THE EFFECTS OF ENVIRONMENT ON MEMORY AND REASONING SKILLS:

COMPARING NATURAL AND ARTIFICIAL ENVIRONMENTS

by

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DEDICATION

This work is dedicated to the one who reminded me, and the only one.

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I would like to thank Dr. Cade for encouraging me to pursue this degree, others who contributed to this project with suggestions and constructive criticism, and the three hundred and eighty students who participated.

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ABSTRACT

The Attention Restoration Theory (ART) suggests that our directed attention is subject to fatigue, and that the presence of nature and natural environments allows us to recover from that fatigue, consequently improving cognitive function. Three hundred and eighty undergraduate degree-seeking students of all classifications from diverse academic disciplines at Texas State University were tested using modified forms of the Sentence Repetition Test and the California Verbal Learning Test to test verbal memory and verbal learning, and a modified form of the Wechsler Adult Intelligence Scale-IV Matrix Reasoning to test non-verbal reasoning/fluid intelligence. Half of the subjects (190) were tested in their classroom at the regularly scheduled class time or one located in the same building at a predetermined date and time. Half of the subjects (190) were tested in an outdoor garden classroom at a predetermined date and time. No significant difference was found to exist between either the memory or reasoning scores of the two groups. Comparisons of subjects in the same demographic categories produced three significant P values. Students classified as seniors (P=0.035), students ages 36-40 (P=0.030), and students ages 41 and above (P=0.041) who were tested in the natural environment performed significantly better on the Sentence Repetition Test than those tested in the artificial environment.

I. INTRODUCTION

Erich Fromm first used the term biophilia to describe a psychological orientation which he defined as a love of life or living systems (Eckerdt, 1992). In his book entitled *Biophilia,* Edward O. Wilson defines the term as, “the innate tendency to focus on life and lifelike processes” (Wilson, 1984, prologue). This innate tendency is beyond the simple appreciation of aesthetically pleasing landscapes, colorful foliage, or a panoramic sky. Humans’ affinity to other forms of life is intrinsically linked to the physiological and emotional necessities required to sustain and perpetuate their existence, and one which Ulrich (1993) has suggested is contingent upon a genetic predisposition. Wilson describes this affinity as a deep and complicated process in mental development, and a propensity on which our existence depends (Wilson, 1984, prologue).

Bratman et al. (2012) define living systems as those which contain the elements of plants and nonhuman animals which can span the range of human-managed landscapes and parks to areas of pristine wilderness. Humans’ daily exposure to these natural elements has progressively declined. Evans and McCoy (1998) estimated that the typical American spends 90% of their lives inside. Such a decline in exposure to nature is suggested to be a critical variable in decreased physical, emotional, and psychological well-being (Bratman et al., 2012).

Humans’ affinity to nature has commonly been expressed in art, architecture, and personal space. The ancient gardens of Egyptian nobility, Persian settlements, and Chinese merchants exemplify the propensity to surround themselves with nature (Ulrich, 1993). Tomb paintings and excavations of ruins in Egypt and Italy have shown that plants were incorporated into homes and gardens more than 2,000 years ago (Manaker, 1996).

The understanding of the healing and restorative effects of nature dates back to the Middle Ages, where gardens and natural areas were incorporated into infirmaries, as they later were in hospitals throughout Europe from the 1600s–1800s (Marcus and Barnes, 1999).

As research began to demonstrate how incorporating nature into a built environment improved health and productivity, the modern architectural paradigm became one which sought to connect people to the patterns and features of nature by providing a greater presence of light, fresh air, plants, and green spaces (Ramzy, 2015). Landscape architecture no longer attempted to simply achieve the best environmental and aesthetic outcomes in designs, but to positively impact social-behavioral outcomes as well (Jellicoe et al., 1987). Urban planners realized that integrating natural elements such as flowers, trees, water, and winding pathways into their designs improved mood and reduced stress (Heerwagen, 2009). Grassroots efforts such as community gardening found improvement of individuals' moods and perceptions of their quality of life (Marcus and Barnes, 1995; Waliczek et al., 1996). When residents at six low-rise apartment communities were asked to rate their level of satisfaction with their neighborhood, as well as their overall sense of well-being, those with window views of nature reported feeling more relaxed, more effective, and less distracted compared to those whose windows did not have views of nature (Kaplan, 2001). Adding plants to an indoor work environment, and the presence of window views to green spaces increased job satisfaction (Dravigne et al., 2008) and decreased self-reported sick leave (Bringslimark et al., 2007).

Seeking a more objective measurement than self-reported health indicators, Thompson et al. (2012) used cortisol levels, a steroid hormone released in response to stress, to determine the potential effects of the quantity of green space to which subjects were exposed. Subjects were asked to take four salivary samples a day over a two-day period. Percentages of green space in their respective residential environments were calculated. In general, cortisol levels are highest shortly after awakening and decrease throughout the day. Results indicated a significant relationship existed between cortisol levels and the amount of time subjects were exposed to green space. Subjects living in residential areas with a higher percentage of green space exhibited greater declines in cortisol levels than those living in areas with less green space. Van den Berg and Custers (2011) compared the effects of gardening and reading after administering a stressful Stroop task to 30 gardeners. While gardening and reading both decreased salivary cortisol levels and improved mood, the decrease was significantly higher, and positive mood was fully restored after gardening. Similar declines in cortisol levels were reported in mentally challenged adults and dementia patients who had participated in horticultural therapy programs (Lee, 2010; Yun and Choi, 2010). In addition to the visual effects of plants, there is evidence to suggest that fragrance, enhanced acoustics, improved humidity and air quality have beneficial effects on health, and though most studies have concentrated on the benefits of an association with plants, lack of this association can translate into a reduced quality of life (Grinde and Patil, 2009).

The therapeutic benefits of nature go well beyond improving mood and reducing stress. In a seminal work, *View through a window may influence recovery from surgery* (Ulrich, 1984), gall bladder surgery patients having a window view of an outdoor landscape exhibited shorter hospital stays, faster recovery times, and used fewer and milder analgesics when compared to patients with a window view of an adjacent brick wall. Similar outcomes were reported in a study in which heart surgery patients were assigned one of three visual stimulation conditions: nature pictures, abstract pictures, or a control condition of a white panel or no pictures. Results suggested patients exposed to the nature pictures were less anxious during the recovery period and suffered less pain (Ulrich et al., 1993). Studies by Cimprinch (1993) and English et al. (2008) indicated that recovering breast cancer surgery patients exhibited many of the same post-operative therapeutic benefits when exposed to natural views. In two studies, Park and Mattson also reported the positive healing effects of plants and flowers during hospital recovery (Park and Mattson, 2009a; Park and Mattson, 2009b).

