THE ROLE OF PHYSICAL ENVIRONMENT IN STRESS REACTIVITY

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THE ROLE OF PHYSICAL ENVIRONMENT IN STRESS REACTIVITY

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DEDICATION

This manuscript is dedicated to the memory of Maxine Mathisen Buchwald and to the memory of Alice Lyons Brooks.

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ABSTRACT

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This study examined the role of the physical environment (restorative v. non-restorative) in physiological and psychological reactivity to a cognitive stressor and investigated the potential for hostile personality to moderate this process. Globally, a strikingly high prevalence of cardiovascular disease as well as affective disorders such as anxiety presents enormous costs and concern for human health. Aside from behavioral, physical, and genetic risk factors, stress and hostility are leading psychosocial contributors to these conditions. Although many factors affect stress reactivity in the collaborative, biopsychosocial construction of health, one essential albeit often overlooked contributor is the physical environment. The physical environment consists of architectural, ambient, and design features that may be either built or natural. Through psycho-evolutionary cognitive and emotional processes, certain environmental characteristics considered to be restorative in nature are thought to influence emotional and physiological states through the mechanisms of attention restoration and stress reduction. Because the stress-related illness burden continues to grow, it is increasingly important to understand and target the processes by which environmental surroundings influence health. Fifty-nine participants at a large university were randomly assigned to either a restorative or non-restorative environment condition in this experimental design. It was hypothesized that participants in the restorative environment would show less affective and physiological stress reactivity and greater recovery than those in the non-restorative environment. Psychological and physiological changes were measured at baseline, during reactivity to a cognitive stressor, and at recovery. Participants were assessed with regard to psychological variables including positive/negative affect, state anxiety, and hostility while physiological changes in blood pressure and heart rate were recorded. Repeated measures ANOVAs and ANCOVAs were used to test the null hypotheses of the major research questions. Ancillary analyses were conducted using meditational regression. Tests for statistical significance revealed that changes in systolic blood pressure and heart rate, but not diastolic blood pressure, interacted by condition over time indicating that the restorative environment was more effective at suppressing reactivity and promoting recovery. Affective analyses revealed non-significant interactions for both negative affect and positive affect, but showed emerging patterns that would otherwise support the hypothesis. Also, a significant hostility (high v. low) by anxiety interaction was found. Although hostility did not significantly moderate effects by condition, a pattern emerged which, if significant, would support the hypothesis. An ancillary meditational regression analysis suggested that effects of hostility on anxiety may be mediated by sensitivity to the environment. Mixed findings offered weak albeit partial support for the insight that the environment meaningfully affects stress reactivity. The findings of this study merit future research into environmental stress reactivity and moderating personality variables. Implications for the design of healthcare and other environments are discussed.

CHAPTER I

INTRODUCTION

Among some of the world's most widespread human health problems, cardiovascular illnesses and affective disorders are arguably the most debilitating and costly. Risk factors such as socioeconomic status, genetic predisposition, physical inactivity, diet, and substance use are all associated with the onset or development of both cardiovascular disease and anxiety disorders (World Health Organization [WHO], 2011). Stress is the most salient of these contributing psychosocial factors, making these conditions known as stress-related illnesses. While many variables affect stress reactivity, it is physical environmental stimuli which are ever-present in our lives as sentient beings. Although until recent years often overlooked, environmental stressors are gaining recognition as having significant influence on health outcomes in multiple spheres including healthcare, occupational, educational, and domestic settings. The effects of the physical environment on risk for these and other illnesses hinges largely on processes of psychological and physiological stress reactivity.

Theories of human health from environmental psychology have historically focused on the effects of natural- versus urban-outdoor environments. This dichotomy reminds us that the physical environment exists on a continuum from natural to wholly human-made. Although it seems that a paradigm shift has occurred in defining a natural environment untouched by human influence, what is termed the 'built environment' refers to anything created, arranged or maintained by humans. The built environment shapes human behavior and reciprocally is shaped by it (Sobal & Wansink, 2007). Because many people in industrialized societies spend around 90% of their lives indoors, it is crucial to examine the role of the indoor built environment on human health (Evans & McCoy, 1998). While the environment affects many types of behavior (e.g., social, physical), those addressed by the current study are physiological, cognitive, and affective. Because these behaviors are not always conscious, it is a challenge to understand exactly how one's surroundings affect health; thus, a review of current literature on the subject is needed to parse out the mechanisms of action.

Adequate evidence is not available to determine the specific mechanisms by which our physical surroundings affect physiology, cognition, and emotion, especially under stress. Theories of natural restorative environments hold that such places allow individuals to reorient to a state of unimpaired emotional, cognitive, and physiological functioning, thereby reducing reactivity to stress and thus ultimately benefitting health (Health Council of the Netherlands, 2004). The current study aims to contrast the effects of a restorative environment with those of its counterpart - a non-restorative environment - which may contain caustic sensory stimuli such as harsh lighting, crowding, occlusive architecture, views which are overly complex, and monotonous sensory deprivation (Evans & McCoy, 1998). In reference to urban environments, we commonly use statements such as "eye sore," "noise pollution," and "concrete jungle," to describe the psychological impact of such input overload. The threatening perceptual cues embedded within these types of environments (Kasmar, 1970) demand an excess of both attention and physiological energy, leading to mental fatigue and a diminished capacity to cope with stress (Kaplan, 1995).

Inconclusive evidence from past research calls for a careful examination of the psychological and physiological effects of the two types of environments in an attempt to integrate the two dominant competing theories of how place influences health - stress reduction (Ulrich, 1983) and attention restoration (Kaplan & Kaplan, 1989). More recent research indicates that both attention restoration and stress reduction may play equal parts in benefitting health, albeit through different antecedents and outcomes (Hartig, Evans, Jamner, Davis & Garlind, 2003). This analysis is critical to understanding what other, individual variables play a role in the effects of sensory environment on health outcomes, especially cardiovascular illness and anxiety. Furthermore, studies investigating the effects of physical environment on health have focused narrowly on clinical or behavioral outcomes without defining mediating or moderating variables in the process. So, the need to investigate such factors remains.

CHAPTER II

LITERATURE

It is important to begin by defining the construct of a restorative environment and the proposed mechanisms by which it affects health so that a non-restorative environment may be defined in opposition to that. Certain types of environments are considered restorative because they are relatively free from threatening stimuli or overt demands on directed attention. Natural restorative environments may contain features such as sunlight, nature, vegetation, a spectacular sunset, or shelter from threatening stimuli, which promote positive emotions. Other characteristic examples that are also pervasive in built environments include physical cues that aid in navigation, balanced visual complexity, legibility or the comprehension of spatial configuration, view through a window, control of privacy, and ambient design elements (e.g., water features) (Evans & McCoy, 1998). Restorative environments may enact their restorative effects through the restoration of attention (Kaplan & Talbot, 1983) and/or the reduction of stress reactivity (Ulrich, 1983). Such environments are thought to benefit health, in part, through the facilitation and promotion of healthy levels of autonomic arousal (Hartig et al., 2003) or by restoration of the cognitive capacities necessary to function adaptively (Kaplan, 1995). Thus, the process of restoration lies in the opportunity for the body and mind to ‘rest’ or to restore basal capacities.

Non-restorative environments may provoke anxiety or sympathetic overactivation through overstimulation, sensory deprivation, incompatibility, confusion, discordance, or otherwise threatening stimuli (Evans & McCoy, 1998). For example, extreme temperature, clutter, noise, crowding, incompatibility, odor, perceived threats, and generally poor aesthetic quality are all environmental characteristics which have been shown to produce differential affective reactions and clinical outcomes alike (Dijkstra, Pieterse, & Pruyn, 2008; Evans & McCoy, 1998; Grinde & Patil, 2009; Hartig et al., 2003; Ulrich, Quan, Zimring, Joseph & Choudhary, 2004; Ulrich et al., 1991). In these places, health is affected in the opposite way of restorative environments. The notion then is that the body and mind are chronically engaged in attempts to cope with the stress through exaggerated responses to noxious environmental stimuli without opportunity for recovery. Thus, psychological and physiological resources are overwhelmed and the capacity for effective coping is diminished. If the experiencing individual remains in the environment for an extended period of time, the stress/fatigue response accumulates and effects on even cognitive performance may emerge (Hartig et al., 2003). However, empirical research does show that even a very brief exposure is sufficient to incite physiological (4 minutes) and affective (10-15 minutes) changes through differential effects on stress and attention (Grinde & Patil, 2009; Hartig et al., 2003), which play a key role in risk for anxiety, depression, and cardiovascular illness. Although most of the literature presented here focuses on the notion of a restorative environment, the term non-restorative environment is applied to those environments which lack the beneficial features of the former or otherwise contain characteristics which are evidenced to have detrimental effects on psychological and physiological states. It is, however, important to remember that the characteristic stimuli of each of these environments do not exist in mutually exclusive settings; there is always room for the element of ambiguity lying in the perceptions of the beholder.

The seminal theoretical viewpoint regarding the mechanism by which the environment influences health is Roger Ulrich's (1983) psycho-evolutionary model which names stress as the acting variable in this process. Ulrich's claim is that humans are pre-wired to prefer environmental characteristics that mark opportunities for survival. Some of these perceivable features are focal points, gestalt structure, natural features such as vegetation and water, low appraised threat, and balanced visual depth and complexity. It is thought that the perception of such elements aids in positive physiological and emotional changes and, when the environment is the impetus for these changes following a stressful event, this is known as restoration. Psychophysiological stress recovery is supported by the inhibition of negative emotions, the invocation of positive emotions, and reductions in autonomic activation. Another effect of this process is that restorative environments may allow non-vigilant attention to be sustained by the viewer thereby suppressing autonomic arousal to a healthy level. This recognition of attentional processes segues to the opposing theoretical viewpoint proposing attention as the key mechanism in the environment-health relationship (Hartig et al., 2003).

