NURTURING NATURE AND THE HUMAN PSYCHE: UNDERSTANDING THE PHYSIOLOGICAL, PSYCHOLOGICAL, AND SOCIAL BENEFITS OF INDOOR NATURE EXPOSURE

By

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DEDICATION PAGE

I dedicate this work to my grandmother and grandfather. You started this journey with me, and now watch down on me as I finish. I miss you both more than words can express.

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ABSTRACT

The purpose of this dissertation was to examine the nature-health relationship by exploring facets of physiological, psychological and social health when engaging in INE. Using the properties of biophilic design and the stress-reduction theory to guide inquiry, this study examined the influence of a multi-sensory and immersive nature-based indoor environment on physiological stress, mood, and pro-social intentions and behaviours.

One hundred and forty-seven (118 females) undergraduates were randomly assigned to either an experimental (indoor nature environment) or control (no nature) condition. Participants were exposed to their condition for 20 minutes. Heart rate variability (HRV) assessed physiological stress, and self-reported mood, environmental preference, nature relatedness, and individual demographics were measured. Following the completion of the study, participants were prompted to engage in a pro-social behavior.

Results highlight the theoretical underpinnings (e.g., stress-reduction theory) and the individual-level factors (e.g., environmental preference and nature relatedness) that influence the nature-health relationship within indoor environments. Physiological stress markers were immediately reduced when exposed to INE regardless of an individual's preference for nature or their surrounding environment. INE resulted in an increase in positive affect and was related to environmental preference which was influenced by individuals' nature relatedness. Lastly, pro-social intentions and behavior showed no relationship with INE.

This project was one of the first of its kind to test the use of a multiple sensory nature-based indoor environment on health outcomes, and found that INE produced similar physiological and psychological benefits as being outdoors. Results suggest that more work needs to be done to explore not only the benefits of multi-sensory INE, but also how individual-level variables influence the strength of these outcomes.

LIST OF ABBREVIATIONS USED

ANCOVA	Analysis of Covariance
ANS	Autonomic Nervous System
ART	Attention Restoration Theory
AVNN	Average NN Intervals
CNS	Central Nervous System
EAS	Environmental Assessment Scale
ECG	Electrocardiogram
HAS	The Helping Attitude Scale
HF	High Frequency
HR	Heart Rate
HRV	Heart Rate Variability
INE	Indoor Nature Exposure
LF	Low Frequency
NA	Negative Affect
NN	Period between successive heart beats
NR	Nature Relatedness
PA	Positive Affect
PANAS	Positive and Negative Affectivity Scale
PET	Psycho-evolutionary Theory
PNS	Parasympathetic Nervous System
POMS	Profile of Mood States
SAM	Search and Memory Test
SLSI	Student-Life Stress Inventory
SN	Sinoatrial node
SNS	Sympathetic Nervous System
ZIPER	Zuckerman Inventory of Personal Reactions

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CHAPTER 1 INTRODUCTION

"The pursuit of 'the good life' is through our broadest valuational experience of nature."

-Kellert (1993, pp. 60)

Summary of problem

The physical environment can influence our health through a multitude of physiological, behavioural, social and psychological channels (Abraham et al., 2009; Largo-Wight, 2011; Northridge et al., 2003). A large body of research examining the human-environment relationship focuses on the negative impacts of the built environment, urbanization and hazardous exposures (indoors and outdoors) through physiological pathways (Frumkin, 2001), and have often been the focal point for health interventions in environmental and health studies (Largo-Wight, 2011). In addition to the negative physiological impacts, environments can threaten our psychology and social health. Much work has highlighted the impact of urban characteristics such as overcrowding, noise exposure, inadequate housing, and sprawl on stress-related outcomes (Evans et al., 2001; Leventhal & Brooks-Gunn, 2003; Maxwell, 2003; Ouis, 2001). As much as environments can threaten wellbeing, our physical surroundings can also promote and sustain health.

Interaction with nature[1] can be described as any interaction between humans and the outdoors, plants, landscapes and/or animals. It can be as simple as taking a walk in an

[1] Nature has typically been a broad and encompassing definition that has a variety of meanings. Due to the vastness and ambiguity of the term, this dissertation will define nature as outdoor spaces that incorporate a range of plants, animals, landscapes and water features. This definition captures both the lay or common definition of nature (Vining, Merrick, & Price, 2008), and how researchers to date have conceptualized and/or operationally defined nature. For example, Capaldi, Passmore, Nisbet, Zelenski & Dopko (2015) and Hartig, Mitchell, de Bries & Frumkin (2014) define nature as

urban park, watering a plant on your windowsill, flipping through nature photos, or playing with a household pet (Frumkin, 2001). A growing body of evidence outlines the vast range of physical, psychological and social health benefits of nature exposure, and supports that nature can be used as an effective strategy to prevent and promote many facets of human health (Maller et al., 2005, pp 45). However, our current lifestyle (i.e., largely inside and within non-nature built environments) does not necessarily support or facilitate spending time in nature.

A rapid shift to urbanization has left more than half of the world's population living in urban centers (Zipperer & Pickett, 2012), and it is estimated that the continual growth of urban areas will result in this number increasing to 70% by 2050. Examining human health in an environmental context has shown that there is a distinct mismatch between the environments we currently live and spend our days within, and those that promote and sustain our health and wellbeing. For example, in industrialized nations people spend, on average, less than 10% of each day outdoors (Evan & McCoy, 1998; Matz et al., 2014). This increase in population growth within our cities results in marginalization (e.g., low-income[2]), increases in pollution and hazardous waste concerns, crime frequency increases, and over-crowding (Berrigan & Troiano, 2002; Garrett, 2001; McNeill, 2000; Melosi, 2000; Newman, 1986; Sampson, Raudenbush & Earls, 1997). Urbanization has not only shaped our cities, but we are seeing evidence of this drastic shift in environments impacting human health and wellbeing.

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environments and physical features of nonhuman origins, ranging from rural landscapes to biological plants.

[2] As of 2008, 37% of the world's poverty exists in urban areas (United Nations, 2008).

One way to combat the negative impacts of urbanization is to integrate nature and/or nature-based characteristics into our built environments (Gesler, 1992; Milligan, Gatrell & Bingley, 2004). Considering the beneficial properties of nature, exposing individuals to natural elements through indoor environmental characteristics (e.g., natural light, potted plants, nature sounds and smells) may be an effective means of improving health by adapting our existing indoor environments into healthy places.

There are several therapeutic benefits of nature contact within indoor environments. For example, Ulrich's (1984) work with cholecystectomy surgery patients demonstrated that patients randomized to post-operative rooms with a view of a small wooded area had faster recovery times, were discharged more quickly, consumed less analgesics, and had fewer negative evaluations from hospital staff than patients who were assigned a room with a view of a brick wall. In fact, the use of nature to promote the recovery of health is not new. The first use of nature for health promotion dates back to the 15^{th} century with the construction of a hospital which included gardens, water therapy, and aromatherapy (Abramsson & Tenngart, 2003). Horticulture therapy (e.g., farming or gardening activities) was a popular form of treatment for illness until the rapid rise of pharmaceutical-based treatments and the modernization of hospitals forced clinic gardens and farms to close (Sempik & Aldridge, 2006). This 'green' healthcare extends far beyond horticultural therapy and has included wilderness therapy and retreats, animal assisted therapy and the integration of other nature strategies (e.g., nature sounds) into clinical care (Adhamer, 2008; Burns, 2005; Cohen, 1997). Regardless of the wealth of evidence that supports the benefits of nature, we as a population are spending more time indoors and away from nature-based environments and features. Rather than focusing on encouraging individuals to go outside in nature, we should consider how our indoor spaces can be adapted and recreated in order to replicate the benefits of being outdoors, and examine how indoor nature exposure (INE) can be used as a health promoting tool.

Understanding health

The medical definition of health is simply a state of being free from physical disease or pain in order for the body to function properly (World Health Organization (WHO), 2005). However, health is more than merely the absence or presence of disease or pain, it is a positive concept emphasizing the complete physical, psychological and social wellbeing of an individual. Understanding health broadly through these three facets, enables the investigation of the nature-health relationship to use a health promotion lens where nature exposure is viewed as a tool to promote and aid the health and wellbeing of the whole person.

As defined by the WHO's (2005) Bangkok Charter for Health Promotion in a Globalized World, health promotion is "the process of enabling people to increase control over their health and its determinants...[and] moves beyond a focus on individual behaviour towards a wide range of social and environmental interventions" (pp. 1). This perspective is essential in examining the nature-health relationship and developing crucial and valuable implications for research, programs, practice and policies related to health (Barton & Pretty, 2010; Hansen-Ketchum & Halpenny, 2010). This research can help direct the usage of natural and human resources, and identify transformations that need to take place to ensure healthy living conditions that are sustainable and accessible, and be applied at various levels that reflect this broad and holistic conceptualization of health. For example, using the social ecological model (Figure 1) to guide the application of these results, we can see that INE can be integrated into individuals' homes and lifestyles, at an organizational level (e.g., through the construction of natural features in work places, universities), and at a policy level where legislation and regulation seek to include INE to promote health and welling. INE may prove to be a crucial health promotion program with considerable preventative properties that can be applied at both a micro-level (i.e., focused on individual health outcomes) and macro-level (incorporating public and environmental health outcomes). This socio-ecological conceptualization recognizes that INE has distinct personal and community level benefits (Adhamer, 2008; Maller et al., 2002), and highlights the reciprocity between our environment and health.

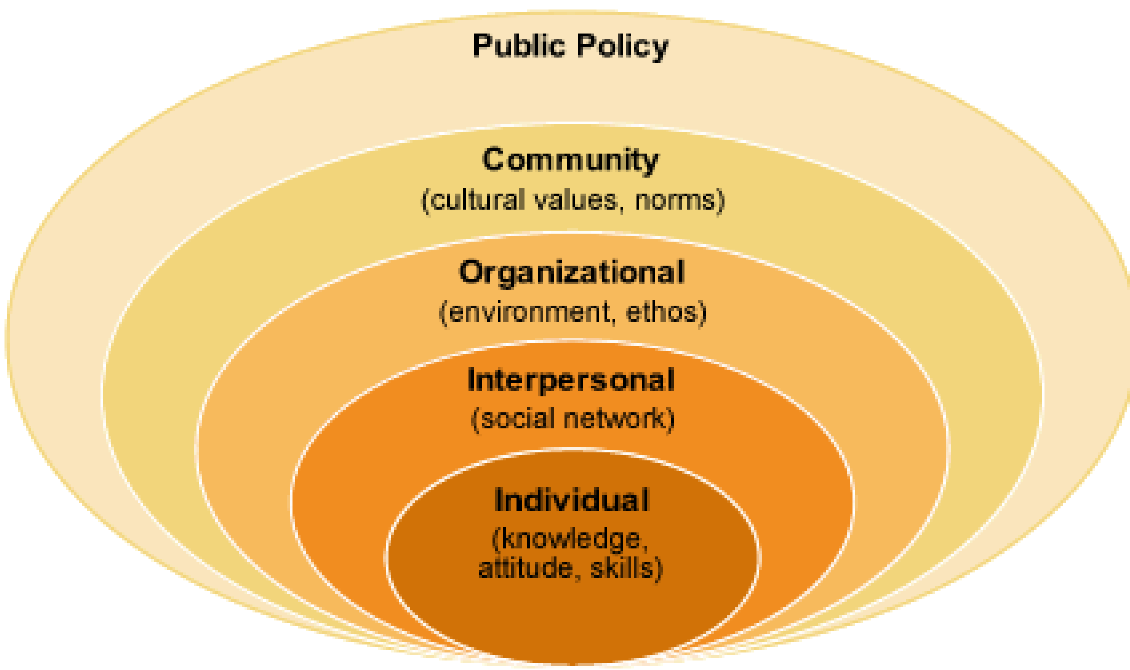

Figure 1. The Social Ecological Model (Bronfenbrenner, 1977).

By adopting a socio-ecological rather than bio-medical model of health, the project rests within the domain of *environmental health sciences*, as it looks to understand how environmental attributes (such as natural light, plants) impact our wellbeing, rather than solely focus on individual factors (e.g., genetics, lifestyle choices). Specifically, this project focuses on how natural and built features within indoor environments influence health and wellbeing, and how INE can increase accessibility and exposure to nature. By incorporating an environmental health perspective into this dissertation, it recognizes that the environment can directly impact our health through physiological, psychological, and social pathways, and that a holistic understanding of health needs to be considered when understanding the influence of INE (Largo-Wight, 2011).

What we know about the nature-health relationship

Chapter 2 of this dissertation provides an in-depth review of the existing evidence of INE, this section will highlight this work by exploring the theoretical frameworks that support the health promoting benefits of INE. The nature-health literature largely focuses on three major theories that can provide insight into why nature is beneficial to our health and well-being: biophilia, stress reduction, and attention restoration. By using these theories which are grounded in evolutionary psychology, this dissertation spanned the disciplines of environmental sciences, psychology, and health promotion, and formed a bridge that will allow the results of this project to be applied to multiple settings and populations, and continues to capture the broad and reciprocal relationship between human health and our environment (Hartig & Staats, 2007).

The biophilia hypothesis stipulates that humans have an innate affiliation with nature as a result of adaptive behaviours developed throughout the course of human evolution (Wilson, 1984). Outdoor natural environments provide an abundance of food, security, and sanctuary, and provided a range of positive physiological, psychological, and social benefits during the course of human development (Lorh & Pearson-Mims, 2000). Humans have begun living in urban environments only recently within an evolutionary context (Wilson, 1984), therefore we still have an innate connection towards natural environments. An evolutionary theory such as biophilia is difficult to test, however evidence shows that humans prefer to view natural scenes over built environments (Dopko, Zelenski, & Nisbet, 2014; Kaplan & Kaplan, 1989; van den Berg, Koole, & van der Wulp, 2003), and that there is an innate attraction to nature at a young age (Kahn, 1997) and across cultures (Newell, 1997; Ulrich, 1993).

Stress-reduction theory (also known as the psychoevolutionary theory (PET)) builds on the evolutionary properties of the biophilia hypothesis (Ulrich, 1983; Ulrich et al., 1991). The stress-reduction theory suggests that compared to urban environments, exposure to natural environments automatically elicits positive affective relaxation and recovering psychophysiological responses (e.g., reduction in heart rate, improved mood; Ulrich, 1979, 1981; Ulrich et al., 1991). Through our innate connection with nature, we immediately and unconsciously react with calmness and relief from stress when exposed to unthreatening nature and nature-based characteristics because they are a place of safety and retreat (Annerstedt, 2011). For example, access to nearby nature is a buffer against stress (Stigsdotter et al., 2010; Ulrich, 1981), and over a decade of evidence from Japan on forest bathing suggests that being in nature can reduce cortisol levels, lower heart rate, and improve immune functioning (Parks et al., 2008, 2009, 2010; Tsunetsugu, Park, & Miyazaki, 2010).

The Attention Restoration Theory (ART) provides another mechanism for the promotion of health via nature exposure (Kaplan, 1987; Kaplan & Kaplan, 1989). ART asserts that viewing or spending time in nature allows a recovery of cognitive resources that are needed to concentrate. These cognitive resources are separated into two forms of concentration: directed attention (which is used for prolonged focus) and involuntary attention (which is effortless). Directed attention is a limited cognitive resource that becomes fatigued and depleted after extended use. Once directed attention is gone, it becomes difficult to concentrate and can result in negative affective states (e.g., depression, irritability). ART suggests that through four central characteristics (being away, extent, fascination, and compatibility), natural environments engage an individual's involuntary attention which allows for the replenishment of directed attention. Through this restorative mechanism, natural environments and nature-based characteristics can promote cognitive performance and positive affect (e.g., relaxation, happiness) by restoring directed attention. While this dissertation does not directly test the ART and the depletion/replenishment of cognitive resources by INE, it is important to recognize that the restorative properties of nature may be indirectly influencing the psychophysiological responses of INE.

If we combine the existing evidence that supports the healing and health promoting benefits of being outside in nature with theoretical frameworks that describe the adaptive presence and benefits of nature (e.g., the biophilia hypothesis), we can rethink how to create spaces within urban and built-environments that emulate the experience of being outside in the hopes of also replicating the benefits we receive when being in nature. One approach to combine theory into practice is through the use of biophilic design, which captures humans' innate affiliation with nature through design by fostering the sense of safety, calmness, and rejuvenation that one experiences when in nature (Lorh & Pearson-Mims, 2000; Wilson, 1984). Biophilic design uses natural characteristics of our built environment that directly (e.g., contact with sunlight and/or plants), indirectly (e.g., contact with features that require human assistance such as potted plants, aquariums), and symbolically (e.g., contact representations of nature such as a picture of painting) reflect the innate connection between people and nature (Kellert, 2005). While we live in built environments that are drastically different than those that we evolved in for much of our human development (i.e., nature), we can adapt our current indoor spaces to reflect the properties of natural outdoor spaces that are health promoting and capture the many dimensions of health.

Nature Contact vs. Nature Connection

While it is important to investigate the nature-health relationship at a broad theoretical level, it is also critical to understand how individual perspectives and relationships with nature may impact how one interacts and experiences their surroundings. Nature contact and nature connection are two distinct, but related, aspects of the human-nature experience (Capaldi et al., 2015), and are important to distinguish at the onset of this dissertation as they contribute to the health promoting properties of INE at an individual level. Nature contact, in its most simple form, is interacting with nature, natural items (e.g., plants), representations of nature (e.g., photos of landscapes), and/or nature-based characteristics (listening to taped sounds of birds). Contact with nature may be brief, intermittent, or regular; and when outside, is often linked to a sense of immersion, as these environments provide an opportunity for an individual to interact and engage with their surroundings through the use of their senses. A limitation of much of the current work on nature exposure within indoor settings is whether or not the representations of nature (e.g., a potted plant, a landscape painting) accurately capture the experience of being outside and in contact with nature (de Kort et al., 2006; Bateson & Hui, 1992; Kjellgren & Buhrkall, 2010; Stamps, 1990; van den Berg et al., 2003). Studies of indoor nature largely employ visual representations of nature (e.g., artwork, photos), which lack the rich and sensual components of outdoor nature (de Kort et al., 2006). Creating indoor environments that replicate the experience of being outdoors – that is, engaging multiple senses and offering the opportunity for immersion in the environment – has yet to be explored in the INE literature, and may offer important insights in how best to design our indoor environments. Using biophilic design, we can explore how an indoor envirionment with a variety of nature-based characteristics (e.g., views of nature, nature sounds, natural scents) can impact health and wellbeing.

Nature connection, in comparison to nature contact, refers to one's own sense of connection with the natural world (Mayer & Frantz, 2004; Nisbet & Zelenski, 2011). Individuals with high nature connection tend to spend more time outdoors and rate nature as an environment that they prefer and enjoy engaging with (Mayer & Frantz, 2004; Nisbet, Zelenski, & Murphy, 2009). Nature contact often increases momentary feelings of nature connectedness (Mayer, Frantz, Bruehlman-Senecal, & Dolliver, 2009; Nisbet, 2013, 2014; Nisbet & Zelenski, 2011), and shapes how we engage with, and perceive, natural environments (Kjellgren & Buhrkall, 2010; Ottosson & Grahn, 2005). People with high nature connection seek out natural environments, as they perceive them as being pleasing and restorative, and more preferable than other environments, such as urban areas (Bratman et al., 2012; Epstein, 1991; Korpela, Hartig, Kaiser and Fuhrer, 2001). Nature contact and nature connection, while separate, are inherently linked and important in understanding how individuals interact with INE. To date, little is known about how an individual's preference for being in nature, and their nature connection impacts the nature-health relationship.

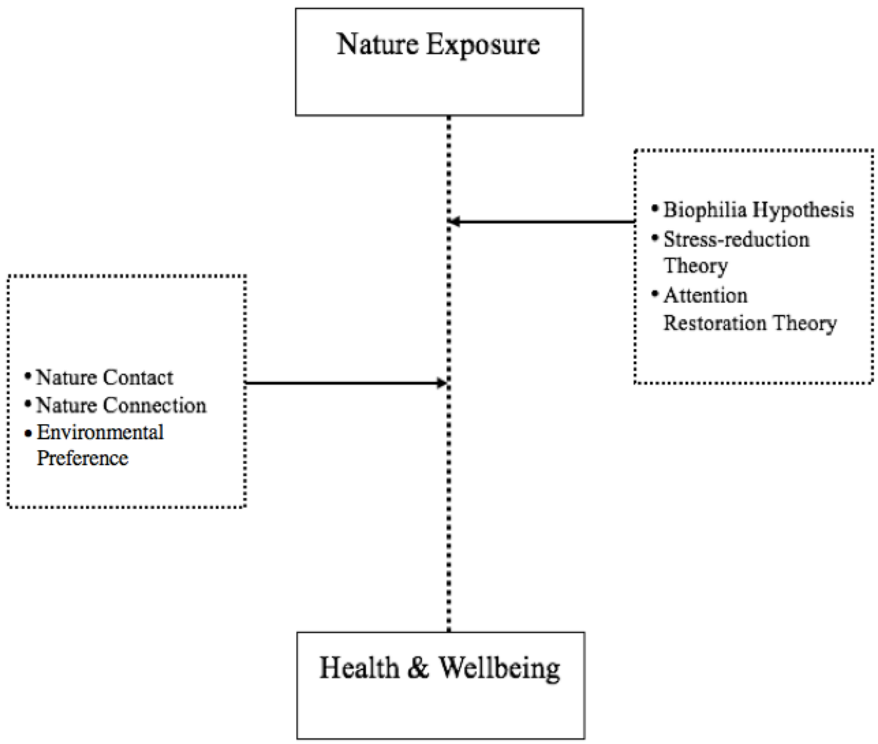

Figure 2. Integrated framework on the relationship between nature exposure and health and wellbeing outcomes.

An Integrated Framework

While brief, the above sections have outlined both the broad theoretical and individual-level factors that influence the human health and nature relationship. Figure 2 provides a guiding framework for understanding the relationship between our experience with INE within the context of this dissertation. When exposed to nature, our health and wellbeing (i.e., physiological, psychological, and social) are not only influenced through evolutionary and psychophysiological pathways explained by the biophilia and stress reduction theories, but also through our individual interactions, connections, and contact with nature, as these shapes how we perceive and engage with our surroundings.

To understand the impact on health and wellbeing, three measures were used to represent each domain of health and wellbeing.

Physiological health and wellbeing.

A variety of measures have been used in the nature-health literature to investigate physiological health. Chapter 2 outlines in detail the various indicators of physical health in the existing body of literature, which includes heart rate (HR), blood pressure, cortisol levels, and temperature. The most widely used indicator of physiological health is heart rate variability (HRV). HRV is a non-invasive measure of the functioning of the autonomic nervous system (ANS) (Borell, Langbein, Despres, Hansen, Leterrier et al, 2007), which can be used to investigate changes related to physiological stress. Outlined in Figure 3, the sinoatrial node (SN) acts as the primary generator for heart beats or HR, and increases during periods of excitement or stress. The SN is controlled through the parasympathetic (PNS) and sympathetic nervous system (SNS), any changes in either the PNS and SNS will cause the SN to respond (i.e., decreases or increases heart beats respectively). Changes in the PNS will cause a quicker response in HR (typically within 5 seconds) than that of the SNS (maximum response after 20 to 30 seconds), and result from chemicals present in the SNS (e.g., adenylyl cyclase) that regulate cardiac activity. Separate effects of these two branches of the central nervous system (CNS) cannot be identified easily, as they do not always function independently of each other. For example, an increase in HR may be the result of reduced PNS activity and increased SNS activity; thus, measuring HR does not always give an accurate understanding of CNS activity (i.e., changes in physiological stress).

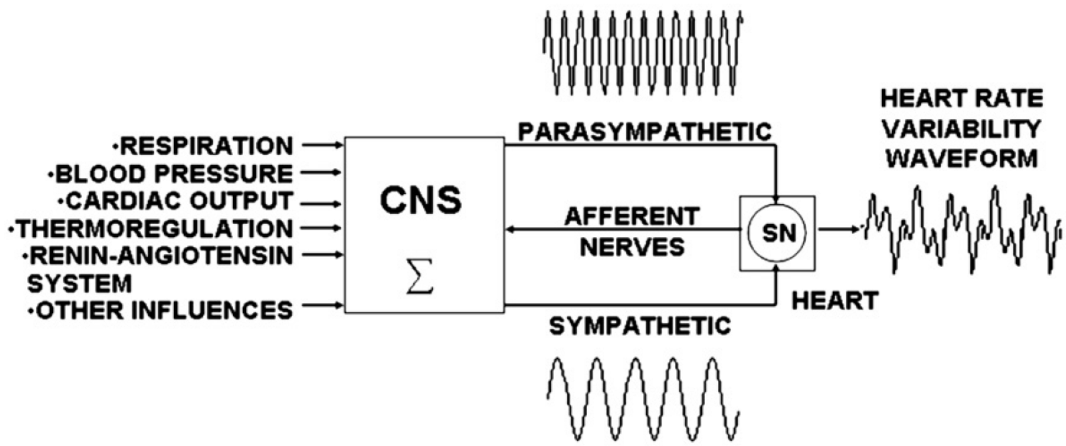

Figure 3. Model of the formation of HRV (from Borell et al, 2007).

