US A	-.087037(*)	0.014	0.000
		US SA	-.070910(*)	0.014	0.000
		TW CP	-.054938(*)	0.014	0.006
		TW A	-.058796(*)	0.014	0.002
		TW SA	-.060688(*)	0.014	0.001
	US CPR	US CP	-.051978(*)	0.014	0.018
		US A	-.107997(*)	0.014	0.000
		US SA	-.091870(*)	0.014	0.000
		TW S	-.067606(*)	0.014	0.000
		TW CP	-.075898(*)	0.014	0.000
		TW A	-.079756(*)	0.014	0.000
		TW SA	-.081647(*)	0.014	0.000
	US SA	US S	.048477(*)	0.014	0.038
		US R	.070910(*)	0.014	0.000
		US CPR	.091870(*)	0.014	0.000
		TW R	.055946(*)	0.014	0.004
		TW CPR	.060834(*)	0.014	0.001
	TW S	US CPR	.067606(*)	0.014	0.000
	TW CP	US R	.054938(*)	0.014	0.006
		US CPR	.075898(*)	0.014	0.000
	TW A	US R	.058796(*)	0.014	0.002
		US CPR	.079756(*)	0.014	0.000
		TW CPR	.048720(*)	0.014	0.039
	TW R	US A	-.072072(*)	0.014	0.000
		US SA	-.055946(*)	0.014	0.004
	TW CPR	US A	-.076961(*)	0.014	0.000
		US SA	-.060834(*)	0.014	0.001
		TW A	-.048720(*)	0.014	0.039
		TW SA	-.050612(*)	0.014	0.026
	TW SA	US R	.060688(*)	0.014	0.001
		US CPR	.081647(*)	0.014	0.000
		TW CPR	.050612(*)	0.014	0.026

Multiple Comparisons					
Bonferroni					
Dependent Variable	(I) GrpTaskINT	(J) GrpTaskINT	Mean Difference (I-J)	Std. Error	Sig.
EDA mean	**US S**	TW CP	-.279713(*)	0.057	0.000
		TW A	-.283758(*)	0.057	0.000
		TW SA	-.239646(*)	0.057	0.002
	US CP	US R	.220869(*)	0.057	0.007
	US A	US R	.227674(*)	0.057	0.005
	US R	US CP	-.220869(*)	0.057	0.007
		US A	-.227674(*)	0.057	0.005
		TW CP	-.316825(*)	0.057	0.000
		TW A	-.320869(*)	0.057	0.000
		TW CPR	-.209406(*)	0.057	0.019
		TW SA	-.276757(*)	0.057	0.000
	US SA	TW CP	-.213744(*)	0.057	0.012
		TW A	-.217789(*)	0.057	0.009
	TW S	TW A	-.194240(*)	0.056	0.039
	TW CP	US S	.279713(*)	0.057	0.000
		US R	.316825(*)	0.057	0.000
		US SA	.213744(*)	0.057	0.012
		TW R	.259441(*)	0.056	0.000
	TW A	US S	.283758(*)	0.057	0.000
		US R	.320869(*)	0.057	0.000
		US SA	.217789(*)	0.057	0.009
		TW S	.194240(*)	0.056	0.039
		TW R	.263486(*)	0.056	0.000
	TW R	TW CP	-.259441(*)	0.056	0.000
		TW A	-.263486(*)	0.056	0.000
		TW SA	-.219374(*)	0.057	0.008
	TW CPR	US R	.209406(*)	0.057	0.019
	TW SA	US S	.239646(*)	0.057	0.002
		US R	.276757(*)	0.057	0.000
		TW R	.219374(*)	0.057	0.008
EDA MaxMin	**US S**	US A	.374343(*)	0.106	0.031
		US R	.409421(*)	0.105	0.008
		TW R	.374014(*)	0.105	0.026
	US A	US S	-.374343(*)	0.106	0.031
		TW CP	-.365927(*)	0.105	0.037
	US R	US S	-.409421(*)	0.105	0.008
		TW CP	-.401006(*)	0.105	0.010
	TW CP	US A	.365927(*)	0.105	0.037
		US R	.401006(*)	0.105	0.010
		TW R	.365598(*)	0.104	0.032
	TW R	US S	-.374014(*)	0.105	0.026
		TW CP	-.365598(*)	0.104	0.032