Attention Restoration Theory (ART) proposes that natural environments counteract the cumulative depletion of affective, physiological, and attentional resources that results from sensory input overload in urban environments. From this perspective, four characteristics of restorative environments, or rather facets that characterize people's interaction with the environment, affect health through the restoration of mental capacity:

being away, fascination, extent, and compatibility. "Being away" refers to the sense of being physically and/or conceptually distant from everyday settings and mental tasks. "Fascination" refers to the notion of effortless attention to inherently interesting objects (e.g., sunsets, clouds, moving water), which allows for reflection on other thoughts. "Extent" refers to a sense of vastness and connectedness or being in a world of its own (e.g., distant wilderness); this can be found even in small areas (e.g., winding paths in a small garden). Finally, "compatibility" refers to the degree of conduciveness of the environment to one's purposes. Natural settings are thought of as usually having strong compatibility with the human behaviors for which we are evolutionarily adapted, requiring less effort and attention (e.g., fishing, gardening, hiking, fire-building) (Hartig et al., 2003; Kaplan, 1995). Although the name of this theory emphasizes the fact that it is just that - theory - there is empirical support for the existence of attention-mediated health effects of restorative (and threatening) environments. Social-cognitive research offers evidence for how stressful environments might affect attention. A study conducted by Fox, Russo, Bowles, and Dutton (2001) investigating the effects of threatening visual cues (i.e., a menacing face) on attention (i.e., recognition of target words) concluded that high state anxiety is characterized by the inability to disengage attention as well as by attentional dwell time.

The physical environment affects both attention and stress reactivity through sensory perceptions of environmental stimuli and appraisals of their threat, aesthetic, and affective values. From the attention perspective, Kaplan (1995) explains that a restorative physical environment facilitates involuntary (not directed or effortful) attention or "fascination," allowing the experiencing individual an opportunity to replete cognitive and attentional resources necessary for directed attention. From this viewpoint, health is most probably affected through the inhibitory role that directed attention plays in executive functioning (1995) as well as in controlling fear and anxiety responses that spring from the limbic system in response to environmental threats (real or imagined). In opposition, Ulrich (1983) claims that psycho-evolutionary processes have made vigilant observation or constant scanning of threatening environments key to survival while non-threatening restorative environments allow for a respite from these tasks. This process affects health through suppression of sympathetic nervous system activation, promotion of parasympathetic activities, and increases in positive affect. Kaplan (1995) emphasizes the message embedded in that statement – that psychological and physiological stress reactivity are intertwined and never occur exclusively of one another. Ulrich suggests that while attentional vigilance does play a role in restoration, it does not precede affect. Thus, the stress model hinges on the primary evolutionary value of emotion: "[…] virtually no meaningful thoughts, actions, or environmental encounters occur without affect […] (1983, p. 85). This implies that the potential for attentional restoration should not be considered apart from emotional changes that also necessarily occur.

Because perceptual psychology indicates that our visual systems are designed to respond most sharply to inorganic horizontal and vertical lines, to change or difference, and to otherwise threatening stimuli, it seems intuitive that cognitive attention is pulled by non-natural visual features or by the sharp contrasts found in the constructed world. Additionally, the perception of these elements and changes in cognitive function are most certainly accompanied by affective reactions on at least a very basic biophilic level. Indeed, a review of research from environmental psychology by Joye (2007) concludes that visual contact with natural objects and shapes are beneficial for humans' emotional and cognitive functioning. This seems like an argument for the integration of both the attention and stress models. Our neuroanatomy is already guiding our attention toward the stimuli which are more likely to elicit stronger affective reactions – an adaptive integration of both cognition and emotion from which it is difficult to discern the primary player. On the evolutionary level, these theories regard only natural environments; however, in modern societies, the physical environmental characteristics that we most often encounter are often found in the built environment or what is essentially the human-constructed world (Evans & McCoy, 1998). Thus, it is essential to also apply restoration theories to indoor built environments.

Recent research into the effects of the physical environment on health and well-being largely addresses either the impact of nature exposure on stress and attention or the notion of the healing environment in healthcare settings. The current study integrates ideas from these two bodies of knowledge in an attempt to draw conclusions about the role of the environment in stress reactivity.

Grinde and Patil's (2009) meta-analysis of 50 empirical studies revealed that contact with nature does indeed impact psychological well-being. From the perspective of the biophilia hypothesis – that humans have an inherent preference for plants and other organic things- the authors conclude that environments lacking nature or natural elements have a negative impact on the human mind. Beyond a simple mismatch between modern living conditions and the environment to which humans are evolutionarily adapted, the discordance between manmade urban environments and biophilia has the potential to diminish health-related quality of life. The authors introduce the concept of the

Environment of Evolutionary Adaptation (EEA) to explain that there is a certain natural physical environment to which humans have adapted. The problem arises from the observation that an absence of such environmental qualities (i.e., plants as an indicator of food, water, and shelter) promoting human survival negatively affects human behavior, whether conscious or not. The main modality of nature contact in the reviewed studies is visual, which is not surprising as this is generally the dominant sense in human beings. Most theorizing about the restorative psychological effects of nature come from the study of environmental psychology. In the context of this meta-analysis, restoration refers to the process of recovering physical, psychological, and social functional capacities. According to the authors, visual environments which reflect nature (e.g., presence of plants) through aesthetic values (e.g., color, complexity, and balance) may reduce stress, anxiety, and fatigue of directed attention. All of these impact health in various ways. Studies of indoor environments containing elements of nature were concerned with people in mundane settings such as work, school, and hospitals. While the results of these studies were mixed and outcome measures varied (e.g., affect, physiological arousal, pain perception), none showed evidence of any negative impact. The review found that increasing numbers of studies of outdoor environments continue to amass evidence that living close to nature is associated with increased positive health indicators including stress reduction, improvement in attention and coping with attention deficits, increased longevity, and self-reported health.

Dijkstra, Pieterse, and Pruyn’s (2006) meta-analysis of 30 controlled, peer-reviewed clinical trials defined the environmental stimuli which affect patient well-being representing the concept of a healing environment. A healing environment is simply a restorative environment in the context of healthcare. The notion of a healing environment reflects the idea that architectural choices influence psychological outcomes (Dijkstra et al., 2008). The authors' 2006 study highlighted the need to understand the cognitive and emotional processes that mediate and moderate the health effects of environmental stimuli; the present study responds to this need. Of the 17 total environmental stimuli that were examined as variables in this review, consistently positive effects were found for only four of these including sunlight, odor, windows, and seating arrangements. The authors note the importance of understanding the effects of these specific stimuli within the context of the whole environment because of the beneficial effects of healing environments on health markers such as anxiety and cardiovascular reactivity, which are important not only to patients but also to individuals in their daily lives. Although this research is generalizable to a variety of contexts and populations, research into healing environments has great potential because the characteristic of being a hospitalized patient is akin to being a canary in the coal mine when it comes to determining the psychophysical effects of the built environment.

Dijkstra et al. (2008) outline three dimensions of the physical environment which are thought to affect behavior and health are the architectural, the ambient, and design dimensions. The architectural dimension consists of features such as spatial layout and stimulus shelter. The ambient dimension consists of features such as sunlight, noise, odor, and crowding. The design dimension consists of features including indoor plants, color and art (Evans & McCoy, 1998). The notion of the healing environment in healthcare involves elements in all of these dimensions. Thus, the task of research in this area is to determine what specific stimuli significantly impact the whole environment and to evidence the mechanisms by which the built environment facilitates healing. For example, through the reduction of patient stress and pain or through the reduction of medical errors by means of reducing staff stress and fatigue – a need highlighted by the Institute of Medicine (Ulrich et al., 2004). Dijkstra et al. (2008) conducted a study to determine whether perceived attractiveness played a mediating role between the presence of indoor plants and stress as measured by the 4-point scale 18-item Stress Arousal Checklist. Results of a meditational regression analysis supported the hypothesis that this specific environmental element, indoor plants, was in fact a significant mediator in the process by which the built environment affects stress.

Further review is necessary to demonstrate the great impact that these processes have on physical and mental health. The debate regarding the mechanisms by which the environment influences health pits the capacity for directed attention (Kaplan & Talbot, 1983) against affective and physiological stress reduction (Ulrich, 1983). More recent literature calls for an integration of the two theories (Hartig et al., 2003; Health Council of the Netherlands, 2004; Kaplan, 1995). With attention and stress both working as part of one's reaction to the physical environment, it is essential to consider the cumulative effects on physical health. Two major components of stress reactivity addressed by this study are physiological and affective reactions. Psychophysical reactions to environmental stressors burden health, in part, through cardiovascular reactivity, anxiety, and negative affectivity. This line of reasoning leads to the first hypothesis of this study (H1): Exposure to a restorative environment will result in less stress reactivity, both affective and physiological, and greater physiological recovery than exposure to a non-restorative environment.

Chronic stress plays a major role in the development of mild, severe, and chronic mental and physical illnesses. Among many stress-related mental illnesses, affective disorders (i.e., anxiety and depression) are some of the most common as well as the most costly due to healthcare overutilization, sickness absenteeism, and lost productivity (Aday, 2003; Health Council of the Netherlands, 2004).

Among stress-related physical illnesses, cardiovascular disease (CVD) is among the most common and costly. CVD encompasses a group of disorders including coronary heart disease, cerebrovascular disease, peripheral arterial disease, rheumatic heart disease, congenital heart disease, deep vein thrombosis and pulmonary embolisms. The WHO recognizes that, taken together, these constitute the leading cause of death throughout the world. Globally, more people die each year from CVD than for any other reason. It is common for CVD to be termed stress-related illnesses because one of the major underlying determinants is stress (poverty is another). It is projected that CVD will remain the single leading cause of fatality in the foreseeable future, thus the need for programs aimed at prevention (WHO, 2011).

Furthermore, cardiovascular reactivity is a critical marker for the body's response to environmental stressors, but the ability for individual psychosocial factors to predict reactivity is still relatively unknown. Risk factors such as raised blood pressure (hypertension) substantially contribute to the development of CVD. However, collectively, the major risk factors for CVD including hypertension, cholesterol, smoking, alcohol dependence, and physical inactivity only account for about 50% of the variance in the relationship between psychosocial variables and risk. Therefore, such variables are receiving increased recognition as etiological factors with great practical significance. A chronically hyperactive cardiovascular response to stressful environments is a strong predictor of risk for cardiovascular disease and substantial empirical evidence supports the notion that hostility is a major psychosocial contributor to this process (Guerrero & Palmero, 2010).

