THE EFFECTS OF PROCESSING FLUENCY ON RESTORATIVE ENVIRONMENTS

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ABSTRACT

Attention Restoration Theory (ART) maintains that directed attention, a type of attention that requires effort, is a resource that is susceptible to fatigue after prolonged use. This directed attention fatigue, commonly known as mental fatigue, is a factor linked to performance and safety decline in the workplace. Many studies have found that contact with nature promotes restoration from directed attention fatigue; however, there is little research on how nature has this effect. The aim of the present study was to explore whether natural environments have restorative potential given their higher degree of processing fluency. College students (N=78) were mentally fatigued by performing a sustained attention task. Then they viewed a natural photograph or urban photograph presented in various degrees of fluency (manipulated via visual clarity) and performed the sustained attention task again. Mood ratings were also examined. In line with ART, participants who viewed the natural environment photograph showed a larger improvement in the sustained attention task compared to those who saw the urban environment photograph; however, this was not influenced by fluency levels. Mood ratings were also not influenced by the type of environment or fluency levels. The research promotes the exploration of specific mechanisms underlying restorative environments which in turn would provide landscape designers, spatial planners, and employers a basis for green designs and interventions.

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The Effects of Processing Fluency on Restorative Environments

One of the challenges facing humans today is the ability to sustain attention for long periods of time. As our world becomes increasingly urbanized, there are more distractions than ever before. The constant demands of our environment can be mentally exhausting—traffic, multitasking, and general noise all take their toll on us. According to the Bureau of Labor and Statistics (2012), on an average day an adult in the United States will spend more than half of their waking hours either working or participating in work-related activities, which require focused attention for long periods of time. Consequently, *human error* is frequently cited as a contributing factor in the decline of safety and performance in the workplace (e.g., Barker & Nussbaum, 2010; Shappell et al., 2007).

The challenge for many organizations is to ensure accuracy, efficiency, and most important, safety. In some instances, human error might only lead to small mishaps, which can be easily repaired. In other cases, this error can lead to very devastating consequences. For example, in the health care field, preventable medical errors are the cause of more than one million injuries and between 44,000 to 98,000 patient deaths each year in the United States (Kohn, Corrigan, & Donaldson, 1999). In aviation, between 60% and 80% of the accidents are attributable to human error (Shappell & Wiegmann, 1996).

The cause of errors and accidents in the workplace are both multidimensional and complex and no one would argue that uncontrollable factors such as equipment failure or bad weather do not contribute to these mistakes. However, another major factor is mental fatigue, which is an aspect that can be managed. According to Fritz, Lam, and Spreitzer (2011), over the past 20 years there has been considerable interest in the sustainability of organizations, including *human sustainability*. This refers to the idea that humans, like batteries, have energy that becomes depleted over time. Those interested in studying human sustainability search for ways to reduce fatigue and increase vitality in employees and in turn, reduce human error. For example, workplaces might shorten the duration of work shifts, employ alternative work schedules, or decrease the workload. Although these strategies might work for some organizations, they are not always feasible for others. For instance, it is impossible to predict how many patients will be admitted into a hospital on a given day; therefore workload cannot be predicted. Further, there may not be enough resources (i.e., funds) to hire more employees or there may be a shortage of workers in a particular profession.

One alternative method to reduce fatigue in the workplace is taking breaks, which provides employees with a period of time away from their work duties. It is common for employers to offer breaks to its employees with the prospect that this will help replenish both physical and mental energy. However, simply taking a break from work duties does not necessarily facilitate the recovery from fatigue. The locations and the activities done within those break periods matter. Fritz and her colleagues asked 214 employees in professional and clerical positions to "report the extent to which they engaged in [a pre-organized list of] strategies with the intent to manage their energy at work" (Fritz et al., 2011, p. 33). The following emerged as the top five strategies used during work breaks: drink water, have a snack, go to the bathroom, drink a caffeinated beverage, and do some form of physical activity, including walking or stretching. While these strategies emerged as the most frequent, it was found that none of the top five strategies were significantly related to lower levels of fatigue or higher levels of vitality (Fritz et al., 2011). Therefore, these frequently reported strategies are not ideal if the goal is to replenish energy.

