THE RESTORATIVE IMPACTS OF NATURE ON DISTRIBUTED ATTENTION AND WORKING MEMORY: AN EYE-TRACKING ANALYSIS



Dakota Dehn

Submitted to the Psychology Department, Allegheny College
in partial fulfillment of the requirements for the degree of
BACHELOR OF SCIENCE
March 31, 2014

THE RESTORATIVE IMPACTS OF NATURE ON DISTRIBUTED ATTENTION AND WORKING MEMORY: AN EYE-TRACKING ANALYSIS

A Senior Comprehensive Project
Presented by:
Dakota Dehn

March 31, 2014

Pledge: _____

Approved:

_____

Dr. Aimee Knupsky

_____

Dr. Lauren Paulson

ACKNOWLEDGEMENTS

Professor Knupsky: I can't thank you enough for the guidance you have given me over the years. It was truly a pleasure to work with you over the summer conducting research and being a part of the eye-tracking lab group for the past three years. Your support and encouragement have far exceeded anything I could have hoped for in an advisor. Thank you for being patient with me through not only the comping process, but through all of my many questions over the years. I have learned so much from you, and want to thank you for instilling confidence in me not only as a student, but also as a person. My experience at Allegheny would not have been the same without you.

Professor Paulson: Thank you so much for all of the advice you have given me. Thank you for taking the time to talk with me about my future plans and always being there for any questions I had. You have been an invaluable mentor to me, and I will forever use the knowledge and lessons you have given me. I want to thank you for being so passionate about psychology and counseling, and I hope someday I can exhibit the same professionalism and sincerity you do.

My Research Assistants: You guys were the best. Thanks for bearing with me through the comp process and always showing up for our meetings eager to contribute. I could not have done it without you. Thank you for being there for me to bounce ideas off of you, and thank you most of all for taking the time out of your busy schedules to learn about my comp. I know it was frustrating at points, but you guys helped me out tremendously.

TABLE OF CONTENTS

Acknowledgements……..3

Table of Contents……4

Abstract……5

Introduction……..6

Nature As a Restorative Environment……8

Backward Digit Span Task……11

Attention Network Test (ANT)……..12

Eye-Tracking As a Method of Assessing Distributed Attention……...13

Method……...16

Design……16

Participants……17

Apparatus……...18

Materials……18

Procedure……...20

Results……22

Suspended Analyses and Dropped Participants……22

Short Term Recall Across Time……24

Distributed Attention Quadrant Proportion Analysis……24

Distributed Attention Quadrant Fixations Analysis……..26

Discussion……28-35

References……36-38

Appendix……..39-46

ABSTRACT

The main goal of the present study was to examine the impacts of viewing different scenes on attention and memory while also implementing an eye-tracking analysis to assess how attention was distributed across those scenes. Extending upon previous research demonstrating the restorative impacts of nature scenes on working memory and attention, the present study developed a method of analysis using fixations and fixation durations to assess visual behavior when viewing different scenes. A 2x2 mixed design was used with picture type (nature vs. city scenes) as the between-subjects variable and time (pre vs. post) as the within-subjects variable. Twenty-two participants took part in assessments measuring recall and attention. They were then randomly assigned to view a series of nature scenes or a series of city scenes. Participants then completed the assessments measuring recall and attention a second time. Results indicated there was no difference in recall across time. Results also showed picture type had no impact on recall. Finally, no difference in the distribution of attention in both picture type conditions was found in the eye-tracking analysis. Overall, the findings failed to replicate previous research, suggesting the use of an eye-tracker might have an impact on the results. However the development of the distributed attention analysis provides an informative tool for future research.

THE RESTORATIVE IMPACTS OF NATURE ON DISTRIBUTED ATTENTION AND WORKING MEMORY: AN EYE-TRACKING ANALYSIS

In early conceptions of nature, philosophers, writers, and laypeople alike revered the environment for its qualities. Law Olmsted, a famous landscape architect, firmly believed interacting with nature was unlike any other experience an individual could have, allowing individuals to benefit physically and mentally through the, "contemplation of natural scenes of an impressive character" (Cronon, 1995, p. 93). He believed these benefits occurred because individuals were able to experience a, "relief from ordinary cares, change of air and change of habits, being occupied without purpose" (p. 93). By engaging these qualities of nature, individuals are allowed to refresh mind and body, be free from stress, and have an opportunity for escape. Nature was a perceived as necessary for human life for Olmstead, and is why he set out to preserve it with the creation of several parks and recreation areas that endure to this day. As a result of work like his, the perceived value and importance of nature persists.

To empirically examine the properties of nature as a restorative environment, Berman, Kaplan, and Jonides (2008) conducted a study where they found when individuals were exposed to natural environments as opposed to city environments, significant improvements in working memory and attention (as demonstrated by quicker response times on a selection task) occurred. In related research, Tennessen and Cimprich (1995) found those who were exposed to more "natural views" in a university dormitory had significantly better scores on tests of selective attention and higher ratings of attentional functioning. Kahn, Severson, and Ruckert (2009) demonstrated that nature could also have restorative effects even when presented via media. Results however were not as significant as having individuals actually go out in the environments and experience their qualities. Specifically, they found that participants who

viewed nature on a plasma TV showed increased working memory compared to a group of participants who had no exposure to elements of nature. These results demonstrated how effective exposure to natural settings could be in impacting cognitive processes such as working memory. Furthermore, taking walks in natural environments has also been shown to noticeably improve mood in individuals with Major Depressive Disorder (Berman et al., 2012). The resulting change of mood has also been found to translate back into improvements in cognitive functioning increasing attentive focus. For example, Cimprich and Ronis (2003) found that exposure to nature environments helped to restore attention in women diagnosed with breast cancer while simultaneously improving mood, effectively lessening symptoms of depression and anxiety. The woman as a result had a more optimistic outlook on the future and their condition.

Although the benefits of interacting with nature seem evident, research on these benefits has often narrowly focused on behavioral measures. Specifically, research has focused on how nature environments improve attention and memory (Berman et al., 2008), but has not explored how visual assessment could play a role in the restorative impacts of nature environments. For example, research has neglected the role that visual search through an environment could play in contributing to the observed behavioral outcomes. Such a focus may allow researchers to pinpoint the visual characteristics of natural environments that may lead to the restorative benefits found in previous research. With the implementation of an eye-tracker to examine visual search of these scenes, we could determine useful information including the number of fixations made during the search, the number and types of objects on which people fixate, and also how those fixations might be distributed across the visual scene. Therefore, the goal of the present study was to consider how the viewing of natural environments might impact working memory recall and distributed attention by assessing characteristics of visual search through such scenes.

Doing so may help discover whether the restorative benefits of nature may be the result of the differences in how we distribute our attention across different types of environments.

To examine these possibilities, the research supporting the idea of nature as a restorative environment will be explored. Particular attention will be paid to the Attention Restoration Theory (Kaplan, 1995) in the context of the current study as well as its importance in understanding the construct of attention. Next, the behavioral measures employed in the present study to assess working memory and attention will be discussed. Finally, the rationale for incorporating the eye-tracker as an integral feature to the present study will be explored as well as how the eye-tracking data was used to measure the distribution of attention. The concept of distributed attention represents a unique contribution to the present study that will expand upon the work from previous research. Evidence has suggested that there are benefits to viewing nature scenes (even via a computer screen), but what is not clear is which elements of those scenes may contribute to those restorative benefits. This was a key consideration for the present study.