It is also likely that high levels of anxiety experienced by hostile individuals in response to stressful environments reinforce this pattern of exaggerated cardiovascular response. This sets the stage for hostile personality as a possible moderating variable. It is known that factors such as culture may moderate the relationship between environment and restoration (Ulrich, 1983), but personality types within cultures might also moderate it. Hostility is a measure of not only interpersonal style but has also been evidenced as a measure of general psychological distress (Butcher, Graham, Ben-Porath, Tellegen & Dahlstrom, 2001). Because hyper-vigilance often accompanies psychological distress, hostility might also be conceptualized as increased sensitivity to one's environment; thus it is important to determine whether this individual variable impacts environmental stress reactivity. Because research indicates that persons with high hostility are at greater risk for negative health outcomes (Butcher et al., 2001), it follows to inquire whether non-restorative environments (e.g., a chaotic, noisy, and crowded emergency room) take a greater psychological (i.e., anxiety and affect) and physiological (i.e., blood pressure and heart rate) toll on these individuals. If they do, then an individual with high hostility should show greater reactivity to stress in a non-restorative environment when compared with those with low hostility. Conversely, it would also be beneficial to know whether restorative environments are more beneficial to persons with high hostility, especially in light of the dearth of research investigating the potential for positive emotions and cognitions to protect against negative cardiovascular outcomes (Gallo, Ghaed & Bracken, 2004). If restorative environments are more beneficial for these individuals, then those with high hostility should show less reactivity to stress in a restorative environment than individuals with low hostility. Extensive evidence shows that hostility and related constructs (e.g., anger, distress) as well as negative affectivity (i.e., anxiety, depression) contribute to the onset and progression of CVD (Gallo et al., 2004; Sirois & Burg, 2003; Smith & Ruiz, 2002; Stewart & Fitzgerald, 2010). Furthermore, because these negative emotional factors tend to cluster within individuals (Stewart & Fitzgerald, 2010), there are important interventional implications for determining how hostility and anxiety interact in relation to the environment. This line of reasoning leads to the second research hypothesis (H2): Hostility moderates the relationship between environment and changes in state anxiety in response to stress such that individuals with high hostility will show greater sensitivity to the environment than those with low hostility (i.e., greater in the non-restorative environment and lesser in the restorative environment).

A model which accounts for personality variables such as hostility and which may further help to explain how the environment affects health through physiological stress reactivity is allostasis. From a psychobiological perspective, the concept of allostasis models how the brain makes trade-offs between stressors in the physical environment and individual physiology in order to adapt to change by anticipating needs. Allostasis, which is rooted in the theory of homeostasis, is an organism's attempt to maintain stability through changing circumstances. It differs from homeostasis in that, rather than an organism being a passive reactor to stressors, a pivotal role is given to the central nervous system which uses prior knowledge and experience to physiologically adapt to environmental events (Ganster & Perrewe, 2011). The control given to the central nervous system in this model, however, is also what allows an organism to anticipate the use of resources and adjust the cardiovascular (or other) systems accordingly even in the absence of any real threat or demand. This also explains how pathological anxiety may develop as a result of chronically stressful environments – through cognitive attributions given to these physiological responses. According to this model proposed by Sterling and Eyer (1988), the constant engagement of the stress response in answer to sensory stressors will lead to fatigue and exhaustion. Although this is an adaptive process, it becomes problematic in the situ of chronically stressful environments because if no opportunity for recovery exists, it will ultimately lead to illness or death. Seyle's General Adaptation Syndrome (GAS) conceptualizes an organism's response to stress in three stages: a stressor first acts as an alarm activating the HPA-axis stress response, secondly resistance occurs in which an organism's biological response to the stimulus habituates and symptoms disappear, and finally exhaustion occurs when physiological coping resources are depleted and symptoms return. This process is further impacted by allostatic load, or the cumulative effects of previous stressors (Ganzel, Morris, & Wethington, 2010). It is not only discrete stressful events that contribute to allostatic load, but also, and perhaps more importantly, daily low levels of environmental stress. This model is one possible explanation for how being in a chaotic or stressful physical environment day in and day out leads to poor physiological outcomes and also leads to poor mental health by implicating anxiety as a product of the stress-coping process that is influenced by individual experience.

The research questions guiding this study are a) does a restorative environment foster less physiological and affective stress reactivity than a non-restorative environment in human participants, and b) does a hostile personality moderate the relationship between environment and changes in state anxiety? The first question seeks to experimentally confirm evidence from previous research that there are differential effects of restorative and non-restorative environments on behavior as it relates to human health. The second question addresses whether an individual variable – hostile personality – moderates the process highlighted by the first question.

To reiterate, the research hypotheses are as follows:

H1: Exposure to a restorative environment will result in less stress reactivity, both affective and physiological, and greater physiological recovery than exposure to a non-restorative environment.

H2: Hostility moderates the relationship between environment and changes in state anxiety in response to stress such that individuals with high hostility will show greater sensitivity to the environment than those with low hostility (i.e., greater in the non-restorative environment and lesser in the restorative environment).

CHAPTER III

METHODS

Approval for this study was obtained from the Institutional Review Board of Texas State University–San Marcos. Participants were students recruited from undergraduate Psychology courses at Texas State and were offered extra credit in return for their participation. An alternative assignment for extra credit was available, although no one declined to participate in the experiment. Informed consent was obtained from all participants prior to beginning the experimental manipulation.

Participants

Fifty-nine participants ranged in age from 18 to 36 years (M=19.76) and most were female (85%). One participant was excluded from all analyses due to being under the age of 18. The majority were unmarried (95%). Whites were the majority ethnic group (49.2%) followed by Hispanics (25.4%), mixed ethnicities (16.9%), African Americans (6.8%), and Asians (1.7%). Nearly one half (49.2%) of participants held a first-year standing at the university followed by juniors (22%), sophomores (18.6%), and finally seniors (10.2%). By means of random assignment, 28 participants were placed in the restorative condition and 31 were placed in the non-restorative condition. Participants were instructed not to consume caffeine for at least an hour prior to arrival.

Participants were screened for medications which may affect cardiovascular function, mood, and concentration. Thirty six percent of female participants reported use of hormonal contraceptives. Ninety five percent were non-nicotine users and 42.4% reported no alcohol use in the past 30 days. Most participants, about 81%, reported consuming fewer than 3 caffeinated drinks per day. About 41% of participants reported living with only one other person followed most closely by those living with three other people (27%).

Design and procedure

Participants were randomly assigned to one of two conditions of an experimental design in which the manipulation was the indoor physical environment. Condition one was set in a restorative environment which was a room with non-threatening and/or pleasant sensory stimuli. Condition two was meant to reflect a chaotic, non-restorative environment which was a room with noxious and/or unpleasant sensory stimuli. Each condition was a small room within the faculty lab area of the Psychology building on campus. The rooms were adjacent but only the participants' assigned condition was visible to them. The restorative condition consisted of multiple physical environmental stimuli which have been evidenced to induce restorative effects in vivo and in laboratory settings (Dijkstra et al., 2006; Dijkstra et al., 2008; Evans & McCoy, 2008; Hedge, 2000; Kweon, Ulrich, Walker & Tassinary, 2008; Tennessen & Cimprich, 1995; Ulrich, 1984; Ulrich et al., 2004). These stimuli include windows, natural lighting, a view to nature (trees), privacy (closed door), landscape poster, and open space free of clutter (Appendix A). The non-restorative condition, which attempted to counterbalance the features and characteristics of the restorative condition, consisted of multiple physical environmental stimuli that have been evidenced to induce fatigue or distress and to prolong healing (Dijkstra et al., 2008; Evans & McCoy, 1998; Grinde & Patil, 2009; Hartig et al., 2003;

Ulrich, 1984; Ulrich et al., 2004; Ulrich et al., 1991). These stimuli include an absence of windows, fluorescent lighting, lack of privacy (open door), bare walls, and clutter (Appendix A). Apart from the stated manipulations, both rooms were approximately the same size and shape, were entered into from the same type of door, and were painted the same color.

Before being introduced to the variable environment, participants completed informed consent in an adjacent room. Participants were then led into the assigned environment and allowed to acclimate to it for at least 10 minutes before engaging in the stressor task. Baseline blood pressure was assessed over this period of acclimation, at approximately two minute intervals, during which time participants completed demographic questionnaires as well as instruments measuring positive and negative affect, hostility, and state anxiety.

Then, participants were engaged in the stressor task which was an impossible word search puzzle, that is, a word search that could not be solved. The puzzle was generated using a web-based word search generator and did not contain words with any inherent affective valence. When participants were given the word search, they were told that most people completed it within five minutes. To increase the stressfulness of the event, the participants were interrupted after seven minutes of working on the task at which time the researcher entered the room and inquired whether the task was complete; participants were then told that they only had a few minutes remaining to complete the task. During this task, reactivity was measured by a series of five blood pressure assessments, at two minute intervals, over a period of approximately 10 minutes.

After the 10 minute period, the researcher entered the room again and told the participants that it was time stop working. Immediately following the stressor task, recovery blood pressure was assessed by five readings, at two minute intervals, over a period of at least 10 minutes. During this time, a second affect assessment was administered to determine affective reactivity as well as a follow-up assessment of state anxiety. Additionally, self-report measures were administered to determine the subjective pleasantness of the environment, sensitivity, the degree of distress felt before and during the task, and how much effort participants felt that they gave to the task. A brief questionnaire regarding the use of alcohol, nicotine, and other substances and medications was administered at this time. Final physiological readings were followed by debriefing.

Instruments

State anxiety was assessed using the Spielberger State-trait Anxiety Inventory (STAI; Spielberger, 1968). Reliability coefficients (Chronbach's alpha) for state anxiety were α=.86 at baseline and α=.93 at recovery. Affect was assessed using the Positive and Negative Affect Schedule (PANAS; Watson, Clark & Tellegen, 1988). Chronbach's alpha coefficients for positive affect were α=.87 at baseline and α=.92 during recovery. Chronbach's alpha coefficients for negative affect were α=.83 at baseline and α=.78 during recovery. Hostility was assessed using the Cook-Medley Hostility Scale (Ho; Cook & Medley, 1954), a subscale of the Minnesota Multiphasic Personality Inventory, on which t-scores above 60 are associated with increased risk for health problems (Butcher et al., 2001). The Chronbach's alpha coefficient for this measure was α=.75. Blood pressure and heart rate were assessed using a GE Medical Systems Dinamap PRO

Series 100-400V2 digital monitor. Physiological information, together with the assessment of emotions (i.e., anxiety and affect), is critical to the measurement of stress reactivity because elevations in the former may be considered as physical manifestations of elevations in the latter (Spielberger & Reheiser, 2009). Self-report questionnaires were used to assess perceived stress, perceived effort, perceived pleasantness, substance use, menstrual phase, and demographic information. See Table 1 for means, standard deviations (SDs), and reliability coefficients for all variables.

