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The Restorative Effects Of Color And Environment Type On Cognitive Functioning

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THE RESTORATIVE EFFECTS OF COLOR AND ENVIRONMENT TYPE ON COGNITIVE FUNCTIONING

by

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ABSTRACT

Although individuals have limited directed attention capabilities, it has been shown that exposure to natural environments elicit cognitive restoration (i.e. Berman, 2008). It has also been shown that individuals prefer blue and green colors because they are relaxing and prompt happy feelings (Guilford & Smith, 1959; Mahnke, 1996; Wexner, 1954). The question however, is what aspects of nature elicit these effects: is it the natural colors, the environmental setting, or both? The present experiment will examine the effects of color (Blue, Green, Black and White, & Natural) and environmental setting (Urban, Foliage, & Aquatic) on measures of attention, short term memory, and mood. Additionally, this study was designed to replicate the findings of Berman et.al 2008, all while rigorously controlling for the pictorial content of its manipulation. Due to the exploratory nature of this study, no specific hypotheses were made. However, the goal of this research was to “tease apart” the effects of color and environment on the restoration of cognitive abilities. One hundred and nineteen non-color blind individuals completed pre and post tests for the State Trait Anxiety Inventory (Form Y-1), Backwards Digit Span, and the Attention Network Task and viewed one of the twelve color/environmental setting picture sets between the pre and posttests. Results of the 2x3x4 Mixed ANOVAs do not support past research which suggests that natural environments are restorative in nature.

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CHAPTER ONE: INTRODUCTION

At least since the time of Henry Thoreau's book, Walden, people have turned to nature to seek relaxation and tranquility from the rigors of their everyday lives (1997). In modern life however, there are many demands on people's attention and working memory, making them more prone to distraction which leads to errors in judgment (Boksem, Meijman, & Lorist, 2005). Additionally, from an occupational perspective, there are many jobs that require a high cognitive demand for multiple hours at a time, such as medical personnel and first responders whose ability to attend to details and make quick, rational decisions is crucial in saving people's lives. Unlike Thoreau, however, escaping to nature is not always an option. Many researchers have recently found improvements in cognitive functioning as well as a reduction in stress not only when in the presence of a natural environment, such as a forest, but also in the laboratory when viewing depictions of natural environments (Berto, 2005; Coon et al., 2011; Hartig, Mang, & Evans, 1991; Hartig, Evans, Jamner, Davis & Garling, 2003; Kaplan, 1995; Kaplan & Berman, 2010; Ottosson & Grahn, 2005). Similar effects have also been seen when viewing the colors blue and green (Mahnke, 1996; Spielberger, Gorsuch, & Lushene, 1970). Moreover, both the aforementioned colors as well as natural environments have been shown to evoke feelings of relaxation and tranquility (Guilford & Smith, 1959; Mahnke, 1996; Wexner, 1954). Therefore, the question becomes what is causing these restorative effects? Is it the natural scenery, the colors existing in the natural environment, or both?

CHAPTER TWO: LITERATURE REVIEW

Attention

Attention is a limited resource which can become fatigued as a result of "intense mental activity" or sustained attention. Attentional fatigue can result from a number of tasks such as problem solving, inhibition, and planning (Broadbent, 1958; Depledge, Stone, & Bird, 2011; Kaplan, 1995). This deficit in one's attentional capacity which may result in performance errors is commonly referred to as mental fatigue (Boksem, Meijman, & Lorist, 2005). Kaplan proposed that natural environments are inherently fascinating, therefore grabbing ones attention involuntarily. In doing so, this elicits the restoration of one's attentional capacity by allowing one's directed attention to rest. This concept helps form the basis of Kaplan's Attention Restoration Theory (ART) (1995).

The Attention Restoration Theory (ART) proposes that restorative environments (environments that restore directed attention) are comprised of four main factors: being away, extent, compatibility, and fascination (1995). Kaplan refers to *being away* as removing yourself either "physically" or "mentally" from the situation that is attention draining (Kaplan, 1995; Felsten, 2008, p.160). Similarly Kaplan defines *extent* as perceiving or having the feeling of being in a "whole other world" (1995, p. 173). This refers to being in a different setting that has an abundance of content to make the "world" feel realistic. The third factor described in ART is *compatibility* which refers to the fact that not only does an environment have to be mentally engaging, but it has to be looked at with an individual purpose. For instance, what is the perceived goal that one would like to accomplish in the setting? The fourth and final factor of

ART is *fascination*. As mentioned previously, fascination does not require directed attention, but is instead automatically activated by stimuli in ones' environment.

Overall, it has been found that nature most readily incorporates these four factors found in ART. When combined, these factors lead to directed attention restoration; however, in regards to previous cognitive restoration studies, fascination is the factor that is most frequently discussed (Kaplan, 1995). These studies have found that when individuals are exposed to environments that do not require directed attention such as nature (e.g. involuntary attention or fascination) this exposure allows for stress reduction as well as restoration of directed attention capabilities (i.e. Berto, 2005; Berman, 2008; Kaplan & Berman, 2010; Kweon, Ulrich, Walker & Tassinary, 2008; Ottosson & Grahn, 2005).

Effects of Natural vs. Urban Environments

Many studies have been conducted in which researchers have examined the effects of type of environment (nature vs. urban) on cognitive restoration (i.e. Berman; 2008; Kaplan & Berman, 2010; Tennessen & Chimprich, 1995). Overall, researchers have found that when placed in either a natural environment like a forest, or an urban environment like a busy street, individuals who are mentally fatigued have better performance on tests of cognitive abilities, have an increase in positive affect, and experience stress reduction only in the natural environment condition (Berto, 2005; Coon et al., 2011; Hartig, Mang, & Evans, 1991; Hartig, Evans, Jamner, Davis & Garling, 2003; Kaplan, 1995; Kaplan & Berman, 2010; Ottosson & Grahn, 2005). For instance, Berman, Jonides, and Kaplan (2008) displayed this effect in their study which analyzed the restoration of directed attention after an hour walking in a natural environment versus an hour walk in an urban environment. A backward digit span task was administered before and after walking in each condition to measure the restoration of one's attention. Results showed a significant improvement in directed attention capabilities only for the individuals who walked in the natural environment (Berman et al., 2008). Similarly, Hartig, Evans, Jamner, Davis, and Garling (2003) found that individuals who walked in a natural, as opposed to an urban, environment performed better on measures of attention. In fact individuals who walked in the urban environment performed significantly worse on the tests of attention after the walk as compared to before the walk (Hartig et al., 2003).

Both Berman et al. (2008) and Hartig et al. (2003) showed that exercising in a natural environment promotes cognitive restoration, however, the question that remains unanswered is: does cognitive restoration occur in natural environments when not exercising? Ottosson and Grahn (2005) found this to be the case as a result of their study involving elderly individuals who either spent an hour relaxing in an outdoor garden or in a room indoors. They found that individuals who were exposed to the outdoor garden had better attentional capabilities than individuals indoors.

Furthermore, past research has shown that one's presence in a natural environment is not necessary for the restoration of attention (Berman, Jonides, & Kaplan, 2008; Chimprich & Ronis, 2003; Tennessen & Chimprich, 1995; van den Berg, Koole & van der Wulp, 2003). These restorative qualities also occur in a number of other instances. One of those instances was studied by Tennessen and Chimprich (1995) who researched the effects of types of environmental views from dormitory windows on tests of directed attention. They found that individuals who had a view of a natural environment performed significantly better on tests of directed attention than individuals who had an all urban or mostly urban view (Tennessen & Chimprich, 1995). Additionally, attention restoration has been shown to occur when individuals are no longer in the presence of a natural environment, but rather viewing pictures of nature. Berto (2005) explored this idea by displaying pictures that are considered restorative (i.e. nature) and pictures that are not considered restorative (i.e. urban) for either a set amount of time (15 sec.) or for as long as the individual liked (which was significantly less than 15 sec.). Berto found that regardless of exposure length individuals displayed improved performance on measures of attention after viewing pictures of a natural environment (2005). Berman et al.'s study used pictures of both urban and natural environments to study effects of pictures on attention restoration (2008). Berman et al.'s study further corroborated Berto's results which suggest that the attention restoration theory holds true for viewing pictures of nature (Berman et al., 2008). This effect can be seen while viewing videos of natural environments as well (Chimprich & Ronis, 2003; van den Berg, Koole & van der Wulp, 2003).