Nature As a Restorative Environment

Kaplan (1995) explored the benefits of nature and in his work attempted to create a model illustrating why those impacts occurred. Specifically, Kaplan described the restorative impacts of nature, which he accounts for in his theory known as the Attention Restoration Theory (ART). In his theory, Kaplan conceptualizes attention as a finite resource that has a limited capacity for use and is broken into two separate concepts. The first form, selective attention, is what he describes as attention we actively use to attend to certain stimuli while simultaneously inhibiting distractors. This ability to inhibit distractors can become important when carrying out daily tasks and without it, individuals would be unable to dedicate necessary

resources needed to accomplish those goals (Pennebaker, 1992). For example, listening in class would require what Kaplan describes as selective attention, requiring students to maintain focus in class while also inhibiting distractors. Inhibition could work in this situation to allow an individual to effectively listen to a professor while ignoring distracting acts like the tapping of a pencil or chewing of gum. The next form of attention Kaplan conceptualizes within the ART, he calls involuntary attention (Kaplan, 1995). Involuntary attention, as described by Kaplan, is attention that is attracted or captured by something stimulating or interesting. For example, a bright flash from a camera or a loud noise could capture involuntary attention. Similarly, Treisman (1982) refers to this attraction of attention as the "pop out" effect. When an easily distinguishable stimulus with highly discriminable features is placed within a homogenous or compatible environment, it is more easily discernable, "popping out," whereas if the stimuli were intermingled within a complex environment it would not emerge as quickly to the individual and would require more conscious search (Treisman, 1982). The involuntary attention mechanism functions out of our control requiring little effort and strain on attentive capacities. Unlike involuntary attention, however, selective attention requires effort and the ability to hold attention and to do so continuously focusing on stimuli while also simultaneously inhibiting distractors. As a result, the use of selective attention often depletes our limited attentional resources, which leads to less effective performance as time progresses. In contrast, activation of involuntary attention is much less dramatic, requiring fewer attentional resources, reducing the impact on subsequent performance.

Kaplan argues that the answer to the restorative effect of natural environments can be found in the differences between how these two attention mechanisms function and the resources they require. Natural environments, which contain inherently interesting and fascinating stimuli,

capture attention in a bottom-up fashion through the features of the environment itself (Kaplan, 1995). As a result involuntary attention is captured in a subtle fashion without much effort. In contrast, city scenes, which contain ambiguous stimuli, capture attention in a dramatic way. Specifically, selective attention is required for individuals to navigate the city environments amid distractions (e.g., a loud car horn) and specific goals (e.g., attempting to avoid traffic). This is not to say that selective attention would not be necessary in natural environments, nor that involuntary attention would not be used in city environments. Instead, the idea is that attention is attracted without conscious control by nature scenes and requires less strain and fatigue on attentive stores. Unlike nature scenes, city scenes contain stimuli that often require much more interaction and vigilance forcing individuals to focus on specific tasks and in doing so to inhibit distractors that may disrupt that process. Selective attention therefore must be sustained constantly, which in return weakens attentional resources as time progresses, and as a result inefficiency increases when performing tasks (Berto, 2005). Because nature scenes invoke involuntary attention more often and selective attention less often, Kaplan believes selective attention as a result, has a chance to replenish. Natural environments have also been found to be more compatible with our perceptions of nature, meaning what we think of nature is often what we see when we are in nature. Other environments, like a city setting, can be constantly changing and contain ambiguous or distracting stimuli that require selective attention, thereby depleting attentional stores (Kaplan, 1995). In other words, it would be harder to anticipate what you might encounter in a city environment. Kaplan offers an important perspective for why nature could act as a restorative environment for attention in his ART model establishing a useful foundation for the field of research.

More recently, using the ART as a foundation, Berman et al. (2008) conducted several

experiments demonstrating that by having individuals take walks in nature, attention and working memory could be greatly enhanced. In the same study, Berman et al. (2008) also demonstrated that increases in attention and working memory could be observed by simply having individuals view pictures of the environments via a computer screen. To demonstrate these impacts, Berman and colleagues employed pre and posttest behavioral measures of working memory and attention. Specifically, the Backward Digit Span task was employed to measure working memory while the Attention Network Test (ANT) was employed to measure attention. As a measure of attention, the ANT is used to assess three attentional networks: alerting, orienting, and the executive functioning network. To understand why these measures were used, I will briefly examine their reliability and validity as measures of attention and memory.

Backward Digit Span Task

Emerging as a popular measurement of behavior, the Backward Digit Span task has been employed in numerous studies measuring the impacts of various experimental manipulations on recall (Berman et al, 2008; Baddeley, 2000; Lehto, 1996). More specifically, this task was designed to assess working memory. Working memory is the set of cognitive processes that allows individuals to hold information in focus for later recall, providing the temporary storage necessary for completion of important tasks like comprehension, learning, and reasoning (Baddeley, 2000). Working memory is important when trying to remember specific information or numbers where immediate recall would be needed. Working memory can be impacted by a number of factors including the length of words or numbers, similarity effect (words or numbers that sound the same are harder to recall accurately), articulatory suppression (when subjects are prevented from rehearsing information they have just heard), and familiarity of information

presented (Baddeley, 2000). This measurement in the context of the current study was relevant because it required resources from selective attention stores by requiring individuals to hold numbers in focus and then repeat those numbers in a backwards order. By using this task, manipulations of selective attention could occur depleting those stores. This task has demonstrated efficiency by consistently requiring individuals to constantly move items in and out of their attentional focus (Cowan, 2001). Comparing performance on the Backward Digit Span task before and after an experiment illustrates the impacts nature and city scenes can have on the mechanism of working memory.

Attention Network Test (ANT)

Fan, McCandliss, Sommer, Raz, & Posner (2002) created the Attention Network Test to assess the independence of various attentional networks. Portions of the ANT have also been used to assess working memory capacity (WMC) (Redick & Engle, 2006). For example, the Attention Network Test has been used to study the relationship between individual WMC and specific types of attention. Several researchers have posited that attention is much more than just one system, and in fact may include three separate components, each of which function differently (Fan et al., 2002; MacLeod et al., 2010). Fan and colleagues have been adamant supporters of this theory, positing that independent attentional networks exist and can be examined through the Attention Network Test. These networks include the alerting, orienting, and executive function attention networks. The alerting network is defined as maintaining an alert state (e.g. providing an individual with a cue to signal an upcoming trial). The orienting network is defined as the selection of different information from sensory inputs (e.g. a flash or sound in an area before a stimulus appears, can be a spatial cue indicating where the stimulus will be shown). The final network, known as the executive function network, is defined as the

network used to resolve conflict among responses. In the ANT, this network is assessed by presenting groups of arrows of various different orientations. In some trials, groups of five arrows were shown with the four outermost arrows facing one direction and the center arrow the opposite direction. Some groups were presented with all arrows facing in the same direction. The purpose of these arrangements was to put the participant in a situation where they had to resolve a conflict by selecting the correct direction of the central arrow. It is also important to note that in the theory proposed by Fan et al. (2002), the alerting and orienting networks are often associated with involuntary attention and the executive function network is often associated with selective attention. Because the alerting and orienting mechanisms do not require individuals to carry out a specific task or goal-oriented task, involuntary attention mechanisms are employed. In the conflict resolution trials individuals must consciously maintain focus on the center arrow and be able to discriminate between the four outermost arrows and the center arrow, exhausting selective attention stores in the process. Trials were presented as congruent (e.g. all arrows face one direction) and incongruent (e.g. four outermost arrows face one direction while the center arrow faced the opposite) consistently requiring individuals to make a distinction. For the present study, an examination of the executive network was conducted, disregarding the alerting and orienting networks. Because selective attention and the impacts of this mechanism were of key significance in the present study, scores were only calculated assessing the executive network to determine how the environments differed.