Table 1: Descriptive statistics for all survey variables (pooled conditions).

Variable	Mean	Standard Deviation	Reliability (Chronbach's α)
State Anxiety Time 1	35.43	8.12	.86
State Anxiety Time 2	41.00	11.10	.93
Positive Affect Time 1	33.41	7.22	.87
Positive Affect Time 2	27.36	9.16	.92
Negative Affect Time 1	17.04	5.52	.83
Negative Affect Time 2	15.77	4.74	.78
Hostility	24.09	6.39	.75

CHAPTER IV

RESULTS

Because the experimental manipulation depended on participants' visual perception of their environments, a five-point Likert scale item that asked how pleasant the room was in which they were working served as a manipulation check. Results of an independent samples *t*-test revealed that those in the restorative environment did indeed perceive it to be more pleasant (M=3.14, SD=1.18) (t(57)=2.21, p=.031) than did those in the non-restorative environment (M=2.52, SD=1.00) (Figure 1). Obviously, participants could not be asked the extent to which the environment was 'restorative' before they were debriefed; nonetheless, this measure of perceived pleasantness served as a valid indicator of the same. See Table 2 for *t*–tests of all major dependent variable means.

Stress Reactivity

Physiological

Only participants that had data for all 15 readings were included in the physiological reactivity analyses; this resulted in the exclusion of two participants (restorative n=28, non-restorative n=29). Average measures for systolic blood pressure, diastolic blood pressure, and heart rate for baseline, reactivity, and recovery were calculated by averaging all five readings from each time period. The variable Body Mass Index (BMI) was a significant predictor (F(1,53)=4.40, p=.041) for systolic blood pressure only. Although BMI was not a significant predictor of diastolic blood pressure or heart rate, analyses were conducted for these measures with and without BMI as a covariate; the patterns in the significance of results persisted. For this reason, reported analyses included BMI as a covariate only for systolic blood pressure analyses.

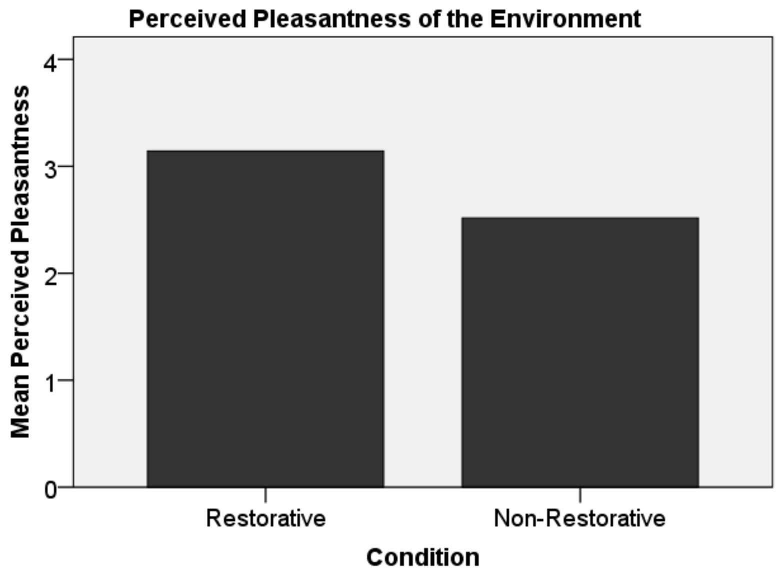

Figure 1. Perceived pleasantness of the environment. This figure illustrates the mean pleasantness of the room environment as perceived by participants in each condition.

A repeated measures ANCOVA was conducted in order to answer the first research question of whether exposure to a restorative environment results in less physiological and affective stress reactivity than exposure to a non-restorative environment. A preliminary repeated measures ANOVA revealed that the between-subjects factor of alcohol use (yes or no in the past 30 days) had a significant interaction with systolic blood pressure ($F(1.97,108.27)=6.50$, $p=.002$) and therefore was used as a covariate in the main analysis. No other reported drug use, including that of tobacco, significantly affected systolic or diastolic blood pressure or heart rate. While associations are weaker than for older adults, previous research has indicated that alcohol use affects systolic blood pressure in young adults (Dyer et al., 1990). Although not in the hypothesized direction, participants in the non-restorative condition displayed a greater physiological reaction (deviation from baseline) to the cognitive stressor. After controlling for the effects of alcohol and BMI, results indicated a significant interaction between change in systolic blood pressure over time and environment ($F(2.00,105.77)=3.98$, $p=.022$) (Figure 2). The difference in the pattern for each group was notable. While participants in the restorative environment showed a steady decrease in systolic blood pressure ($M1=111.94$, $M2=109.09$, $M3=107.29$) from baseline to recovery, participants in the non-restorative condition showed an initial decrease which was much sharper ($M1=111.55$, $M2=105.81$) from baseline to reactivity and then flattened out during recovery ($M3=105.54$). Interestingly, these differential patterns were similar to those that appeared when alcohol alone was used as the between-groups factor (alcohol use in the past 30 days: $M1=112.88$, $M2=107.19$, $M3=106.21$; no alcohol use in the past 30 days: $M1=110.07$, $M2=107.77$, $M3=106.68$).

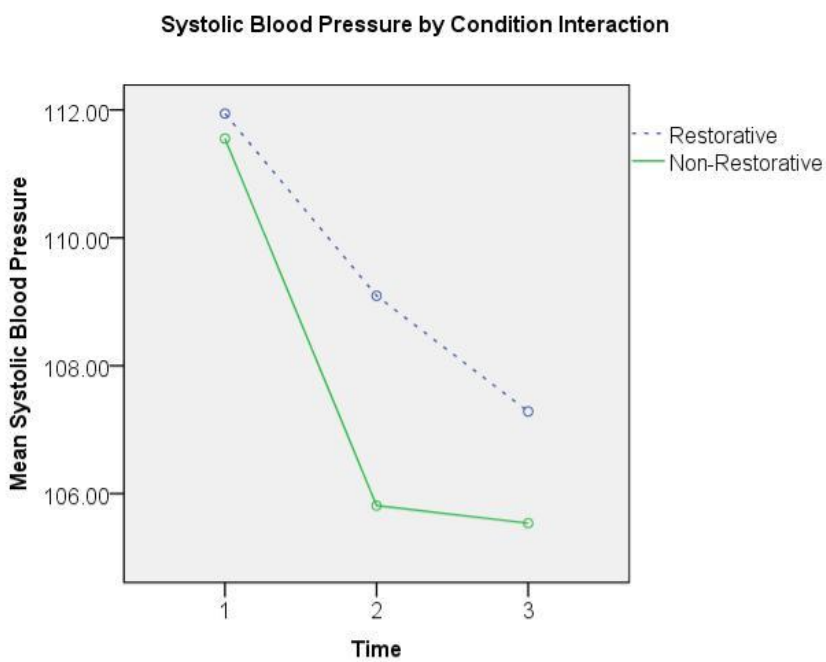

Figure 2: Systolic blood pressure by condition interaction. This figure illustrates the interaction of environmental condition with systolic blood pressure over time.

A post-hoc analysis of pairwise comparisons revealed that changes in systolic blood pressure were statistically significant at all three time changes in the restorative condition (baseline to reactivity (MD=2.85, p=.001); reactivity to recovery (MD=1.81, p=.048); baseline to recovery (MD=4.66, p=.000). The nature of the interaction becomes apparent in the analysis of pairwise comparisons in the non-restorative condition where, although changes from baseline to reactivity (MD=5.74, p=.000) and baseline to recovery (MD=6.01, p=.000) are significant, the non-significant change in systolic blood pressure from reactivity to recovery (MD=.27, p=1.000) does not mirror the same change in the restorative condition. Here, there is essentially no difference; potentially, a floor effect.

A repeated measures ANOVA was conducted to test the effects of environmental condition on the dependant variable diastolic blood pressure. While there was a significant main effect for diastolic blood pressure (F(1.98,108.66)=42.03, p=.000), there was no significant interaction between conditions (p=.119). Although the main effect indicated that participants were showing different physiological responses from baseline to recovery, the non-significant interaction in this analysis did not support the hypothesis. Nonetheless, the changes in diastolic blood pressure over time showed patterns similar to that of systolic blood pressure for both groups. Participants in the restorative condition showed a steady decrease from baseline to recovery (M1=68.77, M2=66.90, M3=65.94), whereas those in the non-restorative condition showed an initially sharper decrease from baseline to reactivity (M1=66.69, M2=63.62) and slightly increased at recovery (M3=63.88).

A repeated measures ANOVA was conducted to test the effects of environmental condition on the dependant variable heart rate. Alcohol was not a significant predictor for this variable and therefore was not included as a covariate. Although not in the hypothesized direction (increase) the notion of greater reactivity was supported such that participants in the non-restorative condition showed a greater physiological reactivity (deviation from baseline functioning) to the cognitive stressor. Results showed a significant interaction between change in heart rate over time and environment ($F(1.89, 103.66) = 5.83$, $p = .005$) (Figure 3).