Cognitive Restoration and Lack of Control in Studies

One can see from the above literature review that research on the restorative effects of natural environments has greatly increased over the past decade. While this research has revealed many things, as with all newly explored research topics there are a number of limitations to these early studies. Firstly, some studies demonstrated the differences in cognitive restorative power between environments by simply comparing the posttests (Tennessen & Cimprich, 1995; van den Berg, Koole, & van der Wulp, 2003); such comparisons do not allow researchers to isolate the effects of the environments specifically. The lack of pretest makes it difficult to ascertain whether exposure to natural environments offers restorative benefits or if urban environments are simply more cognitively draining.

A second limitation faced by a number of these papers is a failure to adequately control the myriad of environmental factors contained within the urban and natural environments. Many of the studies have been conducted in actual natural and urban environments and, as one might expect, they were unable to completely control all of the elements found in those environments (i.e. Berman, Jonides, & Kaplan, 2008; Berman et al., 2012; Coon et al., 2011; Ottosson & Grahn, 2005). Examples of confounds commonly found in natural environments include time of day, inclement weather conditions, seasonal and regional influences, the presence of man-made objects in natural environments such as benches, paths, nearby buildings, etc., and the presence of natural elements such as trees, grass, flowers, etc. Additionally, several studies have presented the environments pictorially (Berman, Jonides, & Kaplan, 2008; Berto, 2005; Felsten, 2009) and still fail to rigorously control all of the elements in those depictions.

Perhaps the element that has most obviously should have been controlled in the environments is the presence of water and the type and condition of that water which has been found to have a significant impact upon cognitive restoration.

Effects of Water

Past research suggests that water is perceived to have better restorative qualities than natural environments that contain predominately foliage (Hipp & Ogunseitan, 2011; Ulrich, 1981; White, et al., 2010). Although these studies were based on self-reports, there was a definite preference for water over both environments containing green foliage and urban environments.

Additionally, the aforementioned studies showed that natural pictures of and with water were associated with increased positive affect and a greater perceived restorative effect (Ulrich, 1981; White, et al., 2010). More specifically, White et al. (2010) found that individuals prefer aquatic only environments more so than environments that contained mostly foliage and small amounts of water; however, environments that contained mostly water with a small amount of foliage were preferred over aquatic only environments. Although overall, participants preferred aquatic environments over, both "green" environments and urban environments (White et al., 2010).

Preference and Restorative Potential

Preferences toward natural environments have been studied by a number a researchers. However, the self-report measures that are used to capture ones' affinity towards these environments vary. Three main types of self-report questions that were frequently used in past research include how much the individual likes the environment, how "willing" they would be to visit the environment, and the degree to which they find the environment "tranquil", all of which ask, the extent to which individuals find the environment to be calming, relaxing, peaceful, etc. (Berman, Jonides & Kaplan , 2008; Hertzog, 1992; Hertzog, 1997; White et al., 2010). Additionally, studies such as White et al. (2010) and Luttik (2000) have also demonstrated individuals' preferences for natural environments over built environments by measuring how much more individuals were willing to pay for real estate in natural environments.

Not only have individuals displayed higher preferences for natural environments over built (urban) environments, van den Berg, Koole, van der Wulpe (2003) found that these preferences were related to "greater affective restoration"(p. 143). However, both van den Berg, Koole, and van der Wulpe, (2003) and Berman, Jonides, and Kaplan (2008) did not find statistical significance in regards to preferences ratings and cognitive restoration. Although, it is important to note that van den Berg, Koole, and van der Wulpe's results were trending towards significance, therefore more research is needed in this area (2003).

Stress and Restorative Environments

Although results are mixed, it has been found that stress can negatively impact individuals' executive functioning, including decision making and attention (Gray, 1999 & LeBlanc, 2009). Hartig, Evans Jamner, Davis, & Garling (2003) conducted a study in which they looked at both stress and attention restoration in natural and urban environments and found that not only did performance on a test of attention improve, but they also observed reduction in stress and anger, along with an increase in positive affect, which was associated with walking in a nature reserve. However, the inverse occurred when individuals walked in an urban setting. Similarly, like attentional fatigue, the restorative effects of stress have also been shown to occur while viewing videos of natural environments and even when looking at posters of nature (Kweon, Ulrich, Walker & Tassinary, 2008; Lee, Park, Tsunetsugu, Kagawa & Miyazaki, 2009; Urich et al., 1991; Ulrich, Simons, & Miles, 2003).

Colors and Stress Reduction

Many studies have shown that colors affect mood (i.e. Guilford & Smith, 1959; Wexner, 1954). For instance, blue and green are the most preferred colors with blue being associated with feelings of being secure, comfortable, and tender (Guilford & Smith, 1959; Wexner, 1954).

Furthermore, the color green has been found to be soothing, refreshing, and relaxing. Green elicits feelings of happiness, whereas blue evokes passivity, cleanliness, and quietness (Mahnke, 1996). Spielberger, Gorsuch, and Lushene's (1970) found that when viewing the color green as well as blue, individuals scored significantly lower on a State Anxiety Inventory than when viewing the color red, further corroborating the fact that green and blue appear to be relaxing or stress reducing colors.

Furthermore, many studies have researched the effects of color on cognitive task performance. In general the research seems to be inconclusive due to conflicting results. Overall, most of the research that has been conducted has predominately studied the cognitive effects of the colors green, red, and blue on measures of performance. As previously mentioned, results of these experiments are conflicting. Stone and English (1998) found no significant difference performance on cognitive tasks while in a blue or red workspace. Hatta, Yoshida, Kaeakami and Okamoto (2002), on the other hand, found that the color red on a computer display significantly reduces performance on visual tasks compared to the color blue, however they found blue to be detrimental to visual task performance when the workload was highly demanding. Alternatively, Etnier and Hardy (1997) found that working in green and blue offices significantly improved one's performance on cognitive tasks. Due to the inconsistencies of the past research in this area, Mehta and Zhu (2009) attempted to resolve these discrepancies. They found that the color red elicited an avoidance motivation and was found to improve one's recall of fine details, whereas blue elicited an approach motivation and was found to improve one's creativeness. A number of studies have been conducted on this issue, and the results still prove to be inconclusive.

Despite the discrepancies in cognitive improvements with regards to color, it has been found repeatedly that color does play a role in our everyday lives. More specifically, the colors green and blue are irreplaceable due to their ability to provide humans with feelings of happiness, security, and tranquility (Guilford & Smith, 1959; Mahnke, 1996; Wexner, 1954).

Hypotheses

In summary, past research indicates that directed attention and stress have a symbiotic relationship which can lead to individuals becoming mentally fatigued. Additionally, individuals experience restoration of cognitive abilities as well as reduction in stress when exposed to natural environments such as forests and lakes or oceans, even when these exposures are in the form of pictures or video. Furthermore, individuals find both natural environments and the colors green and blue to be calming and relaxing. These findings beg the question: What elicits these restorative effects, is it the natural setting itself or the colors in the environment, or both?

Besides White et. al.'s (2010) study on one's preference for type of environmental setting no one has tried to control the different aspects of natural and urban environments. Therefore, color and type of environmental setting are always confounded with one another. As a result, this current study was exploratory in nature and no specific hypotheses were made. However, the goal of this research was to "tease apart" the effects of color and environment on the restoration of cognitive abilities.