Eye-Tracking As A Method of Assessing Distributed Attention

In the present study an eye tracker was employed to build upon the behavioral analysis presented in previous research on the restorative impact of natural environments. While this previous work has offered a compelling glimpse into the restorative impacts of nature

environments, they were only able to demonstrate that the benefits occurred, not *why* they occurred. In the present study, the eye tracker was employed to examine how individuals viewed different pictures of two environment types. Data that was of value included the number of fixations on certain aspects of the pictures, or how many times individuals stopped to take in visual information while viewing the pictures, and also what areas of the pictures were of little or no interest to the participant. Of particular importance, a new method to analyze "distributed attention" was used to measure the spread of fixations among the different areas of the pictures. Distributed attention was examined through a proportional quadrant analysis conducted on each picture used within the study. Each picture was divided into four equal quadrants and then analyzed using eye-tracking software to assess the number of fixations within each quadrant. The numbers of fixations in each quadrant were compared across all of the quadrants in the picture to determine the spread of fixations. Because nature environments potentially offer a restorative benefit, an analysis of distributed attention could help to illustrate if that impact occurs because of a reduction in fixations and reduction in the spread of those fixations. In comparison, this method of analysis could determine how viewing city scenes impacts fixation behavior and the spread of fixations when viewing those environments. Distributed attention could offer insight into why nature environments produce a restorative effect by effectively examining the distribution and allocation of attention among different environment types.

Henderson and Hollingworth (2003) contend that visual representations of a scene are constructed by previous ideas and perceptions of a scene. Furthering expanding on that idea, this could explain why behavior of fixations differs in some environments over others. City scenes and the perceptions of city scenes may dictate certain representations influencing the behavior of fixations. For example, a busy and hectic city scene may have caused an individual to draw upon

previous experiences influencing the individual to act in a certain way when visually navigating the scene, much differently than when viewing a nature scene. Those individuals as a result of past experiences may have seen a city scene as chaotic, increasing vigilance and the visual scope of the scene, effectively distributing attention to more areas increasing the number of fixations. In a nature scene individuals may again have operated from past visual representations of the environment focusing on fascinating and interesting parts of the environment reducing the need for distribution of attention, and as a result produced a fewer number of fixations. Because representations differ between nature and city environments, it would be expected fixations and the distribution of those fixations would differ as well.

Fixation duration has also been used to measure cognitive processing and when examined in conjunction with the distribution of attention could offer insights into why nature environments differ from city environments in regards to the impacts they have (Rayner, 1998). Fixation duration has been a notable measure when assessing levels of cognitive processing, and particularly relevant when examining visual search and scene perception. Because city scenes often contain ambiguous and attention-grabbing stimuli, fixation durations may increase as individuals attempt to identify an object, depleting stores of attention. City scenes also often contain much more stimuli, requiring attention to be disbursed more among a scene to take in all that is presented. In comparison, nature environments because they attract attention much more subtly and often do not contain surprising and ambiguous stimuli, may decrease fixation durations. As a result, attention may be more efficiently allocated maintaining attention stores.

In the present study, the eye-tracker was used to assess fixation duration when viewing the different environment types. City scenes may require a greater level of cognitive processing, resulting in longer fixations. Kaplan (1995) suggests an increase in cognitive processing could be

contributed to reliance on selective attention when viewing city scenes because of the way the environments dramatically attract attention. Nature scenes in comparison may result in shorter fixation durations and distributed attention because they are not as hectic and contain less ambiguous stimuli to focus on. As a result, the restorative benefits could be contributed to how attention is distributed. Specifically of interest in the present study was to measure the number and duration of fixations as well as the distribution of those fixations when participants viewed the different environments. The goal was to see how fixation behavior related to the performance on subsequent attention and memory tasks.

The present study examined the impact of nature and city scenes on executive attention, working memory, and distributed attention. Based on findings from previous research, I hypothesized a main effect of scene type. Specifically, those who viewed nature scenes would show higher executive attention on ANT scores and greater working memory performance with increased scores of the digit span task. They would also show less distributed attention, meaning they would show fewer fixations, and shorter fixation durations in the nature scenes as opposed to city scenes. Second, I hypothesized no main effect of time of test. Finally, I predicted an interaction such that participants who viewed nature scenes would show improvement in executive attention and working memory from pre to posttest. In contrast, participants who viewed city scenes would not show this improvement, or would show a decrease in measures.

Method

Design

The present study used a 2x2 mixed design with type of environment type (nature vs. city scenes) as the between subjects variable and time (pre-test vs. post-test) as the within subjects variable. Across these conditions, assessments of memory and attention were recorded. Number

of fixations in each of the quadrants and the total number of fixations in each picture was examined using an eye-tracker. An analysis of proportions fixated on was also conducted using data collected from the eye-tracker.

Participants

Twenty-two participants (11 male and 11 female) participated in the present study. Twelve participants were placed in the nature condition and 10 participants were placed in the city condition through random assignment. Participants were college students, ranging in age from 18-23 years old. They were recruited through introductory psychology courses using the on-line SONA system in the Allegheny College Department of Psychology. Participants were also recruited from courses outside of the department. Sixty-four percent of participants were recruited from outside of the department and 36 percent were recruited from within the department. Two of the 22 participants who participated in the study were removed from the eye-tracking analysis proportion due to improper tracking and calibration. One participant was removed from the behavioral analysis portion of the study measuring recall and response times due to complications with the eye-tracker and participant computer. The participant as a result was unable to view one of the two conditions resulting in a debriefing and dismissal from the study. After the removal of participants from the analyses, 20 participants were included in the eye-tracking analysis and 21 were included in the behavioral measures analysis. All participants had normal to corrected-to-normal vision. Participants were tested individually in one session lasting approximately 60 minutes. Individuals were told they were participating in an eye-tracking experiment to assess how individuals viewed different types of pictures, involving some deception. This was necessary to prevent bias in the different conditions and to prevent participants from discovering the purpose of the study. Participants received compensation in the

form of research credit or course credit depending on the policy of their instructor.

Apparatus

In the present study, an Applied Sciences Laboratory (Bedford, MA) Eye-Trac 6 Control Unit and User Interface Software along with an H6 Head Mounted Optics unit was utilized. The head mounted unit was fitted to the participant's head comfortably and then the participant's eyes were calibrated to the computer screen directly in front of them. E-Prime 2.0 software (Psychology Software Tools; Pittsburgh, PA), which was used to program the study, was also responsible for recording the number of fixations throughout the experiment. After all of the data from the eye-tracking machine was recorded, an analysis was run using the program ASL Results to determine the number of fixations as well as the quadrant analysis proportions.

Materials

Backward Digit Span Task

The first task to be completed was known as the Backward Digit Span task (see Appendix C). This task was researcher generated and was delivered verbally by the researcher to assess memory recall. The Backward Digit Span Task is a test used to measure working memory recall (Berman et al, 2008: Cowan, 2001). The Backward Digit Span Task actively requires numbers to be held in focus, where participants are then required to repeat the numbers in a backwards order. This test consisted of several sets of different series of numbers. Numbers began in lower number series (e.g., 1-2-3) and progressed to higher number series (e.g., 1-2-3-4-5-6-7). These series of numbers were delivered in sets of two (e.g., First Trial - 1-2-3, Second Trial - 4-5-6). When a participant answered incorrectly for two sets in a row, the researcher ended the test and moved on to the next objective.