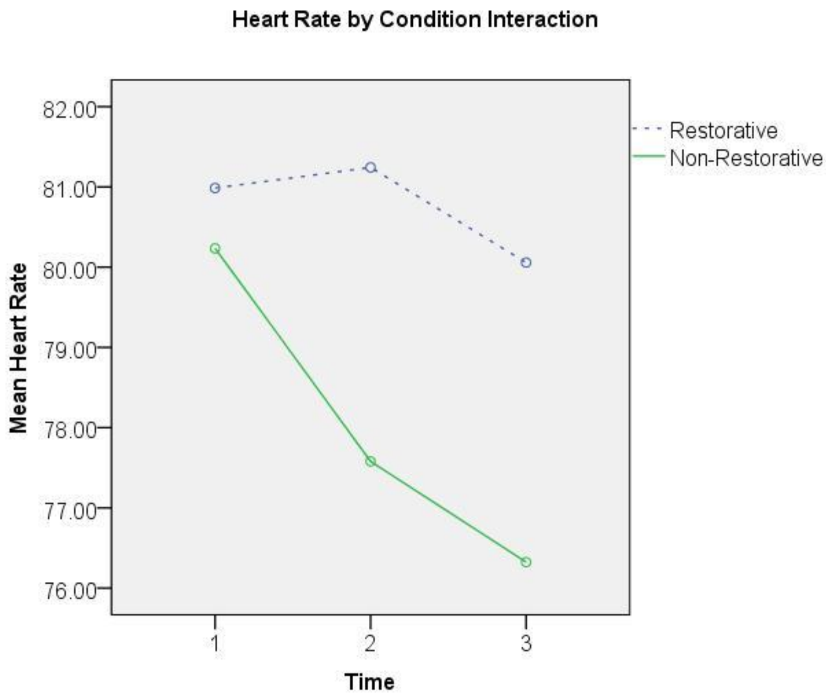

Figure 3: Heart rate by condition interaction. This figure illustrates the interaction of environmental condition with heart rate over time.

In this analysis, the difference in patterning between groups deviated from that of systolic- and diastolic blood pressure. Participants in the restorative condition maintained a relatively steady heart rate from baseline to recovery (*M*1=80.99, *M*2=81.24, *M*3=80.06) whereas those in the non-restorative condition showed a significant decrease over time (*M*1=80.23, *M*2=77.58, *M*3=76.32). A post-hoc analysis confirmed that significant mean differences only existed in the non-restorative condition from baseline to reactivity (*MD*=2.66, *p*=.003) and from baseline to recovery (*MD*=3.91, *p*=.000). Thus, the nature of the interaction is seen in the comparison of very little change in the restorative condition to a consistent decrease in the non-restorative condition. In other words, the restorative condition facilitated less reactivity and greater recovery than did the non-restorative condition.

Affective

Effects for affective stress reactivity were tested using repeated measures ANOVAs to assess changes over time for both positive affect and negative affect. For each scale, missing values were calculated for the PANAS by dividing the number of items on the scale by the number of items actually answered and then multiplying by the sum obtained from the answered items (National Institute of Child Health and Human Development, n.d.). These values were input for items to which participants did not respond. This input of missing data resulted in *n*=28 for the restorative condition and *n*=31 for the non-restorative condition so that every participant was included in the affective analyses. While the positive affect by environment interaction approached (but did not obtain) significance (*p*=.066), there was a significant main effect for positive affect (*F*(1,57)=50.32, *p*=.000) (Figure 4). Although the non-significant interaction did not support the affective component of the first hypothesis, the different patterns of affective change between groups was in the expected direction. Whereas both conditions were relatively equivalent at baseline (time 1), at recovery (time 3) the restorative condition had retained a great deal more positive affect (*M*1=33.79, *M*2=29.39) than did the non-restorative group (*M*1=33.07, *M*2=25.52) who experienced a more dramatic loss. In support of this pattern, results from an ANCOVA revealed that the main effect of condition on positive affect at recovery approached significance (*F*(1,56)=3.71, p=.059, R^2=.52) after parsing out the variance accounted for by positive affect at baseline. These results suggest that more positive emotionality may have been facilitated in the restorative environment than in the non-restorative environment.

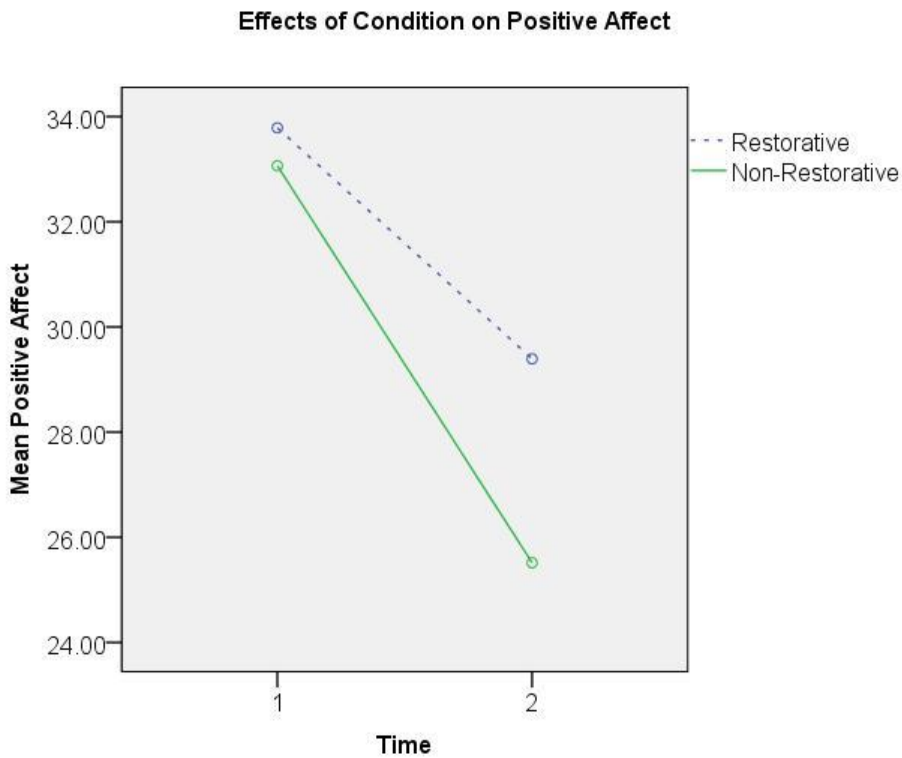

Figure 4: Effects of condition on positive affect. This figure illustrates how environmental condition affected positive affect over time.

There was no significant interaction for negative affect by condition (*p*=.211), nor was there a significant main effect (*p*=.068). Although the affective component of the first hypothesis was not supported by the non-significant interaction in this analysis, the different patterns of change in negative affect were in the expected direction. The non-restorative condition averaged somewhat higher (*M*1=17.52) than the restorative condition (*M*1=16.50) at baseline as well as maintaining most of their negative affect (*M*2=17.10) whereas the restorative condition (*M*2=14.30) decreased noticeably on this measure of negative affect (Figure 5). Confirming this pattern, results from an ANCOVA revealed that there was a significant main effect of condition on negative affect at recovery ($F(1,56) = 5.05$, $p=.029$, $R^2=.26$) after parsing out the variance accounted for by negative affect at baseline. This indicates that the restorative environment facilitated less negative emotionality than did the non-restorative environment.

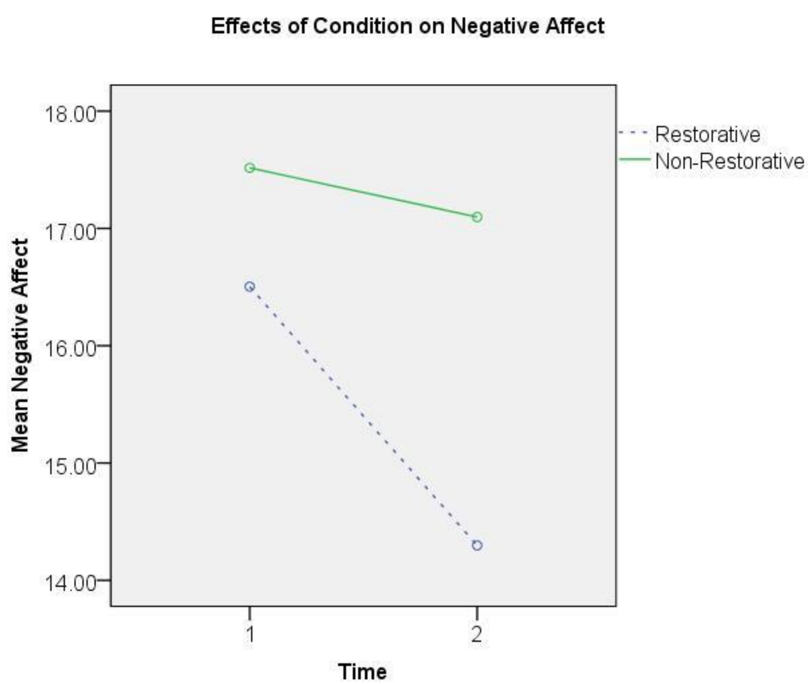

Figure 5: Effects of condition on negative affect. This figure illustrates how environmental condition affected negative affect over time.

Hostility and Anxiety

For all analyses, the variable hostility was converted to a standardized *t* score for males and females and divided dichotomously into low scorers ($n=29$) and high scorers ($t>60$) ($n=30$), with a high score indicating greater hostility and increased risk of health problems (Butcher et al., 2001).

A repeated measures ANOVA was conducted to answer the second research question of whether the individual variable hostility moderates the relationship between environment and changes in state anxiety. While there was a statistically significant interaction between change in anxiety and level of hostility ($F(1,51)=10.16$, $p=.002$), the interaction between change in anxiety and condition did not reach statistical significance ($p=.202$).

Regardless of condition, a post-hoc analysis revealed that the mean difference between baseline and recovery anxiety levels was only statistically significant for those with high hostility ($MD=-8.96$, $p=.000$) and not for those with low hostility ($MD=-2.16$, $p=.170$). The interaction lies in the significantly different degrees of change between levels of hostility (i.e., higher hostility resulted in greater anxiety at baseline and a greater increase at time 2). While these results imply that the high hostility group was more sensitive to stress in general across environments, the potential for a characteristic sensitivity to the environment to mediate these effects is presented in the results for ancillary analyses.

Although there was no significant interaction by condition, the difference in the patterns of change for those with high and low hostility is notable (Figure 6). Overall, for both high hostility and low hostility participants, baseline means for state anxiety in the restorative condition were lower and increased to a lesser extent than in the non-restorative condition. Those with low hostility showed less change overall than those with high hostility. For low hostility participants in the restorative condition there was almost no change between baseline and recovery ($M1=35.25$, $M2=35.58$), whereas in the non-restorative condition change in anxiety was greater ($M1=32.54$, $M2=36.39$). Although anxiety increased noticeably more ($M1=34.25$, $M2=42.17$) for high hostility participants in the restorative condition than for their low hostility counterparts, there was a higher mean at baseline as well as a greater increase for these participants in the non-restorative condition (*M*1=38.75, *M*2=48.50). Overall anxiety means for all four groups suggest that environmental condition did in fact differentiate between high hostility individuals (*MD*=5.42) more than those with low hostility (*MD*=-.96). The implication of this is that high hostility does represent a greater sensitivity to the physical environment, but this does not necessarily differentially impact stress reactivity.