HRV was chosen as a measure for physiological health to assess the INE-health relationship as it has the ability to parse out various measures of the CNS which provides a more accurate understanding of physiological stress compared to other measures (e.g., HR, blood pressure), allows for comparability across the literature, and provides a measure of stress that can be used to assess the stress reduction theory.

Psychological health

Within the nature-health literature, mood is largely used as a representation of psychological health and wellbeing (Chapter 2), and is measured using self-report rating scales such as the Profile of Mood States (POMS) (Schachem, 1983), the Zuckerman Inventory of Personal Reactions (ZIPER) (Zuckerman, 1997), or the Positive and

Negative Affectivity Scale (PANAS) (Watson, Clark & Tellegen, 1988). Mood is a state of being that is triggered by a particular event or experience, and can result in either a positive of negative affect (PA and NA, respectively) (Olson, 2006). The stress-reduction theory emphasizes that nature increases positively-toned emotional states like calmness (i.e., PA) and reduces negatively-toned emotions such as fear (i.e., NA), which trigger physiological responses in stress (Hartig et al., 2003; Ulrich, 1983). To examine mood, the Positive and Negative Affect Schedule (PANAS) a 20-item measure designed to evaluate both PA and NA was used (Watson, Clark, & Tellegen, 1988). The PANAS was chosen to represent psychological health and wellbeing because it is used the most in the INE literature to date and provides comparability of results from this dissertation to other studies, and demonstrates the strongest convergent/discriminant correlations compared to other affect measures (Watson et al., 1988).

Social health

While research has outlined the social benefits of nature (Armstrong, 2000; Leyden, 2003), little work has investigated the social impacts of INE. It is possible that INE may serve at an individualistic (physical and psychological benefits) and communal (social) level (Figure 1). An important aspect of social collectivism is pro-social behaviours, which are actions by an individual that will potentially benefit another, while personal benefits are secondary (Grant & Gine, 2010; Levine, Raysen & Ganz, 2008; Twenge et al., 2007), and are considered primarily altruistic (Levine et al., 2008; von Dawan et al., 2012). Pro-social behaviours are thought to be motivated by both dispositional (e.g., individual) and situational (e.g., environment) factors (Batson & Powell, 2003), and could therefore be influenced by the presence of INE. To capture the social facet of health, two measures of pro-sociality were used. The Helping Attitude Scale (HAS) is a measure of an individual's attitudes towards helping others (Nickell, 1996) and represented someone's beliefs and intentions of engaging in pro-social behaviours. To measure engagement in pro-social behavior, participants were prompted to donate the $5 that they had received for completing the study to a local charity.

Research Plan

To date, little research has investigated the impact of a multi-sensory nature-based indoor environment on the physiological, psychological or social health and wellbeing of individuals. Moreover, the integration of individual-level factors, such as environmental preference and nature connection has not been examined as potential variables influencing these outcomes. Using the above framework, this dissertation sought to provide an empirical understanding of the effect of INE on health and wellbeing. In order to understand how INE impacts nature-health relationships, research objectives targeted three specific facets of health and wellbeing and were as followed:

1. To objectively measure changes in physiological stress before, during and after exposure to INE.
2. To assess changes in mood before and after exposure to INE.
3. To assess whether INE encouraged pro-social intentions and behaviours.

Two additional objectives were sought in order to understand how individual factors influenced outcomes:

1. Measure self-perceived environmental preference in order to assess whether an individual's environmental preference influenced the primary research objectives.
2. Assess whether an individual's nature connection influenced the primary research objectives.

Research design.

A mixed 2x2 factorial design was employed to understand the impacts of INE through the use of a randomized, controlled, experimental study. Using convenience sampling through the Dalhousie University psychology research pool, campus advertisements, and snowballing, undergraduate university students were recruited to participate. Students were eligible if they were currently attending Dalhousie University, and ineligible if they had a known cardiovascular illness, an allergic reaction to organic-based scents, consumed alcohol and/or caffeine at least an hour prior to arrival, and/or engaged in moderate to strenuous physical activity that day. All subjects were required to read and sign an informed consent form prior to participation. Participants received $5 for participating in the study and the option to receive one bonus point towards a psychology course of their choosing.

Environmental exposure.

To understand the impact of a multi-sensory INE environment on the research outcomes, two exposure environments were used: (a) an experimental condition and (b) a control condition. The experimental condition used the properties of biophilic design to create a multisensory indoor nature environment. This space was equipped with a small table, chair, desk, green leafy plants[3], a painting of a landscape, a window with a view of a mixed urban landscape, nature sounds, and the scent of pine. For the control, the same environment was used, except the windows were covered to eliminate any views of the outside, and plants, photos, sounds and scents were removed.

Dissertation Structure

The following chapters of this thesis are full articles that, at the time of submitting this thesis, were either under-review or published in peer-reviewed journals. Following the introduction (Chapter 1) is an overview of the INE literature and the proposed framework which this thesis is based on (Chapter 2). Chapter 2 was published in the journal, *Health Promotion International*, and highlights the existing gaps in the INE literature. The methods and results are written as full papers in Chapters 3, 4 and 5, with each chapter addressing one of the three main research questions (i.e., questions A-C). The thesis concludes with Chapter 6, a discussion of the findings and a review of the primary research questions, and and in-depth examination of the subsidiary research questions (i.e., questions D and E) and the contribution of this dissertation to the nature-health literature, and its potential applications.

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[3] All plants were flowerless green leafy species, as work from Kaufman and Lohr (2004) and Li et al. (2012) found that variations in color influenced responses. For example, green invoked positive responses, while orange, brown and purple colors were received more negatively.

CHAPTER 2 INDOOR NATURE EXPOSURE (INE): A HEALTH PROMOTION FRAMEWORK

Indoor nature exposure (INE): A health promotion framework.

McSweeney, J., Rainham, D., Johnson, S.A., Sherry, S. B., & Singleton, J.

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Abstract

Engaging in outdoor nature-based spaces has significant positive physiological and psychological health benefits. Although the integration of nature into indoor spaces is rarely considered a health promoting tool, it may be an effective method for increasing nature engagement in a largely urbanized world. This paper presents a framework for the integration of indoor nature exposure (INE) by synthesizing the results of a literature review on INE. Results show that INE can be a health promoting tool through the interaction of nature-based stimuli and individual characteristics (e.g., gender, age). This framework can be used to facilitate INE programs and policies targeting health promoting environments.

Introduction

Nature is typically defined as untouched and unspoiled outdoor spaces that incorporate a range of plants, animals, and water features (Garling & Golledge, 1993). Studies examining the nature-health relationship suggest that nature-based characteristics (e.g., plants) are effective at reducing stress, increasing the human immune system, improving cognitive function and mood, and enhancing social bonds and community cohesion (Berman et al., 2008; Boniface, 2006; Cimprich & Ronis, 2001; Loeffler, 2004; Ohtsuka, Yabunaka, Takayama, 1998; Park, Tsunetsugu, Kasetani, Kagawa, & Miyazaki, 2010; van den Berg & Custers, 2011; Wichrowski, Whiteson, Haas, Mola, & Rey, 2005; Wu & Lanier, 2003). These health promoting properties are purportedly linked to humans' adaptive connection to nature. During the course of evolution, outdoor environments provided humans with food, security, and a place of restoration, which resulted in positive physiological and psychological benefits (Lorh & Pearson-Mims, 2000). However, the 21st century Westernized landscape is a drastic change from the environment in which humans evolved in.

Advances in technology have resulted in over 50% of the world's population living in urban areas (Zipperer & Pickett, 2012), and projections estimate that by 2050, 70% of the 9 billion people worldwide will live in urban areas where individuals are likely to spend 90% of their time indoors (Setten, Hystad, Poplawski, Cheasley, Cervantes-Larlos et al., 2013). Humans are now functioning largely within built spaces void of natural stimuli, despite their physiological and psychological functions being adapted to nature-based environments. Data now suggests this rapid change and nature deficit is linked to the growing mortality and morbidity rates associated with chronic stress and poor mental health (Selhub & Logan, 2012). While urbanization has drastically changed the appearance of outdoor environments, the ability to adapt built environments offers the opportunity to facilitate nature interaction within indoor spaces. Through ambient (e.g., nature-based art) and architectural designs (e.g., access to natural lighting), indoor built spaces can incorporate natural light, plant-based features, and organic textures, sounds and aromas to replicate outdoor nature-based environments.

Reviews summarizing the effects of nature contact have not focused on indoor nature exposure (INE). Instead, current work on nature and health has typically focused on outdoor and untouched nature-based environments (e.g., mountainous landscapes or forests) or urban environments. Little work has been done to understand how these two environments can merge to create restorative nature-based spaces within built environments. The present review synthesizes the current evidence on INE, the proposed pathways in which INE influences health, and aims to develop a nature-based health promotion framework. From a health promotion perspective, understanding the link between nature-based indoor environments and health is important for the incorporation of nature into health sustaining and promoting ventures in a largely urbanized world.

Table 1. Search terms used in electronic databases.

Nature search terms	**Health search terms**	
Natur*	Healing	Therap*
"Nature assisted"	Health	Attention
"Nature based"	Psycholog*	Mood
Indoors	Wellbeing	Stress
Plant*	Restorati*	Physical
	Cognitive	

*Indicates multiple endings possible

Methods

Literature was included if it made theoretical or empirical assessments of INE, evaluated a physical, biological, psychological, and/or social component of health, examined INE in an adult population with no indications of ill-health (i.e., chronic disease), was published in English, was peer-reviewed, and was published within the last twenty years. All articles were identified through electronic databases (including EBSCO, Cumulative Index to Nursing and Allied Health Literature (CINAHL), ProQuest, PubMed, Science Direct and Web of Science) and reference lists of reviewed articles. Key search words were selected from two broad areas: health and nature (Table 1).

Table 2. Overview of literature.

Author	Nature definition	Health Measurement	Discipline	Study outcomes
Aries et al. (2010)	Sunlight and view of nature (undefined)	Attractiveness, Mood, Restorativeness	Psychology	View, view quality and people sharing a window influenced discomfort. Nature reduced discomfort through office impression, but increased discomfort directly.
Adachi et al. (2000)	Flowers and potted plants	Mood	Horticulture	Flowers improved mood and affected women positively. Foliage increased temper, but affected males positively.
Berman et al. (2008)	Scenery undefined nature	Cognition	Psychology	Nature improved cognitive functions and task performance, was more refreshing, enjoyable, and likable.
Berto (2005)	Photos of landscapes	Restorativeness	Psychology	Nature improved attention and were viewed longer.
Bringslimark et al. (2009)	Potted plants	Cognition, Perceived stress	Psychology	View or presence of plants reduced sick leave and productivity, and was positively correlated with stress.
Cackowski & Nasar (2003)	Pictures of trees	Cognition	Psychology	Nature improved cognition.
Chang & Chen (2005)	A window with a view of a tree, and potted plants	BVP, Brain activity, Mood	Horticulture	Nature increased brain activity and reduced anxiety. Just a nature views impacted BVP more than a view of nature and a plant, and a view of a city and a plant.
Chang et al. (2008)	Photos of landscapes	BVP, Brain activity, Restorativeness	Planning & Design	Nature increased restorativeness, brain activity and lowered BVP.
Coleman & Mattson (1995)	Potted plant and a photograph of a plant	Temperature	Horticulture	Nature lowered stress more than non-nature.
de Kort et al. (2006)	A video of landscapes, animals, and plants	Mood, Presence, SCL	Psychology	Nature reduced stress and improved affect.
Dijkstra et al. (2008)	Potted plant	Attractiveness, Perceived stress	Medicine	Nature reduced perceived stress through the perceived attractiveness of the room.
Dravigne et al. (2008)	Potted plant, and a window with a view of greenspace (undefined)	Attractiveness, Job satisfaction	Horticulture	Nature increased job satisfaction and wellbeing. Men had the highest satisfaction with plants/no window, and the lowest with no plants/windows.
Felsten (2009)	Images of landscapes	Restorativeness	Psychology	Nature increased restorativeness.
Fjeld (2000)	Potted plants and sunlight (manmade)	General health	Horticulture	Nature improved health, discomfort, neuropsychological symptoms (fatigue and headache) and mucous membrane symptoms (dry and hoarse throat).

Fjeld et al. (1998)	Potted plants	General health	Planning & Design	Complaints of cough, fatigue, dry/hoarse throat and dry/itching facial skin decreased in nature.
Gladwell et al. (2012)	Photos of nature (not defined)	BP, HR, General health	Psychology	No significant cardiovascular or respiratory differences. Viewing nature increased parasympathetic activity.
Han (2010)	Photos of landscapes	Attractiveness, Restorativeness	Psychology	Preference mediated scenic beauty and restoration.
Hartig et al. (1996)	Photos of a dirt path in a forest	Cognition, Mood	Psychology	Nature resulted in less error, positive affect, were more relaxing and increased wellbeing.
	Photos of a forest	Attractiveness, Mood, Restorativeness, Social stimulation	Psychology	Nature increased attitudes, recovery, reflection and social stimulation.
Hartig & Staats (2006)				
Herzog et al. (2000)	Photos of a field or a forest	Restorativeness	Psychology	Nature was more restorative and preferred.
Herzog & Chernick (2000)	Photos of landscapes	Attractiveness, Restorativeness	Psychology	Restorativeness and environmental attractiveness increased depending on characteristics of the landscapes (e.g., danger vs. safe).
Hinds & Sparks (2011)	Photos landscapes	Mood	Psychology	Nature improved mood depending on previous nature experiences.
Jin et al. (2009)	The scent of fresh flowers	BP, HR, SCL, Temperature	Horticulture	Nature scents reduced physiological stress, and increased temperature.
Kahn et al. (2008)	A window view of a grass and trees	HR	Psychology	Nature increase in HR recovery.
Kaplan (2001)	Picture or a window with a view of nature	Attractiveness, Restorativeness	Psychology	Nature increased satisfaction with nature and neighbourhood, and improved restorativeness. A park view reduced satisfaction but a garden increased it.
Kaufman & Lohr (2004)	Computer generated photos of trees	Attractiveness	Horticulture	The colour of nature influenced environmental attractiveness. Green and red trees had positive responses, purple and orange had negative. People also responded different to trees within the same color hue.
Kim et al. (2010)	Photos landscapes	Brain activity, Mood	Medicine	Nature improved mood.
Kweon et al. (2008)	Photos of landscapes	Mood, Perceived stress	Psychology	Males had more anger and stress to no nature, and females had lowest anger and stress to nature.
Larsen et al. (1998)	Potted plants	Attractiveness, Cognition, Mood	Psychology	Nature increased productivity and attractiveness. Open-ended comments were grouped into positive (e.g., lack of distraction); negative (e.g., blandness) and qualities (e.g., soothing,).
Laumann et al.	A video of natural	BVP, Cognition, HR	Psychology	Nature reduced HR.

(2002)	waterscapes and sounds of nature			
Leather et al. (1998)	A window with sunlight and a view of nature	Attractiveness, General health, Job satisfaction, Mood, Perceived stress	Psychology	Sunlight and/or a nature view increased job satisfaction, reduced intention to quit, and lower feeling worn out and uptight
Li et al. (2012)	A window view of water or a grassy hill	Noise annoyance	Planning & Design	Nature view reduced noise annoyance.
Li et al. (2012)	Computerized photos of various plantscapes	BP, HR, Mood, SCL	Horticulture	The color of nature influenced stress and mood. Red, yellow and green reduced stress and improved mood.
Lohr & Pearson-Mims (2000)	Potted Plants	BP, Mood, Pain tolerance, Temperature	Horticulture	Nature was rated more positively, had higher levels of positive emotions, and increased pain tolerance.
Lohr, Pearson-Mims & Goodwin (1996)	Potted plants	BP, Cognition, HR, Mood	Horticulture	Nature increased performance and reduced stress.
Ozdemir (2010)	A window view of trees and/or vegetation	Attractiveness	Planning & Design	Nature increased view satisfaction.
Parsons et al. (1998)	Photos of vegetation	BP, Brain activity , HR, Restorativeness, SCL	Psychology	Nature reduced BP and brain activity, improved mood and restorativeness.
Pretty et al. (2005)	Photos of rural landscape (not clearly defined)	General health, Mood	Medicine	Nature reduced BP and increased mood.
Raanaas et al. (2011)	Potted plants	Cognition	Psychology	Nature improved task performance.
Sakuragawa et al. (2005)	Wooden furnishings	Attractiveness, Mood, Restorativeness	Horticulture	Nature decreased BP for those who liked the environmental features. Non-nature was decreased environmental attractiveness and mood.
Shibata & Suzuki (2002)	Potted plants	Attractiveness, Mood	Psychology	Nature improved mood, and was associated with a silent and small room.
Shibata & Suzuki (2001)	A window view of vegetation and/or woods	Attractiveness, Cognition , Mood, Restorativeness	Psychology	Plants increased female performance and was related to preference. Nature improved mood overall.
Shibata, & Suzuki (2004)	Potted plants	Cognition, Mood	Psychology	Females felt the plant to be less distracting and had a greater feeling of familiarity than men, but did not impact performance.
Staats et al. (1997)	Photos trees, fields, and foliage	Mood	Psychology	Mood was influenced by nature-based features in photos (e.g. accessibility, density).
Staats et al. (2003)	Photos of forests	Attractiveness, Restorativeness	Psychology	Nature was preferred, decreased fatigue, and has greater restorativeness.
Tennessen &	Photos of trees, grass,	Cognition, Mood	Psychology	Nature increased attention, but did not impact

Cimprich (1995)	bushes, and lakes			mood or performance.
Tsunetsugu et al. (2007)	Wooden furnishings	Attractiveness, BP, HR	Planning & Design	The 45% room, decreased BP and increased HR, and was the most comfortable. The 90% room decreased BP, but caused a decrease in brain activity and increased HR.
Valtchanov et al. (2010)	A virtual forest	Cognition, Mood, SCL	Psychology	SCL and mood increased in nature. No differences cognition.
Vincent et al. (2010)	Photos of landscapes	BP, HR, Pain tolerance, Presence	Medicine	Hazardous features of nature influenced pain tolerance and mood.
Vincent et al. (2010)	Photos of landscapes	BP, HR, Pain tolerance	Medicine	Negative features (e.g., hazard) of nature influenced pain tolerance, stress and mood.
White et al. (2010)	Photos of landscapes	Attractiveness, Mood, Restorativeness, Presence	Psychology	Nature was preferred more. Increasing aquatic features increased preference and mood. Adding water to nature increased restorativeness, only aquatic reduced restorativeness.

BP-Blood Pressure; BVP-Blood Volume Pulse; EEG- Electroencephalography; EMC- Electromagnetic Compatibility; HR-Heart Rate; SCL- Skin Conductance Level.

Results and Discussion

The initial search resulted in 4,573 articles. After assessing the title and abstracts of articles, a final total of 51 articles met the inclusion criteria. The articles used a wide range of self-reported and objective physical and psychological measures and provided evidence that INE promotes health and wellbeing (Table 2). A synthesis of the results is presented in Figure 5 illustrating the health promoting features of INE through the interaction of environmental and individual characteristics.

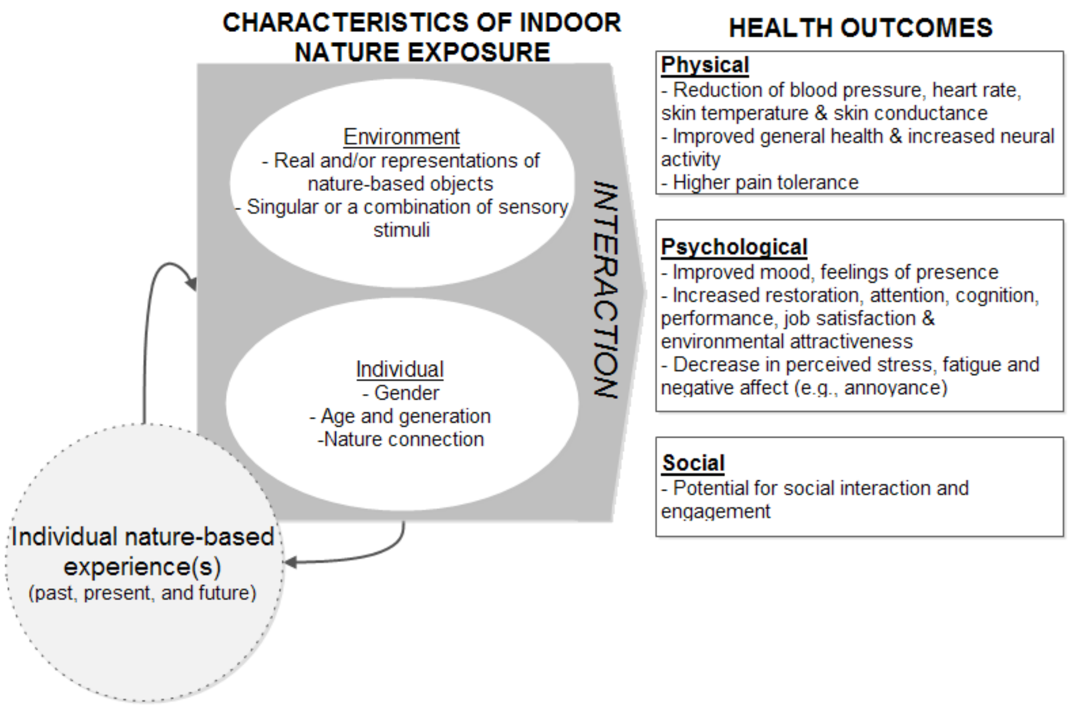

Figure 4. INE framework.

Health Outcomes

The review illustrates the physiological and psychological mechanisms present in the INE-health relationship. INE promotes health when individuals are presented with nature-based stimuli that they perceive as attractive, pleasing, and pleasant to all their senses. A range of physiological and psychological health benefits were identified (Table 2), such as:

- a decrease in physiological stress indicators (e.g., a reduction in heart rate, blood pressure, skin temperature);
- increased comfort (i.e., individuals felt INE created a reflective, restorative, relaxing, peaceful and pleasing environment);
- improved health (e.g., a reduction of headaches, itchy skin, dryness, sick leave and increased energy);
- higher pain tolerance;
- improved facets of mood such as increased relaxation and happiness, and decreased anger and frustration;
- higher self-rated quality of life and wellbeing; and
- better cognitive function (e.g., increased task performance, attention, memory).

Stress and Nature

One clear finding is that the physiological and psychological benefits of INE are often facilitated through stress-reduction and stress-recovery. These benefits have been examined through several nature-based theories including the Attention Restoration Theory (ART) (Kaplan, 1987; Kaplan & Kaplan, 1989) and the psychoevolutionary theory (PET) (Ulrich, 1983; Ulrich, Simons, Losito, Fiorito, Miles et al., 1991). The proponents of ART suggest that restorative settings remove an individual from their daily tasks, contain features that hold their attention with little effort (e.g., clouds, rustling leaves) and restores their ability to concentrate, allowing them to recover from stress (Kaplan, 1987). It is argued that these aspects are more likely to occur within a natural setting where one can have the sense of being removed from the everyday (i.e., urbanized) world, feel a part of a larger process, be in an environment that is rich in elements and stimuli that allow for recovery from mental fatigue, and be in harmony with an environment humans are pre-disposed to feel comfortable in. Through the PET, Ulrich (1983) and Ulrich et al. (1991) propose that our bodies create physiological reactions when presented with stressful environments that threaten our health (i.e., urban areas). Recovery from stress can occur in environments that are pleasant, calm, and moderately interesting to an individual by replacing negative affect (generated from stress) with positive affect, and reducing autonomic arousal (e.g., blood pressure). Much like ART, PET suggests that nature-based environments encompass features that promote and enhance stress recovery.

Early work from Ulrich (1979; 1981) Ulrich et al. (1991) on PET confirmed that physiological changes occur when an individual is exposed to nature. When viewing nature-based scenes, participants experienced increased alpha wave amplitudes, which is often associated with increased serotonin production (a neurotransmitter that is a primary target of anti-depressants and anti-anxiety medications) Selhub & Logan (2012) also suggest that exposure to INE can increase dopamine production, which elicits feelings of wellbeing, positive mood, and the perception of less stress. Thus, much like outdoor nature, INE can facilitate physiological changes in individuals that enhance both physical and psychological health.

The Social Impacts of INE

Only one study examined social aspects of health in the context of INE (Hartig & Staats, 2006), and found that photos of forest environments (nature) were significantly less socially stimulating than photos of urban environments. With such little research examining the social aspects of INE, it is difficult to deduce the social benefits of INE. Future research should consider the social benefits of INE, and the potential it has for creating communities within the built environment.

Environmental Characteristics

INE consisted of real (n=27) or representations (n=29) of nature-based items (e.g., plants vs. a picture of a plant) that elicited at least one sensory response with participants. Real nature-based items were typically plants (59%) or windows with a view of nature (37%), and representations of nature were often photographs, paintings or videos of plantscapes (85%) and landscapes (44%). While representations may produce positive health outcomes, direct comparisons of the effects of these depictions and real nature-based stimuli is limited (de Kort et al., 2006; Kjellgren & Buhrkall, 2010; van den Berg et al., 2003). Kahn et al. (2008) found greater stress recovery in the presence of a window with a nature view than in the presence of a plasma screen (representation) with the same view. Work from Kjellgren & Buhrkall (2010) found simulated nature-based environments were as effective at reducing stress as real environments, but were less preferred. Participants felt that “there was something missing” (p.470) and left them “longing to be in real nature” (p.470), suggesting that representations may not be a preferred substitute for nature, and raises questions of effectiveness and realism.