Attention Network Test

Participants were then asked to complete the Attention Network Task (ANT) to assess attention through measurement of response times on a selection task delivered via a computer screen (Fan, 2002). Participants viewed a computer screen showing groups of five arrows of various orientations and were asked to indicate the direction of the center arrow as quickly as possible. Participants' response times for each of the trials was measured by clicking either the right or left button on a mouse depending on the direction of the center arrow (see Appendix D for an example trial). Participants took part in several trials, where the task lasted approximately 20 minutes in length, and was delivered over three sections. The ANT can be used to assess three attentional networks: alerting, orienting, and executive attention. For the purposes of this study only the scores derived from the executive attention portion of the test were analyzed based on previous research showing this measure to be impacted by the manipulation of environment type.

Environment Pictures

Participants viewed nature scenes or city scenes (see Appendix E) in the eye-tracking portion of the study. Pictures used were obtained from a set used in previous research demonstrating the impacts nature environments have on working memory and attention (Berman et al., 2008). These pictures were presented using the E-Prime 2.0 software (Psychology Software Tools; Pittsburgh, PA). E-prime also recorded the eye-tracking data (number of fixations and fixation durations) while participants viewed the pictures. The viewing of the different pictures in one of the two conditions was the only part of the study where participants were tracked. Participants randomly assigned to one of the conditions viewed 50 pictures either in nature environments or city environments. Each picture was displayed for approximately 7 seconds via a computer screen. Pictures were shown to each subject in the same order and were not randomized due to later analysis that required consistent ordering of the pictures. The

pictures reflected different types of nature and city environments. For example, in a nature scene participants may have been presented with a picture of a mountain and stream, void of any man-made elements. In a city scene, participants may have been presented with a picture containing several buildings, people, cars, and signs.

Picture Rating Sheet

Accompanying the pictures presented via a computer screen, participants were instructed to verbally rate how much they enjoy each of the pictures displayed on a 1-3 scale (1-Don't like the picture, 2-neutral, 3-Like the picture). The rating sheet was a researcher generator document providing a rating checklist for all 50 of the images presented (see Appendix F). The rating sheet allowed the researcher to indicate condition type and the participants unique randomly assigned number for later data analysis.

Procedure

In the present study, participants selected an individual test time via SONA to take part in the single session experiment. Upon arrival participants were given the informed consent and were allowed to ask any questions they had about the study. Participants were then given a brief description of the study where the researcher explained to the participants they would be taking part in an experiment observing how individuals viewed a variety of different pictures. The researcher provided a vague topic of what the participants would be looking at to prevent the influence of viewing behavior. Individuals were then led into the eye-tracking room where they were seated facing towards the participant computer monitor. Individuals were placed approximately two feet away from the screen at a comfortable viewing distance. They then were instructed to remain facing forward for the duration of the experiment.

Participants then took part in the first task known as the Backward Digit Span task. The

researcher administered this task verbally and recorded the participant's responses. This test took approximately 5 minutes to complete. After completion of the Backward Digit Span task, participants then took part in the first Attention Network Test (ANT). This task was completed on the computer located directly in front of the participant. Individuals were prompted with instructions on how to complete the task, and then give the chance to practice a few of the trials before the three sets of experimental trials begun. This task took approximately 20 minutes to complete. Rest breaks were given after each of the three sets were completed and were signaled by the ANT program on the computer screen. Participants were instructed to select their response as quickly as they could.

After the ANT task was completed, individuals were then familiarized with the eye-tracking equipment and the various parts were explained. The researcher then placed the head unit on the participant. Adjustments were made to accommodate the participant by tightening or loosening the unit until a comfortable fit was achieved. A glass mirror was then placed above the left eye to reflect light back to the camera, which allowed the tracking unit to measure the fixations and durations of fixations while communicating with the control unit and software on the researcher computer. The researcher manipulated this glass mirror until a steady and strong track was accomplished. The researcher then presented a calibration screen, which consisted of nine various dots to calibrate the individual to the machine, allowing for proper data recording. The calibration screen was then checked a second time by having the participant view certain points to ensure tracking. Participants were presented several pictures on a computer screen directly in front of them via the E-Prime 2.0 program. Participants were randomly assigned to the picture type condition, either viewing 50 nature scenes or 50 city scenes. Participants viewed each of the 50 pictures for seven seconds each and then were asked to verbally rate how much

they enjoyed the image on a 1-3 scale (1-Don't like the picture, 2-Neutral, 3-Like the picture). The significance of the rating task was to keep individuals conscious of their viewing behavior to promote the most naturalistic experience. During the viewing of the different environment types, the ASL Eye-Trac 6 unit recorded fixations and fixation durations. The task lasted approximately 10-15 minutes. After the task was completed, the researcher removed the head unit from the participant. The participant was then instructed to take part in the Attention Network Task (ANT) a second time. Instructions were given again, and the participant was able to complete the task as they previously had done.

Participants then took part in the second Backward Digit Span task. The Backward Digit Span series was modified so that sets of numbers differed from the previous series presented in the beginning of the experiment. It was hoped by changing the series of numbers, participants would not experience a practice effect. After participants completed the final task of the Backward Digit Span, they were given a debriefing form (Appendix B) and asked if they have any remaining questions about the study. Participants were then told they were taking part in a study that was trying to identify the restorative aspects of nature environments with the addition of an eye-tracker to assess the distribution of attention. The researcher explained the study in its entirety and informed the participant of any deception used. Overall, the experiment lasted for a duration of 45-60 minutes.

Results

Suspended Analyses and Dropped Participants

Due to a restricted timeline for data analysis, the analysis of response times for the ANT (the executive attention measure) was dropped from the present study. This analysis will be carried out in a subsequent presentation of the results of this project. Consequently, the only

behavioral measure reported is the analysis of working memory derived from the recall scores on the Backward Digit Span task.

Upon review of recall data collected from the Backward Digit Span Task, it was observed that one of the 22 participants was unable to complete both portions of the task. Specifically, the participant only completed the first recall portion of the study because the researcher was unable to track the participant after several attempts and had to end the testing session early. This participant's recall data was removed from the analysis resulting in a total of 21 participants included in the analysis, nine in the city condition and 12 in the nature condition.

Upon initial review of the eye-tracking data collected, it was found that two of the 22 participants who completed the study had data that was recorded improperly. A proper calibration was unable to be achieved resulting in an inaccurate recording of fixations and fixation durations. Several attempts were made to track the participants, but the eye-tracker was unable to hold a steady track. Both of those participants were removed from the eye-tracking analysis portion of the study leaving a total of 20 participants, nine in the city condition and 11 in the nature condition. After removing these participants from the analysis, all remaining participants' eye-tracking data was examined and found to be recorded properly.

Due to timing constraints for the analysis, an analysis of fixation durations was dropped from the quadrant analysis portion of the study. Only an analysis of number of fixations and the proportions of those fixations among the four quadrants of each picture was conducted. The analysis of fixation durations and the proportions of those fixations durations among the four quadrants in each picture will be conducted for a subsequent report of the results of the study.

Finally, to expedite completion of the quadrant analysis, only the first 25 pictures out of 50 total pictures for each condition was examined to assess the validity of the new distributed

attention measurement. The remaining 25 pictures will be examined and added to a subsequent report of the results for the study.

Short Term Recall Across Time

A 2x2 mixed ANOVA with Time (Pre vs. Post) as the within subjects variable and Picture Type (Nature vs. City) as the between subjects variable was conducted to determine the impacts on working memory after participants viewed one of the two environment type conditions via a computer screen. The main effect for time was not significant, $F<1$. Recall scores on the Backward Digit Span Task before viewing scenes (M=8.67, SD=2.373) were not significantly different than scores after viewing the scenes (M=8.52, SD=1.861). The main effect of picture was not significant, $F<1$. Participants in the nature condition performed the same on the Backward Digit Span Task (M=8.875, SD= 2.042) as participants in the city condition (M= 8.22, SD=2.273). Finally, there was no significant interaction between time and picture type, $F<1$. In the nature condition, participants' pre-recall scores (M=8.92, SD=2.234) were not significantly different than their post-recall scores (M=8.83, SD= 1.850). Similarly, in the city condition, participants' pre-recall scores (M=8.33, SD= 2.646) were not significantly different than their post-recall scores (M=8.11, SD=1.861).