CHAPTER THREE: METHOD

Participants

One hundred and thirty three individuals were initially recruited for this study, however, three participants were not able to further participate due to not fulfilling the aforementioned criteria, ten others were withdrawn from the study due to uncontrollable environmental circumstances or cell phone use, and one participant's data were thrown out due to below normal scores. Therefore, participants were comprised of 119 students (59 male and 60 female) enrolled in psychology courses at the University of Central Florida. Participants' ages ranged from 18 to 48 years with a mean age of 19.35. Furthermore, their reported races consisted of 4 Asian, 17 African American, 93 Caucasian, and 5 that were given the designation of "Other" which occurred when the participants did not choose one of the five races provided on the demographic questionnaire (see Appendix B). Participants were recruited via Sona Systems as well as flyers posted in designated places in the Psychology building. Upon consenting, participants were randomly assigned to one of twelve groups based on a randomized block design. There were a total of 12 blocks; each block randomized the order of the 12 experimental conditions. Furthermore, participants were required to have at least 20/40 normal or corrected to normal near vision and no color deficiencies. Upon the completion of the study each participant received 90 minutes of Sona Systems credit.

Materials

The Optec 5500P was used to screen for near visual acuity (i.e. Snellen acuity) as well as color blindness before participants were able to further continue in this study. After the screening, participants filled out a demographics questionnaire.

A Dell Precision Workstation running 64 bit version of Windows 7 Enterprise and a Dell LCD 24 inch monitor with a resolution of 1600 x 900 and a refresh rate of 60 hz was used to run E-Prime©. E-Prime©, which is a computerized software for experiment design, was used to administer an anxiety inventory as well as two attention based tasks.

The State Trait Anxiety Inventory (STAI) Form Y-1 created by Spielberger, Gorsuch, Lushene, Vagg, and Jacobs (1983), was used to assess one's state (current) anxiety is based on 20 items such as, "I am relaxed", "I feel calm", and "I feel uncomfortable". Items were measured using a four point Likert scale which included the following responses in order of appearance: Not at all, A Little, Somewhat, and Very Much So. Furthermore, a number of researchers have found this scale to be indicative of one's level of environmental stress (Auerbach, 1973 & Chapman & Cox, 1977, as cited in Speilberger et al., 1983).

Furthermore, a backward digit span task was used to monitor changes in directed attention as well as one's short term memory capabilities (Berman, Jonides, and Kaplan, 2008; Miller, 1956). This backward digit span task was modeled after Berman, Jonides, and Kaplan's (2008) in which a series of three to nine digits, which were randomly ordered, were presented verbally by the computer in increasing lengths. Participants then had to type on the keyboard the series of digits in reverse order correctly. This was an adaptive test, therefore each set, starting with the series of three digits was presented, if the sequences were correctly answered in reverse twice, the digit length would then increase by one digit. However, if the series of digits was not answered correctly, digit length would decrease by one, for a total of 14 trials. It is important to note, however, that digit length could not be less than the initial 3 digits, even when answered incorrectly. The length of digits answered correctly upon the 14th trial, were recorded for this study.

Finally, the Attention Network Test (ANT) is a task that measures three different factors of attention (alerting, orienting, and executive control) during a reaction time experiment, was administered. This task required individuals' to monitor a computer screen and respond to the direction of the center arrow amongst four other arrows ("flankers") that were either congruent or incongruent with the center arrow (Fan, McCandliss, Sommer, Raz, & Posner, 2002; Fan, McCandliss, Fossella, Flombaum, & Posner, 2005). This test consisted of a total of 288 trials of which there may or may not have been a cue alerting participant of an upcoming trial or a spatial cue to orient them to the location of the upcoming trial. Furthermore, like Berman, Jonides, and Kaplan (2008), both accuracy and reaction times for the 72 trials not containing cues were analyzed, as it was a measure of one's ability to voluntarily direct one's attention to a stimulus.

One hundred and fifty high resolution environmental pictures were used in the study. Non copyrighted pictures were obtained from Stock.XCHNG (http://www.sxc.hu/) as well as Google pictures. The resolution and size of the pictures were controlled for using Adobe Photoshop. Resolution on all pictures was reduced to 1000 x 750. In addition, all pictures were constrained to daylight hours and optimal weather conditions. Furthermore, all pictures were horizontally oriented with the dimensions, measured in inches, of 12 x 16.

The aforementioned 150 environmental pictures were comprised of 50 Urban, 50 Foliage, and 50 Aquatic. Urban photos consisted of a city scene comprised of buildings and streets which included a moderate number of signs, people, and cars based on the average ratings of 10 individuals. Foliage pictures consisted only of green nature such as forests and wooded mountains. Furthermore, it is important to note that unlike most research regarding cognitive restoration in natural environments, pictures in the Foliage condition did not include water of any kind. Finally, the third environmental type (Aquatic) consisted of photos of water. The Aquatic only pictures included blue water that was either below or above the surface and contained only minor portion of land, if any at all. For instance, a little sand from a beach may have been visible; however no green foliage appeared in the picture. Additionally, each of these three aforementioned environmental pictures was altered in various ways. The first set of 150 pictures was changed to be black & white. The second set of 150 pictures remained untouched to maintain their true colors (referred to as Natural). The last two sets of environmental pictures were modified by the researcher in the following ways. Each of remaining sets were first changed to be black & white, after which, either a blue or green filter was placed on each set of 150 pictures. This controlled for the issue of color constancy between the green and blue filters and the colors in the pictures. After completing all of the aforementioned modifications the researcher was left with 12 sets of 50 pictures which varied based on color and type of environment, samples of which are provided in figure 1.

Figure 1: Environment displayed from left to right: Urban, Aquatic Only, & Foliage Only. Colors for each picture from left to right: Green filter, Blue filter, Natural (Untouched), & Black & White.

E-Prime was used to create a platform for viewing these pictures on a computerized display. Pictures were randomized for every participant, in every condition, and were programmed to be displayed on the monitor for 7 seconds each. Furthermore, each picture was followed by a black screen which asked the participant to rate the picture on a Likert scale from one to seven in terms of how much they liked the picture, ranging from not at all to very much, for all 50 pictures.

Procedure

Participants were recruited via Sona systems where they scheduled a time to meet the researcher at the Technology and Aging Laboratory. Upon arrival to the lab, each participant was presented with an informed consent document. Upon consent, the participant was asked to complete the preliminary visual screening measures on the OPTEC. The experimenter then conducted tests for near visual acuity and color blindness. To further participate in this study the participant was required to have at least 20/40 normal or corrected-to-normal visual acuity as well as normal color vision. If the participant did not meet one of the criteria, he/she was excluded from the study and compensated for his/her time in the amount of 90 minutes of SONA Systems credit.

After passing the above-mentioned tests, each of the 120 participants were assigned to one of the twelve randomized colored environmental conditions (mentioned in detail below), based on the randomized block design. Each participant was then asked to complete a demographics questionnaire. After which, he/she was escorted over to the computer to complete the State Trait Anxiety Inventory (Form Y-1), the Backward Digit Span task and the Attention Network Task (ANT) on E-Prime©. Upon completion of those tasks, the participant viewed a set of 50 pictures. These pictures varied based on which one of the twelve colored environmental conditions the participant was assigned to: Black and White (Urban, Foliage, or Aquatic), Natural (Urban, Foliage, or Aquatic), Blue (Urban, Foliage, or Aquatic), or Green (Urban, Foliage, or Aquatic). Each picture from the assigned set was displayed on a monitor for 7 seconds. Following each picture the participant was asked to rate how much they liked the picture on a scale of one to seven, where one corresponded to not at all and seven corresponded to very much. Upon viewing the entire set of 50, participants were given the backwards digit span, ANT, & the State Anxiety test, in that order. Upon completion of the post tests, each participant was debriefed and 90 minutes of SONA Systems credit was allocated for his/her time.