Mental health professionals have realized the efficacy of incorporating nature and natural environments into treatment protocols. Gonzalez et al. (2011) reported a decrease in the severity of depression in patients involved in horticultural activities. Bragg and Atkins (2016) presented evidence that green care interventions such as social and therapeutic horticulture contributed to a reduction in levels of anxiety and depression. Symptoms of attention-deficit/hyperactivity disorder were reduced in children whose activities were conducted in green or natural settings as opposed to those conducted in indoor settings (Kuo and Fabor, 2004). Beneficial effects of outdoor space and horticultural therapy has been observed in patients with Alzheimer's (Brawley, 2002) and dementia (Gigliotti et al., 2004). Treatment protocols similar to the German *Kur*, which utilizes naturopathic remedies including walks in garden environments (Maretzki, 1987) have been incorporated by many psychotherapists who conduct therapy in a natural environment outside of the clinical or office setting (Chalquist, 2009).

The importance of surrounding greenspace cannot be understated. In a meta-analysis of related literature, Lee and Maheswaren (2011) found that studies generally supported the idea that green spaces had beneficial effects on both physical and mental health. Van den Berg et al. (2010) found that individuals with high amounts of surrounding green space reported a less-stressful life than those with low amounts. Takano et al. (2002) reported an increase in longevity among senior citizens with access to walkable green spaces compared to those who did not have access.

Zhou and Wang (2011) estimated that by 2025, 65% of the population will reside in urban areas. Lee and Maheswaren (2011) reported similar findings, suggesting that the number of persons living in urban areas will rise from 46.6%, currently, to 69.6% by 2050. As urbanization continues to consume green spaces, not only is physical health negatively impacted by the consequential increases in pollution, heat island effects, and climate change, but so is mental health, as well (Lee and Maheswaren, 2011).

These are only a few examples of the research which supports the beneficial effects of nature and natural environments on physical and mental health. If mood and self-esteem, productivity, stress, anxiety, depression, psychological disorders, and hospital recovery times can be positively affected, it is understandable why research has also focused on the potential impact nature may have on cognition and mental processes such as perception, memory, reasoning, learning, and judgement. This paper will concentrate on the relationship between nature and the effectiveness and quality of memory and reasoning, including a review of related literature, implementation of a protocol to measure potential relationships of memory and reasoning to nature, and the study's results and conclusions. Applications, if any, and suggestions for further research will be discussed.

Problem Statement

The beneficial effects of a natural environment on physical and mental health has been well-documented. The purpose of this study is to determine if the cognitive functions of memory and reasoning are enhanced when exercised in a natural environment as compared to when they are exercised in an artificial environment. For the purpose of this study, a natural environment is defined as one comprised of elements existing or caused by nature, and an artificial environment as one comprised of elements made or caused by humankind.

Study and Objectives

The main objective of this research was to determine if a relationship existed between the effectiveness and quality of mental processes and the environment in which they were exercised. Specific objectives included:

1. To investigate if memory was improved in a natural environment vs. an artificial environment.
2. To investigate if reasoning was improved in a natural environment vs. an artificial environment.
3. To compare subjects in the same demographic categories to investigate if memory and/or reasoning was improved in a natural environment vs. an artificial environment.

Hypothesis

Subjects will exhibit an enhanced level of performance on memory and reasoning exercises when the research testing instrument is administered in a natural environment as compared to when the instrument is administered in an artificial environment.

Limitations

1. Study was limited to being conducted in environments located at Texas State University.
2. Study was limited to a sample of undergraduate students attending classes at Texas State University.
3. The collection of data and the administration of the testing instrument was limited by students' availability and proximity to the testing environments, and its completion within a 40-minute time frame.

Definition of Terms

Alerting. The attentional process of becoming aware of something (Jonides et al., 2008).

Aphasia. An impairment of language, affecting the production or comprehension of speech and the ability to read or write (National Aphasia Association).

Attention Network Test. A tool used to assess the efficiency of the three attention networks - alerting, orienting, and executive control (MacLeod et al., 2010).

Digit Span. Individuals are presented with a series of digits (e.g. 2,4,6,8) and immediately asked to repeat them back in the order they are read (DSF), backwards (DSB), or as a combined score (Ohly et al., 2016).

Episodic Memory. A neurocognitive (brain/mind) system, uniquely different from other memory systems, that enables human beings to remember past experiences (Tulving, 2002).

Executive Function. The attentional process to hold and replay visual and auditory stimuli with the potential to manipulate them according to rules stored in short-term memory (Jonides et al., 2008).

Fluid intelligence. The ability to reason and to solve new problems independently of previously acquired knowledge (Jaeggi et al., 2008).

Necker Cube. A three-dimensional cube which may be perceived from alternative perspectives resulting from reversal of the foreground and background (Ohly et al., 2016),

Orienting. The attentional process of taking actions to focus on a stimulus (Jonides et al., 2008).

Positive and Negative Affect Schedule (PANAS). A self-reporting questionnaire consisting of two 10-item mood scales that measure positive and negative affect (Watson and Tellegen, 1988).

Profile of Mood States (POM). A commonly used measure of psychological distress (Curran et al., 1995).

Search and Memory Test. Participants memorize five target letters and subsequently cross off the target letters during searches of 59 letters (Ohly et al., 2016).

Stroop Test. A computer-administered task consisting of 10 test trials and 200 experimental trials in which the word 'red' or 'blue' appears on the screen of a laptop.

Participants identify the color of the word by hitting two selected keys from the keyboard (Van den Berg and Custers, 2011).

Sustained Attention to Response Test. A tool used in cognitive neuroscience to identify brain regions associated with failures of sustained attention (Smilek et al., 2010).

Symbol Digit Modality Test. The participant is given nine pairs of symbols (e.g. 1#, 2X). After practice, the participant is given a blank sheet of paper and is asked to write the correct number for each symbol in 90 seconds (Ohly et al., 2016).

Symbol Substitution Test. The participant is given nine pairs of symbols (e.g. 1#, 2X). After practice, the participant is asked to assign the correct digits to a series of blanks, each paired with a symbol (Ohly et al., 2016).

Trail Making Test. On paper or computer, participants must connect 25 numeric targets (e.g. 1,2,3,4,5) in the correct ascending order as quickly as possible (Ohly et al., 2016).

Working memory. A brain system that provides temporary storage and manipulation of the information necessary for such complex cognitive tasks as language comprehension, learning, and reasoning (Baddeley, 1992).

II. REVIEW OF LITERATURE

As research continued to support the benefits of a natural environment on physical and mental well-being, two theories arose regarding the restorative benefits of nature. The Stress Reduction Theory (SRT) suggests that an automatic and unconscious regenerative process occurs when humans are present within or simply see nature, consequently reducing stress. It is posited that as humans developed, they found safety within certain environments, particularly those with close proximity to water and greater visible horizons, the consequence of which ultimately fostered higher survival rates. It is suggested that this almost innate developmental response to seek respite, safety, and security explains humans' continued affinity to such surroundings (Bratman et al., 2012).