Table 4: Group x Task Interaction Delta Descriptives

Group X Task Interaction								
		HR	RMSSD	LF	HF	RR	EDA mean	EDA MaxMin
US S	Mean	-6.533	11.636	-506.859	419.443	-0.016	-0.640	2.066
	N	36	36	36	36	36	36	35
	Std. Deviation	4.437	31.792	2998.117	856.339	0.042	1.671	3.155
US CP	Mean	3.432	1.165	-118.623	128.451	-0.007	1.124	0.024
	N	37	37	37	37	37	37	36
	Std. Deviation	7.363	18.515	2714.009	685.111	0.057	2.580	3.370
US A	Mean	2.129	-6.104	-773.375	9.007	0.048	1.147	-0.079
	N	37	36	36	37	36	37	36
	Std. Deviation	3.293	9.445	1137.070	177.699	0.064	1.605	1.633
US R	Mean	-0.091	-3.743	194.181	28.890	-0.037	-0.802	-0.418
	N	37	36	37	37	37	37	36
	Std. Deviation	2.708	15.875	2569.004	676.121	0.061	1.236	2.694
US CPR	Mean	2.144	4.833	525.502	1.224	-0.057	0.473	0.073
	N	34	34	34	34	34	36	35
	Std. Deviation	4.961	21.714	2149.807	1214.453	0.069	1.740	2.323
US SA	Mean	-4.465	6.467	-644.566	265.427	0.033	-0.105	0.277
	N	37	36	34	35	37	37	36
	Std. Deviation	5.689	20.744	1099.802	670.661	0.056	1.510	2.540
TW S	Mean	-1.672	7.417	-123.475	218.658	0.010	0.066	0.750
	N	37	37	37	37	37	37	37
	Std. Deviation	4.010	21.806	517.272	938.197	0.047	1.472	2.477
TW CP	Mean	1.114	14.051	824.255	1531.173	0.017	1.200	1.300
	N	37	37	37	37	37	36	36
	Std. Deviation	8.551	23.358	2255.357	7276.214	0.079	1.909	2.322
TW A	Mean	2.752	-1.005	-309.922	31.713	0.023	1.118	0.358
	N	36	37	37	37	37	37	37
	Std. Deviation	4.536	6.725	890.063	332.190	0.050	1.818	2.117
TW R	Mean	-0.972	-0.325	-295.795	50.605	-0.022	-0.278	0.092
	N	37	37	37	37	37	36	36
	Std. Deviation	2.742	11.076	1097.587	630.346	0.044	1.618	1.803
TW CPR	Mean	2.840	8.164	279.311	208.047	-0.027	0.364	0.680
	N	35	35	35	34	34	37	37
	Std. Deviation	6.568	19.114	1294.423	1057.185	0.061	1.685	1.887
TW SA	Mean	0.546	-0.291	-332.153	-69.587	0.028	0.846	0.837
	N	35	35	36	35	36	36	36
	Std. Deviation	5.126	15.407	802.808	506.594	0.068	1.575	1.342

Table 5: Task Main Effect Delta Bonferroni Post Hoc Analyses
Only significant findings are displayed (p≤0.05)