CHAPTER FOUR: RESULTS

A 4x3 MANOVA was initially considered for the statistical evaluation, however, due to a lack of correlation between the STAI, BDS, and ANT a series of mixed 2x4x3 repeated measures ANOVAs were calculated instead. The aforementioned ANOVAs were used to assess the effects of color (black & white, natural, green, & blue) and type of environment (urban, aquatic & foliage) on pre and post test scores for each of the dependent measures. The within-subject factor for all of the mixed ANOVAs was time of test (pre & post) and the between-subjects factors were color and environment. In addition to the mixed measure ANOVAs, a two-way between subjects ANOVA was calculated to examine the effects of color and environment type on preference ratings. All analyses were performed using the IBM SPSS V.21 GLM, with alpha set at the .05 level. Additionally, a series of one-way, between subjects ANOVAs verified that pre test scores did not vary among conditions for all aforementioned measures. For a complete listing of effect sizes please refer to Table 4 in Appendix E.

State Anxiety

The effects of picture type on State Anxiety scores (pre & post), as measured by the State Trait Anxiety Inventory, Form Y-1 were assessed. A significant within-subjects main effect was found for pre and post test scores, $F(1, 107) = 11.48$, $p = .001$(*partial* $\eta^2 = .10$). This indicates that there was a statistically significant difference in anxiety level between pre ($M = 30.49$, $SD = 7.64$) and post ($M = 33.18$, $SD = 9.22$) tests, such that individuals' anxiety levels increased after viewing the pictures. However, no statistically significant interactions were found for pre and post test scores on: color, environment, and color by environment (see Appendix E for Table 1).

Furthermore, there were no significant main effects for color or environment and no significant interaction effect for color by environment.

Backwards Digit Span

The effects of picture type on pre and posttest backwards digit span scores were tested. The results indicated a significant within-subjects main effect for pre (*M* = 5.38, *SD* = 1.08) to posttests (*M* = 5.64, *SD* = 1.34), $F(1, 107) = 4.62$, $p = .03$ (*partial* $\eta^2 = .04$) (see Figure 2). This indicates that regardless of color or environmental condition participant's performance improved overall after viewing pictures. Furthermore, a marginally significant pre to post test by color interaction was observed, $F(3, 107) = 2.60$, $p = .083$, *partial* $\eta^2 = .06$ (see Figure 3). However, statistical significance was not reached for the interaction of pre to post test by environment or pre to posttest by environment by color.

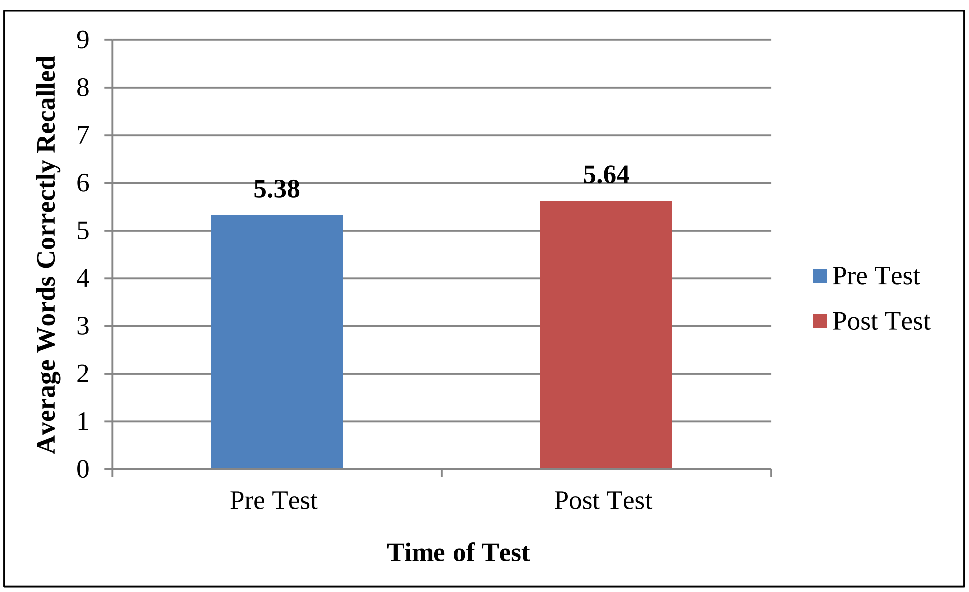

Figure 2: Average Number of Words Recalled on the Backwards Digit Span

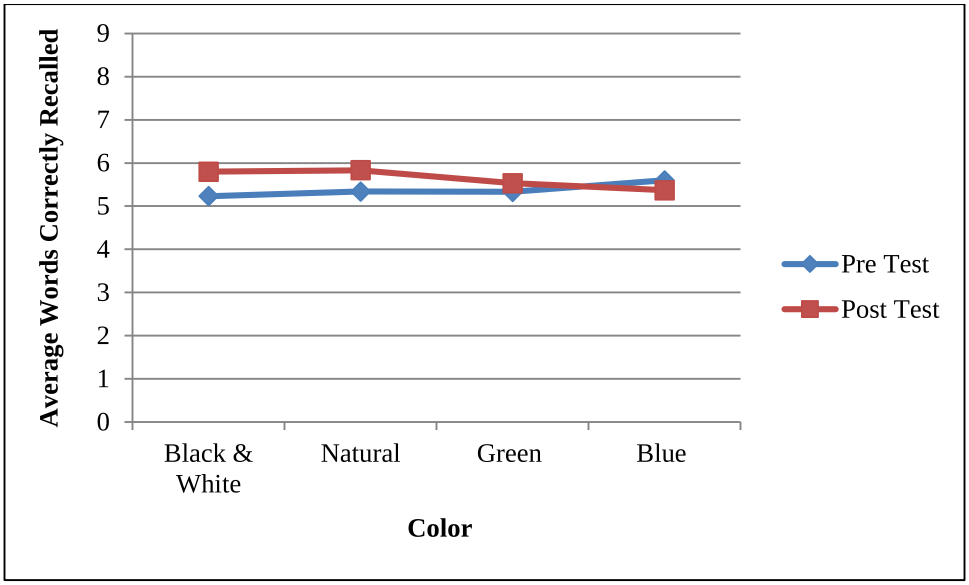

Figure 3: Color by Pretest & Posttest Interaction on the Backwards Digit Span

Attention Network Task (Executive Functioning)

The effects of picture type on pre and posttest reaction time scores for executive control, as measured by the Attention Network Task were examined. A significant within subjects' main effect was found for pre to post tests on reaction time, $F(1, 107) = 18.44$, $p < .001$ (*partial* $\eta^2 = .15$). Upon further investigation the results indicated that participants reaction times decreased from pretest ($M = 118.14$, $SD = 54.25$) to posttest ($M = 102.34$, $SD = 36.43$). However, no within-subjects main effect for color, environment, or an interaction thereof was found. Furthermore, no significant between-subjects main effects or interactions were found for color, environment, or color by environment.

Picture Preference

A between subjects ANOVA was conducted to analyze the effects of color and environment type on preference scores. No significant difference was observed for color (Black and White, Natural, Green & Blue) on picture preference scores $F(3, 107) = 0.62$, $p = .60$. However, a significant difference was observed for environment type (Urban, Foliage, & Aquatic) on picture preference scores, $F(2, 107) = 7.36$, $p = .001$, *partial* $\eta^2 = .12$ (see Figure 4). Furthermore, post-hoc comparisons on type of environment were conducted using the Tukey HSD test. Results indicated that individual's preference ratings for the Aquatic ($M = 4.70$, $SD = 0.89$) environment were significantly higher than both the Foliage ($M = 4.20$, $SD = 1.06$) and the Urban ($M = 3.94$, $SD = 0.77$) environments; however, no statistically significant differences in preference ratings were observed between the Foliage ($M = 4.20$, $SD = 1.06$) and Urban ($M = 3.94$, $SD = 0.77$) environments.