The second, the Attention Restoration Theory (ART), suggests that our directed attention is subject to fatigue, and that the presence of nature and natural environments allows us to recover from that fatigue, consequently improving cognitive function. The review of literature and subsequent study will be framed within the context of this theory.

William James first posited the concept of "voluntary attention" in 1892 (Kaplan, 1995). James suggested this type of attention was consciously engaged when something did not intrinsically attract attention yet was important to address, and one in which effort was expended to perform. For James, voluntary attention not only meant focused concentration, but also the suppression of potential distractions. Fredrick Law Olmsted, a contemporary of James and considered the father of landscape architecture in America, realized that this process might be subject to fatigue and incorporated nature into his urban designs as a remedy for recovery (Kaplan, 1995). Clinical neurologists, recognizing a similar process based on work with patients who had suffered brain damage, have defined the process as "directed attention." Kaplan adopted this term, rather than "voluntary attention," to avoid confusion with James' terminology (Kaplan, 1995).

Expanding upon the concepts previously described by James and others, Kaplan and Kaplan (1989) introduced their theory of Attention Restoration Theory (ART). The theory suggested that directed attention is subject to fatigue but can recover by removing attention-demanding activities and resituating oneself within an environment which requires only "involuntary attention." Involuntary attention is that which requires no effort since that which draws attention does so innately. Again, to avoid confusion with James' terminology, Kaplan (1995) substituted the term "fascination" for "involuntary attention." He then distinguished two types of fascinations along a "hard-soft" continuum.

A "hard fascination" can be defined as one that draws attention in a dramatic fashion. Examples would be a loud noise, an event consistent with imminent danger, or watching an auto race. A "soft fascination" is one that draws attention in an undramatic way. Examples would be a walk in a garden, or time spent in or near natural settings such as parks, lakes, mountains, or pastures. Soft fascinations, ones performed in certain natural settings, are those which provide the best environment for reflection and can most effectively enhance recovery from directed-attention fatigue (Kaplan, 1995).

Although fascination is the central element to directed-attention fatigue recovery, it is not the only nor the singularly sufficient. Kaplan describes three others: "being away," "extent," and "compatibility." "Being away" involves removing oneself from habitual activities that require directed attention. The experience can be objective or subjective in form. The shift can involve a physical escape to a new environment, or a conceptual escape as one's gaze or focus looks at a familiar environment in a new way. "Extent" means that the scope of a restorative environment must present an entirely different perspective, and one that is expansive enough to engage as many faculties of thought as possible. "Compatibility" means that the environment must be consistent with the goals and purposes of the individual. The setting must accommodate the desired outcome, allowing the individual to think and behave naturally without cognitive effort or struggle. The sounds and smells of a lake or ocean may be compatible to one who has fond memories of events surrounding that environment. Another, who may for whatever reason have a fear of water, may not find this environment compatible (Kaplan, 1995).

Kaplan (1995) cites four studies that are particularly notable and relevant to the theory. Hartig et al. (1991) compared the pretest and posttest results of a proofreading exercise (which requires a high degree of directed attention) among individuals who had taken a wilderness vacation (backpacking), a non-wilderness vacation (car tours, visiting friends, sightseeing tours), and those who took no vacation and continued to perform everyday activities. The wilderness group showed significant improvement in performance while the non-wilderness and the control group's performance declined.

In a second study, Hartig et al. (1991) reported similar results between participants who had been randomly assigned to take a walk in a nature setting or in an urban setting, or who sat quietly and read for 40 minutes, each after being subjected to attention-demanding tasks to induce cognitive fatigue. Not only did the "nature walk" group perform significantly better on proofreading performance, but also self-reported a higher degree of "perceived restorativeness" than did the other two groups.

Cimprich (1993) observed that patients recovering from breast cancer exhibited a high degree of directed-attention fatigue. Using the Necker cube, a three-dimensional cube which may be perceived from alternative perspectives resulting from reversal of the foreground and background (Ohly et al., 2016), the capacity of each participant to maintain directed attention was observed. After a baseline measure was taken three days post-discharge, participants were randomly assigned to one of two groups. The experimental group participated in 20-minute restorative therapies at least four times a week. Most participants chose a nature-based environment for their therapy. The control group participated in no restorative therapy. Participants were again observed on days 18, 60, and 90 post-discharge. The experimental group showed significant improvement in performance at each interval while the control group's performance declined over the 90-day period (Cimprich, 1993).

Lastly, Tennessen and Cimprich (1995) studied how different views from college dormitory windows might impact the attention-restorative process among students. Four categories of views were identified ranging from all natural to all built. In addition to performing better on the Necker cube test and the Symbol Digit Modalities Test (a test used to screen for organic cerebral dysfunction in both children and adults) students with a greater natural view from their windows rated themselves better able to perform directed-attention activities than those with built views.

Kaplan et al. (1988) reported that employees working in offices with window views of nature not only reported feeling less stressed, less pressured, and a greater degree of restorativeness, but also that the degree to which the participants reported their satisfaction and feelings of restorativeness increased proportionately with the quantity of natural elements available. Citing this work, Kaplan (1993) suggested that the opportunity to move one's focus away from work and experience nature, even for brief moments, can help recovery from directed-attention fatigue.

In several studies, college students were asked to assess their perceived restorativeness of different environments. Students rated natural settings, scenes of natural settings, urban settings with green space, and natural environments higher in perceived restorativeness than urban settings, built environments, urban settings with no green space, and even sports and entertainment settings (Hartig et al., 1997; Laumann et al., 2001; Purcell et al., 2001; Herzog et al., 1997). Using four categories of scenes: no views of nature, window scenes with views of nature, murals with water features and murals without water features, Felsten (2009) evaluated college students' perceived restorativeness of indoor campus settings used for the purpose of a study break. Actual campus settings were reimaged on a computer screen depicting these four categories as background views, as well as classrooms and work areas. Using the four elements Kaplan (1995) described as essential to the Attention Restoration Theory, scores for being away, extent, fascination, and compatibility recorded by the students were assessed for each view. The means for each of the four categories indicated the scene with no view of nature as the least restorative. The means of the window views of nature, views of land murals, and views of murals with water increased, respectively. Based on the findings that students' perceived restorativeness of the window scenes increased as each new element of nature was added, Felsten concluded that indoor settings with nature murals and settings with actual views of green space be provided, whenever possible. Felsten also suggested administrators and architects incorporate green spaces within the design or renovations of campus environments.