Distributed Attention Quadrant Proportion Analysis

A series of one-way ANOVAs with picture type (Nature vs. City) was run on the proportion of fixations in each of the four quadrants across pictures (top left; bottom left; top right; bottom right). These analyses were conducted in an attempt to develop a new assessment for measuring distributed attention across visual scenes. Proportions were calculated by dividing the number of fixations in each quadrant by the total number of fixations for each picture (e.g., Quadrant 1 Picture 1 fixations divided by the total number of fixations in Picture 1). An average

Quadrant 1 proportion of fixations was then created by averaging across all 25 pictures for each quadrant (e.g., Quadrant 1 proportions for each of the 25 pictures divided by 25 to obtain the average Quadrant 1 proportion for each participant).

Table 1 depicts the distribution of fixations across quadrants calculated as proportions. There was no main effect for picture type in Quadrant 1, $F(1,19)=1.561$, $p=.228$, $\eta_p^2=.08$. There was no significant difference found in the proportion of fixations recorded in Quadrant 1 in the nature condition ($M=.22$, $SD=.089$) compared to the proportion of fixations recorded in Quadrant 1 in the city condition ($M=.28$, $SD=.146$). No main effect was found for picture type in Quadrant 2, $F(1,19)=3.074$, $p=.097$, $\eta_p^2=.146$. There was no significant difference found in the proportion of fixations recorded in Quadrant 2 in the nature condition ($M=.31$, $SD=.103$) compared to the proportion of fixations recorded in Quadrant 2 in the city condition ($M=.24$, $SD=.087$). No main effect was found for picture type in Quadrant 3, $F<1$. There was no significant difference found in the proportion of fixations recorded in Quadrant 3 in the nature condition ($M=.20$, $SD=.064$) compared to the proportion of fixations recorded in Quadrant 3 in the city condition ($M=.22$, $SD=.106$). Finally, no main effect was found for the picture type in Quadrant 4, $F<1$. There was no significant difference found in the proportion of fixations recorded in Quadrant 4 in the nature condition ($M=.27$, $SD=.111$) compared to the proportion of fixations recorded in Quadrant 4 in the city condition ($M=.26$, $SD=.104$). Overall, picture type did not impact a participant's distribution of the proportion of fixations. Participants recorded comparable proportions of fixations in each of the four quadrants in both nature and city conditions.

Quadrant Fixations Proportions

Table 1.	Quadrant 1 Proportions	Quadrant 2 Proportions	Quadrant 3 Proportions	Quadrant 4 Proportions
City Condition	.28(.146)	.24(.087)	.22(.106)	.26(.104)
Nature Condition	.22(.089)	.31(.103)	.20(.064)	.27(.111)

Note. The table presents the average proportions of fixations recorded in each quadrant across all participants.

Distributed Attention Quadrant Fixations Analysis

A series of one-way ANOVAs with picture type (Nature vs. City) was run on the number of fixations recorded in each of the four quadrants in each picture (top left; bottom left; top right; bottom right). This follow-up analysis was conducted on fixations to determine if total number of fixations recorded in each quadrant differed from the quadrant proportion analysis in nature and city conditions. Important beyond the proportion of fixations recorded in each quadrant to assess the distribution of attention, was also the total number of fixations in those quadrants in each of the environment types. Results could have produced similar quadrant proportions, but much different numbers of fixations in each quadrant in the nature and city scenes. Average number of fixations for each quadrant was calculated by adding all of the fixations from one quadrant and then dividing that total by 25 (total number of pictures) to find the average number of fixations for that quadrant for that one participant (e.g. All Quadrant 1 fixations across all 25 pictures were added together and then divided by 25 to obtain the average number of fixations recorded in that one quadrant). Calculations were conducted for each of the four quadrants using this method. Table 2 depicts the distribution of the number of fixations recorded in each of the four quadrants.

There was no main effect for picture type in Quadrant 1, $F(1,19)=2.383$, $p=.140$, $\eta_p^2=.117$.

There was no significant difference found in the number of fixations recorded in Quadrant 1 in the nature condition (*M*=86.31, *SD*=36.61) compared to the number of fixations recorded in Quadrant 1 in the city condition (*M*=109.10, *SD*=27.44). There was no main effect for picture type in Quadrant 2, $F(1,19)=1.550$, $p=.229$, $\eta_p^2=.079$. There was no significant difference found in the number of fixations recorded in Quadrant 2 in the nature condition (*M*=120.78, *SD*=40.68) compared to the number of fixations recorded in Quadrant 2 in the city condition (*M*=97.72, *SD*=41.89). There was no main effect for picture type in Quadrant 3, $F<1$. No significant difference was found in the number of fixations recorded in Quadrant 3 in the nature condition (*M*=84.18, *SD*=29.65) compared to the number of fixations recorded in Quadrant 3 in the city condition (*M*=104.64, *SD*= 60.44). There was no main effect for picture type in Quadrant 4, $F<1$. No significant difference was found in the number of fixations recorded in Quadrant 4 in the nature condition (*M*=109.85, *SD*=44.176) compared to the number of fixations devoted to Quadrant 4 in the city condition (*M*=118.57, *SD*= 48.16). Overall, picture type did not impact the participants' distribution of attention through the number of fixations devoted to each quadrant across both picture type conditions. Participants exhibited a comparable number of fixations for all of the quadrants in both the nature condition and city condition.

Quadrant Numbers of Fixations

Table 2.	**Quadrant 1 Number of Fixations**	**Quadrant 2 Number of Fixations**	**Quadrant 3 Number of Fixations**	**Quadrant 4 Number of Fixations**
City Condition	109.10(27.44)	97.72(41.89)	104.64(60.44)	118.57(48.16)
Nature Condition	86.31(36.61)	120.78(40.68)	84.18(29.65)	109.85(44.18)

Note. The table presents the average number of fixations recorded in each quadrant across all participants.

Discussion

Results Summary

The present study proposed there would be no main effect of time, meaning participants would perform similarly across time on measures of working memory. This hypothesis was supported in the results. The present study, however, proposed an interaction with picture type and time, suggesting individuals would perform better after viewing nature scenes in measures of working memory than after viewing city scenes based on previous research (Berman et al., 2008). The results, however, did not support this hypothesis, showing that participants demonstrated no significant differences in recall in the nature and city conditions.

The present study also proposed that individuals who were placed in the nature condition would have a fewer number of fixations than those placed in the city condition. The results failed to support this hypothesis, showing no significant differences in the number of fixations in the nature and city conditions. The present study also proposed that individuals who were placed in the nature condition would exhibit less distributed attention than those placed in the city condition, meaning participants fixations would be less spread out among the picture, being more grouped together within smaller areas of the pictures. The results, however, failed to support this hypothesis showing that there were no significant differences in the spread of fixations among a scene in the nature and city conditions.

Interpretation of Results

The current study found that when participants were placed within the nature condition as opposed to the city condition, no significant differences were found in working memory recall. Participants performed similarly in both conditions on the Backward Digit Span Task measuring recall across time. These results conflicted with previous research (Berman et al, 2008), which

demonstrated significant performance increases in recall in post recall assessments across time for participants placed within the nature conditions. Previous research also showed a maintained recall or decreased recall in post assessment examination in the city conditions, which was also not replicated in the present study. This is the second time studies conducted within the Allegheny College Eye-Tracking Laboratory have failed to replicate the original findings of Berman et al., directly contrasting with previous research suggesting the restorative impacts of nature environments.