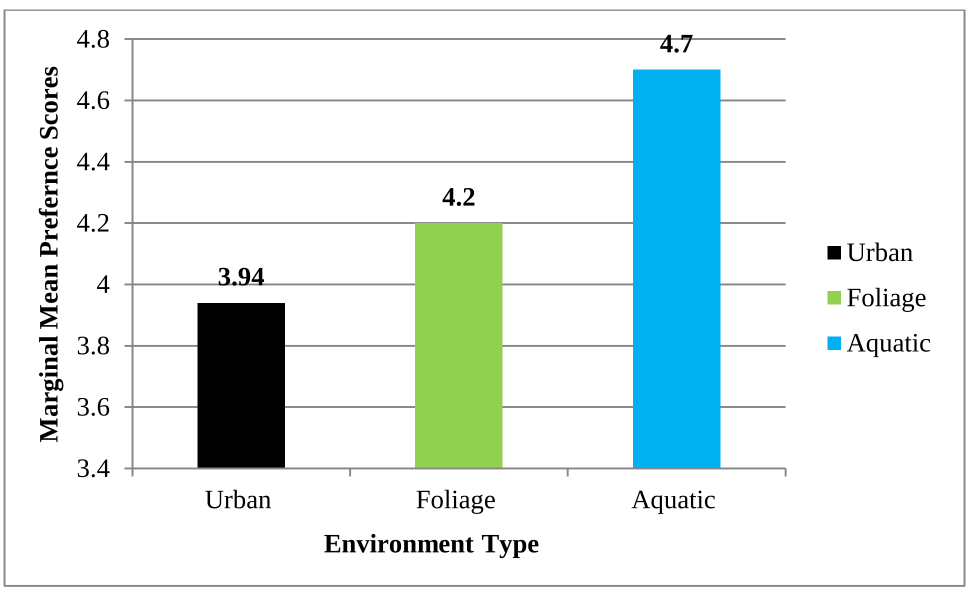

Figure 4: Marginal Mean Preferences Scores for Environment Type

CHAPTER FIVE: DISCUSSION

As previously stated, due to the exploratory nature of this study, no specific hypotheses were made. However, the goal of this research was to "tease apart" the effects of color and environment on the restoration of cognitive abilities, as well as to replicate similar studies on cognitive restoration.

State Anxiety

Results for the effects of color and environment on State Anxiety Scores indicated that in general, each participant's anxiety significantly differed ($p < .05$) from pretest to posttest, such that slight increases in anxiety level were observed from pre to posttests. However, it is important to note that average pre test state anxiety scores fell approximately in the 26th percentile of the reported norms for college students (Spielberger et al., 1983). Furthermore, no significant interactions were found for test scores indicating that neither color nor type of environment influenced participants' ratings of anxiety from pre to posttest. Additionally, between subjects factors, color and environment, were found to have had no statistically significant bearing on state anxiety level.

Previous research indicates that natural environments improve mood by a number of different measures. Upon closer observation, these findings are generally seen only when individuals exercise, whether walking or running, in natural environments as opposed to urban environments (Barton & Pretty, 2010; Berman, Jonides, & Kaplan, 2008; Bowler, Buyung-Ali, Knight, & Pullin, 2010; Coon et al., 2011). Increases in positive affect have also been observed when viewing videos of natural environments (Ulrich et al., 1991). However, similar increases in mood were not observed when viewing pictures of natural environments as indicated by Berman, Jonides, and Kaplan's (2008) results. Furthermore in a more recent study, Berman et al. (2012), did not replicate the findings of his 2008 study in which there were no significant interactions observed for pre/posttest scores and environment on mood, as measured by the positive and negative affect scale (PANAS). Instead, Berman et al.'s (2012) study noted no main effects of time of test (pre & post) or environment on mood, but a significant interaction between time of test and environment was observed. Despite the fact that an interaction was observed in Berman et al.'s (2012) study, no statistical significance was reported for tests of simple effects; therefore it would be hard to conclude that viewing pictures increased positive affect. Similarly, Tennessen and Chimprich (1995) did not find any significant differences in mood when looking out the window at natural or urban environments.

The results of this current study support the non-significant findings of the effects type of environmental pictures on mood mentioned above (Berman, Jonides, & Kaplan, 2008). One potential explanation for this discrepancy in these findings may be due to one's level of immersion in the environment. For instance, one's presence in a natural environment may be very similar to that of viewing videos of a natural environment. Whereas, viewing still pictures of natural environments does not make individuals feel immersed in the setting, and as a result does not influence ones' mood. Additionally, these differences could be due to the environmental stimuli used in the different studies—an issue that will be discussed in further detail in the section titled "pictures a cause for concern". On the other hand, the lack of exercise in this study as a moderator or even by itself could be the reason for which no significant effects of mood were observed for this study, as exercise has been shown to increase positive affect by a number of researchers (Barton & Pretty, 2010; Berman, Jonides, & Kaplan, 2008; Bowler, Buyung-Ali, Knight, & Pullin, 2010; Coon et al., 2011).

Backwards Digit Span

The effects of color and environment on the backwards digit span scores indicated that the amount of numbers each participant was able to correctly recall and manipulate significantly differed ($p < .05$) from pretest to posttest, such that increases in performance were seen from pre to posttests. Picture color may account for this improvement ($p = .056$). Upon further investigation, it was found that Natural (untouched) color pictures (mean difference = 0.66) and the black and white pictures (mean difference = 0.57) displayed the most increases in performance from pre to post tests. However, the effect size was very small, and as such it is not indicative of restorative potential. Additionally, no significant interactions were found for pre/posttests and environment indicating that the urban, foliage, and aquatic environment types had no statistically noteworthy influence on one's short term memory abilities from pre to posttest.

These results did not reflect the general findings that natural environments are restorative. Past research indicates that one's physical presence in a natural environment (Berman, Jonides, & Kaplan, 2008; Berman et al. 2012; Ottoson & Grahn, 2005) significantly improved short term memory performance on the backwards digit span as compared to urban environments. However, it does reflect Berman, Jonides, and Kaplan's, (2008) Study 2 finding which indicated that neither natural nor urban environments affect individuals' performance on the backwards digit span.

Furthermore, despite the fact that the interaction of pre/posttest and color was only trending towards significance, the picture colors that displayed the most improvement were black and white and natural (untouched). Previous research on color, although somewhat inconclusive, suggests that the blue and green colored pictures should have improved ones' STM abilities the most (Etnier & Hardy, 1997).

Attention Network Task (Executive Functioning)

The effects of color and environment on the conflict (directed attention) measure of the Attention Network Task's (ANT) indicated that, overall, participants' reaction times significantly increased from the pretest to the postest; moreover, these results were not moderated by color, environment or a combination of both. Much like state anxiety and the backwards digit span, no significant differences were observed for environment, color, or their interaction on the ANT regardless of time of test.

Unlike Berman et al. (2012) and Berto (2005) these findings do not indicate that cognitive restoration is moderated by type of environment where natural environments elicit restorative experiences and urban environments do not. An explanation for this divergent finding rests in the potential confounds of the manipulations (stimuli) that were used in previous studies, which will be discussed in the section titled "picture variations a cause for concern".

Furthermore, no significant main effects or interactions were found for color. As previously mentioned this does not support the literature that blue and green colors are relaxing (Mahnke, 1996; Spielberger, Gorsuch, & Lushene, 1970).

Picture Preferences

The results indicated a significant main effect for type of environment (urban, foliage, & aquatic) on reports of how much each individual liked each set of pictures. More specifically, participants preferred the aquatic environment significantly more than both the foliage and urban environments; however, no significant differences in preference were observed between foliage and urban environments.