The majority of studies focused only on the impact of a single stimulus rather than the cumulative effect of a variety of sensory interactions. Two studies (Laumann et al., 2002; Li et al, 2009) evaluated non-visual experiences (e.g., sounds and scents) with nature-based items, whereas all others examined visual stimuli. The use of only a single and/or visual stimulus created an INE experience for participants that lacked rich sensory components that occur in outdoor environments, and likely limited an individual's ability to feel a sense of "presence"[4] or connection to the exposure (de Kort et al., 2006, p.312). Anecdotal work by Burns (1998) on nature-guided therapy suggests that auditory and olfactory interactions are particularly influential in creating psychological and physiological responses with nature. Moreover, research shows that the integration of sound and aromatherapy into healthcare setting reduces pain and stress in patients (Dijkstra, Pieterse & Pruyn, 2008), influences psychosomatic reactions (Edris, 2007; Hongratanaworakit, 2004) and boosts immunity (Li ei al., 2006). It is possible that presenting indoor nature stimuli that integrate visual, auditory, and olfactory sensory experiences will better replicate the experience of being outdoors and, thus, enhance the therapeutic benefits of INE.

Through this review, we also determined that the amount (e.g., the number of plants present) and type (e.g., flowers vs. plants) of INE to which an individual was exposed impacted outcomes. In some studies the amount of nature present was positively correlated with stress and higher ratings of unattractiveness, and negatively correlated with productivity (Larsen et al., 1998; Tsunetsugu et al., 2007; White et al., 2010); the color of the nature-based stimuli influenced individuals' preference for the object

[4] Presence refers to an emotive state of existing or being present in a particular place and is linked to enhanced wellbeing and may be a critical component in the therapeutic benefits of nature exposure (de Kort et al., 2006; Sanchez-Vives & Slater, 2005; van den Berg et al., 2003).

(Kaufman & Lohr, 2004; Li et al., 2012); and characteristics of a window view (e.g., park vs. garden) influenced satisfaction with surroundings (Felsten, 2009; Li et al., 2012; Kaplan, 2001). Careful consideration should be made when developing health promoting INE tools, as factors such as the amount, type, and details (e.g., color) of the nature-based stimuli are likely to influence the therapeutic outcomes.

Individual Characteristics

We found that individual characteristics (i.e., sex, age, and nature connection) may influence the health outcomes received from INE. Results showed that females, compared to males, have stronger preferences for nature and experience greater positive outcomes in the presence of nature (Kweon et al., 2008; Shibata & Suzuki, 2001, 2002), indicating a potentially significant interaction between sex and INE. While most of the articles examined the nature-health relationship with a sample that contained both males and females, sex was rarely considered a potentially confounding variable. Females typically have more exposure to plants (Lorh et al., 1996) and more familiarity with nature-based stimuli, which is associated with greater positive experiences with nature (Berto, 2007); and leisure and recreation research indicates that outdoor nature-based activities are a male dominated area (Boniface, 2006; Cimprich & Ronis, 2001). Future research should consider how males and females interact with indoor nature-based stimuli, and how these interactions impact the therapeutic outcomes.

Generation and age may also influence the relationship between INE and health. Research examining the restorative properties of nature indicates significant differences in preference and familiarity between older adults and adolescents, indicating that adolescents are less familiar with and less in favour of nature-based environments. Hinds and Sparks (2011) also found that individuals raised in rural settings or with greater experience with nature-based environments reported more joy and less apprehension to nature experiences than participants from urban childhood locations or with less experience with nature. The studies sample a range of individuals from 18-61 years of age; however, much like sex, age was never considered a potentially mediating variable.

INE: A health promotion framework

Outlined in Figure 5, INE occurs within indoor environments that contain real or representations of nature-based stimuli that engages a variety of senses (e.g., sight, hearing). Variations in the environment (e.g., real or representations of nature) and the individual (e.g., sex, age, nature connection) will impact the health outcomes observed and influence the therapeutic benefits and experience an individual receives from INE. Additionally, nature-based experiences across the life course will also impact the current and future INE experiences, indicating that INE experiences move and change across the life course.

This framework presents a starting point for the integration of INE into daily lives, and is supported by the Ottawa-Charter's call to create supportive and healthy environments for all populations (WHO, 1986). However, this review suggests that there are inherent challenges to this, as individual characteristics likely influence nature preferences and health outcomes. While individual characteristics have not been investigated as mediating factors in the INE-health relationship, it is important to consider their potential influence and resulting implications on the therapeutic benefits of INE.

Individual nature-based experiences

The heavy focus of psychology-based studies (Table 1) may account for the lack of qualitative results that are able to address socially, culturally, and individually constructed meanings of nature. Since the early 1970s, research has focused on exploring the experience of nature through emotions and physical feelings, and has revealed much about the diverse experiences individuals have when engaging with nature. While peoples' experiences are varied, the focus of this work has been on a common natural environment that is shared across and between groups of people. Regardless of similarities, experiences with nature can be, and are, personal and distinctive. Patterson et al. (1998) stated that an experience is "influenced by individuals' unique identities, their current personal projects, past experiences, and situational influences" (p. 244); this suggests that an individual's experience with nature is idiosyncratic, dynamic, and varies across the life course.

Neurobiological research indicates that an individual’s previous interactions with nature-based environments will influence their experience with INE. Biederman and Vessel (2006) suggest that visual stimuli associated with semantic memories (e.g., facts or knowledge) and episodic memories (e.g., personal experiences) will be more pleasing and interesting than stimuli associated with fewer memories. This is because triggering memories releases endorphins that create positive and pleasant feelings. Nature-based stimuli associated with more memories and experiences are thus likely to lead to greater positive feelings (Biederman and Vessel, 2006; Shibata & Suzuki, 2002). INE research to date has focused on the strength and impact of the nature-health relationship, rather than on how an individual develops relationships with nature-based places over time (Boniface, 2006). One study in this review (Larsen et al., 1998) focused on how people perceive indoor nature exposure and highlights this significant gap in the literature.

Limitations of the Review

This review provides a valuable synthesis of the nature-health research within an indoor setting, but is not without limitations. First, while the framework presents an overview of the INE health relationship, interpretation and application should be done with consideration to variations in INE definitions and methodological differences across studies. Second, it is possible that we missed relevant articles, as some databases have poor indexing. Third, the comprehensive process for the review (e.g., using snowballing to find additional sources in article bibliographies) can make replicating the search results difficult. Fourth, the restriction to articles published in English excluded relevant work done in Japan, China, and Korea (n=6), which may have contributed alternative evidence. Last, by limiting the selection of literature to published peer-review journals, the study may be susceptible to publication bias (Rosenthal, 1979). It is possible that the effectiveness of INE is exaggerated as studies showing negative results are less likely to be published.

Conclusion and Future Directions

This review synthesizes existing evidence to support the use of indoor nature as a health promoting resource (Figure 5). The benefits of nature have been recognized for centuries; however, the value of nature and place as a medicinal tool has been lost. The mixture of studies across disciplines (Table 2) demonstrates the growing interest in indoor nature and highlights the interdisciplinary context of this topic. It is hoped that the framework can begin to facilitate the integration of interdisciplinary approaches to understanding INE, and serve as a meeting grounds for future discourses. Creating interdisciplinary research agendas for INE may help refine the existing knowledge, and would highlight the complexity of nature-based health promotion mechanisms. Creating indoor spaces rich in nature may provide an effective means of promoting health inside and out, and embracing the proverbial 'roots' of medicine.

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CHAPTER 3 THE INFLUENCE OF MULTI-SENSORY INDOOR NATURE EXPOSURE (INE) ON PHYSIOLOGICAL STRESS MARKERS

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Abstract
Objectives: Research suggests that spending time in nature is beneficial for stress reduction and recovery. Using the properties of biophilic design, this study examined the influence of a multi-sensory and immersive nature-based indoor environment on physiological stress systems.

Methods: 147 (118 females) undergraduates were randomly assigned to either an experimental (indoor nature environment (INE)) or control condition. Participants were exposed to their condition for 20 minutes. Heart rate variability (HRV) assessed autonomic activity. Self-reported environmental assessments and individual demographics were measured.

Results: Results showed no differences between experimental groups and HRV. Repeated measures ANCOVAs revealed a main effect of time for AVNN (average N-N intervals), indicating differences irrespective of condition ($F_{(4,296)}= 3.2$, $p <.05$). Within-group analyses showed that INE suppressed the sympathetic nervous system over time, and provided recovery immediately after tasks. The experimental condition was rated more positively than the control. Within the control group, greater changes in HRV occurred in individuals who rated the environment negatively. Overall, participants' preference had more impact on HRV changes within the control group than the experimental.

Conclusions: Results suggest that environmental stimuli regulate stress functions and that INE may be an important health prevention tool. INE facilitated relaxation and reduced stressed, and provided recovery after attention demanding tasks. Examination of environmental preference showed that the INE condition was rated more positively than the control, and that individual preferences of the control influenced physiological changes more than the experimental condition.

Introduction

Over the last three decades, a body of literature has investigated the relationship between environment types (i.e., urban vs. natural) and human health, in particular, how our current living environments are contributing to the rising incidences of stress and stress related illnesses (Evans, 2003; Galea & Vlahov, 2005; Velarde, Fry & Tveit, 2007). This work suggests that urban, or built environments, have negative effects on our health and contribute significantly to stress. Other work on 'Shinrinyoku', also known as forest bathing, show that engaging in outdoor natural environments positively impacts stress, as seen in a decrease in blood pressure, reduction of cortisol, and stabilization of respiratory activity (Lee, Park, Tsunetsugu, Kagawa & Miyazaki, 2009; Park, Kasetani, Tsunetsugu, Kagawa & Miyazaki, 2010). It has been hypothesized that these physiological reactions are attributed to a dependent relationship humans have with the natural environment and our current disconnection from nature (Wilson, 1984).

The biophilia hypothesis (Wilson, 1984) suggests that humans have an innate affiliation towards nature and natural stimuli, as the human brain and body evolved in nature and had significant consequences on lifestyle and procreation behaviours (Park, Tsunetsugu, Ishii, Furuhashi, Hirano et al., 2008). Aspects of the natural environment increased our ancestors' chance of survival by fostering a sense of safety and rejuvenation; and for these reasons, contact with nature has a significant association with restoration and relaxation (Lorh & Pearson-Mims, 2000; Wilson, 1984). Ecopsychology suggests that a strong connection to and relatedness with nature promotes human health, and that a bi-product of a largely urban and indoor lifestyle is a disconnection from nature, which has led to poorer health outcomes (Kellert, 1997). Nature relatedness (NR) is believed to be the degree to which an individual sees themselves and the natural world as connected (Mayer & Frantz, 2004), and may directly influence the physiological benefits from being in nature (Kjellgren & Buhrkall, 2010; Ottosson & Grahn, 2005). Little is known about how individuals' preference for nature and NR impact the benefits they received from INE, but Bratman et al. (2012) suggest that both of these factors may influence the outcomes of nature exposure and ultimately shape the physiological benefits one receives from INE.

Research has demonstrated a direct correlation between nature exposure and restorative and stress-reducing health outcomes (Hartig et al., 2013; Kaplan & Kaplan, 1989; Ulrich, Simons, Losito, Fiorit, Miles & Zelson, 1991). Building on the biophilia hypothesis, the “Stress Recovery Theory” proposes that physiological stress is associated with psycho-evolutionary emotional processes (Ulrich, 1983; Ulrich et al., 1991). When environments are perceived as being pleasing, the body responds with feelings of wellbeing, calmness and a relief from stress (i.e., restorative responses). Stress recovery can be facilitated through an increase in positive affect associated with environments we prefer, which is most often nature (Ulrich, 1983), and is reflected in physiological changes and responses to these preferences (Thayer, Hansen, & Johnsen, 2010). Examining nature and health within the context of the Stress Reduction Theory, research has concluded that natural environments reduce self-rated stress and influence biomarkers associated with the reduction of physiological stress (Berto, 2005; Cole & Hall, 2010; de Vries et al., 2003; Evans, 2003; Hartig et al., 1991, 2003; Park et al., 2010).

Environmental surroundings can have a significant impact on the body’s stress-related physiology (Laumann, et al., 2003), and it is important to understand how stress is physiologically manifested. Stress can be simply defined as an individual responding to mental, social, environmental and/or physical demands (Schnell, Potchter, Epstein, Yaakov, Hermesh, et al., 2013). While stress can impact a variety of reactions (e.g., behavioural), it most notably affects the performance of the autonomic nervous system (ANS), which consists of the sympathetic and parasympathetic nervous systems and regulates biological responses (Jonsson, 2007; Vente, Olff, Amsterdam, Kamphuis & Emmelkamp, 2003; Viamontes & Nemeroff, 2009). Depending on the change in the ANS system, one can feel relaxed, aroused, stressed, or rejuvenated. In fact, exposure to nature can immediately stabilize respiration and blood pressure in stressed individuals (Annerstedt, 2011; Chang & Chen, 2005; Ulrich, 1983). These responses are an internal environment (i.e., the body) adapting to external cues, stimuli and responses, and are instantaneous sympathetic reactions of the ANS (i.e., increases in respiration and heart rate (HR)) causing the body to engage in the adaptive 'flight-or-fight' response to external stress (Fich et al., 2014). Alternatively, parasympathetic responses of the ANS control relaxation and recovery, and when the sympathetic nervous system is suppressed, parasympathetic responses facilitate feelings of calmness and induce a relaxed state. When exposed to natural environments and stimuli, the parasympathetic system is activated, while the sympathetic system is suppressed, leading to physiological stress reduction and recovery (Brown, Barton, & Gladwell, 2013; Gathright, Yamada, Morita, 2006; Park et al., 2007, 2008, 2010, 2011).

The restorative influence of nature appears to be partly due to stress reduction mechanisms and is gaining increased interest from health researchers (Frumkin, 2001), as reports indicate higher stress and more incidences of stress-related co-morbidities across populations (Dustin, Bricker & Schwab, 2010; Fich, et al., 2014; Maller, Rownsend, Pryor, Brown & St. Leger, 2005). However, most individuals spend more than 90% of their time indoors (Evans & McCoy, 1998; Klepsis, Nelson, Ott, Robinson, Tsand et al., 2001; Schweizer, Edwards, Bayer-Oglesby, Gauderman, Ilacqua et al., 2007), suggesting it may be important to consider how natural features can recreate the experience of being outdoors within indoor built environments to reduce stress and increase resiliency (McSweeney, Rainham, Johnson, Sherry, & Singleton, 2015; Parsons, Tassinary, Ulrich, Hebl & Grossman-Alexander, 1998). Through the properties of biophilia, design can capture natural dimensions and characteristics within the built environment (e.g., natural sunlight, plants, pictures of landscape; Kellert, 2005), and offer the benefits of being in nature, within indoor environments.

Using biophilic design, indoor nature exposure (INE) is a pathway for adapting the built environment to reflect the restorative properties of nature, and may be an important tool for preventative medicine and health promotion (McSweeney et al., 2015; Ulrich, 2002). However, despite the growing interest and popularity of nature exposure on human health, little scientific evidence for its physiological effects currently exists within the context of INE, and more individual-level and ecologically valid studies capturing exposure to environmental factors are needed (Schnell et al., 2013). The current study attempts to address this gap, by investigating how a multi-sensory and immersive nature-based indoor environment influences human health through physiological stress systems. The goals of this study were (1) to examine the physiological effects of INE by investigating changes in time and frequency domain indices of Heart Rate Variability (HRV) which represent stress responses (Hainsworth, 1995; Jonsson, 2007; Schnell et al., 2013); and (2) produce additional evidence demonstrating the therapeutic effects of nature through measuring changes in HRV while subjects were exposed to either a nature-based indoor environment or a control condition without nature.

Methods

One hundred and forty-seven participants were recruited, and represent a convenience sample of undergraduate psychology students. Students were ineligible to participate if they had a known cardiovascular illness, an allergic reaction to organic-based scents, consumed caffeine and/or alcohol, and/or engaged in moderate to heavy physical activity (e.g., running, strenuous weight lifting) at least 12 hours prior to their participation.

Measures.

Physiological stress. Immediate ANS reactions (i.e., physiological stress responses) can be observed through HRV (Hainsworth, 1995; Jonsson, 2007), which is a non-invasive measure of the functioning of the parasympathetic and sympathetic nervous system, and can be used to investigate changes to physiological stress (Dekker et al., 2000; Task Force of the European Society of Cardiology and the North American Society of Packing and Electrophysiology, 1996). HRV was recorded using the PowerLab 16/30 (AD Instruments, 2009) with three electrodes attached to participants' chest. PowerLab corrected data artifacts and ecotpic beats, and average R-R interval data (milliseconds, msec) were calculated for task intervals (Figure 5). R-R is the time interval measured from the peak of the QRS complex (the section of the ECG that corresponds with the depolarization of the heart), to the peak of the next complex, and represents the ventricular HR (Berntson et al., 1997). Intervals between sinus beats (NN) was calculated as a representation of HR, where msec is an inverse relationship to beats per minute (bpm). Using the maximum entropy method, the frequency domain of HRV was calculated (Kobayasi, Ishibashi & Noguchi, 1999; Ohtomo, Terachi, Tanaka, Tokiwano & Kaneko, 1994). Two major components of HRV were calculated: the low-frequency (LF, 0.15-0.4 Hz) and high-frequency (HF, 0.04-0.15 Hz; ESC/NASPE, 1996). HF power of HRV reflects parasympathetic nervous activity (Capcioppo et al., 1994), and sympathetic dominance can be calculated through the ratio of LF/HF.

Pre-exposure questionnaires completed (10 min)	5 min exposure to condition	Participants complete SAM (10 minutes)	Participants complete DST (5 min)	Post-exposure questionnaires completed (5 min)
T1	**T2**	**T3**	**T4**	**T5**

Figure 5. Experimental timeline, where T* represents the average over that period of time.

Environmental assessment. The Environment Assessment Scale (EAS) (Rohles and Milliken, 1981) is a nine-point scale (1 = *most desirable*, 9 = *least desirable*) that consists of 13 adjective pair. The EAS measures an individual's feelings in response to their environment. The scale has been used to evaluate the affective characteristics of the environment and the attributes/characteristics within it (Lavianna, 1985; Laviana et al., 1983).

Stress and health. The Student-Life Stress Inventory (SLSI) measures students' academic stressors and reactions to stress (Gadzella, 1991, 2004). The SLSI is comprised of 51-items that are rated on a five-point likert scale ranging from 1 (*never*) to 5 (*most of the time*). The scale is broken down into two sections and nine sub-scales including pressures, self-imposed stress, and physiological and emotional reactions to stressors.

Studies on the reliability and validity of the instrument (Gadzella & Baloglu, 2001) have found it to be an acceptable measure of stress in both college males and females. The SLSI was used as a potential covariate to represent school-related stress within participants' lives.

<u>Nature Relatedness</u>. The Short Form Version of the Nature Relatedness Scale (NR-6) is a six-item likert-scale that measures how an individual views their relationship with the natural world (Nisbet & Zelenski, 2013). The scales ranges from 1 (*disagree strongly)* to 5 (*agree strongly)*. Sample items include "My ideal vacation spot would be a remote, wilderness area", and "My relationship to nature is an important part of who I am". The NR-6 was examined as a potential covariate.

<u>Environmental exposure</u>. Using the principals of biophilic design, an INE condition was created. This condition (Figure 6) included a desk and chair facing a window providing natural light and a view of a mixed urban landscape (e.g., campus buildings, trees, and partial view of the ocean), green leafed plants, a painting of a landscape, nature sounds, and an oil diffuser containing organic pine oil. The control condition included the same desk and chair, had the window covered, and did not feature any plants, paintings, nature sounds, or pine oil scent.

Figure 6. Experimental condition (left) and control condition (right).

Filler tasks. The Search and Memory test (SAM) (Smith & Miles, 1987) is a measure of attention performance (e.g., speed and accuracy of completion), and is a collection of puzzles that asks participants to memorize target letters, and search for them within rows of randomized letters. Participants also completed the Digit Span Test, a standardized measure of attention. The researcher read off a sequence of random digits at a pace of one number per second, and participants were required to recall the numbers back in order. The test began at two numbers and finished at nine. Completion of the test was either at the end of the sequence of nine numbers, or when participants incorrectly recalled a set of two sequences consecutively. The final score is the mean proportion of correct numbers.

Procedure. Participants were randomly assigned to either the experimental or control condition upon recruitment. Participants were equipped with three ECG leads, and using the PowerLab 16/30, HRV was recorded. Participants completed a series of questionnaires that asked them about their connection with nature, self-rated stress, and individual demographics. They were then asked to quietly sit in the exposure condition for five minutes, after which they completed a series of filler tasks for an additional 15 minutes. Once all filler tasks were finished, participants completed a final collection of questionnaires and physiological recording was stopped.

Analysis. Baseline data (i.e., Time 1) were compared using paired student's *t*-tests. Repeated measures analyses of covariance (ANCOVA) were used for analyses of physiological measures (e.g., average NN intervals (further referred to as AVNN), HF and LF/HF), with time as the within-subject repeated factor, experimental condition as the between-subject factor and demographic covariates (investigated through bivariate correlations, $p < 0 .05$). Significant effects were reported with Huynh-Feldt adjustments (ε) to correct for violation of the assumption of sphericity, together with unadjusted degrees of freedom, adjusted *p*-values, and Eta^2. Spearman's rank correlations between the change in HRV between T1 to T5 and environmental preference examined if perceptions of the environment influenced physiological stress.

Results

Demographics. One hundred and forty-seven individuals (118 females, 29 males) aging from 18 to 50 years ($M = 21.4$, $SD = 4.2$) participated in the study. Participants were in their first to sixth program year ($M = 2.1$, $SD = 1.2$); and 53.1% ($n = 78$) reported not being employed, while 35.4% ($n = 52$) reported working part-time. Participants' average nature relatedness (NR) scores were 3.2 ($SD = 0.8$, $\alpha = .82$), with no difference in NR between experimental ($M = 3.2$, $SD = 0.9$) and control ($M = 3.3$, $SD = 0.9$) conditions ($F_{(1,145)} = .45$, $p = .50$, $\eta^2_p = .003$). Overall, participants had a SLSI score of 140.5 (*SD* =

22.97, α = .77). SLSI scores did not differ between the experimental (*M* = 140.74*, SD* = 23.74) and control (*M* = 140.26, *SD* = 22.33) group ($F_{(1,140)}$ = .02, *p* = .90, η^2_p = .00), indicating that participants in both groups were experiencing similar levels of academic stress at the time of the study. Bivarate correlations between individual demographics, NR, and HR, HF and LF/HF for each time point indicated significant relationships between SLSI scores at $p < .05$ for HR, and sex and age at $p < .01$ for HF, and were therefore included in all subsequent analyses as potential covariates. NR was not significantly correlated with any HRV markers at any time points, and was not included in additional analyses.

Table 3. Results of the two-way repeated measures ANCOVA of heart rate variability (HRV).

	Main Effect				Interaction	
HRV	**Condition**		**Time**		**Condition x Time**	
	F	***Eta²***	***F***	***Eta²***	***F***	***Eta²***
AVNN	0.113	0.001	3.18*	0.03	1.76	0.02
HF	0.52	0.01	0.26	0.003	0.42	0.01
LF/HF	0.72	0.01	0.12	0.001	1.62	0.02

AVNN: Average intervals between sinus beats (NN), a representation of HR.
HF: High-frequency (range of 0.04-0.15 Hz), reflects parasympathetic nervous activity.
LF/HF: Ratio of low frequency to high frequencies, a measure of sympathetic dominance.
*$p < .05$.

Physiological stress. The groups did not significantly differ ($p < .05$) at T1 (baseline) on any of the HRV indices, suggesting that any subsequent changes were likely due to experimental conditions. Repeated measures ANCOVA (Table 3) revealed a main effect of condition for AVNN, indicating differences over time irrespective of condition ($F_{(4,296)}$ = 3.2, $p < .05$). No other main effects or interactions were present between groups.

Table 4. Physiological measures within conditions.

HRV		Experimental			Control		
		Mean (SD)	***F***	***Eta²***	***Mean (SD)***	***F***	***Eta²***
AVNN	*T1*	529.54 (105.27)	4.84**	.08	540.75 (131.87)	0.83	.01
	T2	540.76 (115.53)			542.74 (139.65		
	T3	548.58 (116.50)			547.13 (134.86)		
	T4	538.87 (107.95)			532.25 (126.04)		
	T5	556.86 (115.92)			543.05 (144.22)		
HF	*T1*	342.14 (480.95)	.12	.00	287.29 (332.53)	1.04	.03
	T2	349.75 (477.82)			425.68 (636.41)		
	T3	309.20 (424.09)			422.12 (518.08)		
	T4	352.70 (465.47)			495.23 (575.0)		
	T5	356.54 (535.0)			403.89 (732.03)		
LF/HF	*T1*	3.21 (2.48)	.50	.01	2.82 (1.71)	.83	.02
	T2	2.75 (1.59)			3.17 (1.94)		
	T3	2.73 (1.34)			2.66 (1.36)		
	T4	2.61 (1.82)			3.17 (3.28)		
	T5	2.59 (1.49)			2.69 (1.54)		

AVNN: Average intervals between sinus beats (NN), a representation of HR.
HF: High-frequency (range of 0.04-0.15 Hz), reflects parasympathetic nervous activity.
LF/HF: Ratio of low frequency to high frequencies, a measure of sympathetic dominance.
** $p < .01$.