Two experiments by Berman et al. (2008) evaluated the cognitive benefits of interacting with nature. In the first, subjects were pretested using the backward digit-span test as well as having their mood assessed with the Positive and Negative Affect Schedule (PANAS). They then participated in an additional task that affected short-term memory, causing further mental fatigue. Half were randomly assigned to take a 50-minute walk through a nearby tree-lined arboretum removed from traffic and people, and the other half to a 50-minute walk along a busy, heavily trafficked city street. After the walk, participants were posttested using the same backward digit-span test and PANAS and answered questions regarding their walk. Those who participated in the nature walk showed a significant improvement in the backward digit-span test where those who walked in the city environment did not. PANAS results indicated that these results were not mood related.

In a second experiment, participants were again pretested using the backward digit-span test and PANAS, but were also tested on alerting, orienting, and executive attention using the Attention Network Test (ANT). Participants were randomly assigned to two groups, one which viewed 50 pictures of nature scenes and rating the degree to which they liked the pictures and the second who viewed and rated 50 pictures of urban settings. Both groups were immediately posttested. Results of the first experiment were replicated in terms of improvement in the backward digit-span test among only those who had been exposed to nature-related scenes. Also, only the nature group showed significant improvement in their executive attention.

Using a similar protocol, Shin et al. (2011) pretested and posttested subjects using the Trail Making Test Part B to test cognitive function and the Profile of Mood States (POMS) to evaluate mood. Subjects were then randomly assigned to a 50-minute nature walk through a nearby heavily forested state park, or a 50-minute walk through the local downtown area consisting of heavy vehicular and pedestrian traffic. The subjects were then immediately posttested. The nature group showed significant improvement in the Trail B tests. Those who walked downtown did not. Additionally, participants who had walked in the forest exhibited a positive change in mood.

Klemmer et al. (2005) compared the scores on a science achievement test of elementary students who had been taught using a traditional yearlong science curriculum to those who had regular gardening activities included in the curriculum. At the end of the school year, students were given the appropriate cognitive test for their grade level to evaluate science achievement. The students in the experimental group, those who had the gardening component incorporated into their curriculum, scored significantly higher on these tests than the control group.

Another study suggesting that cognitive functionality in children can be improved when exposed to a "greener" environment was conducted in 2000 by Nancy Wells. Seventeen children from low-income families living in poor and low rent urban areas participated in the study. The families of these children were part of a self-help program in which they helped build new housing with the intent to purchase the new home. Using a standardized measuring tool, the children's level of cognitive function was measured prior to the move to the new home. Using an existing housing scale instrument, the "greenness" of the surrounding area of each new home was established. Posttest results of cognitive function at least four months after the move showed that the children living in the "greenest" rated environments performed at the higher levels.

"Greenness" can also be evaluated in the context of an indoor environment. There are several requirements that must be met for a building to be certified as a "Green" building, one of which involves air quality. Factors considered include ventilation, low chemical-emitting materials, indoor and outdoor pollutants, thermal and lighting conditions, and daylight views to occupants (Allen et al., 2016). In two separate studies (Allen et al., 2016; MacNaughton et al., 2017) cognitive function was tested using a decision-making management level software tool (SMS- Strategic Management Simulation). MacNaughton et al. (2017) compared the cognitive functions of participants who worked in Green-certified buildings to those who worked in non-certified buildings. Allen et al. (2016) tested the same participants in identical office spaces in which the air quality was manipulated for each test. In both studies, participants exposed to the higher level of "greenness" performed significantly better on the cognitive function test. In the MacNaughton et al. (2017) study, workers from the Green-certified environment reported 30% less sick building symptoms (e.g. headache, dizziness, itching skin, fatigue, cold-like symptoms, and increased asthma attacks) compared to those who worked in non-certified buildings. These studies suggest that indoor environments may have similar impacts to one's cognitive function as do outdoor environments.

According to Kaplan (1995) directed attention requires voluntary effort in the presence of distractions, and reiterated James' notion that there must be an inhibitory mechanism associated with directed attention required to suppress those distractions. Ohly et al. (2016) proposed that greater voluntary effort is expended when exercising executive functions of attention, like working memory, than when exercising less demanding processes of alerting and orienting. While research supports that exposure to nature or natural environments can be a remedy for recovery from directed-attention fatigue, they suggested higher order attentional tasks would be more subject to attentional fatigue than those of lower orders, and therefore, be more likely to show recovery after exposure to nature.

To determine the strength of empirical evidence for the theory of attention restoration, and to investigate if a relationship exists between the intensity of directed attention and subsequent response to an exposure to nature, Ohly et al. (2016) conducted a systematic review of literature addressing attention restoration. Twenty-four articles, which included 31 studies, were chosen based on the search criteria. Studies varied in intensity and duration. Exposure to the controlled environments ranged from less than an hour to subjects who had lived in their particular surroundings for years. Most study designs first established a pretreatment baseline, then exposed the participants to the particular environment, and subsequently tested the participants using the same pretest instrument. Studies that involved real-life settings and long durations of exposure used a single testing protocol for comparisons.

The cognitive tests used to evaluate attention capacity included Digit Span Forward (DSF); Digit Span Backward (DSB); Combined Digit Span Backward/Forward (DSBF/B); Proofreading Task (PR); Necker Cube Pattern Control (NCPC); Search and Memory Task (SMT); Sustained Attention to Response Test (SART); Symbol Digit Modality Test (SDMT); Symbol Substitution Test (SST); and Trail Making Test A and B (TMTA/B).

Results of the review were mixed. Evidence was found to support that subjects exposed to nature or natural settings performed better on the Digit Span Forward, Digit Span Backward, and Trail Making Test B. No significant differences in performances were observed in each of the other attention capacity tests. While the DSF and DSB tests were considered examples of the more demanding tasks, the premise that more demanding tasks would be more likely to show recovery was not supported in all cases. SMT, SDMT, and SST, also those considered among the most demanding, found no significant difference in performance. The authors proposed that the anomalous findings might be attributable to the limited number of studies reviewed, the quality of the investigations, or poor outcome measures. Only two of the studies measured cognitive function while exposed to nature. The authors suggested that more studies be performed in which the testing and exposure to nature are concurrent.

III. METHODOLOGY

Problem Statement

The beneficial effects of a natural environment on physical and mental health has been well-documented. The purpose of this study is to determine if the cognitive functions of memory and reasoning are enhanced when exercised in a natural environment as compared to when they are exercised in an artificial environment. For the purpose of this study, a natural environment is defined as one comprised of elements existing or caused by nature, and an artificial environment as one comprised of elements made or caused by humankind.

Study and Objectives

The main objective of this research was to determine if a relationship existed between the effectiveness and quality of mental processes and the environment in which they were exercised. Specific objectives included:

1. To investigate if memory was improved in a natural environment vs. an artificial environment.
2. To investigate if reasoning was improved in a natural environment vs. an artificial environment.
3. To compare subjects in the same demographic categories to investigate if memory and/or reasoning was improved in a natural environment vs. an artificial environment.