Although there is an abundance of research that indicates that individuals prefer viewing natural environments to urban environments (e.g. Berman, Jonides, & Kaplan, 2008; White et al, 2010), this is not always the case as indicated by Karmanov and Hamel (2008). There are many potential cofounds, that will be addressed momentarily, regarding the pictures or other mediums used to depict natural and urban settings. As a result, the preference, or rather likeness ratings of this current study will be compared to White et al's (2010) findings on the perceived restorative effects of rigorously controlled environments (e.g. time of day, inclusion or exclusion of people or animals, proportion of content, viewing position, clarity, picture size, etc.). Although White et al.'s study explored the differences in preferences for "built", "green", and "aquatic" environments, it also took into account the preference ratings for mixed environments by allowing for specific proportions of the pictures in which there could be an urban scene where a 1/3 would be aquatic and 2/3 would be urban or any other combination thereof (2010). In general, the current study's findings support White et al. (2010) in that they too found that individuals significantly prefer aquatic environments over both "green" (foliage) and "built" (urban) environments. However, unlike their findings, the current study did not find a significant difference in preference ratings for natural and urban environments. White et al. (2010) found that individuals preferred urban environments that contained water just as much as natural environments without water. Although water of any kind was strictly excluded from any of the urban photos used in the present study, blue and green filters were placed over two of the four urban environment conditions. The addition of a blue filter to one of the four environmental conditions may have contributed to this finding as mean preference rating for the blue urban condition were slightly higher than both the natural and black and white urban conditions.

Picture Variations a Cause for Concern

Another probable explanation for the discrepancies between this study and other similar studies were the wide range of variations within picture sets or other mediums. For instance, whether assessing the effects of type of environment on stress, mood, short term/working memory, or attention, the majority of studies did not take into account, or rigorously control for the differences in picture content. For instance, some urban environments contained ponds, lakes, fountains, trees, plants, & people among others, whereas some natural environments contained man-made structures, such as sidewalks, benches, buildings, people, or even water in the form of ponds, lakes, rivers, and oceans (e.g. Cimprich & Ronis, 2003; Kweon, Ulrich, Walker, & Tassinary, 2008; Ottosson & Grahn, 2005; van den Burg, Koole, & van der Wulpe, 2003). White et al., (2010) points out that the lack of standardization specifically in regards to the presence of water, both within a picture set as well as between pictures sets, could influence the outcome of the study. This lack of standardization not just in regards to water but also in regards to any aforementioned content make it difficult to determine the specific effects of each environment on various metrics.

One goal of this study was to replicate the findings of Berman, Jonides, and Kaplan (2008) who found that natural environments elicit cognitive restoration; however, this goal was not obtained. The main differences between Berman, Jonides, and Kaplan (2008) and the current study lie within the environmental pictures used. The pictures used in their study varied within environments. Based on elements contained within the pictures as well as the quality of the pictures themselves it can be estimated that the urban pictures used Berman's study were approximately 30 or 40 years old and as such, they had low resolution, some pictures appeared faded and the style of the buildings and vehicles were much different than what is seen today. Furthermore, 14.8% of the urban pictures were taken at dusk, whereas 100% of the nature pictures were taken during the daytime. Berman, Jonides and Kaplan's pictures of natural environments in general seemed to be more recent and of better quality than the urban environment. This tendency for the low resolution urban photographs, though I am sure was unintentional, in Berman's urban picture set as opposed to his natural environment picture set may have confounded his results. Past research on stimulus degradation has found that individuals significantly prefer non-degraded images to degraded images (i.e. poor color saturation, grainy, low contrast, etc.) regardless of environment type (Tinio, Leder, & Strasser, 2011). Additionally, significant increases in reaction time were found when identifying picture contents in degraded images as compared to a non-degraded images, suggesting that degraded images require more cognitive processing (Sternberg, 1967). Although Berman's Natural picture set was of better quality than his Urban picture set, they still had some potential confounds such as the incorporation of water in the form of ponds, lakes, and flowing rivers, all of which varied in degree of cleanliness. Research suggests that that individuals have higher preferences for clean, tranquil and flowing water than for dirty or stagnant water (Herzhog, 1985; Wilson, Robertson, Daly, & Walton, 1995).

Furthermore, White et al. (2010) disclosed that 78% of Berman et al.'s (2008) pictures of nature contained up to approximately 60% of water, as compared to 0% in the urban pictures. In addition to the lack of standardization of water across environments, both environments varied in perspective in regards to focal point. Depth perception varied greatly not only between but within pictures, for instance some natural and urban pictures were taken close up whereas others far away. Additionally, there were variations in perspective among the pictures; some were taken from above looking down and others were taken from the ground looking up. These differences could have a potential impact on how restorative the environment is based on the fact that pictures that are taken from far away or even pictures taken from the perspective of looking up could greatly impact the restorative nature of the environment when taking into consideration two of the components of Kaplan and Kaplan's Attention Restoration Theory "being away" and "extent". This is because such perspectives could theoretically be allowing the person's mind to openly wander. Many of these potential confounds that were discussed above were rigorously controlled for in the current study (see method section), and as a result may have contributed to the discrepancies in the study's findings regarding not only Berman et al.'s work (2008 & 2012), but other similar studies as well. Furthermore, as indicated by the discrepancies within the existing literature on restorative nature of environments on executive functioning and affect, more studies that did have significant findings regarding restoration may have been subject to

Rosenthal's (1979) file drawer problem, in which studies that have non-significant results are both less likely to be submitted for publication or published.

Limitations

Although the present study controlled for many confounds found in similar studies such as study design and stimuli used, it is not without limitations of its own. Firstly, this study used participants from a single population, which consisted of college students with a mean age of approximately 19 years. This narrow population limits how generalizable the results are, however, many previous studies have used college students as their sole participants and as such, the results are directly comparable. Not to mention, college students are suggested to be more at risk of experiencing attentional fatigue (Tennessen & Cimprich, 1995). Although, this study not only mimicked, but also improved upon the design and stimuli used in previous research on the topic as intended, it did not mentally fatigue participants before further participation. However, other studies such as Berman et al. (2008) and Berto (2005) also did not mentally fatigue their participants first nor did they try and capture their level of fatigue experienced before participation in the study. This leads me to believe that there could be a potential difference between the participants used in each study. Perhaps, if participants' directed attention was depleted before commencing the current study one would obtain results that suggest that natural environments are restorative in nature or even that color plays a key role in cognitive restoration.

Secondly, the ecological validity of this study could come into question as a result of testing the restorative benefits of natural environments in a laboratory setting instead of the natural environment itself.

Lastly, although the currently study controlled for many confounds in regards to the stimuli (pictorial content) that have been observed in many previous studies on the topic, such as picture size, picture orientation, time of day, weather conditions, inclusion or exclusion of people, animals, separation of natural and urban (man-made) content depending on environmental condition among others, there are still some aspects of the stimuli used in this study such as, the color filters, that were used and the inclusion and exclusion of people that could have affected the outcome. For instance, the blue and green colored filters that were placed over black and white environmental images may have been perceived as unnatural and therefore prevented the individual from processing it further, however this does not explain why no significant differences were found between natural and black and white images. Additionally, White et al. (2010) found that individuals had a significantly higher preference and greater affect for environmental pictures that included people as opposed to those that did not. However, it is important to keep in mind that preference has not shown, thus far to be indicative of an environments restorative potential (Berman, Jonides, & Kaplan, 2008; van den Berg, Koole, & van der Wulpe, 2003). Additionally, the removal of presence of people in the urban environment would also hamper the ecological validity of the study as it is not natural for an urban environment to be barren.