Attention Restoration Theory (ART) proposes that interacting with nature is an effective strategy in restoring mental energy. While this idea is not surprising, less is known about how or why natural environments provide such therapeutic effects. This paper describes a study that aimed to explain the relationship between nature and the restoration of fatigue. Below, I begin by providing an overview of ART and its empirical support. This is followed by a discussion of the underlying mechanisms currently used to explain the nature—restoration relationship as well as an additional mechanism, *processing fluency*, that may contribute to explaining this relationship. Finally, I describe the research methods used and results obtained from the present study and end with a discussion of the results.

Attention Restoration Theory

ART was originally proposed by Kaplan and Kaplan (1989; Kaplan, 1995), but has its roots in William James' theory of attention (James, 1985). James described the consciousness as narrow. That is, we are constantly exposed to a vast amount of stimuli; however, "we notice so very small a part of them" (James, 1985, p. 84). If we are only able to notice a small part of the whole *sensory surface*, how do we decide what to attend to? The answer, according to James, relies primarily on both our interests and our effort. This idea formed the distinction between what James called *voluntary* (derived) and *involuntary* (immediate) *attention*.

There are some stimuli that are inherently interesting or instinctive in nature. Our attention to these types of stimuli is effortless, or 'immediate', hence James' *involuntary attention*. An example is witnessing a motor vehicle accident, as it draws one's attention without exertion. Other stimuli are not inherently interesting, but for various reasons, we may need to attend to them. Our attention to these types of stimuli takes effort, which James called *voluntary attention*. James emphasized that when a stimulus requires voluntary attention, we also are making an effort to "resist the attractions of more potent stimuli and keep our mind occupied with some object that is naturally unimpressive" (James, 1985, p. 84). In other words, because the object we need to attend to is uninteresting, there will be competing stimuli (i.e., distractions) that we need to inhibit, which again is a process that requires effort. Reading a textbook on a topic we find boring, but necessary, would elicit voluntary attention.

ART focuses on James' voluntary attention, which R. Kaplan and S. Kaplan (1989) call *directed attention* (in contrast to James' involuntary attention or what the Kaplans call *fascination*, which will be discussed later). Although the term 'directed attention' is used in lieu of 'voluntary attention,' it's important to note that the attributes are not identical to one another. In a 1995 paper, S. Kaplan laid out the properties of directed attention: "it requires effort, plays a central role in achieving focus, is under voluntary control (at least some of the time), is susceptible to fatigue, and controls distraction through the use of inhibition" (p. 170). James did not speak of the susceptibility to fatigue, while the Kaplans highly emphasize this point. Therefore, the ART literature has since focused on the fatigue of directed attention.

How significant is the fatigue of directed attention? Kaplan (1995) argued that although the layperson may suspect that 'directed attention fatigue' is not a significant problem, it "can, and often does, have devastating impacts" (p. 171). It was emphasized that the ability to maintain directed attention is especially critical when problem solving since one must select crucial information from a vast amount of knowledge or stimuli. It's also important when inhibiting one's emotional impulses is necessary. Further, directed attention fatigue is often accompanied by susceptibility to distractions, resulting in unclear perceptions of less interesting, yet valued stimuli. It also impairs our thoughts and actions, as it does not allow us to "step(ping) back from the situation…to get a larger picture of what is going on" (p. 171) and it causes our behaviors to be short-term oriented, which is not always appropriate. Finally, irritability is a common emotion experienced by those suffering from directed attention fatigue. Returning to the original problem discussed at the beginning of this paper, the negative consequences of directed attention fatigue are major contributors to human error in the workplace, reducing overall performance and safety.

Characteristics of a Restorative Environment

According to Kaplan (1995) there are various methods one can utilize to recover from directed attention fatigue. One seemingly obvious strategy is to get sleep. However, this is not always efficient or appropriate, as in the case of an employee in the middle of his/her work shift. Thus another method, as mentioned previously, is to take a break and expose oneself to 'restorative environments' (environments that allow us to rest and restore our fatigued directed attention). Kaplan (1995) presented four properties necessary for a restorative environment — *fascination, being away, extent, and compatibility*. He posits that natural environments are especially likely to have all four components necessary for a restorative experience.