Sample

Participants in this study were undergraduate degree-seeking students of all classifications from diverse academic disciplines at Texas State University. Students were either enrolled in a class taught by an instructor who allowed them to voluntarily participate in the study during the class period, or those who individually volunteered to participate to receive extra credit from their respective instructor. Based on Krejcie and Morgan's (1970) recommendations for sample size, the targeted sample size was 380 participants.

Students were incentivized to participate by being entered into a drawing for an iPad (Shenzhen, China). Many students were offered extra credit by their department or professor for participating. Those who chose to participate completed an informed consent document in accordance with the university's institutional review board. Participants were tested in their classroom at the regularly scheduled class time; in their classroom or one located in the same building at a predetermined date and time; or in the outdoor garden classroom at a predetermined date and time. Students were allowed to participate only once.

Instrumentation

Participants were asked to complete a demographic questionnaire prior to administering the testing instrument. Demographic variables collected included the participant's age, gender identity, race/ethnicity, educational level, and degree program.

Modified forms of the Sentence Repetition Test (test 5) of the Neurosensory Center Comprehensive Examination of Aphasia (Spreen and Benton, 1977) and the California Verbal Learning Test-Second Edition (Delis, 2000) where used to test verbal memory and verbal learning. A modified form of the Wechsler Adult Intelligence Scale-IV Matrix Reasoning (Wechsler, 2014) was used to test non-verbal reasoning/fluid intelligence. Modifications to each instrument were necessary to address limitations of time and the manner in which they could be administered. All three tests are normally administered in a one-on-one setting, incorporating several trials, and examinees' answers are verbalized. For the current study, these testing instruments were modified to allow group administration to be completed within 30 minutes, and all responses were recorded in written form by the participant. Studies have supported the validity and reliability of all three of tests: The Neurosensory Center Comprehensive Examination of Aphasia (Spreen and Risser, 2003); the California Verbal Learning Test (Woods et al., 2006); and the Wechsler Adult Intelligence Scale-IV (Parker et al., 1992).

Exercise One. The Sentence Repetition Test involves immediate working memory for sentences, which are read aloud by the examiner. The test is part of the Neurosensory Center Comprehensive Examination of Aphasia and is typically used to evaluate the loss of ability to understand or express speech because of brain damage. The test is comprised of two lists of 22 sentences of increasing length. For example, the first sentence was a simple one-word sentence such as "Look," and the last, "His interest in the problem increased each time that he looked at the report which lay on the table." The traditional method to administer the test is to read each sentence aloud, and then ask the participant to repeat it to the best of their ability. In the modified form every other odd-numbered sentence from Form A (1, 5, 9, 13, 17, 21) and Form B (3, 7, 11, 15, 19) were read aloud, one at a time, for a total of 11 sentences read. After each sentence, participants were asked to recall the sentence by writing it to the best of their ability. Since the sentences progressed in complexity from a single word to 19 words, no standard time was allocated for each sentence. The next sentence was read when, at the judgement of the proctor, most of the participants had stopped writing the previous sentence. Ten minutes was allotted for completion. A score of one was given for each word correctly recalled in the sequence it was read. Correctness was not contingent upon proper spelling and there was no penalty for writing words not read.

Exercise Two. The California Verbal Learning Test is a neuropsychological test of episodic verbal learning and memory. The complete CVLT-II is comprised of several trials involving immediate recall and delayed recall, and free recall and cued recall, of a list of words read to the examinee. The traditional method to administer the CVLT-II is to read aloud sets of 16 words, and then ask the participant to repeat as many as possible. In the modified form, only immediate free recall was tested. The 16 words from List A were read aloud across a total of three trials. After each reading, participants were asked to recall the words by writing them to the best of their ability. Ten minutes was allotted for completion. A score of one was given for each word correctly recalled for each trial. The terminal score was an aggregate of the three trials. Correctness was not contingent upon proper spelling.

Exercise Three. The WAIS-IV Matrix Reasoning test is used to assess inductive reasoning and fluid intelligence in a non-verbal, visual modality. The test presents a series of matrices from which the participant must determine a rule or pattern relating to the elements which guides the selection of the next appropriate matrix. The problems become more difficult as the test progresses. For example, a simple problem would present three identical red stars. From the choices provided, the participant would select a fourth identical red star. A more difficult problem would present a series of geometrical designs embedded with a secondary geometrical design. From the choices provided, the participant would select the geometrical design that he or she believed best continues the pattern or rule derived from that series. In a standard testing protocol, 26 series of matrices are presented, and the answer is given verbally. In the modified form, 12 of the series were used. Participants were instructed to choose the correct geometrical design to complete the matrix presented on each page from five possible answers, and to record their choice on an answer sheet. Ten minutes was allotted for completion. A score of one was given for each correct answer.

The validity and reliability of the modified forms of each testing instrument were expected to remain consistent with that of the standard comprehensive tests. Consistency in administration and scoring of the testing instrument reduced threats to the modified form's validity and reliability.

Experimental Design

Based on their schedules and logistic availability, participants were tested in one of two testing environments: an experimental group in which the testing instrument was administered in a natural environment, and a control group in which the testing instrument was administered in an artificial environment. The natural environment consisted of an outdoor classroom located within the garden adjacent to the Agriculture Building. The garden was composed of a variety of horticultural elements, crushed stone and rock pathways, tiered landscapes, and an outdoor teaching theater. The artificial environment was any one of several indoor classrooms. Classrooms were first scrutinized to assure no elements of a natural environment were present, e.g. indoor plants or window views of vegetation or landscapes. Participants in the control group met in the scheduled classroom. Participants in the experimental group met in a lobby of the Agriculture Building before being escorted to the outdoor garden.

Students in both environments were first asked to review the informed consent document and to complete a brief demographic questionnaire for later use to obtain comparative data. This document was also designed for use as an answer sheet for the subsequent exercises. After completion of the demographic questionnaire, the testing instrument was immediately administered to both groups. Both groups were administered the testing instrument by one of two researchers involved in the project.

Data Analysis

Scores from the treatment and control groups were compared using PASW® Statistics 22.0 (Chicago, IL). Statistical analysis included descriptive statistics, paired t-tests, ANOVA and Pearson's correlation tests. The *alpha* level chosen to determine if a significant difference existed between groups was 0.05.

IV. RESULTS AND DISCUSSION

This chapter will present, analyze and interpret the data collected in order to fulfill this study's purpose of investigating the effects of natural and artificial environments on memory and reasoning skills.