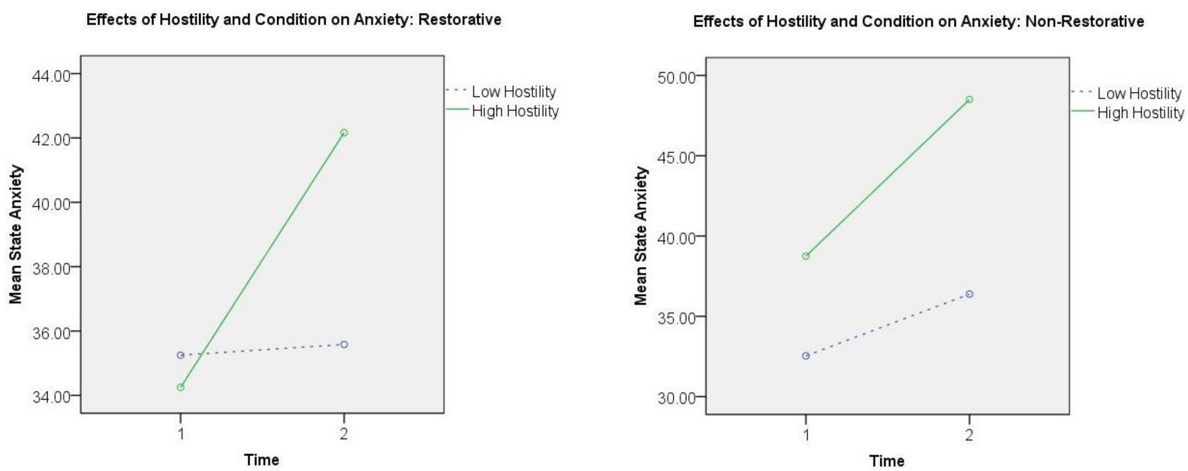

Figure 6: Effects of hostility and condition on anxiety. This figure illustrates how hostility differentially impacted anxiety in the restorative and non-restorative environments.

To further explore this pattern in the data, a split-file (by condition) analysis was used to determine whether hostility by anxiety interaction remained significant when each condition was evaluated separately. It should be noted that the split-file method limits the ability to make comparisons between conditions. Results should be interpreted with the caveat that this analysis is equivalent to testing for effects/interactions within two discrete groups and does not account for variances in the whole number of participants in the experiment. Taking the non-restorative condition as a sample per se, there was a significant interaction by hostility ($F(1,27)=4.30$, $p=.048$). Evaluating the restorative condition as a sample in and of itself also revealed a statistically significant interaction of anxiety by hostility ($F(1,22)=5.43$, $p=.029$). Post hoc analyses showed that in both conditions the change in anxiety was only significant for participants with high hostility and not for those with low hostility. This indicates that hostile individuals are indeed more reactive to stress. Furthermore, the mean difference in anxiety between the two levels of hostility was only significant in the non-restorative environment at time 2 ($MD=12.12$, $p=.002$). This suggests that in the presence of the stressful non-restorative environment hostile participants reacted to a stressful task to an extent that significantly exceeded that of low hostility participants. This did not occur in the restorative environment suggesting that anxious stress reactivity was suppressed. However, it is difficult to conclude that the differences have anything to do with the restorative valence of the environment because the conditions are not actually being evaluated against one another in these analyses.

Ancillary Analyses

A five-point Likert item that asked participants to what extent they thought the room environment affected their performance on the puzzle was utilized as a self-report measure of sensitivity to the environment, a relevant characteristic of hostility. An independent samples *t*-test was conducted to examine differences in sensitivity to the environment between participants with high hostility and those with low hostility. Results revealed that those with high hostility reported being affected by the room significantly more so ($M=2.23$, $SD=1.14$, $t(57)=-4.21$, $p=.000$) than did those with low hostility ($M=1.24$, $SD=.58$).

To further explore this issue of sensitivity to the environment, meditational regression analyses were conducted to determine whether hostility had any predictive power for anxiety as mediated by the variable sensitivity to the environment. A preliminary regression analysis confirmed results of the previously reported hostility by anxiety interaction, showing that hostility was a significant predictor of change in anxiety ($\beta(1,51)=.41$, $p=.002$). A second regression analysis confirmed results of the independent samples *t*-test, showing that hostility was a significant predictor of sensitivity ($\beta(1,57)=.49$, $p=.000$). A final preliminary regression analysis indicated that sensitivity was predictive of change in anxiety on its own ($\beta(1,51)=.43$, $p=.001$). The meditational regression analysis was performed with both hostility and sensitivity as predictors and change in anxiety as the criterion. This analysis revealed that the previous predictive power of hostility became non-significant ($p=.069$) in the presence of sensitivity which retained its significance ($\beta(2,50)=.31$, $p=.033$); this indicates mediation by characteristic sensitivity to the environment.

Table 2: *t*–tests for all major dependent variable means (does not include covariates).

Variable	Restorative Mean(SD)	Non-restorative Mean(SD)	*t*-value	*p*-value
Baseline SBP	112.23(10.32)	112.18(10.95)	.02	.986
Reactivity SBP	109.26(10.37)	106.48(10.34)	1.03	.307
Recovery SBP	107.44(9.86)	105.39(8.51)	.84	.403
Baseline DBP	68.77(6.77)	66.93(6.51)	1.07	.291
Reactivity DBP	66.90(6.89)	64.24(7.23)	1.44	.154
Recovery DBP	65.94(6.61)	63.88(6.07)	1.22	.227
Baseline HR	80.99(11.03)	81.61(15.56)	-.18	.860
Reactivity HR	81.24(10.69)	78.89(14.33)	.71	.482
Recovery HR	80.06(9.76)	76.32(12.81)	1.24	.222
Baseline PA	33.79(6.18)	33.07(8.13)	.38	.705
Recovery PA	29.39(9.14)	25.52(8.92)	1.65	.105
Baseline NA	16.50(6.15)	17.52(4.93)	-.70	.486
Recovery NA	14.30(3.50)	17.10(5.34)	-2.40	.020
Baseline Anxiety	34.80(7.26)	35.97(8.88)	-.52	.603
Recovery Anxiety	38.60(10.52)	43.07(11.35)	-1.49	.142

*SBP= systolic blood pressure, DBP= diastolic blood pressure, HR= heart rate, PA= positive affect, NA= negative affect, SD= standard deviation

CHAPTER V

DISCUSSION

This study aimed to provide evidence for the health-promoting effects of restorative physical environments under stressful conditions as well as to identify key individual variables which affect this process. Overall, results suggested that exposure to the non-restorative environment did adversely affect participants' reactions to stress more than exposure to the restorative environment. Furthermore, a pattern emerged suggesting that level of hostility may differentially affect stress reactivity between the two types of environments and this relationship may be mediated by level of sensitivity to the environment. Although results were mixed, there was partial support for the hypotheses.

Results from the physiological data on stress reactivity indicated that, in general, blood pressure and heart rate decreased in both environments. Condition by physiological change interactions were significant for both systolic blood pressure and heart rate, but not for diastolic blood pressure. This diverges from the hypothesis that a decrease would only be seen in the restorative environment. In searching for an explanation for these findings, it is important to note how the change patterns differed between groups. The hypothesis was partially supported by the finding that there was a steady decrease in physiological functioning in the restorative environment, which was expected. The unexpected finding was that there was an extreme drop in physiological functioning in the non-restorative environment, which was the opposite of what was predicted.

Although not in the expected direction, blood pressure and heart rate did change much more vigorously in this group than in the non-restorative group. If reactivity is considered as conceptualized as a deviation from baseline, then it could be said that this group did indeed show greater reactivity - regardless of valence. Furthermore, the finding that there was almost no change at recovery in this group while there was a continued decrease in the restorative group may indicate that there was less recovery, if recovery is conceptualized as a return to baseline. The fact that blood pressure and heart rate fell instead of rising in the non-restorative environment may represent a greater activation of coping resources (i.e., to cope with the increased threat). There is some evidence for the legitimacy of this explanation because, although not statistically significant (p=.066), participants in the non-restorative environment did report that the stressor task was more "threatening" (M=1.52) than participants in the restorative environment (M=1.14) on a five-point Likert scale. If measurements were extended beyond the approximately 30 minute scope of this experiment, it is possible that a boomerang effect may have presented in the data such that heart rate and blood pressure would have increased for this group once resources were depleted. Another alternative explanation may be that participants in the non-restorative environment experienced stress to an extent sufficient to cross the threshold of cognitive-behavioral helplessness. In other words, they may have given up on the task, becoming less engaged and therefore less reactive.

A technical, methodological issue may have also affected the outcomes in the unexpected direction. Taking repeated measurements of physiological vital signs over a short period of time (i.e., at approximately two-minute intervals) may be problematic because blood flow can be affected/interrupted by the inflation of the arm cuff used to measure it. If this is part of the equation, then it should be taken into consideration that it probably would have affected both groups in the same way.

Results from the data on affective stress reactivity showed an emerging pattern indicating that the restorative environment may have had a more beneficial effect on participants' psychological states than did the non-restorative environment. This environment seemed to facilitate more positive emotions and less negative emotions, both of which have great implications for functional health, wellbeing, CVD, and anxiety.

In the repeated measures ANOVA, the positive affect by condition interaction approached but did not obtain significance (p=.066) meaning that there was no statistically significant difference in the way that anxiety changed over time. However, because the different patterns of change between groups seemed a promising indicator of differential effects, an ANCOVA was conducted to test for effects of condition on positive affect at recovery with positive affect at baseline as the covariate. A nearly significant main effect for condition suggested that, although the manipulation was not powerful enough to detect an interaction between conditions over time, there were notable differences in the levels of positive emotionality, with positive affect being higher in the restorative condition. Furthermore, the large effect size indicated that about half of the variance in positive emotion was accounted for by the environment. So, there was partial support for the affective component of the first hypothesis, that participants exposed to a restorative environment would demonstrate less reactivity in response to stress. While this group did not retain enough post-stress positive emotionality to account for an interaction with the non-restorative group, they did possess greater positive affect overall.