Fascination, akin to James' involuntary attention, is the most crucial factor for a restorative environment (Kaplan, 1995). As James (1985) described, inherently exciting stimuli produce involuntary attention (fascination) and attending to these stimuli is not difficult and does not take any effort. ART maintains that holding one's attention without effort facilitates the restoration of fatigued directed attention. It is important to note that not all stimuli that are fascinating are necessarily restorative. Specifically, Kaplan (1995) makes a distinction between 'soft' fascination and 'hard' fascination. That is, fascination can be elicited when an environment is bold and loud (e.g., harsh rapids) but this type of hard fascination "is very intense, rivets ones attention, and leaves little room left over for thinking" (Herzog, Black, Fountaine, & Knotts, 1997, p. 166). On the other hand, soft fascination is produced when an environment is subtle, gentle, and rhythmic (e.g., rustling leaves). This type of fascination elicits interest without too little or too much arousal.

Nature offers many ‘soft’ fascinations that hold one’s attention in a subtle manner. For example, when walking through a forest one can become engrossed in the view of the sunset or the patterns of the grass. These aesthetically pleasing scenes capture our attention but not to arouse us with too much excitement. Although fascination is described as being the most crucial characteristic for a restorative experience, it does not guarantee this experience nor does it necessarily work alone.

The second component, *being away* refers to the idea that one is *conceptually* distant from that which is contributing to directed attention fatigue (Kaplan, 1995). It is important to note that *physically* being away, although helpful, is not necessary for restoration. As Kaplan noted, if an individual brings his/her worries to a physically distant environment, he/she is not going to experience restoration. However, being conceptually away, “in principle, frees one from mental activity that requires directed attention support to keep going” (Kaplan, 1995, p. 173).

People often choose natural environments such as forests, lakes, and mountains to ‘get away’ from their everyday routine and free themselves from the various sources that are requiring directed attention (e.g., work). While this may be desirable, we live in an urbanized society and getting away to these types of destinations is not always possible. Kaplan (1995) stressed that even an easy-to-access natural environment (e.g., a nearby park) is more likely to facilitate restoration compared to other environments (e.g., the break room at one’s place of employment).

The third component, *extent*, is two-fold. It refers to an environment that has sufficient content and scope to engage one’s mind and allow for the feelings of being in a “whole other world" (Kaplan, 1995, p. 173). Also, the elements within the environment must be coherently related. Just as with *being away*, *extent* is more conceptual rather than physical in nature. For example, a mountain or a national park clearly has the ability to elicit feelings of being in another world; however, an environment does not need to be physically large to allow those feelings. Kaplan (1995) provided an example of Japanese gardens, which may be physically small but provide sufficient content and scope to engage the mind.

The fourth component, *compatibility*, refers to the fit between an environment and what the individual is trying to achieve—his/her inclinations and goals (Kaplan, 1995). A compatible environment reduces effort (and demand on directed attention), as it allows for less selectivity (Kaplan, 1995). Herzog, Maguire, and Nebel (2003) noted that this component is complex because at any given time, an individual's needs are multifaceted and an environment can be compatible on one level but incompatible on another. Natural environments seem to be complex enough to support a wide range of activities that correspond to various inclinations (Herzog, et al., 2003). For example, natural environments generally permit vigorous activities such as hunting, walking, hiking, and gardening, but they also allow an individual to simply read a book or sit peacefully under a tree (Kaplan, 1995).

Although the current paper focuses on the restoration of attention (in particular, ART), there is an alternative theory of restoration, which deserves some consideration. This alternative theory emphasizes physiological and emotional changes that occur while viewing an environment. Specifically, Ulrich's (1983) Stress Recovery Theory (SRT) is concerned with the recovery of stress, as opposed to the recovery of attention, per se.

Ulrich et al. (1991) defined stress as a response to a situation in which one's well-being is threatened or challenged. The stress response can be divided into three categories: psychological (e.g., fear, anger, and sadness), physiological (i.e., activity of bodily systems, sometimes contributing to fatigue), and behavioral (e.g., avoidance and decline in cognitive performance). Ulrich et al. (1991) maintain that certain environments are able draw out positive psychological, physiological, and behavioral responses, which are experienced as stress recovery or 'restoration'. Additionally, he emphasizes that this is an affect-driven process, occurring without elaborate cognition or processing of the environment.