Further inspection of AVNN differences within conditions (Table 4, Figure 7), revealed significant differences over time for the experimental condition, but not the control. Figure 7 shows significant differences between T1 - T3 ($p < .01$), T1 - T5 ($p < .001$), T2 - T5, ($p < .05$), and differences approaching significance for T1 - T2 ($p = .086$**)** and T4 - T5 ($p = .056$). While both groups follow a similar reduction in HR between T1 - T3 (i.e., an increase during the filler task (T4) and then a decrease after the filler tasks), these changes are significantly greater for the experimental group, suggesting that INE provided stress recovery immediately after a stress-inducing cognitive task (i.e., T4 increase in AVNN), as well as over time (i.e., significant increase between T1 and T5).

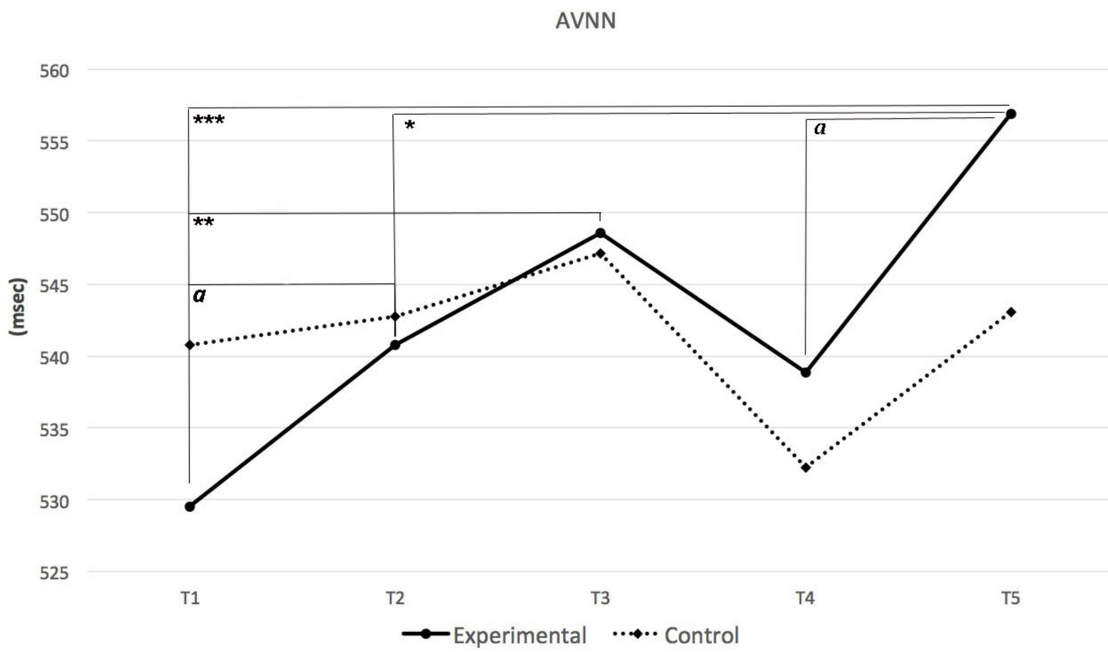

Figure 7. Average change in N-N intervals for all time points between groups.

Figure 8 shows that HF power in the control was higher than that of the INE group, and suggests that, while not significantly different (Table 3 and 4), participants in the control condition experienced a change in parasympathetic nervous system dominance unlike the experimental condition. Figure 9 shows LF/HF ratio values of HRV, which mediate the activity of the sympathetic nervous system. While no significant differences were found between the two experimental groups (Table 3), LF/HF consistently reduced over time in the experimental condition, and was significantly lower at Time 5 than at baseline (Time 1), suggesting that over time, INE significantly suppressed the sympathetic nervous system, and reduced physiological stress responses.

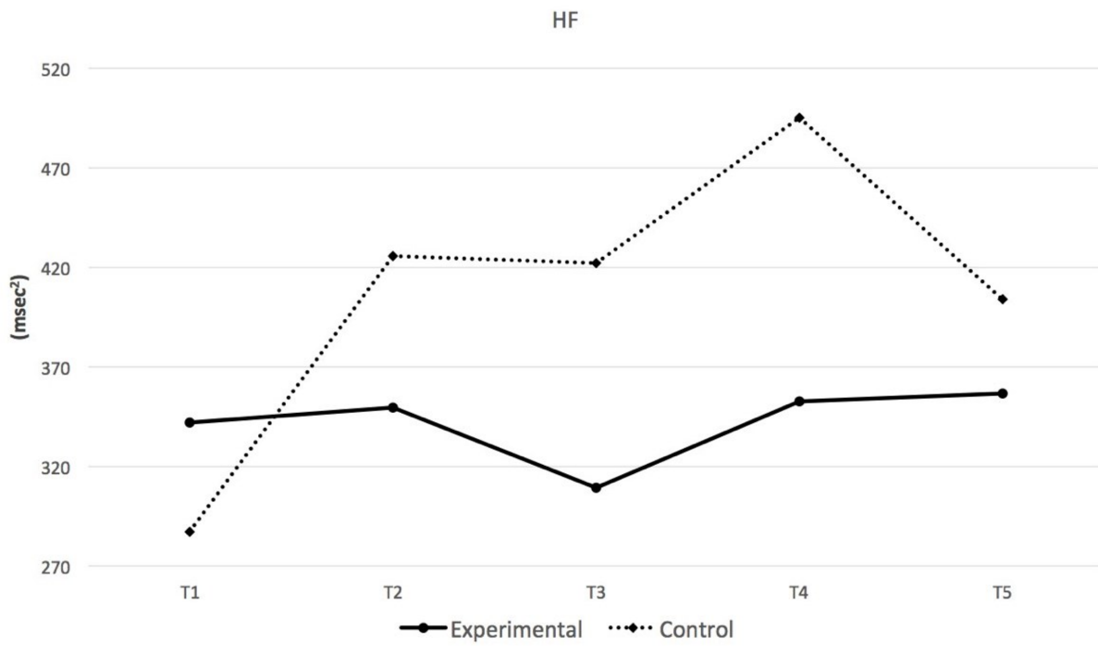

Figure 8. Average change in HF power for all time points between groups.

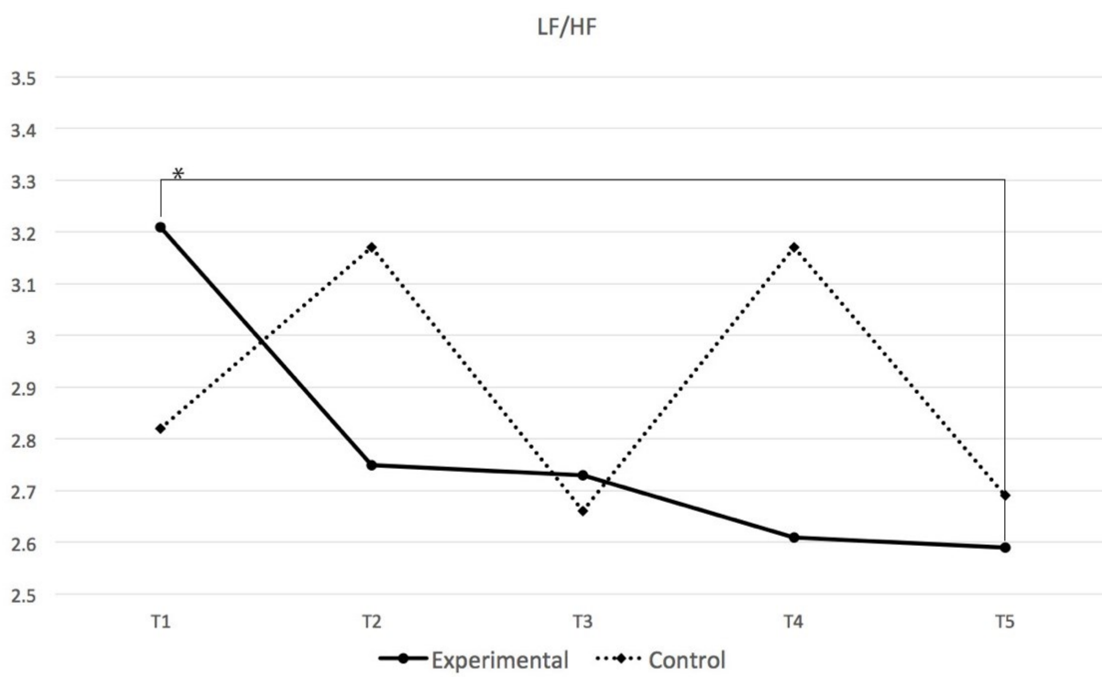

Figure 9. Average change in LF/HF ratio for all time points between groups.

Filler tasks. Both experimental groups identified an average of 8 target letters, and scanned nearly 600 letters during the SMT. Both groups completed an average of 10 correct digits on the digit-span forward, and 7 on the digit-span backwards. Groups did not differ on either filler task (Table 5) suggesting that INE did not impact attention and/or cognitive performance during exposure.

Table 5. SMT, DF and DB between conditions.

	Experimental	**Control**		
	Mean (SD)	***Mean (SD)***	***F***	***Eta²***
SMT Accuracy	7.93 (4.75)	7.72 (4.93)	.09	.001
SMT Speed	596.64 (191.04)	608.99 (204.33)	.15	.011
Digit-span Forward	10.44 (2.52)	10.48 (2.40)	.00	.00
Digit-span Backwards	7.00 (2.56)	6.91 (2.47)	.10	.001

Environmental Preference. Excluding "quiet - noisy", participants in the experimental condition rated their surroundings as significantly more desirable on all EAS items (Table 6). Items that had the greatest differences between conditions were "colorful - drab" and "attractive - unattractive". Participants in the experimental group rated their environment as more colorful (M = 3.87) compared to control, which rated their condition as more drab (M = 6.36). Similarly, experimental participants rated their condition more attractive (M = 3.3) compared to the control (M = 5.32).

Table 6. Means (standard deviations) of EAS items between conditions.

	Experimental	**Control**		
EAS Items	***(1-9 scale)¥***		***F***	***Eta²***
Satisfying - annoying	2.38 (1.29)	3.65 (1.75)	22.89***	.15
Clean - dirty	1.34 (.53)	1.94 (1.11)	15.92***	.11
Relaxing - stressing	1.97 (1.07)	3.64 (1.89)	39.93***	.23
Comfortable - uncomfortable	2.01 (1.11)	3.68 (1.92)	37.98***	.22
Colorful - drab	3.87 (1.43)	6.36 (1.82)	78.68***	.37

Happy - sad	2.97 (1.41)	4.86 (1.63)	51.80***	.28
Pleasant smell - unpleasant smell	3.32 (1.61)	4.33 (1.28)	16.05***	.11
Bright - dull	2.58 (1.64)	3.74 (2.0)	13.51***	.09
Spacious - crowded	3.34 (4.49)	4.49 (1.72)	15.03***	.10
Calming - irritating	2.44 (1.32)	4.22 (1.65)	12.78***	.26
Warm - cool	2.96 (1.59)	4.01 (1.69)	13.58***	.09
Attractive - unattractive	3.30 (1.52)	5.32 (1.65)	54.65***	.29
Quiet - noisy	2.21 (1.72)	2.46 (1.82)	.46	.003

¥ 1 - Most desirable, 9 - Least desirable.
*** $p < .001$.

Overall differences in HRV measures between groups show several significant correlations between environmental preference and physiological stress reduction (Table 7). Within the control group, greater changes in AVNN and HF occurred in individuals who rated the environment as sad, unpleasant smelling, dull, irritating and noisy. While the experimental group had greater suppression of the sympathetic nervous system (i.e., reduction in stress) when they rated the condition as quiet. Overall, participants' preference of the control condition appeared to have more impact on HRV changes than the preference for the experimental.

Table 7. Correlations between T1 and T5 HRV differences by EAS items.

	Experimental			Control		
EAS Items	*AVNN*	*HF*	*LF/HF*	*AVNN*	*HF*	*LF/HF*
Satisfying - annoying	.09	-.03	-.17	.14	.07	-.07
Clean - dirty	.22	-.03	-.17	.09	.05	-.12
Relaxing - stressing	.16	.09	-.14	.18	-.03	-.07
Comfortable - uncomfortable	.23	.025	-.17	.05	-.02	-.06
Colorful - drab	.08	-.14	-.15	-.02	-.04	.15
Happy - sad	.18	-.001	-.09	.26*	-.09	-.08
Pleasant smell - unpleasant smell	.08	-.100	-.13	.25*	.05	-.02
Bright - dull	-.03	-.03	.02	.48**	-.21	-.02
Spacious - crowded	.11	.22	-.15	.23	.04	-.20

Calming - irritating	.05	-.04	-.09	.30*	-.05	-.09
Warm - cool	.01	-.08	-.14	.13	-.20	.12
Attractive - unattractive	.08	-.19	-.09	.01	-.24	.21
Quiet - noisy	.05	.05	-.27*	.12	*.03	.005

AVNN: Average intervals between sinus beats (NN), a representation of HR.
HF: High-frequency (range of 0.04-0.15 Hz), reflects parasympathetic nervous activity.
LF/HF: Ratio of low frequency to high frequencies, a measure of sympathetic dominance.
* $p < .05$. ** $p < .01$.

Discussion

More work on the physiological effects of nature exposure is needed to inform clinical investigations into the benefits of nature for human health (Park et al., 2010). This study is one of the first to investigate how INE impacts physiological health outcomes, and contributes to the growing body of literature calling for greater evidence to support the preventative and therapeutic benefits of INE. Using the properties of biophilic design, this study sought to understand how a multi-sensory and immersive nature-based indoor environment influenced physiological stress. Results showed no differences between experimental groups and HRV. However, within-group analyses suggest that INE suppressed the sympathetic nervous system over time, and provided stress recovery immediately after attention demanding tasks, as indicated by increases in N-N intervals and a significant reduction in LF/HF ratios. Previous work on nature exposure has found similar suppression of the sympathetic nervous system during exposure to forest environments (Lee et al., 2011; Park et al., 2010; Yamaguchi, Deguchi, & Miyazaki, 2006) and viewing images of forests (Brown et al., 2013; Hartig et al., 2003; Laumann et al., 2003; Park et al, 2008; Ulrich, 1981; Ulrich et al., 1991), and suggests a dominance of parasympathetic activity which is typically observed in conditions that promote relaxation (Lee et al., 2011). This is further supported by significant increases in N-N intervals, which is a major component of physiological stress response and is usually elevated in reaction to stress (Laumann et al., 2003). Therefore, results suggest that INE allowed participants to feel relaxed and less stressed, and may act as a tool for preventative health interventions (Brown et al., 2013).

According to the Attention Restoration Theory (ART; Kaplan 1983; 1995), natural settings may allow for restoration after the depletion of attentional resources, and the results from this study suggest that INE may be a source of stress recovery after attention demanding tasks. INE was rated as more relaxing, calming, comfortable and happy compared to the control condition, which indicates that INE may have provided a restorative environment that facilitated recovery from mental fatigue and stress. This environmental perception corresponds with other studies that show individuals find natural settings to be more relaxing, calming and comfortable (Park et al., 2008; Shin, 2007). Unlike previous studies that have found improved cognitive performance after INE (Berman, Jonides, & Kaplan, 2008; Cackowski & Nasar, 2003; Raanaas et al., 2011), filler tasks assessing attention and cognitive performance showed no differences between the two experimental groups. The absence of a mentally fatiguing task prior to exposure may have caused INE to act as a buffer during stress recovery (Brown et al., 2013). Future work should consider the timing of tasks in relation to exposure, and whether or not cognitive performance is altered.

Environmental preference evaluations show that those in the INE condition rated their environment more positively than those in the control, and that individual preferences of the control environment influenced physiological changes more than the experimental condition. Work on environmental perception has shown that a sense of sight, hearing and smell are important in field experiments examining the nature-health relationship (Ulrich, 1981). Natural environments are multi-sensory, and consist of many kinds of stimuli. This study was the first of its kind to investigate how a multi-sensory and immersive indoor nature environment influenced physiological stress when exposed to nature through the built environment. Environmental characteristics may be an important factor to consider in the design of INE. The flight-or-fight stress systems theory, in which an organism determines its behavior based on an appraisal of immediate threat (Burns, 1998; Cannon, 1914; Schnell et al., 2013), suggests that characteristics associated with sound (Schnell et al., 2013; Dijkstra, Pieterse & Pruyn, 2008), spatial openness (Finch et al., 2014), colours (Kaufman & Lohr, 2004), and scent (Edris, 2007; Jin et al., 2009) may trigger stress responses unknowingly. For example, characteristics of surrounding environments might be mediated through spatial features (e.g., size of room, open layout), and those characteristics, such as whether escape is possible, might influence the magnitude of stress reaction (Fich et al., 2014). Future work should examine the cumulative effects of a variety of sensory interactions and how spatial characteristics of INE may mitigate the impacts of nature exposure on stress reduction and recovery.

The results of the study confirm previous research that suggests environmental stimuli regulate ANS functions. Research suggests that this may be a 'top-down mechanism' (Brown et al., 2013, pp. 5567) beginning within the brain (Brown et al., 2013; Gladwell, Brown, Barton, Tarvainen, Kuoppa et al., 2012; Lederbogen, Kirsch, Haddad, Streit, Tost et al., 2011). When viewing urban scenes, fMRI images show increased activity in the amygdala (which is associated with emotional control), compared to when viewing nature scenes (Kim, Jeong, Kim, Baek, Oh et al., 2010). This activity is likely to engage the ANS (Brown et al., 2013; Lederbogen et al., 2011; Thayer & Lane, 2009), and may be responsible for the parasympathetic and sympathetic nervous system changes seen in this study. The suppression of the parasympathetic nervous system occurs within the prefrontal cortex which sends signals through the amygdala, and engages the body's flight-or-fight response. INE results from the current study suggest that the parasympathetic nervous system was dominant, indicating an absence of threat within the INE condition (Brown et al., 2013).

The current study examined a short duration of exposure (20 minutes), which is known to increase HRV (Brown et al., 2013; Gladwell et al., 2012). It is unknown if additional time would enhance the changes seen in the current study; however, recent work within laboratory settings suggests that even an additional 5 minutes of INE exposure would not be as effective as the primary dosage (Brown et al., 2013), and would likely not enhance the current results. Regardless, much work needs to be done to understand the impact of INE duration on stress reduction and recovery and future work should consider optimal lengths (McSweeney et al., 2015).

While the primary objective of this study was to assess the impact of INE on physiological stress, and additional point to note is the lack of a relationship between HRV and nature relatedness (NR). NR is believed to be the degree to which an individual sees themselves and the natural world as connected (Kals, Schumacher, & Montada, 1999; Mayer & Frantz, 2004), and views themselves as a part of nature (Schultz, 2002). Research on nature exposure suggests that individuals' previous experience and connection with nature influences the benefits they receive from exposure (Kjellgren &

Buhrkall, 2010; Ottosson & Grahn, 2005), and has been linked with varying levels of mood (Nisbet, Zelenski & Murphy, 2011), and higher positive appraisal of natural environments (McSweeney, Rainham, Sherry, Johnson, & Singleton, 2015). Recent research has suggested that work needs to be done to understand if this relationship mediates stress recovery and restoration (Brown et al., 2013; McSweeney et al., 2015), and this was the first study to investigate individual beliefs about nature on HRV outcomes. The results showed that NR was not related to differences in physiological stress; however, it seems important to note that subjective and psychological factors of the human-nature relationship are mediated by NR (Nisbet et al., 2011), but that nature is physiologically beneficial regardless of an individual's NR.

There are a number of limitations associated with the results. The study included healthy undergraduate students, making the results unrepresentative of the population regarding age and health. The results also only identify INE as a potential tool in the reduction of brief stress, and any implications on chronic or prolonged stress is unknown (Finch et al., 2014). Work has shown the restorative benefits of viewing nature; a substantial amount of this research has also demonstrated the stress inducing influence of viewing urban images (Berman et al., 2008; Herzog, Maguire & Nebel, 2003). The view from the INE condition contained mixed urban landscape, and may have unknowingly influenced HRV. Lastly, it is known that respiration and control of respiration directly influence sympathetic and parasympathetic activity (Billman, 2013; Thayer et al., 2010). The current study had participants stay in a sitting position throughout the duration of the experiment, but participants' respiration was neither measured nor controlled.

Conclusion

Given the rising rates of stress and stress-related illnesses (Kim et al., 2010; Lederbogen et al., 2011), INE may play an important role in preventative medicine given the potential to promote stress-reduction and recovery. The current study indicates that indoor nature exposure can effectively relax and provide restoration, which is the result of the domination of parasympathetic activity. INE appears to increase autonomic recovery to stress, and provides a rationale for incorporating biophilic design into indoor environments. Schools, workplaces, hospitals and homes may use INE as an effective tool for stress reduction and recovery.

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CHAPTER 4 THE USE OF A MULTI-SENSORY INDOOR NATURE-BASED ENVIRONMENT ON MOOD

Title: The use of a multi-sensory indoor nature-based environment on mood.

Submitted to: *Environment and Behaviour* (April 2016).

Abstract

Background: Creating indoor environments that reproduce the experience of being in nature may prove to be as beneficial to an individual's mood as being outdoors. This study examined how a multi-sensory nature-based indoor environment impacted both positive and negative affect, and the role of environmental preference and nature relatedness in this relationship.

Methods: One hundred and forty-seven undergraduate students (118 females) were randomly assigned to an experimental (an environment with nature sounds, pine-oil scent, plants, and a view of the outside) or control (an environment with no nature sounds, scents, plants or view) condition. Participants completed a series of pre- and post-exposure questionnaires, including measures of mood, environmental assessment, and nature relatedness.

Results: There were no significant differences between positive or negative affect (PA or NA) between groups. Within subject differences show significant changes in pre- and post-exposure PA scores for the experimental ($p < 0.05$), but not the control group. The experimental condition was rated as significantly greater in environmental preference, and those who viewed their environment as more attractive reported greater changes between pre- and post-exposure PA. Nature relatedness had no impact on environmental ratings for the control group, but was associated with finding the experimental condition more preferable.

Conclusion: The use of INE offers an opportunity to adapt indoor environments in order to provide a variety of health benefits and reconnect humans to nature. Results found that indoor nature exposure provided a significant boost to mood, and that there is a

bidirectional relationship between environment preference and mood, which nature relatedness influences.

Introduction

Investigation of human-environment relationships shows that time spent in nature has a positive effect on mood. For example, visual and/or physical access to natural spaces near work or home reduces stress, regardless of sex, age or socioeconomic status (Grahn & Stigsdotter, 2003; Stigsdotter, 2004); and research from Japan on "Shinrinyoku" (i.e., forest bathing) shows that spending time outdoors in nature promotes positive mood, decreases negative mood, and reduces stress (Lee, Park, Tsunetsugu, Kagawa & Miyazaki, 2009; Ohtsuka, Yabunaka & Takayma, 1998; Park, Tsunetsugu, Kasetani, Kagawa, & Miyazaki, 2010; Park, Tsunetsugu, Kasetani, Morikawa, Kagawa et al., 2009; Wu & Lanier, 2003).

One mechanism that may explain the benefits of nature exposure is our innate psychophysiological connection to nature, outlined in the stress-reduction theory (Ulrich, 1983). This theory proposes that much of the process of human evolution has been situated in natural environments, and when exposed to nature, we interpret the experience as pleasant, calm and engaging. These feelings or emotions about our surroundings create an affective restorative response where stress-generated negative affect is exchanged with positive affect (Ulrich, 1983; Ulrich, Simons, Losito, Fiorit, Miles & Zelson, 1991). For example, patients in clinical settings perceive their environment as more relaxing (e.g., welcoming, cheerful and less stressful) (Stiles, 1995), and more attractive (Dijkstra, Pieterse & Pruyn, 2008) when waiting areas include interior plants. This influence of nature contact is not limited to 'real' nature (e.g., flora and fauna) but can also be extended to representations and nature-based imagery. Photographic images of various plants and landscapes, when compared to images of urban landscapes, are more likely to be rated as relaxing, peaceful and satisfying (Hartig et al., 1996; Kim et al., 2010; Leather et al., 1998). Thus, the notion of stress-reduction is supported through an involuntary evolutionary interaction between people and nature.

While being exposed to nature, even for brief periods, produces measurable changes in affect (Hartig et al., 1991), recent data suggests that the average adult spends 90% of their waking time indoors and away from natural environments (Zipperer & Pickett, 2012). Therefore, the majority of our activities limit us from experiencing the preventative and therapeutic benefits associated with being outdoors. Architectural and built features of indoor environments that capture dimensions and characteristics of the natural world (e.g., contact with sunlight or plants, representations of nature such as a picture of painting, physical plants) may replicate the positive benefits of being in nature and may be one way to target mood. Recreating the experience of being outdoors within indoor environments may serve to promote the health and wellbeing of individuals by targeting the generation of positive affect and reduction of negative affect through the stress-reduction properties of nature.