One important difference between the present study and previous studies that could contribute to the differences in results is the use of the eye-tracker in the present study. Specifically, previous research has suggested that when individuals are required to wear an eye-tracker, a hypervigilant-avoidance state can occur (Weiser, Pauli, Weyers, Alpers, & Muhlberger, 2009). Individuals because of the fear of negative evaluation become increasingly vigilant and aware. In the present study, this hypervigilant state could have in return created a similar viewing behavior for participants placed in both the nature and city conditions allowing for an indistinguishable difference in visual search and distributed attention. Because participants may have become increasingly alert, the restorative impact of the nature scenes could have been affected. Consequently, this hypervigilant state could have impacted measures of recall as well. As noted in previous research, selective attention requires individuals to sustain a state of focus when encountering stimuli, often with the purpose of carrying out a specific task or goal (Kaplan, 1995). As a result of wearing the eye-tracker, participants who took part in the study may have consistently been put in a state of hypervigilance in both conditions, requiring a greater level of selective attention. Participants who were placed within the nature conditions may not have had the opportunity to benefit from the environment, showing no difference in recall scores

across time.

The hypervigilant state could also have created an unnaturalistic viewing behavior, causing participants to fixate and distribute their attention in an abnormal way, much differently than if the eye-tracker was not present. Inadvertently, this unnatural behavior could have caused participants to neglect certain aspects of a picture within the nature conditions that could have effectively offered the restorative impact. As a result, attention resources may have been utilized less effectively, being selectively focused and sustained depleting resources rather than being attracted involuntarily maintaining important selective attention stores. When wearing the eye-tracker, individuals often feel an intrusion of personal space, increasing awareness, and especially in the presence of a researcher (Weiser, Pauli, Weyers, Alpers, & Muhlberger, 2009). As a result, individuals tend to sporadically examine visual scenes to reduce the evaluative tension they are experiencing. Individuals may look at objects or areas and focus on them to attempt to enhance or influence evaluation in some way where they might not have if it were not for the eye-tracking apparatus.

In the current study, it was found there was no significant difference in proportions of fixations devoted to each quadrant in both conditions. In addition to the comparable number of fixations within nature and city scenes, a comparable distribution of those fixations was found as a result of the quadrant proportion analysis. Participants in both conditions exhibited similar behavior in the way fixations were distributed among a scene, showing no outstanding quadrant proportion differences. Similar proportions of fixations were distributed among the four quadrants in the nature and city conditions. Again, this result could be contributed to the presence of the eye-tracker. As previously stated, individuals tend to become much more sporadic in viewing behavior when they are consciously aware of evaluation, and this behavior

increases as individuals become more anxious and alert (Weiser, Pauli, Weyers, Alpers, & Muhlberger, 2009). This type of behavior is expected in city scenes as they are often perceived as being much more hectic and dramatic in the way they attract attention (Kaplan, 1995). However, this type of behavior was not expected for natural scenes, where attention and visual search were thought to be attracted much more subtly. Because of the presence of the eye-tracker, individuals could have become influenced causing them to perform in an unnatural way when viewing nature scenes. Impacting recall, the number of fixations, and the proportion of fixations, the eye-tracker could have played an integral part in the final results and overall conflicting perspective to previous research examining the restorative benefits of nature environments (Berman et al, 2008; Kahn, Severson, & Ruckert, 2009; Berto, 2005).

Limitations of Current Study

In the present study, there were a few key limitations. Most notably, the implementation of the eye-tracker could have functioned as a possible limitation. The addition of the eye-tracker to examine visual search behavior however was an important element, expanding upon behavioral assessments. Research has repeatedly demonstrated the restorative impacts of natural environments on working memory and attention (Berman et al., 2008; Kahn, Severson, & Ruckert, 2009; Berto, 2005), but has been unable to assess *why* those restorative impacts occur. With the addition of the eye-tracker, it was hoped that visual search behavior data could be used assess the distribution of attention to better explain why restorative impacts occurred in nature scenes as opposed to city scenes. Without the eye-tracker the method of analysis focusing on the allocation of attention among different scenes as a possible explanation for the restorative impacts would not have been possible.

As previously mentioned, however, the eye-tracker could have influenced an unnatural

behavior creating a hypervigilant state for participants (Weiser, Pauli, Weyers, Alpers, & Muhlberger, 2009). The current study utilized an H6 Head Mounted Optics headpiece, which was placed on the participants' head with a mirror positioned directly in front of the left eye. Participants were cognizant of the head unit and were often instructed to not make any sudden movements that would disrupt tracking. As a result of this vigilant state, many key aspects of the investigation including recall, the number of fixations, proportion of fixations, and overall distribution of fixations could have been influenced. The vigilant state could have required a more sustained focus of attention resulting in no significant change of working memory by consistently depleting vital selective attention stores in both the nature and city conditions. The vigilant state could also have contributed to no significant differences in visual search and visual behavior participants exhibited when viewing nature and city scenes. Individuals may have felt an increase in anxiety and as a result this could have manipulated those individuals into exploring the scenes in a much different way than if they were viewing the scenes without the eye-tracking machine. A heightened sense of awareness in this case could have worked against the restorative elements of nature effectively rendering them useless. Future research should focus on implementing less invasive eye-tracking machines like a desktop mounted unit. Desktop mounted systems don't required participants to wear a unit, and could effectively capture eye-behavior more naturally as it occurs.

Another important limitation to be noted was in regards to the process for assessing distributed attention. In the current study, only the first 25 pictures from each condition were included in the analysis of the quadrant proportions and number of fixations in each of the quadrants. Due to a restricted timeframe and immense data input load, nearly half of the total 50 pictures shown in both the nature and city conditions were dropped. Posing as a potential

limitation, dropping half of the pictures could have severely weakened the power of the newly constructed method of assessing distributed attention. The analysis would not have impacted recall scores, because all participants were exposed to all 50 pictures in both conditions. However, this analysis could have inaccurately represented the viewing behavior expected while observing nature scenes. As previous research has shown (Berman et al., 2008), a continued exposure to natural environments must occur for the restorative benefits to become present. In the current study because only the first 25 pictures of the total 50 were assessed, this prolonged exposure was not accurately examined. Viewing behavior could have normalized over the continued exposure of the nature scenes producing a much different outcome than what was recorded in the results. Affecting the analysis of quadrant proportions and the number of fixations devoted to each quadrant, an analysis of the remaining 25 pictures could offer insight into a more conclusive position on the implementation of the eye-tracker and the data that could be extrapolated as a result of it.

The number of quadrants assessed using eye-tracking data also could have posed as a limitation. In the newly developed method of analyzing distributed attention, pictures were divided into four quadrants. Using only four quadrants to assess distributed attention could have impacted the accuracy of fixation information. Because the pictures were only divided into four sections, the quadrants examined composed a large area of the picture. Dividing the pictures into smaller sections could have more accurately represented the fixations behavior and the areas they were recorded in instead of generalizing the behavior to one of the larger areas. This information could have been more effectively used to examine areas of the pictures, which may have contained objects and elements in the environments needed to elicit or hinder the restorative impact. Information also could be used to more accurately explain why attention was distributed

to a certain area or section as opposed to another. Restricting the analysis to examine only four quadrants within each of the pictures was an innovative and informative method, but future analysis could include more accurate readings of fixation behavior and the distribution of attention by dividing the pictures into more sections.