Study and Objectives

The main objective of this research was to determine if a relationship existed between the effectiveness and quality of mental processes and the environment in which they were exercised. Specific objectives included:

1. To investigate if memory was improved in a natural environment vs. an artificial environment.
2. To investigate if reasoning was improved in a natural environment vs. an artificial environment.
3. To compare subjects in the same demographic categories to investigate if memory and/or reasoning was improved in a natural environment vs. an artificial environment.

Demographics

Participants in this study were undergraduate degree-seeking students of all classifications from diverse academic disciplines at Texas State University. The total sample size was 380, of which 190 subjects were tested in the artificial environment and 190 subjects tested in the natural environment. Females represented 69.2% of the sample (263); males 30.3% (115); and 0.05% self-identified as "other" or "transgender" (2). The numbers of males (56, 59) and females (133, 130) participating in each testing environment were almost equal. The percentage of females participating in the study, 69.2%, was higher than the female undergraduate population of Texas State, 59.0%, and the percentage of males participating, 30.3%, was lower than the male undergraduate population, 41.0% (Office of Institutional Research, Texas State, 2020).

Ethnic backgrounds of those participating consisted of 53.2% White/Caucasian (202); 27.4% Hispanic or Latino (104); 11.6% Black or African American (44); and 7.8% as "other" (30). The ethnic demographic of undergraduates at Texas State University is 44.3% White/Caucasian; 38.3% Hispanic or Latino; 10.8% Black or African American; and 6.6% "other" (Office of Institutional Research, Texas State, 2020).

Students between the ages of 18-20 years represented 71.0% (270) of the participants; 21-25 years, 20.7% (79); 26-30 years, 5.7% (22); 31-35 years, 0.8% (3); 36-40, 1.0% (4); and over 40 years, 0.8% (3). The age demographic for undergraduates at Texas State University includes 51% ages 18-20; 38.0% ages 21-25; 6.8% ages 26-30; 1.9% ages 31-35; 0.9% ages 36-40; and age 40 and over 1.2% (Office of Institutional Research, Texas State, 2020).

Those classified as freshmen represented 56.0% (213) of the participants; sophomores, 12.8% (49); juniors, 14.5% (54); and seniors 15.5% (59). The classification demographic for undergraduates at Texas State University is 22.8% freshman; 20.9% Sophomores; 25.1% juniors; and 31.1% seniors (Office of Institutional Research, Texas State, 2020). Agriculture or Horticulture majors represented 8.7% of the participants.

Objective One Findings

Objective one was to investigate if memory was improved when exercised in a natural environment as opposed to an artificial environment. Exercise One, a modified form of the Sentence Repetition Test, was one of two tests used to evaluate memory. The mean score of the Sentence Repetition Test of subjects tested in the artificial environment was 91.77. The mean score of the Sentence Repetition Test of subjects tested in the natural environment was 92.73. Using PASW Statistics 22.0 (Chicago, IL), a two-way analysis of variance was conducted to determine if a significant difference existed between the scores of all subjects tested in the natural environment and all subjects tested in the artificial environment. No significant difference was found to exist between the scores of the two groups (P=0.399).

A modified form of the California Verbal Learning Test was the second test used to evaluate memory. The mean score of the California Verbal Learning Test of subjects tested in the artificial environment was 25.61. The mean score of the California Verbal Learning Test of subjects tested in the natural environment was 24.96. Using PASW Statistics 22.0 (Chicago, IL), a two-way analysis of variance was conducted to determine if a significant difference existed between the scores of all subjects tested in the natural environment and all subjects tested in the artificial environment. Again, no significant difference was found to exist between the scores of the two groups (P=0.708).

An aggregate score was calculated (memory totals) of the two tests used to evaluate memory for each participant. The mean score of the memory totals of subjects tested in the artificial environment was 117.14. The mean score of the memory totals of subjects tested in the natural environment was 117.89. Using PASW Statistics 22.0 (Chicago, IL) a two-way analysis of variance was conducted to determine if a significant difference existed between the aggregate scores of all subjects tested in the natural environment and all subjects tested in the artificial environment. Again, no significant difference was found to exist between the scores of the two groups (P=0.588).

Objective Two Findings

Objective two was to investigate if reasoning was improved when exercised in a natural environment as opposed to an artificial environment. The instrument used was a modified form of the WAIS-IV Matrix Reasoning Test. The mean score of the WAIS-IV Matrix Reasoning Test of subjects tested in the artificial environment was 9.63. The mean score of the WAIS-IV Matrix Reasoning Test of subjects tested in the natural environment was 9.37. Using PASW Statistics 22.0 (Chicago, IL), a two-way analysis of variance was conducted to determine if a significant difference existed between the scores of all subjects tested in the natural environment and all subjects tested in the artificial environment. No significant difference was found to exist between the scores of the two groups (P=0.095).

Objective Three Findings

Objective three was to compare subjects in the same demographic categories to investigate if memory and/or reasoning was improved when exercised in a natural environment as opposed to an artificial environment. Using PASW Statistics 22.0 (Chicago, IL), a two-way analysis of variance was conducted for each demographic group to determine if a significant difference existed between the memory and/or reasoning scores of subjects tested in the natural environment and subjects tested in the artificial environment. The results produced three significant P values.

The analysis of variance comparing those with a grade classification of senior produced a significant P-value of 0.035 for the Sentence Repetition Test. A comparison of the means between seniors who were tested in a natural environment and those tested in an artificial environment indicated that seniors who had participated in the natural environment performed significantly better on this test (Table 1).

Table 1. Sentence Repetition Test[z] analysis of variance comparisons of students classified as seniors tested in a natural environment and of students classified as seniors tested in an artificial environment.

Category	n	Mean Score[y]	SD	df	F	*P*
Natural	37	96.22	9.03	1	4.64	0.035*
Artificial	22	90.45	11.31			

[y]Test 5 Neurosensory Center Comprehensive Examination of Aphasia; Oxford University Press, New York, 2006.
[z] Scores range from 0 to 107 with greater scores indicating a higher degree of sentence recall.
*Statistically significant at P=0.05.

The analysis of variance comparing the age category of 36-40 years produced a significant *P*-value of 0.030 for the Sentence Repetition Test. A comparison of the means between subjects ages 36-40 years who were tested in a natural environment and those tested in an artificial environment indicated that subjects ages 36-40 years who had participated in the natural environment performed significantly better on this test (Table 2).

Table 2. Sentence Repetition Test[z] analysis of variance comparisons of students ages 36-40 tested in a natural environment and of students ages 36-40 tested in an artificial environment.

Category	n	Mean Score[y]	SD	df	F	*P*
Natural	2	97.5	2.12	1	32.11	0.030*
Artificial	2	89.0	0			

[y]Test 5 Neurosensory Center Comprehensive Examination of Aphasia; Oxford University Press, New York, 2006.
[z] Scores range from 0 to 107 with greater scores indicating a higher degree of sentence recall.
*Statistically significant at P=0.05.