Evidence of How Nature Exposure Affects Mood

Mood is a psychological state that generally has either a positive or negative valence (Olson, 2006; Ziegler, 2010), can be triggered by a particular event (Olson, 2006), and is shorter lasting than a 'temperament' or personality trait, such as optimism (Ziegler, 2010). Evidence supports the notion that indoor nature exposure (INE) (e.g., viewing a photo of natural landscape, the presence of a plant and/or nature light) is associated with an increase in positive and a decrease in negative affect. For example, viewing a computer generated forest (Valtchanov, Barton & Ellard, 2010), photos of forests (Hartig et al., 1996), and the presence of potted plants (Lorh & Pearson-Mims, 2000) are associated with a significant increase in positive affect. Although variations in mood can be influenced directly by both real or abstract representations of nature in indoor settings, much less is known about how non-visual exposures to nature influence mood.

Work examining non-visual experiences (e.g., sounds and scents) has found that both auditory and olfactory cues can alter stimulate positive responses. Post-operative patients who listened to nature-based sounds (e.g., whale calls) report significant reductions in stress (Dijkstra, Pieterse & Pruyn, 2008), and individuals experience psychosomatic reactions when exposed to essential oils (Edris, 2007; Hongratanaworakit, 2004). No work to date has examined an indoor environment that combines a variety of nature-based characteristics and replicates the multi-sensory experience of being outside within indoor environments. If the built environment can be adapted to recreate the experience of being outside through the use of multi-sensory nature-based stimuli, INE may prove to be an alternative opportunity for receiving the benefits of being in nature.

Environmental Preference and Mood

Prior evidence suggests that nature elicits changes in mood based on characteristics that are perceived as pleasant and restorative. People tend to seek out pleasing and rejuvenating environments (Bratman et al., 2012; Epstein, 1991; Korpela, Hartig, Kaiser and Fuhrer, 2001), where they experience an improvement in mood, perceived wellbeing (Berman, Jonides & Kaplan, 2008; Lorh & Pearson-Mims, 2000) and reduced stress (Dijkstra, Pieterse & Pruyn, 2008; Dravigne, Waliczek, Lineberger &

Zajicek, 2008). Undesirable environments, often characterized by such things as clutter, noise, perceived threats, and lack of cleanliness trigger anxiety resulting in a state of negative affect (Dijkstra et al., 2008; Evans & McCoy, 1998; Grinde & Patil, 2009; Hartig, Evans, Jamner, Davis & Garling, 2003; Ulrich, Quan, Zimrin, Joseph & Choudhary, 2004; Ulrich et al., 1991). Stress-reduction theory suggests that natural environments provide restoration from stress, at least in part, because they are innately preferred and consist of desirable/pleasing environmental characteristics (Evans & McCoy, 1998; Grinde & Patil, 2009; Hartig, Evans, Jamner, Davis & Garling, 2003). However, while preference for natural environments over urban is seen even at a young age (Kahn, 1997) and across cultures (Newell, 1997; Ulrich, 1993), individual differences appear to influence how much time one spends in nature and how comfortable they are with those surroundings (McKechnie, 1977**)**. For example, older adults report being more familiar with, and relaxed in, nature than youth (Berto, 2007). People who do not perceive nature as beneficial or health promoting tend to rate their preference for nature as low compared to individuals who seek out nature (Hartig, Kaiser, & Bowler, 2001; Hartig, Kaiser, & Strumse, 2007).

One approach to unpacking environmental preference (or preference for nature-based environments) is to evaluate individual feelings of connectedness to the natural world, also known as nature relatedness (Kals, Schumacher, & Montada, 1999; Mayer & Frantz, 2004; Schultz, 2002). Being in contact with nature, whether it is brief or regular, can directly influence how one engages with and perceives their environment (Mayer & Frantz, 2004), and can increase our connection with nature (Nisbet & Zelenski, 2011). For example, individuals who frequently go out in nature report more joy and less apprehension with nature than individuals who spend less time in natural environments (Hinds and Sparks, 2008). Individuals with high nature connection tend to seek out nature (Mayer & Frantz, 2004; Nisbet, Zelenski, & Murphy, 2009), perceive nature to be restorative and health promoting (Kaplan, 2001), and have greater preference for natural environments (i.e., greater environmental preference) (Tang, Sullivan & Chang, 2014**)**. These findings suggest that the benefits of nature may be influenced by individual-level factors related to environmental preference and nature connectedness (Figure 10).

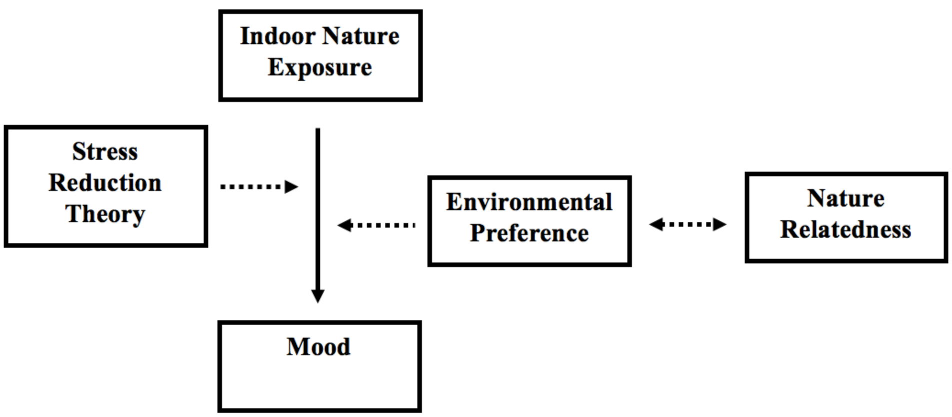

Figure 10. Pathways between indoor nature exposure, stress reduction theory, nature relatedness, environmental preference and mood.

Current Study and Hypotheses

There is mounting evidence that indoor environments infused with natural elements will affect mood, and that environmental preference and nature connection may impact this relationship. However, a gap in the literature exists. There is a lack of research examining the replication of outdoor experiences within indoor environments through exposure to multi-sensory nature-based stimuli (McSweeney et al., 2015). The INE literature largely focuses on the impact of viewing a single stimulus (e.g., a photo or real plant), which lacks the immersive experience of being in nature where you are seeing, hearing, smelling, and feeling your environment. Evidence supports the benefits of either hearing and smelling nature (Dijkstra et al., 2008; Edris, 2007; Hongratanaworakit, 2004), and anecdotal work on nature-based therapy (i.e., using exposure to indoor nature to guide practice) supplements this data (Burns, 1998). Increasing the sensory interactions in an indoor nature-based environment may enhance an individual's experience, and replicate the feeling of being outdoors. To date, little work has been done to understand the impacts of such a multi-sensory environment.

<u>Research Questions</u>

Question 1: Does exposure to a multi-sensory nature-based indoor environment impact an individual's mood? Previous research demonstrates that INE has a direct influence on mood, with an increase in positive affect and a reduction in negative affect. Extending this logic, we hypothesized that a multi-sensory nature-based indoor environment would increase positive affect, and decrease the presence of negative affect.

Question 2: Is a multi-sensory nature-based indoor environment more preferred than a control environment without nature? Based on the evidence above on individuals seeking out and preferring nature-based environments, it was hypothesized that individuals would rate a multi-sensory nature-based indoor environment higher on environmental preference than a non-nature-based environment.

Question 3: Is environmental preference related to any observed changes in mood? If the data suggests that exposure to a multi-sensory nature-based indoor environment impacts mood and is more preferred than a non-nature-base indoor environment, it was hypothesized that those in the experimental group (i.e., those exposed to the multi-sensory nature-based environment) who reported greater environmental preference for their environment would experience greater changes in both PA and NA.

Question 4: Does an individual's connection to nature influence their preference for a multi-sensory nature-based indoor environment? Previous work suggests that individuals with higher nature relatedness perceive nature-based environments more preferably than individuals with lower nature relatedness. We hypothesized that increased nature relatedness would increase the benefits one receive from a multi-sensory nature-based indoor environment (i.e., a greater increase in positive affect and decrease in negative affect) because they would have greater environmental preference for nature-based environments.

Methods

Procedure. Undergraduate student volunteers were recruited and randomly assigned to either an experimental or control condition. All participants completed a series of demographic and psychological questionnaires before and after being exposed to their assigned condition for 20 minutes.

Materials

Mood. Participants completed the Positive and Negative Affect Schedule (PANAS) before and after being exposed to their condition. The PANAS is a 20-item measure designed to evaluate both PA and NA (Watson, Clark, & Tellegen, 1988). Responses are chosen according to a five-point likert-scale ranging from 1 (*very slightly or not at all)* to 5 (*extremely)*. Examples include “inspired” for a positive item, and “scared” as a negative item. The 20 items are divided equally into two subscales (positive and negative affect). Compared to other mood scales, the PANAS demonstrates strong convergent correlations (Watson et al., 1988).

Environmental preference. After exposure to their condition, participants completed the Environment Assessment Scale (EAS) (Rohles and Milliken, 1981). The EAS measures an individuals’ preference for their surroundings through a nine-point scale (1 = *most desirable*, 9 = *least desirable*) that consists of 13 adjective semantic differential pairs (i.e., clean-dirty). The EAS has been used in previous studies to evaluate the affective characteristics of the environment and the characteristics within it (Lavianna, 1985; Laviana et al., 1983) and has been found to test-retest correlations ranging from .45 to .84, and internal consistency correlations of .45 to .73 (Kannegieter, 1986).

Nature Relatedness. Along with completing demographic questions, participants completed the Short Form Version of the Nature Relatedness Scale (NR-6) prior to their exposure. The NR-6 measures how an individual views their relationship with the natural world using a six-item likert-scale (1 = *disagree strongly,* to 5 = *agree strongly*) (Nisbet & Zelenski, 2013). Items are totaled and averaged, with scores closer to five being associated with high nature relatedness. Sample items include “My ideal vacation spot would be a remote, wilderness area”, and “My relationship to nature is an important part of who I am”. The NR-6 has been reported to have high test-retest reliability with convergent validity ranges from 0.64 to 0.75, and no sex differences.

<u>Exposure</u>. All testing took place in a room situated in an office environment measuring 10' (3 m) wide by 14' (4.3 m) in length. The room contained a U-desk with a light birch veneer and two mounted overhead cupboards. Two chairs were placed in the room, one on either side of the desk. The far end of the room had two windows spanning the width of the room approximately 3' (1 m) in height with an eighth-floor eastward perspective of an mixed urban environment, consisting mainly of rooftops, tree crowns, open sky, and partial view of the ocean. In the control condition, the windows were covered with a blackout-type material to reduce the penetration of light from outdoors. The room was illuminated with two fluorescent-type in-ceiling light fixtures found in most office environments. Other than a brass clock on the wall between the windows, the walls were void of photos or other artwork. For the experimental condition window coverings were removed to increase the amount of natural light, and to provide a view of a typical mixed urban landscape (e.g., campus buildings, trees). Green leafed indoor plants were placed on the desk and window ledge, and a landscape painting was affixed to the wall length opposite the bookshelves. The room was also scented using an organic pine oil diffuser, and a soundscape of outdoor 'nature sounds' (e.g., leaves rustling, birds chirping) was played. All testing and measurement occurred during daytime hours.

Analysis. Analysis of covariance (ANCOVA), controlling for sex, age, and stress, was used to compare changes in mood and environmental preference between groups (Questions 1 and 2). Partial correlations between EAS items and pre- and post-exposure positive and negative affect scores explored differences within groups and environmental preference (Question 3). To investigate the impact of nature relatedness on environmental preference within the experimental group, ANCOVAs and partial correlations between mood and nature relatedness examined within-group differences, and partial correlations (controlling for nature relatedness) between positive affect, negative affect and EAS pairs examined the influence of nature relatedness on environmental preference for the experimental group (Question 4).

Results

Preliminary findings. One hundred and forty-seven individuals (118 females, 29 males) ages 18 to 50 years (M = 21.4, SD = 4.2) participated in the study. Participants were in their first to sixth program year (M = 2.1, SD = 1.2) and 53.1% (n = 78) reported not being employed at the time of the study. Sex was significantly correlated with pre- and post- positive affect scores ($r^2 = -0.22$, $p < 0.01$; $r^2 = -0.26$, $p = 0.001$, respectively) but not negative affect, indicating that males scored lower on measures of positive affect, regardless of condition. Age was significantly correlated with only pre-exposure positive affect scores ($r^2 = 0.18$, $p = 0.03$). Both sex and age were included in all further analyses as individual-level covariates.

The Student-life Stress Inventory (SLSI) was used as a measure of pre-existing stress for all participants. The SLSI has been shown to be a reliable and valid measure of students' academic stress (Gadzella & Baloglu, 2001), and is comprised of 51 items rated on a five-point likert scale ranging from 1 (*never*) to 5 (*most of the time*)(Gadzella, 1991, 2004). The scale has a possible range of 51 to 255, with higher scores representing more stress. Participants' SLSI scores did not differ between experimental and control groups ($F_{(1,140)} = 0.02$, $p = 0.90$, $\eta^2_p = 0.00$), suggesting that all participants were experiencing similar levels of stress. The SLSI was not correlated with pre- ($r^2 = -0.13$, $p = 0.12$) or post-exposure positive affect scores ($r^2 = -0.15$, $p = 0.07$), but was correlated to pre- and post-exposure negative affect ($r^2 = 0.23$, $p < 0.01$; $r^2 = 0.21$, $p < 0.05$, respectively), indicating that if participants had higher self-rated stress they also reported greater negative feelings. The SLSI was included in all analyses as an additional covariate.

Question 1: Does exposure to a multi-sensory nature-based indoor environment impact an individual's mood? Pooled variance for the positive affect sub-scale of the PANAS was 0.82 for pre-exposure and 0.89 for post-exposure, and 0.81 for both pre- and post-exposures of the negative affect sub-scale. There were no significant differences between positive or negative affect scores between conditions (Table 8). ANCOVA results show that within group changes between pre- and post-exposure positive affect scores were significantly greater for the experimental group than the control ($F_{(1,138)} = 5.64$, $p < 0.05$, $\eta^2_p = 0.04$), and no difference for negative affect scores ($F_{(1,139)} = 2.34$, $p = 0.13$, $\eta^2_p = 0.02$). This finding indicates that the experimental group experienced a greater change in positive mood than the control group, but that there was no difference between groups for change in negative affect

Table 8. Means (standard deviations) of pre-, post-exposure mood between conditions.

	All			Experimental			Control		
	Pre	Post	Post-Pre[¥]	Pre	Post	Post-Pre[¥]	Pre	Post	Post-Pre[¥]
Positive Affect (PA)	25.70 (6.04)	26.49 (7.03)	0.79 (4.85)	25.66[a] (6.37)	27.20[b] (7.18)	1.53[e] (4.43)	25.75 (5.73)	25.78 (6.86)	0.04 (5.15)
Negative Affect (NA)	13.37 (3.98)	13.53 (4.07)	0.16 (3.88)	13.03[c] (4.09)	13.68[d] (4.38)	0.65[f] (4.02)	13.72 (3.85)	13.38 (3.75)	-0.33 (3.69)

[¥] Differences of scores on pre-exposure and post-exposure were computed.
[a] Comparison to control pre-exposure PA score, $F_{(1,138)} = 0.01$, $p = 0.94$, $\eta^2_p = 0.00$.
[b] Comparison to control post-exposure PA score, $F_{(1,140)} = 2.47$, $p = 0.12$, $\eta^2_p = 0.02$.
[c] Comparison to control pre-exposure NA score, $F_{(1,139)} = 1.0$, $p = 0.32$, $\eta^2_p = 0.01$.
[d] Comparison to control post-exposure NA score, $F_{(1,140)} = 0.26$, $p = 0.61$, $\eta^2_p = 0.002$.
[e] Comparison to control post-pre PA score, $F_{(1,138)} = 5.64$, $p = 0.02$, $\eta^2_p = 0.04$.
[f] Comparison to control post-pre NA score, $F_{(1,139)} = 2.34$, $p = 0.13$, $\eta^2_p = 0.02$.

Question 2: Is a multi-sensory nature-based indoor environment more preferred than a control environment without nature? Participants in the experimental condition, relative to those in the control condition, rated their surroundings as significantly more desirable on all items of the EAS (Table 9), with the exception of “quiet-noisy”. EAS items that had the greatest differences between conditions were "colorful - drab" and "attractive - unattractive". That is, participants in the experimental group rated the environment as more colorful ($M = 3.87$) compared to control, which rated their environment as more drab ($M = 6.36$). Similarly, experimental participants rated their environment as more attractive ($M = 3.3$) verses those in the control ($M = 5.32$). Overall, participants in the experimental group rated their environment more positively than those in the control, suggesting the that multi-sensory nature-based environment was more preferred than the non-nature environment.

Table 9. Means (standard deviations) of EAS items between conditions.

	Experimental	Control
EAS Items	(1-9 scale)[¥]	
Satisfying - annoying	2.38 (1.29)	3.65 (1.75)***
Clean - dirty	1.34 (0.53)	1.94 (1.11) ***
Relaxing - stressing	1.97 (1.07)	3.64 (1.89) ***
Comfortable - uncomfortable	2.01 (1.11)	3.68 (1.92) ***
Colorful - drab	3.87 (1.43)	6.36 (1.82) ***
Happy - sad	2.97 (1.41)	4.86 (1.63) ***
Pleasant smell - unpleasant smell	3.32 (1.61)	4.33 (1.28) ***
Bright - dull	2.58 (1.64)	3.74 (2.0) ***
Spacious - crowded	3.34 (4.49)	4.49 (1.72) ***
Calming - irritating	2.44 (1.32)	4.22 (1.65) ***
Warm - cool	2.96 (1.59)	4.01 (1.69) ***
Attractive - unattractive	3.30 (1.52)	5.32 (1.65) ***
Quiet - noisy	2.21 (1.72)	2.46 (1.82)

¥ 1 - Most desirable, 9 - Least desirable.
*** $p < 0.001$.

Question 3: Is environmental preference related to any observed changes in mood?

Pearson correlations between mood and EAS items show that overall, participants who rated their environment as more satisfying, clean, relaxing, comfortable, colorful, happy, pleasant smelling, calming, warm, attractive and quiet had greater changes in positive affect; environments rated as dirtier and cooler had greater changes in negative affect (Table 10). In examining environmental preferences within groups, only the "attractive – unattractive" item impacted mood in the experimental condition, suggesting that those who viewed their environment as more attractive reported greater changes in their positive affect. Results of environmental preference for the control group show participants experienced greater increases in negative affect when they rated the control environment as higher on annoying, dirty, stressing, uncomfortable, drab, cool and unattractive.

Table 10. Correlations between EAS items and positive affect (PA) and negative affect (NA) between conditions.

	All		Experimental		Control	
EAS Items[¥]	PA[a]	NA[b]	PA[a]	NA[b]	PA[a]	NA[b]
Satisfying - annoying	-0.12*	0.11	0.00	0.08	-0.14	0.28*
Clean - dirty	-0.08**	0.19*	-0.09	0.05	0.02	0.38**
Relaxing - stressing	-0.30**	0.17	0.00	0.15	-0.30*	0.38**
Comfortable - uncomfortable	-0.25**	0.07	0.09	-0.03	-0.28*	0.30*
Colorful - drab	-0.25**	0.11	-0.09	0.07	-0.18	0.38**
Happy - sad	-0.25**	0.30	-0.19	-0.01	-0.11	0.21
Pleasant smell - unpleasant smell	-0.19*	0.09	-0.22	0.11	-0.01	0.18
Bright - dull	0.01	-0.01	0.02	-0.15	0.11	0.16
Spacious - crowded	-0.02	0.09	0.08	0.05	0.02	0.22
Calming - irritating	-0.24**	0.09	0.01	0.19	-0.22	0.21
Warm - cool	-0.18*	0.21*	-0.10	0.22	-0.15	0.32*
Attractive - unattractive	-0.32***	0.11	-0.33**	0.14	-0.19	0.27*
Quiet - noisy	-0.17*	0.12	-0.19	0.13	-0.08	0.19

¥ 1 - Most desirable, 9 - Least desirable.
[a] PA was measured as the overall difference between post- and pre-exposure PA scores on the PANAS.
[b] PA was measured as the overall difference between post- and pre-exposure NA scores on the PANAS.
* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Question 4: Does an individual's connection to nature influence their preference for a multi-sensory nature-based indoor environment? Overall, participants' nature relatedness was 3.2 (SD = 0.8, α = 0.82), with no difference between experimental (M = 3.2, SD = 0.9) and control (M = 3.3, SD = 0.9) groups ($F_{(1,145)} = 0.45$, $p = 0.50$, $\eta^2_p = 0.003$). When controlling for nature relatedness, within group comparisons indicated that positive affect scores were significantly different between conditions ($F_{(1,136)} = 6.34$, $p < 0.05$, $\eta^2_p = 0.05$), but not for negative affect ($F_{(1,137)} = 2.43$, $p = 0.12$, $\eta^2_p = 0.02$). Partial correlations between nature relatedness and positive affect scores for each condition show that in the experimental group, higher nature relatedness scores were associated with a larger difference between their pre- and post-exposure positive scores ($r^2 = 0.28$, $p < 0.05$), but that this relationship was not present in the control group ($r^2 = 0.11$, $p = 0.38$). Nature relatedness was not related to environmental ratings for the control group, but was for the experimental group where those with greater nature relatedness rated the condition as more colourful (r^2 = -0.34, $p < 0.01$), happy (r^2 = -0.28, $p < 0.05$), and attractive (r^2 = -0.26, $p < 0.05$). Exploring this relationship further, partial correlations between positive affect and EAS items for the experimental group show that a more positive rating for all of the environmental items were associated with a significant increase in positive affect except the "attractive - unattractive" (r^2 = -0.28, $p < 0.05$) item.

Discussion

The use of INE offers an opportunity to adapt indoor environments to include nature-based characteristics in order to replicate the experience of being outdoors, and may provide a variety of restorative and therapeutic benefits. The current study examined the impact of a multi-sensory indoor nature environment on mood, and how individuals' environmental preference and nature relatedness influenced this relationship.

Examining the relationship between mood and environment (Question 1), results showed no differences between positive or negative affect scores between the experimental and control conditions. Importantly, changes in pre- and post-exposure positive affect scores were significantly greater for the experimental condition than for the control group, and suggest that INE provided an increase in positive mood. However, negative affect was not impacted by either condition. Although variations in mood and nature exposure have been found in previous literature (Grinde & Patil, 2009; Hartig et al., 2003), studies using short exposure durations (e.g., 10-15 minutes) have noted no significant differences between positive and negative affect (Adachi, Rohde, & Kedle, 2000; Larsen et al., 1998; Shibata & Suzuki, 2001). It may be possible that while a short period of INE can provide an improvement in mood, it may not be a sufficient duration to have a measurable impact on negative affect. Longitudinal research on mood and nature exposure has found that when plants are introduced into an office setting, significant decreases in negative affect occur over a three-month period, while positive affect improves immediately (Burchett et al., 2010). Continuing work on understanding how INE duration impacts health would help to clarify the micro-restorative effects and the long-term benefits of nature, and may lead to finding an optimal level of exposure for targeting both positive and negative affect.

Examination of environmental preference showed that a multi-sensory indoor nature environment was more preferred than a non-nature environment (Question 2), and that being in an environment that one rates highly preferable significantly impacts mood (Question 3). Results of the study (1) confirm that exposure to INE has an automatic psycho-emotional response and support previous work on the stress-reduction theory, and (2) that natural environments are preferred over non-nature-based environments (Dijkstra et al., 2008; Evans & McCoy, 1998; Grinde & Patil, 2009; Hartig, Evans, Jamner, Davis & Garling, 2003; Ulrich, Quan, Zimrin, Joseph & Choudhary, 2004; Ulrich et al., 1991).

Results show that an individuals' nature relatedness influenced the relationship between nature exposure and mood for the experimental group (Question 4). Individuals with greater nature relatedness incurred greater changes in their positive affect, and preferred their environment more (i.e., scored the condition higher on the EAS) than those with lower nature relatedness. While nature relatedness may help to increase and maintain positive affect, additional work is needed to understand the meditational or moderational impact of nature relatedness on environmental preference and mood (Nisbet et al., 2011). Regardless of the connection between nature relatedness and mood, when controlling for nature relatedness, participants in the experimental condition still had a significant increase in positive affect, suggesting additional mechanisms are present.