Conclusion

Today there are many tasks that require individuals to make decisions and take actions that can have major, even life-threatening, consequences, all while avoiding inherent dangers and maintaining a fast pace. In such tasks there is great value in any method by which individuals can quickly and easily relax and replenish their cognitive capacity, improving their ability to function safely and effectively. The current study sought out to both replicate as well as add to the existing literature which explored which aspects of the environment (i.e. color, the degree to which the environment is "natural," etc.) may be capable of improving affect and restoring cognitive abilities. Although this study was not able to replicate the previous findings of similar studies or to demonstrate any effect of color on cognitive restoration, it has shed some light on the areas of those past studies that warrant further attention: the existing literature has employed a wide variety of designs and a plethora confounded manipulations which may have lead researchers to draw conclusions regarding the benefits of natural environments that may not be wholly accurate. Much more controlled research is still needed to investigate the restorative effects of natural environments in order to determine the reliability of the claims that pictorial representations of natural environments are inherently restorative.

APPENDIX A: IRB APPROVAL LETTER

University of Central Florida Institutional Review Board
Office of Research & Commercialization
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: 407-823-2901 or 407-882-2276
www.research.ucf.edu/compliance/irb.html

Approval of Human Research

From: **UCF Institutional Review Board #1**
FWA00000351, IRB00001138

To: **Jessica R. Michaelis**

Date: **July 17, 2012**

Dear Researcher:

On 7/17/2012, the IRB approved the following minor modification to human participant research until 06/10/2013 inclusive:

Type of Review:	IRB Addendum and Modification Request Form
Modification Type:	New undergraduate research assistants are being added to the study: Talena Ramnath, Nick Piedra, and Samantha Dominque. Revised Informed Consent document has been approved for use.
Project Title:	The Effects of Colors of Nature on Mental Status
Investigator:	Jessica R Michaelis
IRB Number:	SBE-12-08475
Funding Agency:	
Grant Title:	
Research ID:	N/A

The Continuing Review Application must be submitted 30days prior to the expiration date for studies that were previously expedited, and 60 days prior to the expiration date for research that was previously reviewed at a convened meeting. Do not make changes to the study (i.e., protocol, methodology, consent form, personnel, site, etc.) before obtaining IRB approval. A Modification Form **cannot** be used to extend the approval period of a study. All forms may be completed and submitted online at https://iris.research.ucf.edu .

If continuing review approval is not granted before the expiration date of 06/10/2013, approval of this research expires on that date. When you have completed your research, please submit a Study Closure request in iRIS so that IRB records will be accurate.

se of the approved, stamped consent document(s) is required. The new form supersedes all previous versions, which are now invalid for further use. Only approved investigators (or other approved key study personnel) may solicit consent for research participation. Participants or their representatives must receive a copy of the consent form(s).

In the conduct of this research, you are responsible to follow the requirements of the Investigator Manual.

On behalf of Sophia Dziegielewski, Ph.D., L.C.S.W., UCF IRB Chair, this letter is signed by:

Signature applied by Joanne Muratori on 07/17/2012 10:53:10 AM EDT

Joanne Muratori

APPENDIX B: DEMOGRAPHICS QUESTIONNAIRE

Demographics Questionnaire

Please answer the following questions to the best of your ability by filling in the blank.

1. How old are you? ____________

2. Circle one Male or Female

3. What is your race? (Circle one)

American Indian or Alaska native
Asian
Black or African American
Native Hawaiian or Other Pacific Islander
White

APPENDIX C: STATE ANXIETY INVENTORY COPYRIGHT APPROVAL

For use by Jessica Michaelis only. Received from Mind Garden, Inc. on June 11, 2012

mind garden

www.mindgarden.com

To whom it may concern,

This letter is to grant permission for the above named person to use the following copyright material;

Instrument: ***State-Trait Anxiety Inventory for Adults***

Authors: ***Charles D. Spielberger, in collaboration with R.L. Gorsuch, G.A. Jacobs, R. Lushene, and P.R. Vagg***

Copyright: ***1968, 1977 by Charles D. Spielberger***

for his/her thesis research.

Five sample items from this instrument may be reproduced for inclusion in a proposal, thesis, or dissertation.

The entire instrument may not be included or reproduced at any time in any other published material.

Sincerely,

Robert Most
Mind Garden, Inc.
www.mindgarden.com

APPENDIX D: STATE TRAIT ANXIETY INVENTORY SAMPLE QUESTIONS

State Trait Anxiety Inventory Sample

Read each statement and select the appropriate response to indicate how you feel right now, that is, at this very moment. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

1	2	3	4
Not at all	**A little**	**Somewhat**	**Very Much So**

1. I feel calm	1	2	3	4
2. I feel uncomfortable	1	2	3	4
3. I am relaxed	1	2	3	4
4. I am worried	1	2	3	4
5. I feel pleasant	1	2	3	4

APPENDIX E: TABLES OF MEANS, STANDARD DEVIATIONS, AND EFFECT SIZES

Table 1: Mean State Anxiety Scores for Color and Environment (with Standard Deviations in Parentheses)

	Environment Type		
Color	Urban	Foliage	Aquatic
Black & White			
Pre	30.30 (7.89)	28.70 (6.31)	30.30 (5.96)
Post	38.30 (6.80)	32.10 (10.61)	31.50 (8.21)
Natural (Untouched)			
Pre	29.40 (7.59)	32.56 (5.90)	26.20 (4.37)
Post	31.40 (6.00)	32.44 (7.62)	28.90 (5.00)
Green			
Pre	31.60 (8.97)	27.20 (6.81)	30.80 (7.16)
Post	35.20 (8.88)	31.60 (7.78)	31.70 (11.18)
Blue			
Pre	30.60 (6.75)	31.40 (7.81)	37.00 (12.04)
Post	35.40 (13.14)	35.30 (11.14)	34.20 (11.68)

Note. N = 119 (One participant was removed from the Natural Foliage Condition).

Table 2: Mean Backwards Digit Span Scores for Color and Environment (with Standard Deviations in Parentheses)

	Environment Type		
Color	Urban	Foliage	Aquatic
Black & White			
Pre	5.50 (1.08)	4.90 (1.29)	5.30 (0.30)
Post	6.20 (1.03)	4.80 (1.65)	6.40 (0.97)
Natural (Untouched)			
Pre	5.50 (1.58)	5.22 (1.20)	5.30 (0.95)
Post	5.50 (1.43)	5.67 (1.73)	6.40 (1.35)
Green			
Pre	5.10 (0.99)	5.50 (0.85)	5.40 (0.84)
Post	5.80 (1.03)	5.20 (1.34)	5.60 (1.65)
Blue			
Pre	5.70 (1.56)	5.40 (1.26)	5.70 (1.56)
Post	5.00 (1.63)	5.70 (1.56)	5.40 (1.26)

Note. N = 119 (One participant was removed from the Natural Foliage Condition).

Table 3: Mean Conflict Attention Network Task Reaction Time Scores for Color and Environment (with Standard Deviations in Parentheses)

	Environment Type		
Color	Urban	Foliage	Aquatic
Black & White			
Pre	126.58 (56.31)	123.82 (89.30)	121.71 (23.63)
Post	113.89 (45.63)	93.46 (28.11)	108.97 (25.20)
Natural (Untouched)			
Pre	138.71 (97.09)	98.66 (25.60)	102.42 (31.03)
Post	111.21 (40.68)	83.76 (22.91)	94.51 (34.06)
Green			
Pre	111.94 (33.08)	130.71 (42.79)	99.11 (59.94)
Post	92.79 (43.42)	118.55 (41.42)	97.33 (39.62)
Blue			
Pre	118.70 (71.53)	128.98 (24.35)	114.49 (40.76)
Post	111.12 (45.07)	113.77 (17.83)	86.83 (37.22)

Note. N = 119 (One participant was removed from the Natural Foliage Condition). Time in ms.