The analysis of variance comparing the age category of 41 and above produced a significant *P*-value of 0.041 for the Sentence Repetition Test. A comparison of the means between subjects age 41 and above who were tested in a natural environment and those tested in an artificial environment indicated that subjects age 41 and above who had participated in the natural environment performed significantly better on this test (Table 3).

Table 3. Sentence Repetition Test[z] analysis of variance comparisons of students ages 41 and above tested in a natural environment and of students ages 41 and above tested in an artificial environment.

Category	n	Mean Score[y]	SD	df	F	*P*
Natural	2	106.5	0.71	1	243.0	0.041*
Artificial	1	93.0	0			

[y]Test 5 Neurosensory Center Comprehensive Examination of Aphasia; Oxford University Press, New York, 2006.
[z] Scores range from 0 to 107 with greater scores indicating a higher degree of sentence recall.
*Statistically significant at *P*=0.05.

Discussion of Results

Attention Restoration Theory (ART) suggests that our directed attention is subject to fatigue, and that the presence of nature and natural environments allows us to recover from that fatigue, consequently improving cognitive function. As well as a physical escape to a new environment, it can also involve a conceptual escape as one's gaze or focus looks at a familiar environment in a new way. These soft fascinations, as defined by Kaplan, are those which provide the best environment for reflection and can most effectively enhance recovery from directed-attention fatigue (Kaplan, 1995). In the context of feeling less stressed, less pressured, and experiencing a greater degree of restorativeness, Kaplan (1993) suggested that even a glimpse of nature for brief moments improves those conditions. Regarding cognitive function, a specific amount of time needed to recover from directed-attention fatigue is not addressed, yet the theory inherently necessitates a time element of some duration to allow recovery to occur.

Several studies cited in the review of literature relating to cognitive function included a period of time in which the subject was exposed to a restorative environment with the intent to induce recovery from directed-attention fatigue, or in which the participants had been exposed to the particular environments for lengthy periods of time (Hartig et al., 1991; Cimprich, 1993; Berman et al., 2008; Wells, 2000). The experimental design of this study intentionally excluded time spent in the presence of nature or a natural environment before testing subjects in the natural setting. Excluding this type of treatment protocol allowed the study to investigate if memory and reasoning was enhanced when exercised concurrently in the presence of soft fascinations.

Test taking requires directed attention. The Sentence Repetition Test and the California Verbal Learning Test required the subjects' directed attention as the sentence or list of words were read out loud, as well as when attempting to recall what was heard. The WAIS Matrix Reasoning Test required the subjects' directed attention to analyze and compare the series of matrices and the selection of the next appropriate matrix.

As stated, directed attention not only involves focused concentration upon that which one is consciously engaged, but also the suppression of potential distractions. In the natural testing environment, directed attention to the demands of the testing instrument may have included the suppression of surrounding soft fascinations, thereby eliminating their potential restorative effects. The suppression of soft fascinations, and consequently their restorative effects, may account for those groups between which no significant differences in memory and reasoning existed.

The limitation of time may have impacted the results of the study. College students were the targeted population from which subjects were recruited. Since the intent was to test many of them in their classroom at the regularly scheduled class time, the time allotted to complete the testing instrument required an accommodation to the shortest class period, which was 50 minutes. The study was designed to include approximately 10 minutes to complete the demographic questionnaire and 30 minutes to complete the testing instrument. To be consistent, all other subjects were tested within the same time frame. The actual time needed to complete the two memory tests was contingent upon how quickly the subjects wrote the sentence or words, therefore, some tests were completed within 25 minutes. Attention Restoration Theory presupposes that one has experienced directed-attention fatigue from which one must recover. The duration of time to complete the test may not have been sufficient to initiate directed-attention fatigue. A testing instrument of longer duration might initiate fatigue which concurrently could be arrested or suppressed by the surrounding soft fascinations. The difficulty of the testing instrument, as well, might not have been sufficient to provoke fatigue. These potentialities may account for the absence of significant differences between most groups.

The limitation of time, which prohibited more than one meeting with the subjects, may have impacted the cognitive condition of those tested in the natural environment. In the course of collecting data, observations were made that subjects tested in the artificial environment appeared comfortable, relaxed, and able to immediately focus upon the testing instrument. A number of subjects tested in the natural environment appeared stressed, uncomfortable, frustrated, and unable to immediately focus. Many of these subjects arrived late, stating they had difficulty finding the testing site. Others sent emails stating they were unable to find the testing site.

Eighty of the 96 freshmen tested in the natural environment were first-semester freshmen. A three-question survey was emailed to these 80 freshmen to evaluate their pretest cognitive condition. The first asked if they had been to the testing site

(Agriculture Building or Garden) prior to the testing date. If they answered “no” they were asked two subsequent questions. Using a five-point Likert scale, the first question asked them to rate their level of agreement or disagreement with the statement, “I felt stressed upon arrival as a result of looking for the test site.” Using a five-point Likert scale the second question asked them to rate their level of agreement or disagreement with the statement, “I feel my stress level impacted my performance on the test.”

There were 45 responses. Thirteen indicated they had been to the testing site prior to the testing date. Thirty-two reported they had not. Of these, 16 reported they agreed or strongly agreed that they felt stressed upon arrival as a result of looking for the test site. Fifteen reported that they agreed or strongly agreed that their performance on the test was impacted as a result of looking for the test site.

Locating the testing site required directed attention. One-third of the freshmen who responded stated they arrived feeling stressed and felt this stress affected their testing. These subjects may have arrived already experiencing a level of directed-attention fatigue. Students tested in their regular classrooms or one located in the same building did not experience this fatigue. The failure of the research design to take this factor into consideration may have created a confounding variable which impacted the findings and may account for the absence of significant differences between most groups.

The participants who performed significantly better on the Sentence Repetition Test included those with a grade classification of senior and those over 35 years of age. The number of subjects over 35 was a very small sample (seven), three of whom were classified as seniors. Yet, the finding that the remaining four still performed significantly better than younger subjects was consistent with the overall findings for these demographic groups. This cohort represented individuals who may have developed more efficient listening skills, memorization strategies, stress management, test-taking techniques, and greater self-confidence as a consequence of their collegiate academic experiences. These enhanced abilities may have reduced the effort expended for both directed attention and the suppression of distractions while performing the task, therefore, allowing the soft fascinations to be concurrently experienced and a restorative effect realized.

Fourteen of the 37 seniors were Agriculture or Horticulture majors. By virtue of the time spent on campus, the balance of seniors and older subjects were most likely aware of the location of the testing site, or better able to navigate to it. Upon arrival, these subjects would not have experienced directed-attention fatigue as might others who were unfamiliar with the location. The baseline of pretest directed-attention fatigue and the ability to immediately focus on the testing instrument was comparable to their artificial environment testing counterparts. The absence of preexisting directed-attention fatigue may have allowed the surrounding natural environment and its soft fascinations to arrest or suppress attentional fatigue caused by taking the test, subsequently resulting in better cognitive functionality than those in the artificial environment who were not exposed.