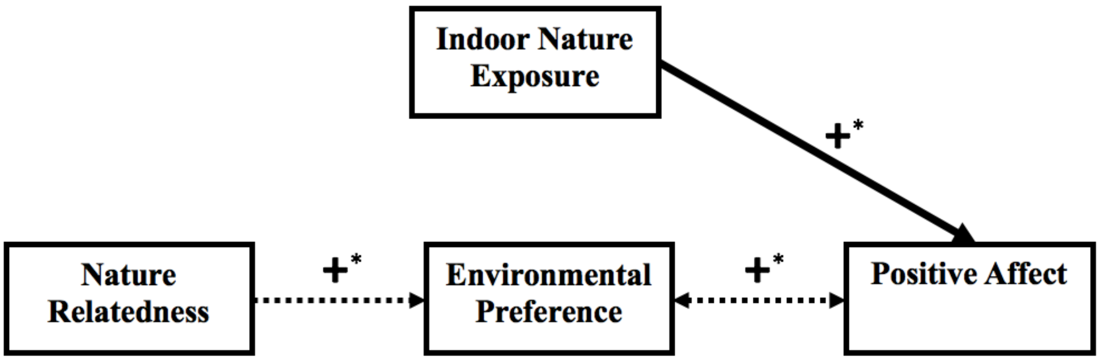

Figure 11. Potential pathways between indoor nature exposure, nature relatedness, environmental preference and mood (+* indicates a significant positive relationship of at least $p < .05$).

Figure 11 outlines the potential relationship between nature relatedness, environmental preference, and mood. As indicated above, through environmental preference, nature relatedness impacted mood for those in the multi-sensory nature-based indoor environment, and suggests that if one is familiar and comfortable in a natural environment they may experience greater benefits from nature. Recent research suggests that preference for, and experiences in, nature may influence the outcomes of nature exposure and ultimately shape the benefits one receives (Bratman et al., 2012). This supplements narrative accounts of nature-based experiences that suggest individuals who spend time in nature begin to see it as a meaningful place that they seek out, rather than just a space that they move through (Humberstone, 1998). Exploring the relationship between nature relatedness, environmental preference and experiences with a multi-sensory indoor nature environment will help to better understand the relationship between INE and mood and how to best replicate the experience of being outside, indoors.

Conclusion

This study sought to investigate the impact of INE on mood, and how individuals' environmental preference and nature relatedness influences these outcomes. Results demonstrate that a multi-sensory indoor environment provides a significant boost to positive affect. Moreover, results suggest a bidirectional relationship between environment preference and mood, and that nature relatedness may influence mood indirectly through environmental preference. Future work should examine baseline environmental preference (Dopko et al., 2014), as the link between mood and indoor nature preference is still unclear. Post-exposure nature relatedness is also important to consider and a limitation of this study, as results suggests that nature exposure may increase connections with place, and indirectly influence environmental preference. Measuring both pre- and post-exposure nature relatedness and environmental preference would further clarify their role in the relationship between INE and mood.

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CHAPTER 5 THE INFLUENCE OF INDOOR NATURE EXPOSURE (INE) ON PRO-SOCIAL INTENTIONS AND BEHAVIOURS.

The influence of indoor nature exposure (INE) on pro-social intentions and behaviours.

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Abstract

Few studies have examined how indoor nature exposure (INE) facilitates pro-sociality. The current study investigated if a multisensory nature-based indoor environment facilitated pro-social intentions and behaviours, and how individual-level factors influenced outcomes. 147 undergraduates were assigned to either an experimental (nature) or control condition (no nature). Participants completed a measure of pro-social intentions, mood, and nature relatedness (NR). Participants were prompted with the opportunity to donate to a local charity, and donating was considered a measure of pro-social behaviour. Weather was recorded during each exposure time. Pro-social intentions and behaviours did not differ between conditions. Individual factors did not impact the relationship between pro-sociality and INE. Participants were more likely to engage in pro-social behaviour on days that were sunny or had precipitation, rather than on days with overcast. Results suggest that INE does not influence pro-social intentions or behaviours. However, characteristics of INE may encourage pro-social behaviours.

Introduction

The benefits of indoor nature exposure. A range of evidence supports the claim that spending time in nature provides a variety of health benefits (Hartig, Böök, Garvill, Olsson, & Gärling, 1996; Hartig, Mang & Evans, 1991; Kaplan, 1995). For example, Wichrowski, Whiteson, Haas, Mola and Rey (2005) found that cardiopulmonary rehabilitation patients had a significant drop in heart rate when moving from indoor to outdoor environments during therapy sessions. Cimprich and Ronis (2001) found that breast cancer patients exposed to nature showed significant cognitive improvements (e.g., directed attention), compared to breast cancer patients without nature exposure. While there is mounting evidence that demonstrates the benefits of nature for our health and wellbeing, we still spend most of our time indoors and away from nature (Evans & McCoy, 1998). The ability to adapt indoor environments to offer greater interaction with nature can potentially influence health and wellbeing through indoor nature exposure (INE).

In his book *Biophilia*, Edward O. Wilson (1984) outlines how humans have an innate affiliation with nature, as it fosters an inherent sense of safety, rejuvenation, and sustenance, making the allure of nature a positive response associated with evolution (Lorh & Pearson-Mims, 2000; Wilson, 1984). Applying the principals of the biophilia hypothesis, biophilic design uses natural dimensions and characteristics of our built environment to directly (e.g., contact with sunlight and/or plants), indirectly (e.g., contact with features that require human assistance such as potted plants, aquariums), and symbolically (e.g., representations of nature through pictures or paintings) reflect the innate connection between people and nature (Kellert, 2005). Using the properties of biophilic design, indoor environments can be adapted to replicate outdoor environments, and recent evidence suggests that INE may be an effective means of improving our health and wellbeing. McSweeney, Rainham, Johnson, Sherry and Singleton (2014) identified 51 relevant INE studies that measured a wide range of self-reported and objective physical and psychological health measures. INE significantly and positively impacts a variety of physiological and psychological facets of health; however, little effort has been allocated to understanding the influence of INE on social behaviour.

Nature and pro-sociality. Plants and nature can foster social and community ties, which in turn encourages individuals to engage with others (Coley et al., 1997; Guéguen and Stefan 2014; Kweon, Sullivan & Wiley, 1998; Weinstein, Przybylski, & Ryan, 2009), and may be explained by the evolution of community and social behaviours within the context of biophilia. Our ancestors largely lived in small nomadic bands as hunter-gatherers (Bellwood, 2004), and were likely egalitarian in their beliefs, behaviours and social structures (Gray, 2014). Their survival was based upon the equal division of duties and resources, and sharing such responsibilities as child rearing, camp protection and resource collection (Gurven, 2004; Ivey, Morelli, & Tronick, 2005). Thus, working together, and engaging in long-term behaviours that benefited the group, ensured individual survival and became an evolutionary trait developed within, and associated with, the natural environment. The effects of nature on physiological and psychological wellbeing have been the primary focus of investigation within the nature-health literature; and few studies have examined how natural environments, specifically indoor spaces adapted for INE, influence social relationships such as pro-sociality.

Pro-sociality is a term that encompasses a broad range of social values and behaviours associated with how people choose to distribute resources between themselves and others (e.g., generosity, altruism; Balliet, Parks, & Joireman, 2009; Wilson, O'Brien, & Sesma, 2009). Pro-social behaviours are voluntary in nature and benefit others, such as helping, sharing or donating (Balliet, Parks, & Joireman, 2009). Several studies to date have investigated pro-social behaviours and attitudes, and nature exposure. For example, work has shown a significant relationship between exposure to neighbourhood greenspace and the development of social relationships (Coley, Kuo & Sullivan, 1997; Kuo, Sullivan, Coley & Brunson, 1998), which supports and encourages greater pro-social behaviours and attitudes between community members (McClintock & Allison, 2006; van Lange, Bekkers, Schuyt, & Van Vugt, 2007). Guéguen and Stefan (2014) found that people engaged more in helping behaviour (i.e., picking up a glove from the ground and returning it to the stranger who dropped it) after exposure to an urban park compared to no exposure. Zhang, Piff, Iyer, Koleva and Keltner (2014) found that exposure to images of nature rated as "beautiful" increased pro-social tendencies (e.g., agreeableness, empathy) more than exposure to nature images rated as less atheistically pleasing. Similarly, Joye and Bolderdijk (2015) found that viewing "awe-inspiring" photos of nature led to pro-social intentions, but not pro-social behaviour (i.e., willingness to donate). While social values and behaviours are often regarded as relatively stable, they have been shown to change across the lifespan and according to varying situations (van Lange, Otten, De Bruin, & Joireman, 1997), and research suggests that even brief exposure to nature may influence pro-social tendencies. INE may offer a means of increasing pro-social intentions and behaviours.

Pro-sociality and mood. Pro-social behaviours are motivated by both dispositional (e.g., individual) and situational (e.g., environment) factors (Batson & Powell, 2003); therefore, INE may facilitate pro-social intentions and behaviours through the creation of environments that directly impact individual factors, such as mood. For example, pro-social behaviours are linked to positive social relationships, and viewing flowers and plants can directly impact these relationships by influencing an individual's mood by increasing positive affect (Guéguen, 2012; Guéguen & Stefan 2014; Haviland-Jones, Rosario, Wilson & McGuire, 2005). According to Fredrickson's (1998, 2001) broaden-and-build theory, positive emotions encourage individuals to broaden their perspectives, which facilitates their engagement in pro-social behaviours that will benefit them in the long-term (Zhang et al., 2014). A number of studies confirm that engaging with nature enhances mood (Hartig et al., 1996; Hinds & Sparks, 2011; Kim, Jeong, Kim, Baek, Oh et al., 2010) compared to urban environments where mood often declines (Berman, Kross, Krpan, Arkren, Burson et al., 2012; Nisbet, Zelenski, & Murphy, 2011; Ryan, Weinstein, Bernstein, Brown, Mistretta et al., 2010). Weather is another facet of nature that has been linked to mood. For example, Denissen, Butalid, Penke, and van Aken (2008), Keller, Fredrickson, Ybarra, Côté, Johnson et al. (2005) and Howarth and Hoffman (1984) all found that sunshine and precipitation affected mood significantly; suggesting that weather related characteristics may be an additional mechanism of nature that leads to greater pro-social tendencies. The above research on mood suggests a likely relationship with nature and pro-social behaviours, and that nature exposure will enhance mood and in turn, encourage pro-social intentions and behaviours. For this reason, mood is an important factor to account for in the investigation of the relationships between INE and pro-sociality.

Pro-sociality and nature relatedness. Nature relatedness is believed to be the degree to which individuals see themself and the natural world as connected (Kals, Schumacher, & Montada, 1999; Mayer & Frantz, 2004; Schultz, 2002). Research on outdoor nature exposure suggests that an individual's previous experience and connection with nature influences the benefits they receive from exposure (Kjellgren & Buhrkall, 2010; Ottosson & Grahn, 2005), and their attitudes towards the environment (Mayer & Frantz, 2004; Nisbet et al., 2009). Additionally, Nisbet et al. (2009) found that an individuals' level of humanitarianism, that is the willingness to help others and have concern for another's well-being, was significantly positively correlated with nature relatedness. Therefore, nature relatedness may be a potential indicator of pro-sociality, and impact its relationship with INE.

The current study. There is little evidence to date that has investigated the influence of INE on an individual's pro-social intentions and/or behaviours. Most research to date has focused on exposing individuals to a single stimulus, such as a plant or photo of nature, which is vastly different than the immersive environment of outdoor nature. McSweeney et al. (2015) suggest that INE research needs to examine how a multisensory environment impacts human health and behaviours. The current study investigated if exposure to indoor nature was related to pro-social intentions and behaviours, and examined how individual factors such as gender, age, mood, and nature relatedness impacted the pro-sociality and INE relationship.

Methods

Participants. Participants were undergraduate volunteers from a psychology participant pool at Dalhousie University, who had no known allergic reactions to organic-based scents. One hundred and forty-seven individuals (118 females, 29 males) participated in the study from October to December of 2014 between the times of 9am and 5pm. Ages ranged from 18 to 50 years ($M = 21.4$, $SD = 4.2$). Participants were currently in their first to sixth program year ($M = 2.1$, $SD = 1.2$); 53.1% ($n = 78$) were not working at the time of the study, while 35.4% ($n = 52$) were working part-time. Results from MANOVAs revealed no main effects for age, years in program or employment status between conditions ($p > .05$), and therefore these variables were not included in analyses.

Materials

Pro-sociality. Two measures were used to assess pro-sociality in participants. The first was the Helping Attitude Scale, a measure of attitudes and intentions towards helping others (Nickell, 1996). The Helping Attitude Scale is a five point likert-scale (1 = *Strongly Disagree,* to 5 = *Strongly* agree) of 20-items consisting of prompts such as: "Helping others is usually a waste of time" and "I donate time or money to charities every month". Scores range from 20 (low pro-sociality) to 100 (high), with 60 being a normal score. The second measure of pro-sociality was whether or not a participant engaged in a pro-social behaviour following a prompt. Once all study tasks were completed, participants were provided with five dollars in compensation for their participation. As they left the laboratory the researcher followed a script and offered them the opportunity to donate their five dollars to a local charity. Donating the bill was considered pro-social behaviour.

Mood. The Positive and Negative Affect Schedule (PANAS) is a 20-item measure designed to evaluate both positive and negative affect (Watson, Clark, & Tellegen, 1988). The measure uses a five-point likert-type scale, ranging from 1 = *very slightly or not at all,* to 5 = *extremely*. Example items include “inspired” for a positive item, and “scared” as a negative item. The 20 items are divided into two subscales (positive and negative affect), each comprised of ten items.

Nature Relatedness. The Short Form Version of the Nature Relatedness Scale (NR-6) is a six-item likert-scale instrument that measures how an individual views their relationship with the natural world (Nisbet & Zelenski, 2013). The scale ranges from 1 = *disagree strongly* to 5 = *agree strongly*. Sample items include “My ideal vacation spot would be a remote, wilderness area,” and “My relationship to nature is an important part of who I am.”

Weather. Prior to the arrival of each participant weather was recorded as: clear, clear with minimal cloud coverage, overcast with minor sunny breaks, full cloud coverage, minor precipitation (e.g., snow and/or rain), major precipitation, or storm. Weather was recategorized into the following three categories: sunny, overcast, or precipitation (e.g., snow and/or rain), for analyses.

Exposure. Using the principals of biophilic design, an INE experimental condition was created. The experimental condition contained a desk and chair facing a window that provided natural light and a view of a mixed urban landscape (e.g., campus buildings, trees, and partial view of the ocean), three green leafed plants, a painting of a field landscape, a mixture of nature sounds (e.g., birds, running water and rustling leaves), and an oil diffuser that contained two drops of organic pine oil. The control condition contained the same desk and chair, had the window covered to prevent natural sunlight and access to a view, and did not contain any plants, paintings, nature sounds, or pine oil scent.

Procedure. Participants were randomly assigned to either the experimental or control condition upon recruitment. They first completed a series of questionnaires that asked them about their connection with nature and individual demographics. Participants then sat quietly and uninterrupted in their exposure condition for five minutes, after which they completed a series of filler tasks (i.e., the Search and Memory Task and the Digit Span Test) for an additional 15 minutes. Once all tasks were completed, they were given a final package of questionnaires that asked them about their current mood (i.e., PANAS) and intentions to help (i.e., Helping Attitude Scale). Once participants finished their questionnaires, they received compensation for participating. The researcher then offered them the opportunity to donate their money to a local charity. All participants were prompted with the same script.

Results

Pro-social intentions. Preliminary analysis showed that Helping Attitude Scale scores ranged from 58 to 100 (M = 84.2, SD = 8.6, α = .84), and indicated that females (M = 85.1, SD = 8.3, CI [83.5, 86.5]) had significantly higher Helping Attitude Scale scores than males (M = 81.1, SD = 9.0, CI [77.6, 84.5]; F(1,144) = 5.2, $p < .05$, CI [81.33, 84.79], η^2_p = .04). Controlling for sex, there were no significant differences between the experimental (M = 84.0, SD = 8.9, CI [81.9, 85.9]) and control conditions (M = 84.5, SD = 8.2, CI [82.5, 86.5]) for scores (F(1,143) =.14, p = .71,CI [82.88, 85.65], η^2_p = .001). Pro-social intentions were significantly correlated with pro-social behaviour (r^2 = .18, $p <$ .05).

Pro-social behaviour. The rate of donations did not differ between sexes (χ^2(1, N = 147) = .03, p = .52), thus sex was not included in any subsequent analysis unless otherwise indicated. A total of 73 (48.7%) participants donated after the prompt. Approximately half of participants in both the experimental (47.9%, n = 35) and control groups (52.1%, n = 38) donated their money, with no significant differences between conditions (χ^2(1, N = 147) = .62, p = .34).

Mood. Participants' positive affect scores (M = 24.5, SD = 7.0, α = .82) were not significantly correlated with pro-social intentions (r^2 = .15, p = .08), but the direction of the relationship suggests that higher positive affect was associated with higher altruistic intentions. Negative affect (M = 13.5, SD = 4.1, α = .89) was significantly correlated with pro-social intentions (r^2 = -.24, p < .01), such that higher negative affect was associated with lower pro-social intentions. However, when controlling for sex and negative affect, pro-social intentions did not differ between conditions (F(1,140) =.07, p = .79, CI [82.92, 85.61], η^2_p = .001). There were no differences between the experimental groups for positive and negative affect (F(1,146) = 1.12, p = .33, CI [25.3, 27.6], η^2_p = .20; F(1, 146) = .86, p = .63, CI [12.9, 14.2], η^2_p = .11, respectively), and therefore mood was not considered as a potential confound in the relationships between INE and pro-social behaviour.

Table 11. Engaging in pro-social behaviour by weather for each condition.

	Experimental[a]		**Control**[b]	
	Yes % (n)	**No** % (n)	**Yes** % (n)	**No** % (n)
Sunny	46.7% (14)	53.3% (16)	61.1% (22)	38.9% (14)
Overcast	26.3% (5)	73.7% (14)	35.3% (6)	64.7% (11)
Precipitation	64% (16)	36% (9)	50% (10)	50% (10)

[a] $\chi^2(2, N = 74) = 7.7, p < .05$. [b] $\chi^2(2, N = 73) = 3.1, p = .21$.

Nature relatedness. Overall, participants NR-6 score was 3.2 (SD = 0.8, α = .82), with no difference in NR between experimental (M = 3.2, SD = 0.9) and control (M = 3.3, SD = 0.9) conditions (F(1,145) =.45, p = .50, CI [3.1, 3.4], η^2_p = .003). Nature relatedness was significantly correlated with participants' Helping Attitude Scale scores (r^2 = .19, p < .05); however, when controlling for sex and nature relatedness, there were no differences between conditions on Helping Attitude Scale scores (F(1,141) =.11, p = .74, CI [82.90, 85.63], η^2_p = .001). Pro-social behaviour was not correlated with nature relatedness (r^2 = .07, p = .22). Neither positive nor negative affects were correlated with nature relatedness (r^2 = -.0003, p = .92; r^2 = - .09, p = .27, respectively).

Weather: Comparing the weather categories within conditions found that weather did not impact pro-social intentions (i.e., Helping Attitude Scale scores) for either the experimental ($F(2, 71) = 1.45$, $p = .24$, CI [82.13, 86.32], $\eta^2_p = .04$) or control ($F(2, 69) = 1.66$, $p = .20$, CI [81.94, 85.96], $\eta^2_p = .05$) conditions. Weather did not impact if participants in the control condition engaged in pro-social behaviours (i.e., donated their reimbursement) ($\chi^2(2, N = 73) = 3.1$, $p = .21$), but did within the experimental ($\chi^2(2, N = 74) = 7.7$, $p < .05$; Table 11). A logistic regression showed that when it was sunny, participants in the experimental condition were 0.4 times more likely to donate money than when it was overcast; and when it was raining and/or snowing, they were 2.0 times more likely to donate than when it was overcast. The weather outside was not related to positive affect ($F(2,142) = 1.76$, $p = .17$, CI [25.3, 27.6], $\eta^2_p = .02$), negative affect ($F(2,146) = .61$, $p = .54$, CI [12.8, 14.1], $\eta^2_p = .008$) or nature relatedness ($F(2, 142) = 1.70$, $p = .19$, CI [3.1, 3.4], $\eta^2_p = .023$).

Discussion

The nature-health literature is dominated by examinations of the physiological and psychological impacts of INE, with few studies focusing on the potential social, specifically pro-social, impacts (Guéguen and Stefan 2014; McSweeney et al., 2014). The biophilia hypothesis provides a theoretical link for the use of nature to enhance pro-social tendencies, as it describes our innate connection with nature and includes kindness and compassion for others as essential traits to our adaptive behaviours (Wilson, 1984). This link is further supported by evidence that suggests exposure to nature is associated with increased pro-environmental and altruistic behaviours (Mayer & Frantz, 2004; Nisbet et al., 2009). The current study compared pro-social intentions and behaviours of individuals who were exposed to INE.

Using random assignment, this study immersed participants in either a nature-filled indoor environment (experimental condition) or a room void of nature (control condition), and assessed their self-reported pro-social intentions and observed whether or not they engaged in pro-social behaviour (i.e., donating their five dollar reimbursement to a local charity). Results suggest that neither pro-social intentions nor behaviour differed between the INE and control groups. While this conflicts with previous work by Guéguen and Stefan (2014), Zhang et al. (2014) and Weinstein et al. (2009), it does support Wells' (2004) study that found no differences in helping behaviour in the presence of nature.

Several potential mechanisms may help to explain these varying results. Research has found that engagement in pro-social behaviours and intentions are linked to individuals' ego-depletion (i.e., a lack of mental resources available for self-control) and self-regulatory capacity (i.e., focusing one's behaviours to reflect certain social standards; Vohs & Heatherton, 2000). Self-regulation requires concentration and focus of finite cognitive resources (Baumeister, Bratslavsky, Muraven, & Tice, 1998), and evidence suggests that when people experience ego-depletion and a deficit of self-regulatory resources, they are less likely to help others (DeWall, Baumeister, Grailliot, & Maner, 2008). That is, ego-depletion prohibits the engagement of self-regulatory actions, and prevents the ability to reflect on behaviours and resulting consequences. The Attention Restoration Theory (ART; Kaplan, 1987; Kaplan & Kaplan, 1989) suggests that natural environments can restore these fatigued resources, and potentially indirectly influence pro-sociality through this mechanism. Unlike previous findings, the results from this study did not show that INE influenced pro-sociality, and it may be that prior work on nature and pro-sociality have inadvertently caused participants to enter a greater state of ego-depletion before being exposed to nature, thus causing a greater restorative effect within nature-based environments. Future work should consider the impact of ego-depletion before, during and after INE, and how exhausting cognitive resources may inadvertently impact outcomes.

Another mechanism that is linked to pro-sociality is mood (Isen & Levin, 1972; Salovey, Mayer & Rosenhan, 1991). Both the biophilia hypothesis (Wilson, 1984) and ART (Kaplan, 1987; Kaplan & Kaplan, 1989) propose that natural environments facilitate a boost in mood and offer a pathway for nature to support pro-social tendencies. These hypotheses are supported by a body of literature that demonstrates nature’s role in enhancing mood (Kweon, Ulrich, Walker & Tassinary, 2008; Nisbet & Zelenski, 2011; Tennessen and Cimprich, 1995). The results from the current study confirm that mood influences pro-social intentions, but do not support the hypothesis that natural environments foster pro-sociality through enhanced mood. These results are similar to findings from Guéguen and Stefan (2014), who concluded that mood mediated the relationship between nature exposure and pro-sociality, but they did not find that nature exposure itself, directly influenced mood or pro-sociality. Much like ego-depletion, it is possible that individuals' mood prior to exposure may impact the boost they receive from the exposure itself. Therefore, examination of mood, pro-sociality and INE should consider pre- and post-exposure moods, and investigate how individual changes in mood due to exposure impact pro-social tendencies. Future work should continue to investigate the impact, both direct and indirect on mood and INE, as results to date appear to be inconsistent.

Zhang et al. (2014) and Weinstein et al. (2009) suggest that individual-level variables can mediate and moderate responses to nature and be another potential mechanism through which INE facilitates pro-social tendencies. Variables such as nature relatedness and sex were investigated in the current study to understand how personal experiences and perceptions influence the nature-health relationship. While the current study found that females engaged in helping behaviour more than males, there was no interaction between sex, experimental condition and pro-sociality, and confirms similar results from Guéguen and Stefan (2014). Nature relatedness was positively associated with pro-social intentions, but unlike previous work from Weinstein et al. (2009) that found nature relatedness mediated the relationship between pro-sociality and nature exposure, nature relatedness and pro-social intentions did not differ between exposure groups. That is, Weinstein et al. found that when individuals were exposed to greater amounts of nature, they felt a greater connectivity to their environment and were more inclined to engage in helpful behaviours. This is consistent with work from Mayer and Frantz (2004) and Nisbet et al. (2009) that found people with higher nature relatedness demonstrated more pro-environmental attitudes and behaviours; however, the results from the current study suggest that nature relatedness is not related to pro-social behaviours, nor were pro-social intentions higher in individuals who were exposed to nature. The current study suggests that individual factors such as sex and nature relatedness do not impact the relationship between INE and pro-sociality; however, given the evidence in the existing literature, future work should consider the impact of mood on individual factors such as nature relatedness.