Results from the repeated measures ANOVA indicated that there was no significant interaction for condition by negative affect (p=.211), which suggests that the physical environment does not significantly impact changes in negative emotionality. However, removing the element of change over time, a supplementary ANCOVA showed that, overall, the amount of negative emotion experienced by participants in the restorative environment was significantly less than that experienced by participants in the non-restorative environment. Furthermore, the R^2 indicated that nearly one third (26%) of the variance in negative emotion was in fact accounted for by the environment. This lends partial support to the affective component of the first hypothesis, indicating that the restorative environment facilitated the suppression of negative emotion. Although, it is unclear whether this suppression occurred in response to stress and thus limits the ability to draw conclusions about environmental effects on stress reactivity.

Results from the analyses of hostility and anxiety partially support the second hypothesis that hostility differentially affects the relationship between environment and anxiety. The repeated measures ANOVA which was conducted to test for a) a hostility by anxiety interaction, and b) a condition by anxiety interaction showed that only the former was statistically significant. This finding confirms the default expectation that hostile individuals are more reactive to stress. However, the non-significant (p=.20) latter interaction suggests that the physical environment does not necessarily differentially affect level of anxiety. This implies that individuals with high hostility may not be more sensitive to different environments, and may in fact be less receptive to restorative environmental qualities. On the other hand, the different patterns of change between conditions and levels of hostility suggested that anxiety could be differentially affected by the interaction of hostility with the type of physical environment. Removing the stress reactivity components, an analysis of overall anxiety means for suggested that environmental condition did differentiate between high hostility individuals more so than those with low hostility. The implication is that hostile individuals are more sensitive to environmental differences, but this does not necessarily impact the process of stress reactivity. In terms of stress reactivity, a comparison of the change in means over time suggested that the opposite was true (individuals with low hostility benefited to a greater extent from exposure to the restorative environment). Nonetheless, both groups benefitted from the restorative environment as indicated by lower overall levels of anxiety.

Although there is thus far only weak support, these findings do not abandon the possibility that hostility does moderate the environment-anxiety relationship. A split-file analysis showed that the significance of the interaction for hostility by anxiety was retained in both environments. While split-file method limits the ability to make comparisons between the environments, these results may indicate that qualities of the non-restorative environment were potent enough to manifest differences in stress reactivity between high- and low-hostility individuals. Results from this analysis supported the conclusion that hostility moderates stress reactivity – but only in the stressful non-restorative environment. Furthermore, results from meditational regression analyses showed evidence for the possibility that the effect of hostility on anxiety in response to stress is mediated by sensitivity to the environment. These outcomes would theoretically differ based on the type of environment such that individuals who are more sensitive – an implied characteristic of high hostility – show a greater increase in anxiety in a non-restorative environment and lesser increase (or decrease) in a restorative environment. Future research is needed to strengthen this conclusion.

Although findings were mixed, and conclusions limited, there is evidence that cannot be ignored for the differential physiological and emotional effects resulting from exposure to restorative versus non-restorative environments during stress reactivity. Although there is only partial evidence for the ability of hostile personality to moderate the environment-emotion relationship in the context of stress reactivity, this too merits further investigation.

One alternative explanation should be addressed. In terms of physiological stress reactivity, the interactions found could have resulted from a difference in the delivery of fresh air and/or oxygen into the rooms. Recall that in the restorative condition the door was closed to manipulate the environmental characteristic of privacy whereas the door was open in the other environment. Although this specific variable was not intentionally manipulated, the real or perceived restriction of air flow could have impacted the psychophysical reactions of participants. However, the likelihood of this explanation is questionable because, if true, it should have impacted participants' affective reactions in the same way.

The major implication of these findings is the prevention of chronic, exaggerated stress reactivity that can lead to a number of physical and mental health problems, two of which are CVD and pathological anxiety. Stressful events (e.g., at work, in the hospital, at home) are unavoidable; thus, the importance of the knowledge gained from this study is that the physical environment has the potential to magnify or diminish reactions to stress, especially for certain individuals. Environments lacking restorative characteristics may not only increase negative emotional and physiological reactions to stress, but may also promote negative emotionality even in the absence of a specific stressor. Likewise, environments containing restorative stimuli have the potential to promote more positive emotions and buffer against reactivity. Presented another way, if the pervasive environments in an individual's life do not have restorative qualities, which exert restorative effects, then the experiencing individual may suffer as a result or at least fail to thrive. While this principle is applicable to multiple domains including healthcare, industrial, organizational, military, educational, and domestic, some are more amenable to change than others, some have the capacity for farther reaching and larger effects, and most are simply not under the control of the experiencing individuals. For these reasons, it is particularly important that policy-makers, funding entities, administrators, and executives are made aware of the potential influence of such environmental characteristics on human health.

The potential for environmental changes in healthcare settings should be investigated with priority because the emerging concept of a "healing environment" is already regarded by some facilities as helping patients to recover faster from hospitalization, reducing pain medication use, shortening hospital stays, and reducing anxiety and fear that is common among hospital patients (Voss, 2010). Re-design of healthcare facilities should also be considered a response to a major problem highlighted by the Institute of Medicine (2001) that health care frequently harms the patients that it intends to help, through medical errors and hospital acquired infections. These types of negative outcomes are thought to be caused by design flaws, which increase staff stress and fatigue as well as patient and family stress, putting patients at risk (e.g., nosocomial infection, falls). These risk factors are driving the need for evidence-based design of physical environmental features shown to improve patient and staff outcomes. The need is magnified by the juxtaposition of these problems with the current hospital building boom in the United States (Ulrich et al., 2004). Providing healthcare environments that are supportive of staff and patient social, ergonomic, and ambulatory needs as well as needs for relaxation, restoration, and privacy should reduce rates of medical errors and infections while improving patient safety and well being. The design of healthcare facilities should go beyond basic functional delivery of healthcare by utilizing environmental characteristics that support positive emotions and healthy autonomic arousal as well as improving compatibility, comprehensibility, and control for staff, visitors, and patients alike.

Another implication that follows from the findings regarding hostile/environmentally sensitive individuals is that the physical environment may be of added importance to these people who are already at an increased risk for CVD and poorer health outcomes. It may be valuable in terms of stress prevention and clinical treatment for employers, healthcare professionals, and others to know who those individuals are that report greater sensitivity to their physical environments. Furthermore, because hostility is associated with negative affectivity (e.g., depression, anxiety, anger), results suggesting that restorative environments may facilitate more positive emotions point to the potential for environmentally-induced positive affectivity and cognition to protect against negative cardiovascular outcomes.

One strength of this study is that it utilized both physiological data and self-report data to provide a more complete picture of stress reactivity. While neither modality is without its vulnerabilities, together they offer greater conclusive power. Another strength is that the experimental design dictated random assignment to groups. Because of this, it is reasonable to expect that any differences found were not due to pre-existing differences.

One weakness of this study is that it was cross-sectional in nature; a longitudinal design would strengthen the ability to establish causality. Another is that the sample population was fairly homogenous socio-demographically; additionally, the fact that most were young adults limited the range of cardiovascular function in the data. For these reasons, findings may not be generalizable to older or more diverse populations. Another weakness of this study is the previously mentioned potential for problems with taking repeated physiological measurements over a short period of time (i.e., two minute intervals). The inflation of the arm cuff of the digital monitor is likely to have interrupted blood flow in some way and, without a sufficient amount of time between measurements allowing for the flow to return to normal, this may have skewed the data for blood pressure and heart rate. Another weakness is that no baseline measures for physiological or psychological measures were taken before participants entered their respective environments. Therefore, there is no information nor can conclusions be drawn about how participants would have behaved outside of that environment. Another weakness is that each run took place over a relatively short period of time – approximately 30 minutes. This may not have been a sufficient time scope with which to see more latent differences in reactivity. Another issue with interpreting the results is that each environment consisted of multiple manipulated stimuli; thus, it is not clear whether effects resulted from the combination of these elements or from individual stimuli. This weakness may have contributed to some ambiguity in each condition because a greater number of manipulations allows for more error. Finally, the fairly small *N* (59) of this study could have stifled the potential statistical significance of some of the patterns that resulted. If the study had been conducted with more participants who continued the noted patterns of behavior, it is likely that many of the tests which approached significance would have obtained it.

This study has added to the existing literature a greater understanding of how the physical environment (restorative v. non-restorative) impacts health and wellbeing through mechanisms of attention and stress reactivity working together. Another insight gained from this study is that hostile individuals, as mediated by increased sensitivity to environmental surroundings, may be vulnerable to a greater psychological impact resulting from the environment. This is likely due, in part, to higher levels of negative affectivity resulting in attention biased toward environmental features that are threatening on an evolutionary level. Returning to the theory of EEA, it seems probable that hostile individuals, because of shared cognitive biases, are more apt to notice when environments are lacking in survival-promoting features and characteristics. This attentional mechanism is inseparable from the emotional reactions that accompany it. If attentions and emotions are constantly being bombarded with threatening cues from the environment and subsequently activating neurochemical/hormonal cascades by means of the sympathetic nervous system, then there is no opportunity for the mind or body to rest and restore.

Future research should be done to clarify the mixed findings presented by this study. Longer intervals between blood pressure readings as well as a longer overall assessment period may help to elucidate the physiological picture. Also, a larger, more diverse sample size may serve to better differentiate between groups based on their affective psychological responses. The issue of the possible moderating effects of hostility should be explored further, perhaps limiting the number of manipulated stimuli in the environment to eliminate some ambiguity which may have confused the interpretation of anxiety responses. Also, the potential for meditational effects of sensitivity to the environment could be examined in future studies of environmental stress reactivity as an individual variable in and of itself. If possible, a longitudinal study could help to make connections between moderating personality variables, antecedent reactivity to the environment, and the health outcomes of CVD and anxiety.

APPENDIX A

PHOTOGRAPHS OF ENVIRONMENTAL CONDITIONS

Condition 1(above): Restorative. This is a photograph of the first experimental condition, illustrating elements of a restorative environment.