The ability to reduce the effort expended for both directed attention and the suppression of distractions, and/or the absence of preexisting directed-attention fatigue may have allowed the restorative effects of nature to arrest or suppress fatigue, thereby improving cognitive function, and accounting for the significant difference between groups.

V. SUMMARY, APPLICATIONS, RECOMMENDATIONS, AND CONCLUSION

This chapter summarizes, presents applications, makes recommendations for further studies, and presents conclusions for the study. The main objective of this research was to determine if a relationship existed between the effectiveness and quality of mental processes and the environment in which they were exercised. Specific objectives included:

1. To investigate if memory was improved in a natural environment vs. an artificial environment.
2. To investigate if reasoning was improved in a natural environment vs. an artificial environment.
3. To compare subjects in the same demographic categories to investigate if memory and/or reasoning was improved in a natural environment vs. an artificial environment.

Summary

The results of this study found that no significant differences existed in the cognitive functions of memory or reasoning between all subjects tested in a natural environment and all subjects tested in an artificial environment. In the natural testing environment, directed attention to the demands of the testing instrument may have included the suppression of surrounding soft fascinations, thereby eliminating their potential restorative effects. The suppression of soft fascinations, and consequently their restorative effects, may account for those groups between which no significant differences in memory and reasoning existed. The difficulty and length of the testing instrument, as well, might not have been sufficient to provoke fatigue.

Results produced three significant differences for the Sentence Repetition Test between subjects classified as seniors, subjects ages 36-40, and subjects age 41 and above who had been tested in the natural environment, indicating they performed significantly better on this test when compared to those in the same demographic who were tested in the artificial environment.

This cohort represented individuals who may have developed more efficient listening skills, memorization strategies, stress management, test-taking techniques, and greater self-confidence as a consequence of their collegiate academic experiences. These enhanced abilities may have reduced the effort expended for both directed attention and the suppression of distractions while performing the task, therefore allowing the soft fascinations to be concurrently experienced and a restorative effect realized.

The failure of the research design to take into consideration that many of the students who were tested in the natural environment may have been experiencing some degree of directed-attention fatigue before testing began as a result of trying to locate the unfamiliar location of the testing site. This may have created a confounding variable which impacted the findings.

Applications

Effectual cognitive function is essential for success in education, business, and our personal lives, and the Attention Restoration Theory presents practical strategies to improve cognitive function.

Programming of interior and exterior space during the construction or renovation of educational facilities should focus on affording the greatest degree of exposure to nature and the natural environment as possible. Landscaped pedestrian pathways and parks, outdoor teaching venues and common areas, window views of green space or interior designs including plants, nature paintings, and murals may be effective strategies for students, faculty, and staff to reduce and/or recover from directed-attention fatigue.

Faculty should consider incorporating recovery time in their teaching protocols. Kaplan (1993) suggested that the opportunity to move one's focus away from work and experience nature, even for brief moments, can help recovery from directed-attention fatigue. Recovery time might include short breaks scheduled throughout the lecture or lab with students being encouraged to momentarily redirect their focus. Ideally, this focus would be directed toward the surrounding areas programmed with elements of nature.

Additionally, personal space, office buildings, retail spaces, and even industrial facilities should model this paradigm of exposure to nature and natural environments. Enhancing cognitive function and reducing directed-attention fatigue may improve decision making, efficiency, productivity, and even customer service. A comprehensive list of strategies is beyond the scope of this work, but one can begin to appreciate the potential benefits that can be realized.

Recommendations for Future Research

Ohly et al. (2016) proposed that some cognitive functions may be uniquely sensitive to a particular testing instrument, and the failure to utilize the appropriate test may fail to determine improvement, even though there may have been. As suggested, the testing instrument used in this study may not have been long enough or difficult enough to provoke fatigue. Better understandings regarding the most efficient ways to measure improvements should be a consideration of future research.

The research design of this project may have created a confounding variable which impacted the findings. Some subjects may have arrived at the testing site already experiencing some degree of directed-attention fatigue, while others did not. Strategies to assure consistent baselines among subjects should be considered. In this case, the limitation of time prevented meeting the subjects being tested in the natural environment prior to the testing date. Having first met at the testing site prior to the testing date would have allowed subjects to familiarize and orient themselves to the location and may have prevented this phenomenon.

The design also neglected to include veteran status as part of the demographic. It was suggested that the reason those who performed significantly better on the Sentence Repetition Test did so because of their ability to reduce directed-attention effort. Veterans may be trained in or have experiences focusing on a particular task while minimizing attention-directed fatigue. Future research might be enhanced by having this demographic as part of the study.

Kaplan (1995) cites four studies particularly relevant to the study, one of which was Hartig et al. (1991). In this study, Hartig et al. compared the pretest and posttest results of a proofreading exercise among subjects that had taken a wilderness vacation (backpacking) to those who had taken a car and sightseeing tour vacation, and those who took no vacation. The wilderness group showed significant improvement in performance while the non-wilderness and the control group's performance declined.

Several studies incorporated community gardening or horticulture therapy, with findings indicating that subjects experienced improvement in mood, perceptions of their quality of life, and a decrease in stress (Marcus and Barnes, 1995; Waliczek et al., 1996;

Van den Berg and Custers, 2011; Lee, 2010; Yun and Byuag, 2011; Gonzalez et al., 2011). Takano et al. (2002) reported an increase in longevity among senior citizens with access to walkable green spaces compared to those who did not have access. In each study, varying degrees of physical activity was performed by the experimental group of which the control group did not. Wells (2000) reported that children's cognitive function was higher in children who were exposed to higher levels of greenspace. Children with greater access to greenspaces would be more likely to engage in physical activity as a result.

Rather than the exposure to nature, the physical activity exercised in the particular restorative environment of these studies may have been the actual cause for improvement. Studies that include a degree of physical activity should balance that degree among the groups being compared. If it is not, this activity may become an extraneous variable that could influence the outcome of the experiment.

Conclusion

Since the physiological and emotional necessities required to sustain and perpetuate human existence is intrinsically dependent upon other living systems, an affinity to these systems is understandable. Although this study returned mixed results, research generally supports the premise that exposure to nature or natural environments can have beneficial effects on physical and mental health, as well as improve cognitive function. Effectual cognitive function is essential for success in education, business, and our personal lives. While the Attention Restoration Theory presents practical strategies to recover from directed-attention fatigue and improve cognitive function, better understanding of the mechanisms of directed-attention fatigue and restoration, the impact of directed-attention fatigue on cognitive function, and efficient ways to measure them are needed.

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