The biophilia hypothesis (Wilson, 1984), ART (Kaplan, 1995), and the broaden-and-build theory (Fredrickson, 1998, 2001) offer potential mechanisms that may explain the INE and pro-sociality relationship. While the current study provides alternative findings to the current body of literature that has investigated this relationship, this may be the result of methodological differences within the current literature. Previous research has defined pro-sociality in a variety of ways, and sometimes intentions and behaviours have been used synonymously. This discrepancy in definitions and measurements may lead to the inconsistency between previous studies and the current study. For example, Murphy, Ackermann and Handgraaf (2011) used hypothetical situations and asked individuals to distribute money between themselves and a fictional participant; Weinstein et al (2009) asked participants to distribute money between themselves and an actual participant; and Dopko (2012) used a virtual simulation of fishing dilemmas to observe how participants harvested resources for money and used this as a measure of cooperation and altruism. In the current study, we used two measures to capture both pro-social intentions and behaviour. Future work should consider the difference between an individual's intentions to engage in pro-social behaviours and actual engagement, and whether or not intentions versus behaviours have different outcomes when exposed to nature.

Although pro-sociality did not differ between conditions overall, results suggest that the view from the nature condition may have indirectly influenced participants' choice to engage in pro-social behaviours. Weather conditions at the time of the study impacted donating behaviour in the INE condition, but not the control condition. This suggests that the presence of a window with a view of the weather influenced pro-social behaviour. Specifically, the results from the current study suggest that weather influences pro-social behaviours and confirms work from Cunningham (1979) that found people engaged in helpful behaviours more on sunny days. Howarth and Hoffman (1984) found that weather was directly related to mood, with greater positive affect on sunny days. In the current study, weather and mood were not related, suggesting that perhaps the view from the window, rather than the weather itself, may be the cause of pro-social behaviour variations. Zhang et al. (2014) examined the impact of beautiful nature on pro-sociality and found that the level of beauty both mediated and moderated the association with pro-sociality. However, a major limitation within that study was the inability to parse out the specific features of nature that lead to the perception of more or less beauty. This inability to understand which details of nature facilitate greater or lesser outcomes is a key limitation within the nature-health literature and is highlighted by McSweeney et al. (2014) in their scoping review. The current study further emphasizes the impact of nature characteristics on outcomes, as pro-social behaviour was influenced by the weather observed within the nature condition. This confirms previous research that suggests characteristics of a window view are more influential than the presence of a window (Felsten, 2009; Kaplan, 2001; Li, Chau, Tse & Tang, 2012; Li, Zhang, Gu, Jiang, Wang et al., 2012). These results have the potential to influence a variety of venues that stage charitable or marketing events, and future work should consider examining the details of nature exposure, and how they may influence the outcomes of INE.

The current study had several limitations. First, the sample consisted entirely of undergraduates, which limits generalizability to other populations, particularly those of differing ages, cultures, incomes, and clinical samples. Second, anecdotal information from participants (e.g., “I can afford to buy a coffee now!”) suggested that students may have been dependent on the monetary reimbursement, and may have had different pro-social behaviours if they were in less financial need. Third, exposure time may not have been long enough to change an individual’s behaviours or ingrained traits. While Guéguen and Stefan (2014) found that even short immersion in outdoor nature elicited altruistic behaviours in individuals, longer durations in nature may increase pro-social tendencies, as individuals feel more present within that environment and are less distracted (Weinstein et al., 2009). It may be that in order to impact intentions and behaviours, individuals require greater exposure time to indoor nature. Future work should examine the impact of dosage on INE outcomes (McSweeney et al., 2014).

Conclusions

To date, the relationship between indoor nature exposure (INE) and pro-sociality has not been investigated sufficiently. Additionally, the body of INE literature largely focuses on exposure to a single indoor stimulus, rather than creating an environment that replicates the multi-sensory immersive experience that is outdoor nature. The current study is the first of its kind to examine the relationship between pro-social intentions and behaviours within an immersive indoor environment. While previous research has found that nature exposure is associated with pro-social tendencies, we found no evidence to suggest that INE influences pro-social intentions or behaviours, and that individual variables such as sex, mood and NR did not influence the relationship between INE and pro-sociality.

However, evidence does suggest that the characteristics of the presented nature may encourage individuals to engage in pro-social behaviours.

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CHAPTER 6 DISCUSSION

Summary

Indoor nature exposure (INE) offers an opportunity to adapt existing built environments to include nature-based characteristics in order to replicate the experience of being outdoors in nature. The purpose of this dissertation was to examine the nature-health relationship by exploring facets of physiological, psychological and social health outcomes when exposed to a multi-sensory indoor nature environment. In the introduction, a framework to guide the inquiry of the nature-health relationship was outlined (Figure 2), and highlights the theoretical underpinnings of this relationship (e.g., stress-reduction theory), as well as the potential individual-level factors (e.g., environmental preference and nature relatedness). Chapter 3 concluded that physiological stress markers are immediately reduced when exposed to INE regardless of an individual's preference for nature or their surrounding environment, and supports previous evidence that found exposure to nature resulted in a reduction of stress (Brown et al., 2013; Lee et al., 2011; Park et al., 2010; Yamaguchi, Deguchi, & Miyazaki, 2006). Results from Chapter 4 showed that while INE had no impact on negative affect, exposure did result in an increase in positive affect and was related to environmental preference. These results support work on the stress-reduction theory that natural environments are preferred due to the stress-reducing properties they provide (Dijkstra et al., 2008; Evans & McCoy, 1998; Grinde & Patil, 2009; Hartig, Evans, Jamner, Davis & Garling, 2003; Ulrich, Quan, Zimrin, Joseph & Choudhary, 2004; Ulrich et al., 1991). Results also indicated that an individual's nature relatedness influenced the relationship between nature exposure and mood via environmental preference. Lastly, in Chapter 5 pro-social intentions and behavior were examined and results showed no relationship with INE.

Stress Reduction Theory

Using the stress-reduction theory as a guiding framework to explain the health promoting mechanisms of INE, this dissertation sought to test whether or not exposure to a multi-sensory indoor environment reduced stress, improved mood, and contributed to pro-social behaviours. To this end, results suggest that stress reduction and increases in positive affect may be explained in part by the stress-reduction theory. That is, when immersed in an indoor environment enhanced with features typically found in nature, one is likely to have a reduction in biological stress markers and an improvement in mood, regardless of their relationship with nature.

Figure 12. Word cloud of participants' adjectives of nature.

The results from this dissertation also provide further evidence to support the biophilia hypothesis (Wilson, 1984), and the notion that humans have an innate and evolutionary-based connection with the natural world. Building on the biophilia hypothesis, the stress-reduction theory suggests that these bio-psychological changes are in part due to an evolutionary-based automatic affective response one has when exposed to non-threatening natural environments (Ulrich et al., 1991). In fact, when asked to describe nature, participants described it as beautiful (n = 55), peaceful (n = 40), calming (n = 28), and relaxing (n = 18) (Figure 12), which supports previous work that found individuals typically view natural settings as beautiful, pleasant, and restorative (Hartig & Evans, 1993; Kaplan & Kaplan, 1989; Stamps, 1996). It is likely that because participants describe nature positively, they rated the INE condition favorably, and triggered the evolutionary environmental preference mechanism that stress-reduction theory is based upon.

The stress-reduction theory describes our preference for nature as a pre-cognitive and involuntary response that influences both physiological and psychological behaviours. The study results suggest that INE may be seen as an unthreatening environment and thus facilitates this stress recovery response (Ulrich, 1993). The integration of nature-based features (e.g., plants, nature sounds) into indoor environments could thus be a means to promote and restore both physiological and psychological stress through this evolutionary-based pathway. However, regardless of this evolutionary-based relationship, additional subjective and individual factors influence the benefits one receives from nature.

The stress-reduction theory (Ulrich et al., 1991) is inherently limited, as there is no way to directly validate its primary mechanism. While the theory suggests that there is an innate response to natural environments based on evolutionary derived environmental preference (e.g., physiological reduction in stress when viewing nature, as described above), there is no way to actually test or predict its power at explaining or understanding the nature-health relationship. The theory relies on the basic mechanism of a universal environmental preference, and it lacks a definitive explanation of how previous environmental exposures and individual preference relates to outcomes. However, Chapter 4 describes the potential role of individual environmental preference and how greater preference for an environment can lead to greater improvements in mood, and suggests that while there is an innate and automatic preference for nature, individual and subjective preference for our surroundings should not be underestimated.

Environmental Preference

We tend to prefer environments that are good for us (van den Berg et al., 2003). From an evolutionary perspective (e.g., the biophilia hypothesis and stress-reduction theory), environmental preference serves an adaptive purpose, by helping us appraise environments that will promote our survival and avoid threatening or harming spaces. Preference in this case is implicit and reflects an automatic physiological and psychological response, while explicit preference reflects an intentional cognitive process and is grounded in previous experiences (Strack & Deutsch, 2004). As noted in Figure 2 of Chapter 1, environmental preference may directly influence the nature-health relationship through both implicit (i.e., the above discussion on stress-reduction theory) and explicit pathways (i.e., individual preference). Results from this thesis suggest that health outcomes from INE may be linked to an individual's subjective (i.e., explicit) appraisal of their environment. If they feel more comfortable within a given setting, they will likely experience greater environmental benefits, such as improved mood and reduced stress.

Recent work investigating nature-based leisure activities suggests that preference for, and experiences in, nature may influence the outcomes of nature exposure and strengthen the benefits one receives (Bratman et al., 2012). Individuals interact with nature differently (Kjellgren & Buhrkall, 2010 Ottosson & Grahn, 2005), regardless of the physical properties of the environment. Experiences and interactions with nature-based environments are often diverse and subjective, and not simply a backdrop for our activities (Conradson, 2005). Environments can hold meaning linked to previous experiences, and thus influence how one engages with their surrounds. For example, higher environmental preference in the experimental condition resulted in a greater improvement in positive affect (Chapter 4). While the stress reduction theory suggests that we have an innate preference for nature, the benefits of INE may be linked to subjective environmental appraisal, rather than its direct resemblance of nature and our innate reaction to nature-based environments (Karmanov & Hamel, 2008). That is, previous experience may encourage a preference through learned associations (Tuan, 1974; Ulrich, 1983). If nature-characteristics are associated with prior experiences that were positive and/or restorative, then they may result in positive appraisal of similar environments.

When asked if participants wanted to make any written comments about nature many discussed past memories in natural environments. For example, one participant said "[Thinking about nature] prompted me to think of memories I have hiking and camping", another wrote "[Thinking about nature] makes me think of home…". Another wrote, "[Thinking about nature] made me think about my father he loves nature. I remember the times when we I would go out for walks with him." If preference for an environment is related to previous actions and experiences within that environment, then it's likely that similar environments, such as the exposure condition used for this dissertation, could build onto those experiences and enhance environmental preference via these explicit pathways.

Nature relatedness

If previous experiences contribute to current environmental preference, then one's nature relatedness may be a way to understand how prior interactions with nature shape how individuals perceive current nature-based environments. When examining nature relatedness, the sample showed that regardless of sex and age, connection with nature was significantly greater when more time was spent in nature. Greater nature relatedness suggests more familiarity, increased comfort with, and a desire to be in, nature (Nisbet et al., 2009). The results from Chapter 4 found that individuals with greater nature relatedness rated INE more positively, and reported increased positive affect. It appears that nature-relatedness may influence how individuals experience nature-based environments, and supports the idea that while the stress-reduction theory may partially explain the nature-health relationship, an individual's subjective preference for nature, which may be governed by nature relatedness, moderates the benefits they receive from INE.

Limitations

Several study limitations were noted in Chapters 3, 4, and 5, such as sample selection, duration of exposure, a lack of baseline nature relatedness, and issues with generalizability. However, a few design and logistical concerns should also be noted in additional to the aforementioned limitations.

While the space was largely functional for the project, there were some issues noted during data collection. The space was on a busy departmental floor in the university, and noise in the hall was often heard while participants were asked to sit quietly in the exposure/control condition. Other sounds such as computers inside the room, work being done outside the building, or noises from the surrounding offices may have distracted participants during the filler tasks, or caused spikes in stress (recorded via HRV) if they were startled. Even though the control condition was created to provide no nature-based characteristics, some sunlight could be seen at the edges of the curtains. While overhead LED lights were on at all times and minimized the visibility of the sunlight, it is important to recognize that a different environment, with no windows, would have ensured no sunlight in the room, or have given the indication that a window was present in the room.

Issues with measurements occurred during the course of the study, and may have biased the self-reported measures. For example, several participants spoke English as a second language and needed questions to be explained in greater detail. Misinterpretation and/or interactions with the researcher may have influenced how participants responded to questions. Another measurement issue was related to priming. Participants answered the Helping Attitudes and Behaviour Scale prior to the pro-social prompt, and this may have encouraged participants to engage in pro-social behaviours or indicated to them that this prompt was a part of the study. Consideration of prompt timing and the influence of other measures that may cue participants to the purpose of the prompt should be done in future studies investigating social behaviours. Lastly, while the Environmental Assessment Scale included a question on the sound of the environment, it largely asked participants about visual cues and characteristics of their surroundings. It would have been beneficial and informative to ask participants questions about non-visual components of the environment in order to understand if specific characteristics were preferred over others. Future research should compare environmental characteristics, and whether or not preference changes between visual and non-visual stimuli.

Sample issues were discussed in previous chapters, however, two major limitations should be noted. First, the sample consisted mostly of females. Given a longer data collection period it may have been possible to recruit more males and examine potential sex differences in more depth. Second, we did not record the ethnicity of participants. Nature interaction and conceptualization vary across cultures, and may be an important factor in environmental preference and nature connection. For example, Cosgriff, Little & Wilson (2010) found that Aotearoa-New Zealand natives feel inseparable from nature, and this belief is ingrained into their culture and social environment and often determines how they engage with outdoor environments. Pitkänen, Puhakka & Sawatzky (2011) interviewed Finnish and Canadian cottagers to understand their nature preference, and found that attachment to nature was formed through cultural meanings and practices. Future work should consider the culture and ethnicity of individuals, and how they may influence environmental preference.

Contributions & Implications

In this dissertation the beneficial effects on INE through physiological, psychological, and social pathways were tested, and the theoretical and individual mechanisms within the nature-health relationship were investigated. Evidence exists for the health benefits of outdoor nature exposure, whereas the evidence base is largely non-existent for the effects of multi-sensory indoor nature-based environments. Although the benefits of viewing natural characteristics indoors has been widely established, this dissertation contributed to the existing nature-health literature in a number of areas. This dissertation added to the existing body of literature by providing an important review of existing INE research (Chapter 2). The review indicated that while there is evidence on INE and its health impacts, it fails at reproducing the multi-sensory experience that occurs in nature. The review also indicated that while a variety of physiological and psychological facets of health has been studied, little work has been done exploring the social benefits of INE. Together, this review provided the foundation of this dissertation and future research, and signaled the importance of taking into account a variety of nature-based characteristics and various facets of physiological, psychological and social health.

Little work has been done to examine how multiple nature-based characteristics, targeted to engage with a variety of senses impacts health and wellbeing. Results from Chapters 3 and 4 show that a multi-sensory nature-based indoor environment can facilitate similar beneficial responses as those found with being outdoors. Results showed that INE is restorative, evoking positive moods and reducing physiological stress, and in turn, has restorative properties. This dissertation provides evidence that our everyday environments can be adapted to provide positive physiological and psychological benefits. Demonstrating a positive connection between the environment and wellbeing may help promote ecological behaviours and encourage individuals to go outside. Traditional "...doom and gloom messages that warn the public to change or die" (Mayer & Frantz, 2004, pp.512) often take an alarmist position and disregard the importance of the message. Providing a positive spin to promote eco-friendly habits and behaviours may be a more effective method to increase sustainable behaviours and environments (Howell, Dopko, Passmore & Byro, 2011), and help people to incorporate nature into their daily lives.

The work of this thesis can be applied to our built environments to enhance the health and well-being of individuals. While this study took place within a university setting and could be used to improve the health and wellbeing of students in universities (e.g., through the integration of INE into classrooms and common areas), residential homes, workplaces, hospitals, hotels, community centres, and businesses could all apply the results of this dissertation and receive positive health benefits. For example, offices could begin to think about how to integrate nature-based characteristics into their designs, by providing access to indoor plants, natural sunlight, playing nature sounds in common areas. Using the social ecological model (Chapter 1, Figure 1), the integration of INE into any of these environments would act as a means of supporting health and wellbeing at an individual and community level.

Additional novel insights were provided through Chapters 3 and 4 on the association of of individual-level factors in the nature-health relationship. Results showed that previous experiences with natural environments influenced appraisal of the INE condition, which impacted the benefits one received from being exposed to nature. These results give support to previous theoretical assumptions that prior associations with nature are a critical element in the therapeutic effects of nature exposure. This also suggests that viewing nature more positively and having positive experiences in nature, may enhance the therapeutic and restorative benefits of nature exposure.

Chapter 5 explored the social benefits of INE, an area of research that is largely undeveloped in the literature. While outdoor nature can provide a variety of social benefits, it appears the INE may not have the same effects. Although these results were not necessarily the outcomes proposed in Chapter 1, they do suggest that further inquiry on behaviours may need to investigate the amount of time spent in nature. It may be that behaviour is impacted by INE through longer durations. Designing longitudinal studies that examine INE over time and at varying lengths may be more effective at understanding the influence of nature on social behaviour.

Overall, this dissertation found that INE confers health benefits. Because it was one of the first experiments to investigate the use of multi-sensory INE, results can be considered a foundation for additional research to build upon. While results suggest that INE may be beneficial for work, hospitals, schools, and home environments, in order to persuade individuals to embrace these benefits and incorporate INE into healthy designs and interventions, there is a need for additional and equally strong empirical evidence using not only cross-sectional designs, but randomized controlled trials that specifically evaluate the amount, type, and length of INE on health outcomes.

This dissertation provides the foundation for further inquiry by highlighting the physiological and psychological benefits of INE, and the potential to adapt existing indoor environments to capture the benefits of being outdoors. In fact, further research on multi-sensory indoor nature could potentially provide a pathway for the creation of therapeutic and healing environments through micro-restorative architectural and design features. While the outcomes of this dissertation do not discard the importance of social facets of health, they do point to the fact that merely existing in indoor environments that contain characteristics of nature is enough to provide positive physiological and psychological benefits. Investigation of longer exposures to nature may be able to provide insight on behavioural and long-term impacts of INE. Most importantly, this dissertation provided empirical evidence that even short durations to indoor natural environments has immediate benefits to health. Thus, even simple nature-based characteristics such as plants or natural sounds could be integrated into environments for the betterment of human health.

CHAPTER 7 CONCLUSIONS

Nature is part of our existence. Until urbanization, humans lived within nature where they received a multitude of benefits from their surroundings. While we exist in drastically different environments than our ancestors, this connection and dependence still exists within our behaviours and involuntary reactions and preferences to natural environments and characteristics. In this dissertation, we looked at the physiological, psychological, and social benefits of adapting existing indoor spaces with a variety of nature-based characteristics in order to replicate the multi-sensory experience of being outdoors. This project was one of the first to test the use of multiple nature-based characteristics on health outcomes, and found that indoor nature exposure (INE) produced similar physiological and psychological benefits as being outdoors.

The stress-reduction theory has been used within the existing literature to explain these benefits. However, this theory does not offer a definitive explanation for the benefits of nature. In this dissertation, results suggest that while evolutionary-based preference may exist, individual environmental preference and nature relatedness play an important role in how one responses to natural environments. This evidence suggests that more work needs to be done to explore not only the benefits of multi-sensory INE, but also how individual-level variables influence the strength of these outcomes.

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Appendix B: Psychology Research Pool Ad

TITLE: Help us understand how campus spaces impact your health- and earn money doing it!

AD TEXT:

We are looking for Dalhousie students to participate in a short (1 hour) experiment on how university spaces impact your health and wellbeing. Participants will receive $5 and the option for credit towards a psychology course of their choice. Please contact jmmcswee@dal.ca if you are interested in participating or learning more about the project!

Appendix C: University Flyer Ad

Help us understand how campus spaces impact YOUR health! And earn money while doing it!

We are looking for Dalhousie students to participate in a short (1 hour) experiment on how university spaces impact your health and wellbeing. Participants will receive **$5** and the option for credit towards a psychology course of their choice! Please contact jmmcswee@dal.ca if you are interested in participating or learning more about the project!

jmmcswee@dal.ca	**jmmcswee@dal.ca**	**jmmcswee@dal.ca**	**jmmcswee@dal.ca**	**jmmcswee@dal.ca**	**jmmcswee@dal.ca**	**jmmcswee@dal.ca**	**jmmcswee@dal.ca**	**jmmcswee@dal.ca**	**jmmcswee@dal.ca**	**jmmcswee@dal.ca**	**jmmcswee@dal.ca**	**jmmcswee@dal.ca**	**jmmcswee@dal.ca**	**jmmcswee@dal.ca**	**jmmcswee@dal.ca**	**jmmcswee@dal.ca**

Appendix D: Screening Tool

Hello ______________,

Thank you for inquiring about the study and showing interest in participating! Before we can officially enroll you into the study, we need to make sure that you meet certain criteria for participating.

If you could please answer the following questions:

1. Do you have any known cardiovascular illnesses?
[ ] Yes [ ] No

2. Do you have any known allergic reactions to organic-based materials or natural scents (e.g., flowers, grass?
[ ] Yes [ ] No

4. In order to be eligible to participate in this study you will be required to:
- ***NOT*** consume caffeine or caffeinated beverages (e.g., coffee, tea, energy drinks, cola) **12 hours** prior to the experiment;
- ***NOT*** consume any alcohol (e.g., beer, wine, etc.) an **12 hours** prior to the experiment; and
- ***NOT*** engage in moderate to heavy physical activity (e.g., jogging/running, strenuous weight lifting) **12 hours** prior to the experiment.

Do you agree to adhere to these requirements and understand that if you do not meet them that you will be ineligible to participate the day of the experiment?
[ ] Yes [ ] No

Thank you for your time in answering these screening questions. You will be contacted shortly by email to discuss your eligibility.

** If student answers “No” to questions 1 and 2, and "Yes" to question 4 they are eligible to enroll in study. **
Eligible to participate:
[ ] Yes [ ] No

Return email response to participants:

If student is eligible to participate:

Thank you so much for answering those questions. Based on our eligibility criteria, you are able to participate in our study. Would you still like to be involved?

If yes, please indicate the times that you are free to participate during a typical week:

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Morning 8-12(AM)							
Afternoon 12-5 (PM)							
Evening 5-9 (PM)							

I will be in touch with you shortly with available times during the next week. Please do not hesitate to contact me if you have any questions and/or concerns.

Thank you

If ineligible: Thank you so much for answering those questions. Unfortunately based on our eligibility criteria, you are unable to participate in our study. We appreciate your interest.

Appendix E: Consent Form

Project Title: Nurturing Nature- Understanding the impact of indoor nature on human health and behavior

Lead researcher: Jill McSweeney, Ph.D(c)
IDPhD Program, Faculty of Graduate Studies
Dalhousie University
jmmcswee@dal.ca
902.403.8580

Other researchers:

Dr. Daniel Rainham, Ph.D
Environmental Sciences
Daniel.rainham@dal.ca

Dr. Jerome Singleton, Ph.D
School of Health and Human Performance

Dr. Shannon Johnson, Ph.D
Department of Psychology

Dr. Simon Sherry, Ph.D
Department of Psychology

Introduction: We invite you to take part in a research study being conducted by Ms. Jill McSweeney through the Interdisciplinary Ph.D program at Dalhousie University. Taking part in the research is up to you; it is entirely your choice. Even if you do take part, you may leave the study at any time for any reason. The information below tells you about what is involved in the research, what you will be asked to do and about any benefit, risk, inconvenience or discomfort that you might experience.

If you have any questions later, please contact Ms. Jill McSweeney.

Purpose of the research study: This research looks at understanding how the use of indoor nature (e.g., potted plants inside) impacts an individual's mood, stress and behaviours.

Study design: This is an experimental study. Participants will be randomly assigned to one of two conditions – an experimental condition, or a control condition. Additional information of the design of the study will be given to you after completion.

Who will be conducting the research?: This research is being conducted by Ms. Jill McSweeney, who is currently completing her Ph.D through the Interdisciplinary Program at Dalhousie University.

Who can take part in the research study?: Any Dalhousie student may participate in this study. However, if you are a Dalhousie student and currently have a known cardiovascular condition, an adverse reaction to scents or organic-based products, have consumed alcohol and/or caffeine within the last 12 hours, and/or have engaged in moderate to strenuous physical activity (e.g., jogging, running) in the last 12 hours, you will be ineligible to participate.

How many people are taking part in the study?: We are hoping to have at least 150 students participate in this study.

What you will be asked to do: To help us understand the impact of nature on students' mood, stress and behaviours, each participant will be asked to fill out a short survey prior to being exposed to their condition, and they will also be equipped with a heart rate monitor which will be used to measure their heart rate during their time in their assigned condition. They will then be asked to complete a 20 minute task. After the 20 minutes is up, all participants will be asked to complete another short survey. We believe that it will take you roughly 60 minutes to participate in the study.

Possible Benefits: Your participation in this study will help develop new information on how indoor learning environments can be created to help improve student health and wellbeing. The results will also help understand how bringing nature indoors can be used to enhance Dalhousie's campus. There is no guarantee that you will directly receive benefits from participating in this study. However, by completing this research, you may develop a deeper understanding of how the environment makes you feel.

Possible risks and conflicts of interest: There are several potential risks and discomforts you may face by participating in the research study.