Multiple Comparisons					
Bonferroni					
Dependent Variable	(I) Task	(J) Task	Mean Difference (I-J)	Std. Error	Sig.
HR	S	CP	-6.415172(*)	0.918	0.000
		A	-6.569531(*)	0.922	0.000
		R	-3.478864(*)	0.915	0.002
		CPR	-6.604541(*)	0.935	0.000
	CP	R	2.936308(*)	0.915	0.022
		SA	4.363844(*)	0.922	0.000
	A	R	3.090666(*)	0.919	0.013
		SA	4.518203(*)	0.925	0.000
	R	CP	-2.936308(*)	0.915	0.022
		A	-3.090666(*)	0.919	0.013
		CPR	-3.125677(*)	0.932	0.013
	CPR	SA	4.553213(*)	0.939	0.000
RMSSD	S	A	.369980(*)	0.081	0.000
		R	.250723(*)	0.081	0.031
	CP	A	.390404(*)	0.081	0.000
		R	.271147(*)	0.081	0.013
	A	CPR	-.324188(*)	0.083	0.002
		SA	-.319379(*)	0.082	0.002
LF	S	CP	-.616935(*)	0.180	0.010
	CP	A	1.064545(*)	0.181	0.000
		R	.580802(*)	0.179	0.019
		SA	1.053539(*)	0.181	0.000
	A	CPR	-.900335(*)	0.184	0.000
	CPR	SA	.889329(*)	0.184	0.000
HF	No sig. results				
RR	S	A	-.037841(*)	0.010	0.003
		CPR	.040087(*)	0.010	0.001
		SA	-.030995(*)	0.010	0.030
	CP	A	-.029739(*)	0.010	0.045
		R	.035393(*)	0.010	0.006
		CPR	.048188(*)	0.010	0.000
	A	R	.065133(*)	0.010	0.000
		CPR	.077928(*)	0.010	0.000
	R	SA	-.058286(*)	0.010	0.000
	CPR	SA	-.071081(*)	0.010	0.000
EDA mean	S	CP	-.185733(*)	0.041	0.000
		A	-.191814(*)	0.041	0.000
	CP	R	.239762(*)	0.040	0.000
	A	R	.245843(*)	0.041	0.000
	R	CPR	-.162125(*)	0.041	0.001
		SA	-.159611(*)	0.041	0.001
EDA MaxMin	S	R	.279019(*)	0.075	0.004
	R	SA	-.227474(*)	0.076	0.042

Table 6: Task Delta Effect Sizes (Glass's Delta)

	Supine	Cold Pressor	Arithmetic	Relaxation	Cold Pressor-Relaxation	Supine Arithmetic
HR	-0.354	0.519	0.241	-0.072	0.189	-0.315
RMSSD	0.323	0.106	-0.226	-0.034	0.285	0.419
LF	-0.259	0.127	-0.416	0.074	0.129	-0.363
HF	0.388	0.343	-0.147	0.016	0.240	0.489
RR	-0.291	-0.164	0.518	-0.517	-0.433	0.460
EDA mean	-0.091	0.233	0.240	-0.030	0.175	0.066
EDA MaxM	0.435	0.248	0.028	0.048	0.168	0.139

Table 7: Task Delta Descriptives

Descriptives					
		N	Mean	Std. Deviation	Std. Error
HR	S	73	-4.069	4.858	0.569
	CP	74	2.273	8.010	0.931
	A	73	2.436	3.940	0.461
	R	74	-0.531	2.742	0.319
	CPR	69	2.497	5.800	0.698
	SA	72	-2.029	5.946	0.701
RMSSD	S	73	9.498	27.085	3.170
	CP	74	7.608	21.914	2.547
	A	73	-3.520	8.518	0.997
	R	73	-2.011	13.667	1.600
	CPR	69	6.522	20.354	2.450
	SA	71	3.136	18.494	2.195
LF	S	73	-312.541	2130.855	249.398
	CP	74	352.816	2523.142	293.309
	A	73	-538.474	1038.771	121.579
	R	74	-50.807	1977.277	229.854
	CPR	69	400.622	1759.547	211.825
	SA	70	-483.897	964.439	115.272
HF	S	73	317.675	898.219	105.129
	CP	74	829.812	5180.650	602.238
	A	74	20.360	264.806	30.783
	R	74	39.747	649.234	75.472
	CPR	68	104.635	1134.802	137.615
	SA	70	97.920	613.643	73.344
RR	S	73	-0.003	0.046	0.005
	CP	74	0.005	0.070	0.008
	A	73	0.035	0.058	0.007
	R	74	-0.029	0.054	0.006
	CPR	68	-0.042	0.067	0.008
	SA	73	0.030	0.062	0.007
EDA mean	S	73	-0.282	1.602	0.188
	CP	73	1.162	2.259	0.264
	A	74	1.132	1.703	0.198
	R	73	-0.543	1.451	0.170
	CPR	73	0.418	1.701	0.199
	SA	73	0.364	1.605	0.188
EDA MaxMin	S	72	1.390	2.884	0.340
	CP	72	0.662	2.944	0.347
	A	73	0.143	1.893	0.222
	R	72	-0.163	2.290	0.270
	CPR	72	0.385	2.118	0.250
	SA	72	0.557	2.037	0.240