Table 4: Effect Sizes for the STAI, BDS, & ANT

	STAI	BDS	ANT
PrePost	.10***	.04*	.14***
PrePost x Color	.02	.06	.01
PrePost x Environment	.04	.02	.01
PrePost x Environment x Color	.04	.09	.04

Note. *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

REFERENCES

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., ... & Jonides, J. (2012). Interacting with nature improves cognition and affect for individuals with depression. *Journal of Affective Disorders*. *140*(3), 300-305.

Barton, J., & Pretty, J. (2010). What is the best dose of nature and green exercise for improving mental health? A multi-study analysis. *Environmental Science & Technology*, *44*(10), 3947-3955.

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

Boksem M.A.**,** Meijman, T.F., Lorist M.M. (2005). Effects of mental fatigue on attention: an ERP study. *Brain Res Cogn Brain Res 25*, 107–116.

Bowler, D. E., Buyung-Ali, L. M., Knight, T. M., & Pullin, A. S. (2010). A systematic review of evidence for the added benefits to health of exposure to natural environments. *BMC Public Health*, *10*(1), 456.

Broadbent, D.E. (1956). Successive responses to simultaneous stimuli. *Journal of Experimental Psycholo*gy, 8, 145-152.

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

Coon, J.T., Boddy, K., Stein, K., Whear, R., Barton, J., & Depledge, M.H. (2011). Does participating in physical activity in outdoor natural environments have a greater effect on physical and mental wellbeing than physical activity indoors? A systematic review. *Environmental Science & Technology*, *45*(5), 1761-1772.

Depledge, M. H., Stone, R. J. & Bird, J. W. (2011). Can natural and virtual environments be used to promote improved human health and wellbeing?. *Environmental Science & Technology, 45* (11), 4660–4665.

Etnier, J. L., & Hardy, C. J. (1997). The effect of environmental color. *Journal of Sport Behavior.* 20(3), 299 – 312.

Fan, J., McCandliss, B.D., Sommer, T., Raz, M. & Posner, M.I. (2002) Testing the Efficiency and Independence of Attentional Networks. *Journal of Cognitive Neuroscience, 14,* 340-347.

Fan, J., McCandliss, B.D., Fossella, J., Flombaum, J.I., & Posner, M.I. (2005). The activation of attentional networks. *NeuroImage,* 26, 471–479.

Felsten, G. (2009). Where to take a study break on the college campus: An attention restoration theory perspective. *Journal of Environmental Psychology*, *29*(1), 160-167.

Gray, J.R. (1999). A bias toward short-term thinking in threat-related negative emotional states. Personality and Social Psychology Bulletin, 25, 65–75.

Guilford, J. P., & Smith, P. C. (1959). A system of color preferences. *American Journal of Psychology, 72,* 487-502.

Hartig, T., Evans, G.W., Jamner, L.D., Davis, D.S., & Garling, T. (2003). Tracking restoration in natural and urban field settings. *Journal of Environmental Psychology, 23,* 109-123.

Hartig, T., Mang, M., & Evans, G.W. (1991). Restorative effects of natural environment experiences. *Environment and Behavior, 23*(1), 3-26.

Herzog, T. R. (1985). A cognitive analysis of preference for waterscapes. *Journal of Environmental Psychology*, *5*(3), 225-241.

Hipp, J.A. & Ogunseitan, O.A., (2011). Effect of environmental conditions on perceived psychological restorativeness of coastal parks, *Journal of Environmental Psychology, 31*(4), 421-429.

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

Kaplan, S., & Berman, M.G. (2010). Directed attention as a common resource for executive functioning and self regulation. *Perspectives on Psychological Science, 5,* 43-57.

Karmanov, D., & Hamel, R. (2008). Assessing the restorative potential of contemporary urban environment (s): Beyond the nature versus urban dichotomy. *Landscape and Urban Planning*, *86*(2), 115-125.

Kweon B., Ulrich R., Walker V., & Tassinary L. (2008). Anger and stress: the role of landscape poster in an office setting. *Environment and Behavior*, *40(3)*, 355-381.

LeBlanc, V.R. (2009).The effects of acute stress on performance: Implications for health professions education. *Academic Medicine, 84*, 25–33.

Lee, J., Park, B., Tsunetsugu, Y., Kagawa, T. & Miyazaki, Y., (2009). *Scandinavian Journal of Forest Research*, *24*(3), 227-234.

Luttik, J. (2000). The value of trees, water and open space as reflected by house prices in the Netherlands. *Landscape and Urban Planning*, 48(3), 161-167.

Mahnke F. Color, Environment, Human Response. New York: Van Nostrand Reinhold; 1996.

Mehta, R., & Zhu, R. J. (2009). Blue or red? Exploring the effect of color on cognitive task performances. *Science, 323*(5918), 1226-1229.

Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits to our capacity for processing information, *The Psychological Review*. 63, 81-97.

Ottosson, J., & Grahn, P. (2005). A comparison of leisure time spent in a garden with leisure time spent indoors: On measures of restoration in residents in geriatric care. *Landscape Research, 30*, 23–55.

Rosenthal, R. (1979). The file drawer problem and tolerance for null results. *Psychological Bulletin, 86*(3), 638-641.

Spielberger, C. D., Gorsuch, R. L., Vagg, P. R. Lushene, R. E. & Jacobs, G. A. (1983). *Manual for the State-Trait Anxiety Inventory*. Palo Alto, CA: Mind Garden Inc.

Starcke, K., Wolf, O.T. & Markowitsch, H.J. (2008). Brand M. Anticipatory stress influences decision making under explicit risk conditions. *Behavioral Neuroscience 122*, 1352-1360.

Sternberg, S. (1967). Two operations in character recognition: Some evidence from reaction-time measurements. *Perception & Psychophysics, 2*(2), 45-53.

Stone, N.J. & English, A.J. (1998). Task type, posters, and workspace color on mood, satisfaction, and performance. *Journal of Environmental Psychology 18 (2)*, 175-185.

Tennessen, C.M., & Cimprich, B., (1995). Views to Nature: Effects on Attention. *Journal of Environmental Psychology 15*(1), 77-85.

Thoreau, H. D. (1997). *Walden*. Boston: Beacon Press.

Tinio, P. P., Leder, H., & Strasser, M. (2011). Image quality and the aesthetic judgment of photographs: Contrast, sharpness, and grain teased apart and put together. *Psychology of Aesthetics, Creativity, and the Arts*, *5*(2), 165-176.

Ulrich, R.S. (1981). Natural versus urban scenes: Some psychophysiological effects. *Environment & Behavior 13*, 523–56.

Ulrich, R.S. (1984). View through a window may influence recovery from surgery. S*cience, 224,* 420-421.

Ulrich, R.S., Simons, R.F., Losito, B.D., Fiorito, E., Miles, M.A., & Zelson, M. (1991). Stress recovery during exposure to natural and urban environments. *Journal of Environmental Psychology, 11*, 201-230.

Ulrich, R.S., Simons, R.F. & Miles, M.A. (2003). Effects of environmental simulations and television on blood donor stress. *Journal of Architectiural & Planning Research 20*, 38–47.

van den Berg, A.E., Koole, S.L. & van der Wulp, N.Y. (2003). Environment preference and restoration: How are they related? *Journal of Environmental Psychology 23,* 135–46.

Wexner, L. B. (1954). The degree to which colors (hues) are associated with mood-tones. *Journal of Applied Psychology, 38,* 432-435.

White, M. P., Smith, A., Humphries, K., Pahl, S., Snelling, D., Depledge, M. H. (2010). Blue Space: The importance of water for preference, affect and restorative ratings of natural and built scenes. *Journal of Environmental Psychology 30*(4), 482-493.

Wilson, M. I., Robertson, L. D., Daly, M., & Walton, S. A. (1995). Effects of visual cues on assessment of water quality. *Journal of Environmental Psychology*, *15*(1), 53-63.