(1) You may not enjoy discussing how you feel or current stresses in your life. Because your participation is completely voluntary, you may choose to withdraw your participation at any point with no consequences. If this is the case, you will still receive compensation (i.e., you will receive the $5 compensation for participating and one course credit point).

(2) Because there will be natural scents involved in this study, you may develop a reaction. If this occurs, you will immediately be removed from the environment, and you will no longer be required to participate in the study. Please note: If your participation

stops because you are feeling ill from the scent or having an adverse reaction, you will still be compensated for your time.

What you will receive for taking part: You will receive $5 for completing the study, and will also receive one course credit point towards a psychology course of your choice.

How your information will be protected: Confidentiality of the data collected will be assured by maintaining all data at the SILK Lab at Dalhousie, where it will only be accessible to the members of the research team. All electronic records will be kept secure in a password-protected, encrypted file on a Dalhousie University secure server. No individual data will be reported, with the exception of some unidentified quotes from survey answers that will be used to illustrate specific findings. You will not be identified in any reports or publications. The research team will store data in a designated locked area within the SILK Lab for five years following publication of the results, and then destroy them.

If you decide to stop participating: You are free to leave the study at any time. If you do leave the study, there will be no impact on you or your grades in any psychology courses, and will still receive the $5 compensation.

How to obtain results: All participants are welcome to receive information of the results of this research. If you would like to receive a copy of the research results, please provide us with an email address (see the following page).

Questions: Should you have any questions about taking part in the study, concerns, or would like more information, please contact: Ms. Jill McSweeney at jmmcswee@dal.ca. In addition, you will be contacted of any new information that may affect your decision to participate in the study.

If you have any ethical concerns about your participation in this research, you may also contact the Director, Research Ethics, Dalhousie University at (902) 494-1462, or email: ethics@dal.ca

Nurturing Nature- Understanding the impact of indoor nature on human health and behavior

S*ignature Page*

I have read the explanation of this study. I have been given an opportunity to discuss this study and my questions have been answered to my satisfaction. However, I realize that my participation is voluntary and I am free to withdraw from this study at any time.

I have:

___ *NOT* consumed caffeine or caffeinated beverages (e.g., coffee, tea, energy drinks, cola) an 12 hours prior to the experiment;

___ *NOT* consumed any alcohol (e.g., beer, wine, etc.) 12 hours prior to the experiment; and

___ *NOT* engaged in moderate to heavy physical activity (e.g., jogging/running, strenuous weight lifting) 12 hours prior to the experiment.

------ I hereby consent that I will participate in this study

_ _
Name of Participant (Please Print)

_ _
Participant's Signature

_ _
Date

STATEMENT BY PERSON PROVIDING INFORMATION ON STUDY
I have explained the nature and demands of the research study and judge that the participant named above understands the nature and demands of the study.

Name (Print): _ Position _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Signature: _ Date: _ _ _ _ _ _ _ _ _ _ _
Time: _ _ _

COMMUNICATION OF RESULTS
If you would like to receive a summary of the results of this study, please provide your email address.

Contact Person: _
_ _ _

Email Address: _
_ _ _ _

Appendix F: Pre-exposure Survey

Pre-Exposure Survey

Participant ID:

Date:

A. PANAS Questionnaire

This scale consists of a number of words that describe different feelings and emotions. Read each item and then list the number from the scale below next to each word. **Indicate to what extent you feel this way right now, that is, at the present moment.**

1	2	3	4	5
Very Slightly or Not at All	A little	Moderately	Quite a Bit	Extremely

______	1. Interested	______	11. Irritable
______	2. Distressed	______	12. Alert
______	3. Excited	______	13. Ashamed
______	4. Upset	______	14. Inspired
______	5. Strong	______	15. Nervous
______	6. Guilty	______	16. Determined
______	7. Scared	______	17. Attentive
______	8. Hostile	______	18. Jittery
______	9. Enthusiastic	______	19. Active
______	10. Proud	______	20. Afraid

B. Connectedness to Nature Survey

Instruction: For each of the following, please rate the extent to which you agree with each statement, using the scale from 1 to 5 as shown below. Please respond as you really feel, rather than how you think "most people" feel.

1	2	3	4	5
Disagree strongly	Disagree a little	Neither agree or disagree	Agree a little	Agree strongly

1. My ideal vacation spot would be a remote, wilderness area. _________________
2. I always think about how my actions affect the environment. _________________
3. My connection to nature and the environment is part of my spirituality. _________________
4. I take notice of wildlife wherever I am. _________________
5. My relationship to nature is an important part of who I am. _________________
6. I feel very connected to all living things and the earth. _________________

7. Please share any comments you may have on the questions, what they prompted you to think about or your thoughts about nature.

8. What size place did you spend most of your childhood?

(1) Rural/small town (less than 10,000 residents)	[ ]
(2) Mid-sized town (10,000 - 99,999 residents)	[ ]
(3) Large town/Suburb/Small city (100,000 to 349,999 residents)	[ ]
(4) Medium sized city (350,000 to 999,999)	[ ]
(5) Large city (1 million or more residents)	[ ]

9. Using the following scale, in the space provided next to each type of terrain, please state how often you spend time in each environment.

Very Frequently	Frequently	Occasionally	Rarely	Very Rarely	Never
6	5	4	3	2	1

___________ a. Ocean/beach
___________ b. River/stream/lake/pond
___________ c. Mountain/hill
___________ d. Forrest
___________ e. Grassland/prairie
___________ f. Recreational park
___________ g. Desert
___________ h. Arctic
___________ i. Other (please specify): ______________________________

10. On average, approximately how many hours per week would you consider yourself to have interacted with nature? (For example, walking outside, biking, gardening, playing sports/games, camping, fishing, reading outside, etc...)

[ ] zero (none)
[ ] 1-5 hours
[ ] 6-10 hours
[ ] 11-15 hours
[ ] 16-20 hours
[ ]21+ hours

11. Please list 3 words that describe nature to you:

1.________________________

2.________________________

3.________________________

C. Student-Life Stress Inventory

Complete this question first:	Mild	Moderate	Severe
Rate your overall level of stress:	☐	☐	☐

This inventory contains statements dealing with student-life stress. Read it carefully and respond to each statement as it has related or is relating to you as a student. Use the 5-number scale which indicates the level of your experience.

1= Never, 2 = Seldom, 3 = Occasionally, 4 = Often, and 5 = Most of the time.

i. Stressors:	**Never 1**	**Seldom 2**	**Occasionally 3**	**Often 4**	**Most of the time 5**
A. As a student					
1. I have experienced frustrations due to delays in reaching my goal.	1	2	3	4	5
2. I have experienced daily hassles which affected me in reaching my goals.	1	2	3	4	5
3. I have experienced lack of sources (money for auto, books, etc.)	1	2	3	4	5
4. I have experienced failures in accomplishing the goals that I set.	1	2	3	4	5
5. I have not been accepted socially (become a social outcast).	1	2	3	4	5
6. I have experienced dating frustrations.	1	2	3	4	5
7. I feel I was denied opportunities in spite of my qualifications.	1	2	3	4	5
B. I have experienced conflicts which were:					
8. Produced by two or more desirable alternatives.	1	2	3	4	5
9. Produced by two or more undesirable alternatives.	1	2	3	4	5
10. Produced when a goal had both positive and negative alternatives.	1	2	3	4	5
C. I have experienced pressures:					
11. As a result of competition (on grades, work, relationships with spouse and/or friends).	1	2	3	4	5
12. Due to deadlines (papers due, payments to be made, etc.).	1	2	3	4	5
13. Due to an overload (attempting too many	1	2	3	4	5

things at one time).					
14. Due to <u>interpersonal relationships</u> (family and/or friends expectations, work responsibilities).	1	2	3	4	5
D. I have experienced					
15. Rapid <u>unpleasant</u> changes.	1	2	3	4	5
16. <u>Too many</u> changes occurring at the same time.	1	2	3	4	5
17. Changes which <u>disrupted</u> my life and/or goals.	1	2	3	4	5
E. As a person:					
18. I like to compete and win.	1	2	3	4	5
19. I like to be noticed and be loved by all.	1	2	3	4	5
20. I worry a lot about everything and everybody.	1	2	3	4	5
21. I have a tendency to procrastinate (put off things that have to be done).	1	2	3	4	5
22. I feel I must find a perfect solution to the problems I undertake.	1	2	3	4	5
23. I worry and get anxious about taking tests.	1	2	3	4	5

<u>ii. Reactions to Stressors</u>

F. During stressful situations, I have experienced the following:					
24. Sweating (sweaty palms, etc.)	1	2	3	4	5
25. Stuttering (not being able to speak clearly)	1	2	3	4	5
26. Trembling (being nervous, biting finger-nails, etc.)	1	2	3	4	5
27. Rapid movements (moving quickly from place to place).	1	2	3	4	5
28. Exhaustion (worn out, burned out)	1	2	3	4	5
29. Irritable bowels, peptic ulcers, etc.	1	2	3	4	5
30. Asthma, bronchial spasms, hyperventilations	1	2	3	4	5
31. Backaches, muscles tightness, cramps, teeth-grinding	1	2	3	4	5
32. Hives, skin itching, allergies	1	2	3	4	5
33. Migraine headaches, hyptertension, rapid heartbeat	1	2	3	4	5
34. Arthritis, overall pains	1	2	3	4	5
35. Viruses, colds, flu	1	2	3	4	5
36. Weight loss (can't eat)	1	2	3	4	5
37. Weight gain (eat a lot)	1	2	3	4	5
G. When under stressful situations, I have experienced:					

38. Fear, anxiety, worry	1	2	3	4	5
39. Anger	1	2	3	4	5
40. Guilt	1	2	3	4	5
41. Grief, depression	1	2	3	4	5
H. When under stressful situations, I have:					
42. Cried	1	2	3	4	5
43. Abused others (verbally and/or physically)	1	2	3	4	5
44. Abused self	1	2	3	4	5
45. Smoke excessively	1	2	3	4	5
46. Was irritable towards others	1	2	3	4	5
47. Attempted suicide	1	2	3	4	5
48. Used defense mechanism	1	2	3	4	5
49. Separated myself from others					
I. With reference to stressful situations, I have:					
50. Thought and analyzed about how stressful the situations were.	1	2	3	4	5
51. Thought and analyzed whether the strategies I used were most effective.	1	2	3	4	5

D. General Health Questionnaire

We want to know how your health has been in general over the last few weeks. Please read the questions below and each of the four possible answers. Circle the response that best applies to you.

Have you recently:	Better than usual 1	Same as usual 2	Less than usual 3	Much less than usual 4
1. been able to concentrate on what you're doing?	1	2	3	4
2. lost much sleep over worry?	1	2	3	4
3. felt that you are playing a useful part in things?	1	2	3	4
4. felt capable of making decisions about things?	1	2	3	4
5. felt constantly under strain?	1	2	3	4
6. felt you couldn't overcome your difficulties?	1	2	3	4
7. been able to enjoy your normal day to day activities?	1	2	3	4
8. been able to face up to your problems?	1	2	3	4
9. been feeling unhappy or depressed?	1	2	3	4
10. been losing confidence in yourself?	1	2	3	4
11. been thinking of yourself as a worthless person?	1	2	3	4
12. been feeling reasonably happy, all things considered?	1	2	3	4

E. Demographic Information

1. Sex: [ ] Female [ ] Male

2. Date of birth ______/______/______ (*date/month/year*)

3. What year of your undergraduate degree are you in? _____________

4. What program are you currently in? _____________________

5. How many courses are you currently enrolled in? _____________________

6. Are you currently employed? [ ] NO [ ] YES

6b. If yes, please identify your employment status:

(1) Paid full-time employment	[ ]
(2) Paid part-time employment	[ ]
(3) Self-employment	[ ]
(4) Non-paid work, volunteer/charity	[ ]
(5) Other	[ ]

(*please specify)*_______________________

7. Current marital status (*Check only one that is most applicable*)

(1) Never married	[ ]	(4) Divorced	[ ]
(2) Currently Married	[ ]	(5) Widowed	[ ]
(3) Separated	[ ]	(6) Cohabiting	[ ]

8. Do you currently smoke?
[ ] Yes [ ] No

Appendix G: Filler Task

Filler Task 1: Search and Memory Test

Each line of letters will contain some or all of the target letters presented below. Memorize the target letters and search through each line only once. Draw a line through each target letter. You will be allowed 10 minutes to complete the task, and after 5 minutes you will be asked to circle the letter that you are looking at.

The target letters are bolded and underlined as a scoring template. They will not be bolded and underlined for participants.

1. a u i t o

w f e n p h z **o** f r r n q m l h z b j j l m w v r c j l l e c g w s q n h c m n s y r m n j
w n j d x m l g q **t** b c p

2. s c h o b

k m d m **h** v y p v **s** y n p t d j g l w f u t g y m w z k n w l n j q y z y r k y w w r y j
v y d y q w m d g g m k m **b**

3. q d x z v

k m r e n o h m f a s g t e y e a a l s c l k r g p e y u g f r o e t w t c m r m n p w w
m r a c a f p m j l y u m h

4. m h f k e

h d c j j x y g a q q d p r g **m** t p b x c c r s s z d x x v g x x r s t n b a l b v **e** d q n l
d q x **k** z y y o b b l **f**

5. p w n l y

p t b q q a x k u g o x v b q f f l s l r g e r u h h **w y** x c k x d t l d s z s s h o v u r d
k e q h v f s f s s e **l**

6. b n r i a

z c j z y t f z o u g o w p j w x z p q x o g z x s **i** j l u u d c y y k q j p y f h o x p q o d u f d e e v s s p w q

7. t e z p q

l o k l w l s h u u s l w x f n d r k b w **q** m s g l j l m x g j o d g b j c k d v l m m m n u **t** g v h a c y u o f m r

8. v t y o x

o h q n f g n k j h m s d u z p k a d **v y** f p b n u p c j a d l q s p r p u s b b e g **t** b g l n z d z m n f p s c g **x**

9. r q i n a

p z x x v u k o u z t k d v t s s u **n** z u h h o z w m o v v o j o p m f s f l g s t j w p z j c u c b j p s z j l s w

10. s v p u g

c m l t l f f q e r a k t w a r b l z x j x a a n f r f q m x c d o i m j x l x c h k m k j l b n o a n r l x w l k l

11. m x c d o

d o l p w a b j j p q e h i l t a h p f l k k l j **m** y b n b h r l i s u t v y a j i n s a w p r e z r t **c** u e l v r **x**

12. g t h b e

q l a j f i c m o m m d m q v v p d r w n o c q y y y q k r v x n o f m a x f o z l i n c p c l c o j q **e** j u z u r w

13. d r w c m

x k e v **d** q l e a u b n q a a f l y n v s f t l n e x g s t b **r** f o k a o z f I v b l l e a o v k k e q p v s a x x e

14. o p t l s

y **t** r m c d i j c w g w c e i m i q i v x k j i k x j v y d c m c j i u j x n c v d a a j i g w f v h v h z g r b c u

15. b q a x i

a l p g j v p u m d d d w s s c f p t h g m z j **q x** f h y l d v v c k n p c d t z d o t h h u g u c v **b** h p g k j o u

16. z n k f c

r m g a j e g r l g g t r d e j u t q b i u d t y s g g i s v a p v u q d d m s m w m t i i j o u v l y w u d u x q s

17. w t a g v

a j e p p c f y j m q f o b p s o d c o r c z p q f b m c d r **g** q y n p u r z b j i i o x e h f f i e o n j d **w** y r o

18. y r b g o

b r v l v x i p v q x u z s c n l s i c h z w z z k k d v s w **o** v q a d j j d k x p u p d j m z h l p s a h h k z n q

Filler task 2

Step 1- Determination of the Subject's Digit Span

Instructions to the Experimenter

You have in front of you a sheet headed *Lists for Digit Span Determination*. You will see that lists are arranged in sets, those in each set being of the same length, the lists becoming progressively longer as you work down the page. In each set, there are nine lists, but that is to allow for the possibility of interruptions. The subject will receive only **six** lists for the actual determination of span.

Say to the subject that you are going to read them lists of digits, and that they are to try to repeat the digits **in the order in which they were read out**. If the subject seems unclear about what is required, go through an example, say, the list: 4, 7, 1. Read the digits in an even tone, at approximately the rate of **one digit per second**.

The subject should be tested on six lists, starting with length 2. Read out the digits at the rate of one digit per second. In the space provided, put a tick if the subject repeats the list correctly, and a cross if they do not. If the subject gets at least five out of the six lists correct, proceed to the lists in the next set. Continue this procedure until the subject gets two lists from the set wrong. At the bottom of the page, enter the subject's Digit Span as the **maximum length of the lists of which the subject recalled at least 5/6 correctly.**

After each of the following lists, in the space provided, enter a tick (√) if the list is correctly recalled and a cross (×) if it is not. At the bottom of the page, in the space provided, enter the subject's Digit Span as the maximum length of the lists of which the subject recalled 5/6 correctly. Present only 6 lists to the subject.

List	Result (√ or ×)	List	Result (√ or ×)	List	Result (√ or ×)
For Span = 2					
83		54		27	
28		37		91	
68		96		87	
For Span = 3					
829		687		871	
132		356		251	
152		637		915	
For Span = 4					
6241		1372		5316	
2359		7392		4815	
7132		6539		1872	
For Span = 5					
84132		85293		79514	
62143		91635		82691	
97438		16592		75468	
For Span = 6					
587261		492617		148239	
261384		247681		423896	

632147		429735		641357	
For Span = 7					
2941378		6297865		1897562	
1285394		8243167		3185624	
8693735		3945782		2473961	
For Span = 8					
65148279		28653197		85729136	
18472913		65792381		76591243	
42785921		74529638		76921358	
For Span = 9					
679174382		239874615		539748216	
746231958		867934612		513985267	
398724615		794831265		231986734	
For Span = 10					
4982176453		2853967624		2914984357	
5731298426		9781734826		6983285149	
8182397465		8491287637		6391727362	

Subject's Digit Span =

Appendix H: Post-exposure Survey

Post-Exposure Survey

Participant ID:

Date:

A. PANAS Questionnaire

This scale consists of a number of words that describe different feelings and emotions. Read each item and then list the number from the scale below next to each word. **Indicate to what extent you feel this way right now, that is, at the present moment.**

1	2	3	4	5
Very Slightly or Not at All	A little	Moderately	Quite a Bit	Extremely

______________	1. Interested	______________	11. Irritable
______________	2. Distressed	______________	12. Alert
______________	3. Excited	______________	13. Ashamed
______________	4. Upset	______________	14. Inspired
______________	5. Strong	______________	15. Nervous
______________	6. Guilty	______________	16. Determined
______________	7. Scared	______________	17. Attentive
______________	8. Hostile	______________	18. Jittery
______________	9. Enthusiastic	______________	19. Active
______________	10. Proud	______________	20. Afraid

B. Environmental Assessment Scale

INSTRUCTIONS: This questionnaire has pairs of adjectives that can be used to describe how the environment in this room feels to you. Look over the list of adjectives and place ONE checkmark in what box comes closest to how you are feeling about this room.

	Very closely	Quite closely	Somewh at closely	Neutral	Only slightly	Somewh at closely	Quite closely	Very Closely	
1.Satisfying room	□	□	□	□	□	□	□	□	Annoying room
2. Clean	□	□	□	□	□	□	□	□	Dirty
3. Relaxing	□	□	□	□	□	□	□	□	Stressing
4. Comfortable	□	□	□	□	□	□	□	□	Uncomfortable
5. Colorful	□	□	□	□	□	□	□	□	Drab
6. Happy	□	□	□	□	□	□	□	□	Sad
7.Pleasant smell	□	□	□	□	□	□	□	□	Unpleasant Smell
8. Bright	□	□	□	□	□	□	□	□	Dull
9. Spacious	□	□	□	□	□	□	□	□	Crowded
10 Calming	□	□	□	□	□	□	□	□	Irritating
11. Warm	□	□	□	□	□	□	□	□	Cool
12. Attractive	□	□	□	□	□	□	□	□	Unattractive
13. Quiet	□	□	□	□	□	□	□	□	Noisy

C. Helping Attitudes Scale

INSTRUCTIONS: This instrument is designed to measure your feelings, beliefs and behaviours concerning your interactions with others. It is not a test, so there is no right or wrong answers. Please answer the questions as honestly as possible. Using the scale below, indicate your level of agreement or disagreement in the space which is next to each statement.

1	2	3	4	5
Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree

	Strongly Disagree 1	Disagree 2	Undecided 3	Agree 4	Strongly Agree 5
1. Helping others is usually a waste of time.	1	2	3	4	5
2. When given the opportunity, I enjoy aiding others who are in need.	1	2	3	4	5
3. If possible, I would return lost money to the rightful owner.	1	2	3	4	5
4. Helping friends and family is one of the great joys in life.	1	2	3	4	5
5. I would avoid aiding someone in a medical emergency if I could.	1	2	3	4	5
6. It feels wonderful to assist others in need.	1	2	3	4	5
7. Volunteering to help someone is very rewarding.	1	2	3	4	5
8. I dislike giving directions to strangers who are lost.	1	2	3	4	5
9. Doing volunteer work makes me feel happy.	1	2	3	4	5
10. I would donate time or money to charities.	1	2	3	4	5
11. Unless they are part of my family, helping the elderly isn't my responsibility.	1	2	3	4	5
12. Children should be taught about the importance of helping others.	1	2	3	4	5
13. I plan to donate my organs when I die with the hope that they will help someone else live.	1	2	3	4	5
14. I would offer my help with any	1	2	3	4	5

activities my community or school groups are carrying out.					
15. I feel at peace with myself when I have helped others.	1	2	3	4	5
16. If the person in front of me in the check-out line at a store was a few cents short, I would pay the difference.	1	2	3	4	5
17. I feel proud when I know that my generosity has benefited a needy person.	1	2	3	4	5
18. Helping people does more harm than good because they come to rely on others and not themselves.	1	2	3	4	5
19. I rarely contribute money to a worthy cause.	1	2	3	4	5
20. Giving aid to the poor is the right thing to do.	1	2	3	4	5

Appendix I: Written Debrief

Nurturing Nature- Understanding the impact of indoor nature on human health and behavior

The purpose of this research is to determine whether indoor nature exposure (or exposure to items like plants indoors) impacts an individual's mood, stress, and behaviours. It has been shown that nature increases a person's mood, reduces their stress, and encourages social behaviours. However, it is unknown how an indoor environment that tries to replicate the sights, sounds, and smells of outdoors, impacts mood, stress and behaviours.

In this study you were presented with either an experimental space that had natural items (e.g., a plant, the smell of pine) or a regular space that had no natural items in it. We then measured your heart rate, to see if it changed during your time in the room. We also had you fill out two surveys, which will help us understand if your mood changed after being exposed to the environment. We wanted to know whether or not a room with nature would impact how you felt.

We also asked you whether or not you would be willing to donate your $5 participation compensation to a charity of your choosing and had you fill out a measure on your desire to help others. We did this because the literature suggests that when you are exposed to environments that you enjoy, such as nature, you're more likely to be selfless. We wanted to see if those people exposed to a nature filled indoor environment would be more willing to donate their $5 compensation and experience intentions of helpfulness. Please note that all donated money will be given to the Nova Scotia Food Bank on behalf of Dalhousie University.

If you are interested in this area of research, the following sources are available via the library:

- Bowler, D.E., Buyung-Ali, L.M., Knight, T.M., & Pullin, A.S. (2010). A systematic review of evidence for the added benefits to health of exposure to natural environments. *BMC Public Health*, 10, 456-66.
- Frumkin, H, (2001). Beyond Toxicity: human health and the natural environment. *American Journal of Preventative Medicine*, 20 (3), 234-240.
- Kaplan, S. (1995). The Restorative Benefits of Nature: Toward an Integrative Framework. *Journal of Environmental Psychology*, 15, 169-182.

We also asked you several questions about your mood, the stresses you are facing, and your academic programme. If you need to talk to someone about this experience or these questions, please contact Dalhousie Counselling Services by phone at 902.494.2081, by email at recepcps@dal.ca, or by visiting their office on the 2nd floor of the LeMarchant Mixed-Use Building at 1246 LeMarchant St.

If you have any complaints, concerns, or questions about this research, please feel free to contact, Jill McSweeney (jmmcswee@dal.ca), Dr. Daniel Rainham, Ph.D (Daniel.rainham@dal.ca, P: 902.494.1286), Assistant Professor of the Department of

Environmental Science, or the Director, Research Ethics, Dalhousie University (P: 902.494.1462, ethics@dal.ca.

Finally, thank you again for helping us with this research.

Appendix J: Reminder Email

Dear _______________,

Thank you for agreeing to participate in my upcoming study. This is just a friendly reminder that we are scheduled to meet tomorrow, (DATE), at (TIME), in (ROOM).

Please remember that in order to be eligible to participate tomorrow you will be required to :

NOT consume caffeine or caffeinated beverages (e.g., coffee, tea, energy drinks, cola) 12 hours prior to the experiment;

NOT consume any alcohol (e.g., beer, wine, etc.) 12 hours prior to the experiment; and

NOT engage in moderate to heavy physical activity (e.g., jogging/running, strenuous weight lifting) 12 hours prior to the experiment.

If you have any questions and/or concerns, please do not hesitate to contact me. I look forward to seeing you tomorrow!