Table 8: Group X Gender Interaction Bonferroni Post Hoc Analyses

Only significant findings are displayed (p≤0.05)

Multiple Comparisons					
Bonferroni					
Dependent Variable	(I) GrpGenINT	(J) GrpGenINT	Mean Difference (I-J)	Std. Error	Sig.
EDA mean	American Women	Taiwanese Women	-.132446(*)	0.036	0.002
EDA MaxMin	American Women	American Men	-.209424(*)	0.065	0.008
		Taiwanese Women	-.276086(*)	0.064	0.000
		Taiwanese Men	-.221929(*)	0.075	0.020

Table 9: Group X Gender Interaction Descriptives

Descriptives					
		N	Mean	Std. Deviation	Std. Error
EDA mean	American Women	13	0.057	1.880	0.214
	American Men	24	0.280	1.942	0.162
	Taiwanese Women	25	0.599	1.664	0.137
	Taiwanese Men	12	0.454	1.935	0.230
EDA MaxMin	American Women	13	-0.455	2.766	0.315
	American Men	24	0.751	2.680	0.229
	Taiwanese Women	25	0.692	1.886	0.155
	Taiwanese Men	12	0.619	2.342	0.278

Table 10: Valence and Activation Response to Task Bonferroni Post-Hoc

Only significant findings are displayed ($p \leq 0.05$)

Multiple Comparisons					
Bonferroni					
Dependent Variable	(I) Task	(J) Task	Mean Difference (I-J)	Std. Error	Sig.
Good	S	CP	2.78(*)	0.389	0.000
		A	2.06(*)	0.389	0.000
		CPR	1.94(*)	0.389	0.000
		SA	1.34(*)	0.389	0.010
	CP	R	-2.66(*)	0.389	0.000
		SA	-1.44(*)	0.389	0.004
	A	R	-1.94(*)	0.389	0.000
	R	CPR	1.81(*)	0.389	0.000
		SA	1.22(*)	0.389	0.030
Calm	S	CP	2.31(*)	0.346	0.000
		A	2.09(*)	0.346	0.000
		CPR	1.75(*)	0.346	0.000
		SA	1.75(*)	0.346	0.000
	CP	R	-2.25(*)	0.346	0.000
	A	R	-2.03(*)	0.346	0.000
	R	CP	2.25(*)	0.346	0.000
		CPR	1.69(*)	0.346	0.000
		SA	1.69(*)	0.346	0.000
Active	S	CP	-1.50(*)	0.394	0.003
		A	-3.38(*)	0.394	0.000
		CPR	-1.84(*)	0.394	0.000
		SA	-2.72(*)	0.394	0.000
	CP	A	-1.88(*)	0.394	0.000
		SA	-1.22(*)	0.394	0.034
	A	CP	1.88(*)	0.394	0.000
		R	2.44(*)	0.394	0.000
		CPR	1.53(*)	0.394	0.002
	R	SA	-1.78(*)	0.394	0.000

Multiple Comparisons					
Bonferroni					
Dependent Variable	(I) Task	(J) Task	Mean Difference (I-J)	Std. Error	Sig.
Unpleasant	S	CP	-3.09(*)	0.340	0.000
		A	-1.28(*)	0.340	0.003
		CPR	-2.06(*)	0.340	0.000
	CP	A	1.81(*)	0.340	0.000
		R	3.34(*)	0.340	0.000
		CPR	1.03(*)	0.340	0.041
		SA	2.41(*)	0.340	0.000
	A	CP	-1.81(*)	0.340	0.000
		R	1.53(*)	0.340	0.000
	R	CPR	-2.31(*)	0.340	0.000
	SA	CPR	1.38(*)	0.344	0.001
Neutral	S	CP	1.44(*)	0.407	0.008
Excited	S	A	-1.44(*)	0.368	0.002
		SA	-1.22(*)	0.368	0.017
Negative	S	CP	-2.13(*)	0.327	0.000
		A	-1.28(*)	0.327	0.002
		CPR	-1.44(*)	0.327	0.000
	CP	R	2.06(*)	0.327	0.000
		SA	1.38(*)	0.327	0.001
	A	R	1.22(*)	0.327	0.004
	R	CPR	-1.38(*)	0.327	0.001
Relaxed	S	CP	2.69(*)	0.396	0.000
		A	2.50(*)	0.396	0.000
		CPR	2.06(*)	0.396	0.000
		SA	1.91(*)	0.396	0.000
	CP	R	-2.50(*)	0.396	0.000
	A	R	-2.31(*)	0.396	0.000
	R	CPR	1.88(*)	0.396	0.000
		SA	1.72(*)	0.396	0.000
Intensity	S	CP	-1.22(*)	0.389	0.030