Like Kaplan, Ulrich (1983) outlined particular components, or what he called 'preferenda' that are typically present in an environment that supports stress recovery. These include moderate complexity, focality (a focal point), patterning, moderate depth, homogenous ground surface texture, a deflected vista (i.e., a visual line that indicates a landscape beyond the visual bounds), natural contents (e.g., vegetation, water), and a lack of appraised threat. Ulrich (1983) further noted that the preferenda, 'deflected vista' is "highly cognitive, and therefore is probably not a major factor in the initial affective reaction" (p. 103). Therefore ART and SRT differ in two key ways: (1) ART examines attention whereas SRT examines stress and (2) ART emphasizes slower cognitive mechanisms and SRT emphasizes quick, affective responses. Further, Ulrich et al. (1991) suggested that attentional fatigue is an aftereffect of stress while Kaplan stated that attentional fatigue is an entity that is susceptible to stress (Kaplan, 1995).

In an attempt to synthesize the two theories, Kaplan (1995) suggested that these conflicting theories are a result of definitional differences. Specifically, Kaplan argued that Ulrich's definition of cognition is too limited and his definition of stress is too broad. There are many researchers who now view these theories as more complementary than opposing, as the conditions for which one becomes restored are similar (e.g, natural environments). Thus, there is considerable research (discussed in the next section) which simultaneously examines both the emotional and cognitive components of restorative environments.

Empirical Evidence

A large body of research confirms the contention that natural environments promote restoration. It is important to again stress that there are many environments that contain the components necessary for a restorative experience (fascination, being away, extent, and compatibility); however, ART maintains that natural environments tend to be best at providing these experiences. Therefore studies that have emerged from this line of research have primarily focused on the comparison of natural and urban environments. For example, Berman, Jonides and Kaplan (2008) randomly assigned participants to take a 50-55 minute walk in a park or downtown after completing two tasks—the backward digit span test and a directed forgetting task. The backwards digit span test was used as a measure of attentional proficiency, which relies on directed-attention abilities and the directed forgetting task was used to fatigue participants even further. They were also given the Positive Affect Negative Affect Schedule (PANAS) to assess their mood. After the walk, participants again completed the backward digit span test and the PANAS. The researchers reported that only those who walked in the park showed significant improvement on their performance on the backwards digit-span test. Further, these results were not driven by changes in mood.

In order to be confident that directed attention mechanisms were restored in their study, Berman et al. (2008) conducted a second experiment where they administered the Attention Network Test (ANT) with trials that elicited three different types of attentional functions—alerting, orienting, and executive attention (directed attention). Alerting and orienting functions require less cognitive control than executive functions, thus they predicted that contact with nature would improve performance on the executive attention trials but not the alerting or orienting trials. The results confirmed their hypothesis: improvements were found only on the trials that required executive attention and only after contact with nature. Again, the results were not driven by changes in mood.

Hartig, Mang, and Evans (1991) examined the restorative potential of different environments in naturally occurring groups in two separate studies. In both studies participants were separated into groups based on where they would spend their holidays (natural or urban environment). They completed a proofreading task (a task which relies on directed attention abilities) before and after their vacation. Both studies showed that those who spent their vacation in a natural environment performed better on the proofreading task after their trip compared to before their trip. Further, there was a decrease in performance on the proofreading task among those who spent their holidays in an urban environment.

As mentioned previously, being physically immersed in nature is not necessary for a restorative experience. In the second study by Berman et al. (2008) described earlier, the researchers used photographs of nature and urban areas as the environmental manipulations, which is a paradigm that has been used by other researchers. For example, Berto (2005) subjected her participants to the Sustained Attention to Response Task (SART), which fatigued their directed attention and was also used as a measure of directed attention abilities. They were then exposed to a series of 'restorative' (natural environments) or 'nonrestorative' (urban environments) pictures on a computer screen. She found that there was improved performance on the SART only in the restorative group, providing support for the restorative power of viewing nature through images.

Other studies have examined the effects of simply looking at nature through windows.