Condition 2 (above): Non-restorative. This is a photograph of the second experimental condition, illustrating elements of a non-restorative environment

APPENDIX B

WORD SEARCH STRESSOR TASK

ID# ____________________

word search

Words may be horizontal, vertical, or diagonal.

D Q W X D J F M M Z V B Q E S Z N D F T S U X B U C X R S W
M N U M C T X X M X S N O K E X A H A D M N T F S U A T Y G
X F Y M K Q E I T L S U T B U G X H D N E H U U L I A O S Y
X Q G N Z R Z M I A K S B T G N W T A P K E L J V H H O K Y
J V U I U I M P P I C I K S X C F Q U H L Y A C U F Q M L C
W C V W D S L T N O W W A W F K C G M I H V K F D I J M L G
F P O J U K A R C V R A Z W E U N Q A E M F L Q M A P P N D
F N J H O U S E S C E A W P S S I R Z H B L F C X P Y N W S
B X V T A J X E Z S U O R Y S E T O Y L W X K C V P A D A I
D D K I O X A Z V Q M V L Y A M I F S G F J L K O I K R F V
I Q N C Z F U P T A N Y I W I V U W R G C V T G O R A O F P
F W D Z S X O Y R L O T P A D V P Y Q I L L K R F V R J G C
X A X X Y B D H C U D X P T R W K A V G O X E R Q S A N A R
O E I Q T G C S M F Z N F S X C X N C U T J B H R T O Q B K
Y A K J A I V A W B R O Z S Z P W G X C H S M L O P H G M F
K B G D A A N H J N E C O N I D W M D N I K J V T S C W M P
S V Q R W Q R T V Z I B I V H C H Y X G N D K H T Q E A H P
O T N I J W E C E M F M J B Z R O I X L G I U I S X I F B N
D I D Z P Q Q R G L S S I F C D P P O N D P U B D C P H J U
T P X A S I Y U N K L F H P R N K E M F M Q I X U F C I O D
N T V N T D D E D B O I L L R E S Y U P H P J D D F E P H Z
F C S C Y G J F H T C Y G X O E E Y V N C U Q W V O G Z U M
F E H D C U E C B N R E P E E M D Z V R L O G L A D R S N M
J H H W E I U D V F P C P G N B X D E I M X U U M D E X H Q
J G Q N P T T H Y Q N C R J Q C L J S X P E X X C I D W G B
J V Z K Z A B G X X T P V Q Y Y E R M V Q S N E D F N L R O
B V V B Z R Y O P R N L L L P K Q M R P T W B V K W M M O U
G C S J L I A O R X I S Y C O F F E V O E Q L N V S Z S A X
F R I C R L W Z J J R M O Z M U B U J X K T U C X X N F U V
T R C G B A L W W K L S H U J T N T C M Q V Q O S K B Z W H

INTELLIGENCE
GEESE
GUITAR
FREEZE
WAX
TEMPORARY
HOUSE
PUB
CLOTHING
PHOTOGRAPHY
RAIL
CHEESE
ZOO

APPENDIX C

SELF-REPORT OF STRESS

Participation Evaluation

The following questions address your experiences during this study.

1. To what extent did you feel stressed when you entered the research room?

Very slightly or Not at all	A little	Moderately	Quite a bit	Extremely
1	2	3	4	5

2. To what extent did you feel stressed while working on the puzzle?

Very slightly or Not at all	A little	Moderately	Quite a bit	Extremely
1	2	3	4	5

3. To what extent do you feel that the room in which you were working affected your performance?

Very slightly or Not at all	A little	Moderately	Quite a bit	Extremely
1	2	3	4	5

4. Do you feel that the room in which you were working was a pleasant environment?

Very slightly or Not at all	A little	Moderately	Quite a bit	Extremely
1	2	3	4	5

APPENDIX D

SELF-REPORT OF EFFORT

Performance Evaluation

Please rate the following items on a scale of **1 = not well to 5 = extremely well.**

1. How well do you think you performed on this task?
2. How well do you think you coped with the demands of this task?

Please rate the following items on a scale of **1 = very little to 5 = very much.**

1. How challenging was this task?
2. How threatening was this task?
3. How important was it to perform well on this task?
4. How stressful was this task?
5. How relaxing was this task?
6. How comfortable was this task for you?
7. How much effort did you devote to this task?

APPENDIX E

DEMOGRAPHICS QUESTIONNAIRE

Demographics Questionnaire

1. Age: ______
2. Gender: ______
3. Height: _______ Weight: _______
4. Ethnicity (please check as many as apply):

   _____ African American
   _____ Asian/Asian-American
   _____ Hispanic/ Latino
   _____ Native American
   _____ White/Caucasian
   _____ Mixed Ethnicity *(please specify):* ___________________
   _____ Other *(please specify):* ___________________

5. Marital Status (please check one):

   _____ Single
   _____ Married
   _____ Separated
   _____ Divorced
   _____ Widowed
   _____ Other: ____________________

6. Do you live alone? _____ yes, live alone

   _____ no, live with other(s) (*with how many others?):* ______

7. Education (please check highest level completed)

   _____ some college
   _____ Associate's Degree
   _____ Bachelor's Degree
   _____ Master's Degree
   _____ Doctorate
   _____ Other: _______________________

8. Current academic standing at Texas State University?

   _____ Freshman
   _____ Sophomore
   _____ Junior
   _____ Senior

APPENDIX F

MEDICATION AND SUBSTANCE USE QUESTIONNAIRE

Medication and Substance Use

1. Are you currently using any prescription medications (e.g., Ritalin, birth control, Ambien)? If so, what are they?
 ____

____

____

2. Have you used any of the following within the last 30 days (circle all that apply)?

alcohol
cocaine
heroin
ecstasy
methamphetamine
prescription stimulants (e.g., Adderall, Ritalin)
prescription opioids (e.g., Oxycontin, Percodan, Darvocet)
prescription tranquilizers (e.g., Xanax, Valium, Ativan, Klonopin)
prescription sedatives (e.g., Lunesta, Ambien)

3. Are you currently using any non-prescription medications (e.g., herbal supplements, diet pills, energy drinks)?____

____

____

Caffeine Use

4. How much caffeine do you consume on a daily basis *on average* (circle one)?

0-2 drinks/day   3-4 drinks/day   5-6 drinks/day   more than 6 drinks/day

What type (e.g., coffee, tea, soda)?______________________________

Smoking History and Habits

5. Do you smoke tobacco? ______________________________
6. What do you smoke (e.g., cigarettes, cigars, pipes)? ______________________________
7. When did you start smoking? ______________________________
8. On average, how much do you smoke per day? ______________________________
9. How long has it been since you last smoked? ______________________________

APPENDIX G

POSITIVE AND NEGATIVE AFFECT SCHEDULE (PANAS)

The PANAS

This scale consists of words that describe different feelings and emotions. Read each item and then mark the appropriate answer in the space next to that word. Indicate to what extent you generally feel this way, that is, how you feel on the average. Use the following scale to record your answers.

1	2	3	4	5
very slightly or not at all	a little	moderately	quite a bit	extremely

______ interested	______ irritable
______ distressed	______ alert
______ excited	______ ashamed
______ upset	______ inspired
______ strong	______ nervous
______ guilty	______ determined
______ scared	______ attentive
______ hostile	______ jittery
______ enthusiastic	______ active
______ proud	______ afraid

APPENDIX H

PERMISSION TO USE THE STATE-TRAIT ANXIETY INVENTORY (STAI)

USF
UNIVERSITY OF
SOUTH FLORIDA

August 10, 2010

Ms. Wendy Brooks, Graduate Student
Health Psychology, Texas State University

Dear Ms. Brooks:

In response to your recent request, I am very pleased to give you permission to reproduce and use the State-Trait Anxiety Inventory (STAI) in your Masters Thesis research, entitled:

Role of sensory environment in stress reactivity:
Implications for pathological anxiety.

It is my understanding that your research will be carried out at:

Texas University – San Marcos Campus.

This permission is contingent on your agreement to share your findings with us when your research is completed. I look forward to receiving further information about your procedures and the results of your study as this information becomes available.

Best wishes on your research project.

Sincerely,

Charles D. Spielberger, Ph.D., ABPP
Distinguished Research Professor of Psychology
Director, Center for Research in Behavioral
Medicine and Health Psychology
Phone (813) 974-2342; E-mail: spielber@cas.usf.edu

CENTER FOR RESEARCH IN BEHAVIORAL MEDICINE AND HEALTH PSYCHOLOGY
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APPENDIX I

PERMISSION TO USE THE COOK-MEDLEY HOSTILITY SCALE (Ho)

UNIVERSITY OF MINNESOTA

University of Minnesota Press

For internal use only

____ Permission for the above request is denied.

_x___ One-time, nonexclusive permission to use/reproduce the items of the MMPI-2 Ho Scale for the above study is granted with the following special provisions:

That the following credit line appears with the copyrighted material:

MMPI®-2(Minnesota Multiphasic Personality Inventory®-2) Manual for Administration, Scoring, and Interpretation, Revised Edition. Copyright © 2001 by the Regents of the University of Minnesota. Used by permission of the University of Minnesota Press. All rights reserved. "MMPI" and "Minnesota Multiphasic Personality Inventory" are trademarks owned by the Regents of the University of Minnesota.

Reproduction of test items is limited to the research/study described above.

This letter also constitutes formal permission for you to reproduce the item numbers for the scales listed above in your thesis. Permission **does not** allow for the reproduction of item content/test items in your thesis. Any other reproduction of test items (in journals, online via the Web or alternative media) would require separate permission.

Tami Brown

July 12, 2010

Tami Brown
Permissions & Translations Coordinator

Date

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VITA

Wendy Lee Brooks was born in Memphis, Tennessee, on June 28, 1985, the daughter of Margaret Beth Brooks and Robert Craighead Brooks. Raised in Memphis, Tennessee, she attended White Station High School from 1999-2003 and then Rhodes College from 2003-2007. Attending Rhodes with a scholarship in Fine Arts, Wendy studied art history and religion abroad in Western Europe. She graduated with a Bachelor of Arts in Psychology in May 2007. After graduation, Wendy moved to Wyoming and then to Austin, Texas where she worked in various settings for two years before beginning graduate school at Texas State University-San Marcos to obtain a Master of Arts in Health Psychology.

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This thesis was typed by Wendy L. Brooks.