Multiple Comparisons					
Bonferroni					
Dependent Variable	(I) Task	(J) Task	Mean Difference (I-J)	Std. Error	Sig.
Passive	S	CP	1.88(*)	0.428	0.000
		A	2.69(*)	0.428	0.000
		CPR	1.66(*)	0.428	0.002
		SA	1.97(*)	0.428	0.000
	A	R	-2.06(*)	0.428	0.000
	R	SA	1.34(*)	0.428	0.029
Positive	S	CP	2.00(*)	0.369	0.000
		A	1.47(*)	0.369	0.001
		CPR	1.63(*)	0.369	0.000
	CP	R	-2.22(*)	0.369	0.000
	A	R	-1.69(*)	0.369	0.000
	R	CPR	1.84(*)	0.369	0.000
		SA	1.22(*)	0.369	0.017
Agitated	S	CP	-1.91(*)	0.325	0.000
		A	-1.69(*)	0.325	0.000
		CPR	-1.13(*)	0.325	0.010
		SA	-.97(*)	0.325	0.049
	CP	R	1.91(*)	0.325	0.000
	A	R	1.69(*)	0.325	0.000
	R	CPR	-1.13(*)	0.325	0.010
		SA	-.97(*)	0.325	0.049
Bad	S	CP	-1.84(*)	0.303	0.000
		A	-.91(*)	0.303	0.048
		CPR	-1.22(*)	0.303	0.001
	CP	A	.94(*)	0.303	0.034
		R	1.75(*)	0.303	0.000
		SA	1.25(*)	0.303	0.001
	R	CPR	-1.13(*)	0.303	0.004
Pleasant	S	CP	3.59(*)	0.371	0.000
		A	2.00(*)	0.371	0.000
		CPR	2.72(*)	0.371	0.000
		SA	1.88(*)	0.371	0.000
	CP	A	-1.59(*)	0.371	0.000
		R	-3.53(*)	0.371	0.000
		SA	-1.72(*)	0.371	0.000
	A	R	-1.94(*)	0.371	0.000
	R	CPR	2.66(*)	0.371	0.000
		SA	1.81(*)	0.371	0.000

Table 11: Valence and Activation Response Descriptive Statistics (Task)
Likert Scale (1-7): 1=least appropriate 7=most appropriate