Finally, one last key limitation that should be noted in the current study was the overall number of participants. Of the 22 participants tested, only 20 participants data was included in the eye-tracking portion of the analysis. Only 21 of the 22 participants data was included in the behavioral analysis portion of the study. In the current study there were only two conditions. However, with 9 participants in the city condition and 11 in the nature condition, power was an issue when examining the results. To be able to reach more conclusive and informative results, additional participants would be desirable in future research.

Implications of the Current Study

The current study was unable to replicate results of previous research demonstrating the restorative impacts of nature on attention and memory (Berman et al., 2008; Kahn, Severson, & Ruckert, 2009; Berto, 2005). Unlike previous research, the present study implemented an eye-tracking machine to attempt to further previous behavioral measures with the addition of eye behavior. These results suggest that with the addition of an eye-tracker, there is possibly a change in awareness among participants resulting in indistinguishable differences in attention and memory across time. Because of the eye-tracker, participants may become unnaturally alert compared to if the eye-tracker was not present, creating sporadic eye-behavior, exhausting selective attention stores. Nature environments as a result become ineffective in restoring attention mechanisms and have no impact on how attention is distributed among a scene.

The results of the present study are in line with previous research demonstrating that with

the use of technology (eye-tracker and computer), the restorative impacts of natural environments can become severely weakened or in some cases nonexistent (Kahn, Severson, & Ruckert, 2009). Although the present study was unable to replicate previous research results, the addition of the eye-tracker provided an interesting perspective to how individuals view different environments and distribute their attention among those environments. Nature environments may effectively help to restore components of attention and memory, but only in the right circumstances. To maximize the restorative benefits of nature, individuals must be able to view the environments in a way where they feel comfortable, fostering visual search in a natural way. As Berman et al. (2008) have demonstrated, implementing the use of technology to elicit these benefits is completely possible, but it must be done so in a way not to overwhelm the individual. When done so correctly individuals can experience a multitude of benefits beyond performance increases in attention and memory, also showing improvements in mood (Berman et al., 2012). These benefits have not only demonstrated their practicality through performance increases on tests, but have also shown real-world significance in business and academic environments, positively impacting individuals within those settings (Tennessen & Cimprich, 1995). As the world continues to grow and develop, nature should always be at the forefront of design to help foster the most productive and efficient environments possible.

References

Baddeley, A. (2000). The episodic buffer: A new component of working memory? *Trends in Cognitive Science, 4* (11), 556-559.

Berman, M. G., Jonides, J., & Kaplan, S. (2008). The cognitive benefits of interacting with nature. *Psychological Science, 19* (12), 1207-1212.

Berman, M. G., Kross, E., Krpan, K. M., Askren, M. K., Burson, A., Deldin, P. J., et al. (2012). Interacting with nature improves cognition and affects for individuals with depression. *Journal of Affective Disorders,140* (3), 300-305.

Berto, R. (2005). Exposure to restorative environments helps restore attentional capacity. *Journal of Environmental Psychology, 25* (3), 249-259.

Cimprich, B., & Ronis, D. (2003). An environmental intervention to restore attention in women newly diagnosed with breast cancer. *Cancer Nursing, 26* (4), 284-292.

Cowan, N. (2000). The magical number 4 in short-term memory: A reconsideration of mental storage capacity. *Behavioral and Brain Sciences, 24* (1), 87-185.

Cronon, W. (1995). Constructing Nature: The Legacy of Frederick Law Olmstead. In W. Cronon, *Uncommon Ground: Rethinking the Human Place in Nature* (pp. 91-113). New York, New York: W.W. Norton & Company, Inc.

Fan, J., McCandliss, B. D., Sommer, T., Raz, A., & Posner, M. I. (2002). Testing the efficiency and independence of attentional networks. *Journal of Cognitive Neuroscience, 14* (3), 340-347.

Feng, G. (2011). Eye tracking: A brief guide for developmental researchers. *Journal of Cognition and Development, 12* (1), 1-11.

Henderson, J., & Hollingworth, A. (2003). Global transsaccadic change blindness during scene perception. *Psychological Science, 14* (5), 493-497.

Kahn, P. H., Severson, R. L., & Ruckert, J. H. (2009). The human relation with nature and technological nature. *Current Direction In Psychological Science, 18* (1), 37-42.

Kaplan, S. (1995). The restorative benefits of nature: Toward an integrative framework. *Journal of Environmental Psychology, 15* (3), 169-182.

Lehto, J. (1996). Are executive function tests dependent on working memory capacity? *The Quarterly Journal of Experimental Psychology Section A: Human Experimental Psychology, 49* (1), 29-50.

MacLeod, J. W., Lawrence , M. A., McConnel, M. M., Eskes, G. A., Klein, R. M., & Shore, D. I. (2010). Appraising the ant: Psychometric and theoretical considerations of the attention network test. *Neuropsychology, 24* (5), 637-651.

Pennebaker, J. W. (1992). Inhibition as the linchpin of health. In H.S. Friedman, Ed., *Hostility, Coping and Health.* Washington, DC: American Psychological Association, pp. 127-139.

Redick, T. S., & Engle, R. W. (2006). Working memory capacity and attention network test performance. *Applied Cognitive Psychology, 20* (5), 713-721.

Tennessen, C. M., & Bernadine, C. (1995). Views to nature: Effects on attention. *Journal of Environmental Psychology , 15* (1), 77-85.

Treisman, A. (1982). Perceptual grouping and attention in visual search for features and for objects. *Journal of Experimental Psychology: Human Perception and Performance ,8* (2), 194-214.

Weiser, M. J., Pauli, P., Weyers, P., Alpers, G. W., & Muhlberger, A. (2009). Fear of negative evaluation and the hypervigilance-avoidance hypothesis: an eye-tracking study. *Journal of Neural Transmission*, *116* (6), 717-723.

Appendix A
Research Participant Informed Consent

The Impact of Viewings Scenes on Attention and Memory

Dakota Dehn
Allegheny College Department of Psychology

Purpose of Research:
The purpose of this study is to examine how individuals view various types of scenes. Much research in the past has examined how individuals view different scenes, but little literature has focused on this research while employing an eye-tracker. During this study, an eye-tracker will be employed to better pinpoint those behaviors of viewing different scenes. This research will help to better extend literature in the area of behaviors surrounding the viewing of different scenes and the impacts they could have on attention and memory.

Procedures:
After informed consent is granted, participants will be instructed to enter the eye-tracking room where they will sit facing the participant computer. The participant will then take part in two preliminary tasks, the first of which will be delivered by the researcher and the second via computer prompted by instructions on the screen. The participant will then have the headgear explained to them and fitted for calibration. I understand that at anytime if I feel uncomfortable I can ask the researcher questions or choose to discontinue with the study. Once the headgear is fitted the next task will begin where participants will view various different pictures for approximately 10-15 minutes. After this task, the participant will be instructed to complete two final tasks. After these tasks, the participant will then be debriefed. The study should take approximately 45-60 minutes.

Risks to Individuals:
I understand that there are possible risks in participating in this study. I may experience a slight headache after viewing the computer screen for a prolonged duration. Viewing the screen for such a long duration could cause itchy eyes as well. There may be slight discomfort from the headgear, but I understand I can ask the researcher to adjust this to my liking to reduce that discomfort. I understand the risks participating in the study are similar to risks I could experience in everyday life.

Benefits to Individual or Others:
I understand that participation in this study could aid research in a new area of viewing various scenes while employing an eye-tracker. I understand that although the benefit to me is minimal, this process and participation could provide me with experience in research. I understand that I will be fully debriefed at the end of the study to expose the true nature of the experiment.

Compensation:
Participation credit will be granted to individuals who take part in the study. This extra credit will be given based on the policies outlined by the instructor. Extra credit will be referred to these policies to determine the nature of the credit granted whether it be research credit or course credit.