For example, Tennessen and Cimprich (1995) measured college students' performances on various measures of directed attention. The college students, who all lived in the campus dormitories, were divided into groups based on their views from their window (ranging from all natural to all built). Tennessen and Cimprich (1995) reported that those with more natural views performed better on the various attentional measures compared to those with built views.

Restorative Components. The aforementioned studies do not directly address *how* contact with nature produced the beneficial effects. Although these studies are important and have given us insight into which environments are likely to be restorative, they do not link specific factors to specific outcomes. Moreover, these studies do not facilitate determining what other types of settings or environments may also be restorative.

Other studies, although less common, have attempted to measure the four components of a restorative setting proposed by Kaplan and Kaplan (1989). These studies have led to the development of measures of restorativeness such as the commonly used Perceived Restorativeness Scale (PRS; Hartig, Korpela, Evans, & Gärling, 1996). In an attempt to validate this measure, Hartig et al. (1996) conducted a series of four studies using a variety of participants (American, Finnish, and Swedish), various environments (indoor/outdoor, natural/built), and different types of media (on-site/field, photographic slides, and video simulation). They were unable to consistently confirm the four-factor structure, which Laumann, Gärling, and Stormark (2001) noted in their attempt to develop another rating scale that more reliably measures the restorative components of environments. The measure developed by Laumann et al. (2001) found that the 'being away' rating scales loaded on two unique factors, novelty (i.e., physically being away in a novel setting) and escape (i.e., psychological feeling of being away from work routine and demands). Thus, their experiment yielded a five-factor structure—novelty, escape, extent, fascination, and compatibility.

Using these types of scales, researchers have attempted to measure the perceived restorativeness of various settings. For example, Felsten (2009) asked 236 college students to "imagine that you have been studying for an exam or working on a class project for several hours…you are mentally fatigued and need to take a break before continuing" (p.164). They were then asked to rate the perceived restorativeness of indoor campus settings. There were various photographs depicting four categories of view—no view of nature, window view of late fall nature, views of murals of fields and forests, and views of murals of seacoast or waterfalls. Felsten (2009) found that students rated the environments with views of nature higher on being away, extent, fascination, compatibility, and overall restorativeness compared to no views of nature. They also found that among the various presentations of nature, a view of dramatic nature murals (e.g., a waterfall scenery) was rated more restorative than mundane window views of nature with built structures present, such as telephone line poles.

Although measures such as the PRS allow us to determine which types of settings are restorative, little research has been conducted regarding additional properties that may make an environment restorative. As mentioned previously, Laumann et al. (2001) reported that a factor analysis determined that the 'being away' component had two unique factor loadings, novelty and escape. This briefly raised the idea that novelty might be another restorative property; however, they dismissed this because it was also found that novelty was either not correlated or negatively correlated with the other four factors. In their conclusion, they maintained that novelty was not an additional restorative component.

Most studies examining the restorative potential of environments now use variations of the PRS, which solely measures the four components originally proposed by Kaplan and Kaplan

(1989). In order to develop remedies for those who are experiencing directed attention fatigue, it is important to continue searching for other components that trigger restorative experiences as well as any underlying mechanisms that can account for the restorative experience. Processing fluency (reviewed in the next section) may be able to provide an answer to that search.

Processing Fluency

At any given time, we are bombarded with a vast amount of sensory information. To make sense of it all, we tend to go beyond the actual stimulus (Häfner & Stapel, 2010). For example, research has shown that people rely on their physiological state when making judgments. In one study, participants judged a hill to be much steeper after an hour long run compared to those who had not run (Proffitt, Bhalla, Gossweiler, & Midgett, 1995). Therefore in this study, nonvisual factors influenced visual perception.

Another source of information that people rely on is how easily a stimulus is processed. This experience is known as *processing fluency*, or the subjective ease of processing information (Reber, Wurtz, & Zimmermann, 2004). According to Alter and Oppenheimer (2009), "every cognitive task can be described along a continuum from effortless to highly effortful, which produces a corresponding metacognitive experience that ranges from fluent to disfluent" (p. 220). For example, reading text in an easy-to-read font is much more fluent than reading text in unclear font (e.g., a bolded, small font).