Descriptive Statistics				
	Task	Mean	Std. Deviation	N
Good	Supine	5.970	1.150	32
	Cold Pressor	3.190	2.070	32
	Arithmetic	3.910	1.445	32
	Relaxation	5.840	1.051	32
	Cold Pressor Relaxation	4.030	1.858	32
	Supine Arithmetic	4.630	1.519	32
Calm	Supine	6.310	0.780	32
	Cold Pressor	4.000	1.626	32
	Arithmetic	4.220	1.475	32
	Relaxation	6.250	1.295	32
	Cold Pressor Relaxation	4.560	1.435	32
	Supine Arithmetic	4.560	1.523	32
Active	Supine	1.780	1.128	32
	Cold Pressor	3.280	1.871	32
	Arithmetic	5.160	1.417	32
	Relaxation	2.720	1.670	32
	Cold Pressor Relaxation	3.630	1.718	32
	Supine Arithmetic	4.500	1.545	32
Unpleasant	Supine	1.530	1.218	32
	Cold Pressor	4.630	1.827	32
	Arithmetic	2.810	1.256	32
	Relaxation	1.280	0.581	32
	Cold Pressor Relaxation	3.590	1.720	32
	Supine Arithmetic	2.220	1.184	32
Neutral	Supine	4.250	1.814	32
	Cold Pressor	2.810	2.007	32
	Arithmetic	3.560	1.458	32
	Relaxation	3.250	1.741	32
	Cold Pressor Relaxation	3.090	1.400	32
	Supine Arithmetic	3.410	1.214	32
Excited	Supine	1.440	0.759	32
	Cold Pressor	2.440	1.813	32
	Arithmetic	2.880	1.454	32
	Relaxation	1.910	1.445	32
	Cold Pressor Relaxation	2.220	1.385	32
	Supine Arithmetic	2.660	1.734	32
Negative	Supine	1.190	0.397	32
	Cold Pressor	3.310	1.857	32
	Arithmetic	2.470	1.414	32
	Relaxation	1.250	0.718	32
	Cold Pressor Relaxation	2.630	1.519	32
	Supine Arithmetic	1.940	1.366	32

Descriptive Statistics				
	Task	Mean	Std. Deviation	N
Relaxed	Supine	6.220	0.870	32
	Cold Pressor	3.530	1.831	32
	Arithmetic	3.720	1.591	32
	Relaxation	6.030	1.694	32
	Cold Pressor Relaxation	4.160	1.609	32
	Supine Arithmetic	4.310	1.712	32
Passive	Supine	5.000	1.566	32
	Cold Pressor	3.130	1.879	32
	Arithmetic	2.310	1.554	32
	Relaxation	4.380	1.963	32
	Cold Pressor Relaxation	3.340	1.578	32
	Supine Arithmetic	3.030	1.675	32
Positive	Supine	5.560	1.243	32
	Cold Pressor	3.560	1.759	32
	Arithmetic	4.090	1.279	32
	Relaxation	5.780	1.237	32
	Cold Pressor Relaxation	3.940	1.831	32
	Supine Arithmetic	4.560	1.390	32
Agitated	Supine	1.250	0.508	32
	Cold Pressor	3.160	1.629	32
	Arithmetic	2.940	1.585	32
	Relaxation	1.250	0.762	32
	Cold Pressor Relaxation	2.380	1.476	32
	Supine Arithmetic	2.220	1.408	32
Bad	Supine	1.060	0.246	32
	Cold Pressor	2.910	1.573	32
	Arithmetic	1.970	1.282	32
	Relaxation	1.160	0.574	32
	Cold Pressor Relaxation	2.280	1.746	32
	Supine Arithmetic	1.660	1.125	32
Pleasant	Supine	5.910	1.118	32
	Cold Pressor	2.310	1.355	32
	Arithmetic	3.910	1.467	32
	Relaxation	5.840	1.394	32
	Cold Pressor Relaxation	3.190	1.786	32
	Supine Arithmetic	4.030	1.694	32
Intensity	Supine	3.840	1.668	32
	Cold Pressor	5.060	1.564	32
	Arithmetic	4.090	1.445	32
	Relaxation	4.630	1.699	32
	Cold Pressor Relaxation	5.000	1.368	32
	Supine Arithmetic	4.440	1.564	32