Confidentiality:
All data obtained from the study will remain anonymous throughout the full duration of the study to the termination of the data when it is no longer needed. Participants will be assigned a random number and that number will only be documented on the data obtained which is separate from consent forms. All data will remain in a locked room within Carnegie (Room 217) until it is no longer needed and discarded. I understand that all data provided today will remain anonymous and only the primary researcher and Professor Knupsky will have access to that data within the locked room.

Voluntary Nature of Participation:
I understand that I must be 18 years of age or older to participate in the study. I understand that at no time am I required to remain in the experimental session. If at anytime I feel uncomfortable, I may ask to discontinue the experiment and leave the study. After informed consent is granted, I may still ask to discontinue the study or opt to not answer certain parts of the study. I may leave at any time I deem appropriate and am in no way required to stay for the full duration of the study or answer any questions I am not comfortable answering.

Contact Information:

Primary Researcher – Dakota Dehn, Phone: 814-558-9735, Email: dehnd@allegheny.edu

Faculty Advisor – Dr. Aimee Knupsky, Email: aknupsky@allegheny.edu

If there are any concerns with the treatment of research participants or the conduct of the experiment, please contact Dr. Rich Bowden.

Chair of the Allegheny College Institutional Review Board (IRB): Dr. Rich Bowden, Email: rbowden@allegheny.edu

Participant's Signature _____ Date:_____

Researcher's Signature_____ Date:_____

Appendix B
Research Participant Debriefing Form

The Restorative Impacts of Nature Environments on Attention and Memory

Dakota Dehn
Allegheny College Department of Psychology

Purpose of Research:
Thank you for your participation in my project. The purpose of this study was to examine the impact on attention of viewing different types of scenes.

Specifically, previous research has shown that viewing nature scenes leads to improved executive attention performance (Berman, Jonides, and Kaplan, 2008). Executive attention is the cognitive process needed, for example, to pay attention to important information in class, while ignoring other distracting information. Consequently, the finding that viewing nature scenes can help restore attention has important educational applications and is in line with other recent studies showing the benefits of various forms of rest on learning in students.

Extending on previous, research the aim of my study was to replicate previous findings while also implementing the eye-tracker as an additional source of information. Specifically, I will be examining fixations and the distribution of those fixations across the various scenes types to see if that distribution could offer insights into why nature environments are restorative. Because city scenes contain so many stimuli, and stimuli that often attracts attention more dramatically, this could explain why nature environments, which attract attention more subtly, are found to have a restorative impact.

Because nature environments have been found to be restorative, I am hypothesizing participants in the nature condition will show improvement in response times, meaning they will be quicker in the second round of tests than the first, and will also show greater recall in the post tests. I am also hypothesizing that participants will show an increased number of fixations in the city scenes with a greater distribution of attention in the viewing of those city scenes because there is simply just more going on in the city scenes requiring more of an allocation of attention, and specifically voluntary or directed attention stores.

Deception:
The present study neglected to tell participants information pertaining to key aspects of the experiment. Participants were not told about environment type because this was believed to influence an unnatural viewing behavior if they were aware of a difference. The title of the experiment was also changed to prevent the divulgence of the hypothesis of the study, which might influence behavior of participants.

Compensation:
Participation credit will be granted to individuals who take part in the study. This credit will be given based on the policies outlined by the instructor.

Confidentiality:
All data obtained from the study will remain anonymous. Participants will be randomly assigned a number and that number will only be documented on the data obtained which is separate from consent forms. All data will remain in a locked room within Carnegie (Room 217) until it is no longer needed and is discarded. I understand that all data provided today will remain anonymous and only the primary researcher and Professor Knupsky will have access to that data within the locked room.

Additional Sources of Information:

Berman, M. G., Jonides, J., & Kaplan, S. (2008). The cognitive benefits of interacting with nature. *Psychological Science, 19* (12), 1207-1212.

Kaplan, S. (1995). The restorative benefits of nature: Toward an integrative framework. *Journal of Environmental Psychology, 15* (3), 169-182.

Berto, R. (2005). Exposure to restorative environments helps restore attentional capacity. *Journal of Environmental Psychology, 25* (3), 249-259.

Contact Information:
If for any reason you have any questions or concerns regarding the study, conduct of the study, or your health as a result of the study, feel free to contact any of the individuals listed.

Primary Researcher – Dakota Dehn, dehnd@allegheny.edu

Faculty Advisor – Dr. Aimee Knupsky, aknupsky@allegheny.edu

Chair of the Allegheny College Institutional Review Board (IRB): Dr. Rich Bowden,

rbowden@allegheny.edu

Allegheny College Counseling Center at 814-332-4368.

Allegheny College Medical Center (Winslow Health Center) at 814-332-4355.

THANK YOU FOR YOUR PARTICIPATION!

Appendix C

Backward Digit Span Task

Example

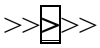
		Correct	Incorrect
1.	Trial A: 6-1	_____	_____
	Trial B: 8-4	_____	_____
2.	Trial A: 4-2-7	_____	_____
	Trial B: 3-5-8	_____	_____
3.	Trial A: 3-2-8-5	_____	_____
	Trial B: 6-5-9-1	_____	_____
4.	Trial A: 4-2-7-9-6	_____	_____
	Trial B: 5-6-8-7-3	_____	_____
5.	Trial A: 6-5-9-3-8-4	_____	_____
	Trial B: 1-6-3-5-4-8	_____	_____
6.	Trial A: 2-3-8-9-7-1-5	_____	_____
	Trial B: 5-8-4-1-2-3-9	_____	_____
7.	Trial A: 8-3-2-6-5-1-4-7	_____	_____
	Trial B: 6-1-7-9-8-5-4-2	_____	_____
8.	Trial A: 7-6-2-3-8-1-9-4-5	_____	_____
	Trial B: 5-4-8-1-7-9-3-6-2	_____	_____

*The task is ended when a participant gets more than one trial wrong in a given set.

Appendix D

Example Trial of Attention Network Task (ANT)

· Task requires participants to select the middle arrow as quickly as they can by selecting the right or left button on a mouse based on the direction of the middle arrow



· Participants in this trial would click the right button on the mouse indicating the direction of the central arrow.

Appendix E

Nature and City Pictures

(Actual Pictures Used)

Nature Picture Example



City Picture Example



Appendix F

<u>Rating Sheet</u> (1-3 Rating Scale; 1- Don't really like picture, 2-Neutral, 3-Like the picture)
Condition _____
Participant Number _____

Picture 1 _____	Picture 20 _____	Picture 39 _____
Picture 2 _____	Picture 21 _____	Picture 40 _____
Picture 3 _____	Picture 22 _____	Picture 41 _____
Picture 4 _____	Picture 23 _____	Picture 42 _____
Picture 5 _____	Picture 24 _____	Picture 43 _____
Picture 6 _____	Picture 25 _____	Picture 44 _____
Picture 7 _____	Picture 26 _____	Picture 45 _____
Picture 8 _____	Picture 27 _____	Picture 46 _____
Picture 9 _____	Picture 28 _____	Picture 47 _____
Picture 10 _____	Picture 29 _____	Picture 48 _____
Picture 11 _____	Picture 30 _____	Picture 49 _____
Picture 12 _____	Picture 31 _____	Picture 50 _____
Picture 13 _____	Picture 32 _____	
Picture 14 _____	Picture 33 _____	
Picture 15 _____	Picture 34 _____	
Picture 16 _____	Picture 35 _____	
Picture 17 _____	Picture 36 _____	
Picture 18 _____	Picture 37 _____	
Picture 19 _____	Picture 38 _____	