Table 12: Supine Correlations

Correlations														
		Age	Med Year	Med day	Med Week	BMI	Houston	Laterality	Depression	Anxiety	Stress	TMSd	TMSc	Stroop
HR	ρ	.354(**)	0.006	-0.035	0.034	0.142	-0.183	-0.012	0.022	0.164	-0.17	-0.016	-0.139	-0.008
	Sig. (2-tailed)	0.002	0.96	0.767	0.778	0.23	0.132	0.92	0.86	0.175	0.159	0.926	0.42	0.964
	N	73	73	73	73	73	69	68	70	70	70	36	36	33
RMSSD	ρ	-0.169	-0.102	-0.11	-0.087	-0.032	0.083	-0.147	0.177	0.09	0.129	-0.076	0.131	0.005
	Sig. (2-tailed)	0.152	0.388	0.356	0.464	0.787	0.495	0.231	0.142	0.457	0.287	0.66	0.447	0.977
	N	73	73	73	73	73	69	68	70	70	70	36	36	33
LF	ρ	-0.013	-0.007	0.062	0.053	-0.009	0.008	-0.072	0.037	0.103	0.019	-0.053	0.106	0.034
	Sig. (2-tailed)	0.912	0.953	0.602	0.657	0.939	0.949	0.557	0.76	0.398	0.876	0.761	0.538	0.853
	N	73	73	73	73	73	69	68	70	70	70	36	36	33
HF	ρ	-0.161	-0.086	-0.01	0.013	-0.078	0.023	-0.038	0.139	0.056	0.172	-0.042	0.117	-0.05
	Sig. (2-tailed)	0.174	0.47	0.931	0.911	0.512	0.852	0.759	0.251	0.642	0.154	0.809	0.498	0.782
	N	73	73	73	73	73	69	68	70	70	70	36	36	33
RR	ρ	-.359(**)	-.351(**)	-.279(*)	-0.187	-0.028	-0.136	-0.23	.268(*)	.244(*)	.372(**)	-.329(*)	-0.324	-.405(*)
	Sig. (2-tailed)	0.002	0.002	0.017	0.114	0.812	0.264	0.059	0.025	0.042	0.002	0.05	0.054	0.019
	N	73	73	73	73	73	69	68	70	70	70	36	36	33
EDA mean	ρ	0.077	-0.143	-.249(*)	-0.151	-0.219	-0.2	0.027	0.007	0.191	0.102	0.034	0.143	0.084
	Sig. (2-tailed)	0.518	0.228	0.034	0.202	0.062	0.1	0.828	0.952	0.113	0.4	0.846	0.407	0.643
	N	73	73	73	73	73	69	68	70	70	70	36	36	33
EDA MaxMin	ρ	0.052	0.054	0.044	0.078	0.057	0.06	0.056	-0.153	-0.008	-0.053	-0.138	-0.115	0.054
	Sig. (2-tailed)	0.662	0.654	0.712	0.514	0.632	0.623	0.651	0.209	0.947	0.663	0.43	0.51	0.767
	N	72	72	72	72	72	69	67	69	69	69	35	35	32

Table 13: Cold Pressor Correlations

Correlations														
		Age	Med Year	Med day	Med Week	BMI	Houston	Laterality	Depression	Anxiety	Stress	TMSd	TMSc	Stroop
HR	ρ	-0.209	-.343(**)	-0.069	-0.1	-0.037	0.145	0.024	0.169	0.143	0.231	0.084	0.09	0.122
	Sig. (2-tailed)	0.098	0.006	0.588	0.432	0.774	0.269	0.858	0.192	0.27	0.073	0.649	0.624	0.527
	N	64	64	64	64	64	60	60	61	61	61	32	32	29
RMSSD	ρ	0.049	0.2	-0.04	-0.051	-0.084	-0.213	-0.1	0.057	-0.004	0.07	-0.081	0.07	-0.146
	Sig. (2-tailed)	0.7	0.113	0.756	0.689	0.51	0.103	0.449	0.663	0.976	0.591	0.661	0.702	0.45
	N	64	64	64	64	64	60	60	61	61	61	32	32	29
LF	ρ	-0.036	0.004	-0.176	-0.187	0.052	-0.057	-0.01	0.155	0.176	0.201	-0.102	0.041	-0.124
	Sig. (2-tailed)	0.775	0.975	0.165	0.138	0.686	0.664	0.941	0.233	0.174	0.12	0.58	0.822	0.521
	N	64	64	64	64	64	60	60	61	61	61	32	32	29
HF	ρ	0.074	0.186	-0.094	-0.096	-0.013	-0.167	-0.054	-0.065	-0.101	-0.043	-.389(*)	-0.162	-0.163
	Sig. (2-tailed)	0.56	0.14	0.459	0.452	0.918	0.201	0.68	0.62	0.438	0.741	0.028	0.376	0.399
	N	64	64	64	64	64	60	60	61	61	61	32	32	29
RR	ρ	0.035	-0.101	0.099	0.196	-0.094	0.088	-0.094	0.038	0.098	0.011	0.004	0.06	0.138
	Sig. (2-tailed)	0.783	0.426	0.437	0.12	0.461	0.506	0.476	0.769	0.453	0.93	0.984	0.745	0.474
	N	64	64	64	64	64	60	60	61	61	61	32	32	29
EDA mean	ρ	-0.152	-.272(*)	-0.142	-0.08	0.069	0.018	0.082	0.052	-0.022	0.187	-0.001	-0.021	0.159
	Sig. (2-tailed)	0.239	0.032	0.272	0.537	0.593	0.894	0.54	0.697	0.867	0.157	0.995	0.911	0.418
	N	62	62	62	62	62	59	58	59	59	59	31	31	28
EDA MaxMin	ρ	-0.052	-0.159	-0.019	0.013	0.184	-0.12	-0.203	0.243	0.155	0.111	-0.242	-0.276	0.031
	Sig. (2-tailed)	0.691	0.218	0.88	0.922	0.152	0.366	0.126	0.063	0.242	0.404	0.189	0.133	0.877
	N	62	62	62	62	62	59	58	59	59	59	31	31	28

Table 14: Mental Relaxation Correlations

Correlations														
		Age	Med Year	Med day	Med Week	BMI	Houston	Laterality	Depression	Anxiety	Stress	TMSd	TMSc	Stroop
HR	ρ	.308(**)	0.219	.249(*)	0.185	-0.074	-0.013	0.07	-0.22	-.314(**)	-.300(*)	.367(*)	.350(*)	-0.065
	Sig. (2-tailed)	0.008	0.061	0.032	0.115	0.531	0.916	0.569	0.065	0.008	0.011	0.026	0.034	0.716
	N	74	74	74	74	74	70	68	71	71	71	37	37	34
RMSSD	ρ	-0.181	-0.032	-0.09	-0.06	-0.066	0.026	-0.147	-0.015	0.094	0	0.088	-0.01	0.222
	Sig. (2-tailed)	0.126	0.785	0.45	0.612	0.578	0.831	0.237	0.903	0.437	0.997	0.608	0.954	0.214
	N	73	73	73	73	73	69	67	70	70	70	36	36	33
LF	ρ	0.014	0.212	0.067	0.083	-0.034	-0.079	0.032	-0.143	-0.022	-0.019	-0.02	0.022	0.039
	Sig. (2-tailed)	0.908	0.07	0.568	0.479	0.772	0.515	0.793	0.235	0.854	0.873	0.907	0.896	0.826
	N	74	74	74	74	74	70	68	71	71	71	37	37	34
HF	ρ	-0.176	0.079	-0.018	-0.005	-0.146	-0.032	-0.187	0.021	0.128	0.047	-0.134	0.026	-0.033
	Sig. (2-tailed)	0.135	0.503	0.879	0.964	0.216	0.795	0.126	0.865	0.288	0.7	0.43	0.879	0.855
	N	74	74	74	74	74	70	68	71	71	71	37	37	34
RR	ρ	-0.065	-0.149	-0.082	-0.04	-0.008	0.083	-.290(*)	0.055	0.164	-0.01	-0.121	-0.242	-0.103
	Sig. (2-tailed)	0.582	0.206	0.486	0.733	0.947	0.493	0.017	0.651	0.173	0.932	0.475	0.149	0.563
	N	74	74	74	74	74	70	68	71	71	71	37	37	34
EDA mean	ρ	0.127	0.132	0.116	0.206	-0.132	-0.164	-0.178	-0.07	-0.059	-0.153	0.031	-0.196	0.247
	Sig. (2-tailed)	0.285	0.264	0.331	0.08	0.266	0.177	0.148	0.564	0.626	0.207	0.857	0.244	0.159
	N	73	73	73	73	73	69	67	70	70	70	37	37	34
EDA MaxMin	ρ	0.1	-0.008	-0.048	-0.053	0.08	0	-0.092	0.008	-0.07	-0.131	-0.007	-0.111	0.244
	Sig. (2-tailed)	0.4	0.945	0.687	0.658	0.499	0.998	0.46	0.95	0.563	0.28	0.969	0.518	0.171
	N	73	73	73	73	73	70	67	70	70	70	36	36	33