Alter and Oppenheimer (2009) conducted a full review, cataloguing eight main types of fluency—concept priming, linguistic, embodied cognition, decision conflict, perceptual, higher order cognition, imagery, and memory-based. The current paper focuses on perceptual fluency (i.e., ease with which we are able to perceive a visual stimulus). Alter and Oppenheimer (2009) divide perceptual fluency into two categories—temporal and physical. Temporal perceptual fluency focuses on frequency of exposure (mere exposure effect; e.g., Willems & Van der Linden, 2006). Research in this area shows that fluency can be enhanced through prior exposures. Other studies show that fluency can be manipulated independently of the frequency of exposure, which is physical perceptual fluency. Fluent processing regarding the latter includes the traditional Gestalt principles such as goodness of form and figure-ground contrast.

Several studies examining physical perceptual fluency concentrate on manipulating the ease of visual clarity. For example, Reber and Schwarz (1999) were interested in how fluency would influence judgments of truth. They presented statements outlined as “Town A is in country B” (e.g., Lima is in Peru) in either highly visible colors (high fluency) or moderately visible colors (low fluency). The researchers reported that participants in the high fluency condition judged the statements as true significantly above chance level whereas participants in the low fluency condition judged the statements as true at chance level. They concluded that fluency influences judgment of truth, regardless of the frequency of exposure.

Other studies have found that perceptual fluency influenced other types of judgments such as typicality (Oppenheimer & Frank, 2008), estimates of distance, and descriptions of various cities (Alter & Oppenheimer, 2008). However, there is a common underlying mechanism that researchers attribute this effect to known as the *hedonic markings principle* (e.g., Reber, Winkelman, & Schwarz, 1998). The basic notion is that high fluency induces positive affect because it is being associated with successful progress toward recognizing a given stimulus. In turn, we are more likely to judge fluent statements as more factual, typical, etc.

The hedonic markings theory has been examined using both self-report and psychophysiological measures. For example, Reber et al. (1998) manipulated the fluency of images via duration of exposure (Experiment 3). The images presented for longer periods of time were assumed to be easier to process. The researchers reported a linear relationship between judgments of liking and time of exposure: the longer the participants spent with an image, the more it was liked.

Winkielman and Cacioppo (2001) provided psychophysiological evidence by measuring facial activity with electromyography (EMG). The researchers presented participants with neutral images. Fluency was manipulated by presenting a prime that either matched or mismatched the target image. They found that the targets that were easier to process (matched primes) were associated with higher EMG activity of the zygomaticus major, which are the cheek muscles used for smiling. Activation of this region is linked with positive affect, suggesting that fluency is associated with positive affect.

Although the hedonic markings theory has received the most attention in the context of the mere-exposure effect, evidence supports that fluent processing leads to increased liking, even after a single exposure. For example, Reber, et al. (1998; Experiment 2) found that affective judgments were influenced by perceptual fluency without manipulating duration or frequency of exposure. Instead, these researchers manipulated figure-ground contrast. Participants liked the fluent objects (high figure-ground contrast) more than the disfluent objects (low figure-ground contrast).

A Synthesis

The theoretical proposition of processing fluency as an underlying mechanism to the nature—restoration relationship has been present in the ART and SRT literature; however, it has not been directly examined. Specifically, Kaplan's (1995) "fascination" is defined as inherently exciting stimuli, which does *not take any effort to attend to*. Similarly, Ulrich (1991) stated that stress recovery through restorative environments is an affect-driven process, which occurs *without elaborate processing of* the environment and include preferenda such as patterning and homogenous ground surface texture. These descriptions hint at the influence of perceptual fluency; however, there is no research directly examining the relationship between processing fluency and restoration.

Natural environments have been found to possess characteristics that make them easier to process. Redies (2007) found that natural scenes have a greater degree of fractal-like structures than other stimuli. Fractal is a term derived from the Latin word *fractus*, meaning broken. This describes self-similar patterns that recur on varying scales of magnitude (Hagerhall, Purcell, & Taylor, 2004). In essence, it is the degree of invariance, which reflects the amount of structure present in an image that remains the same as one zooms in and out of the image. Natural scenes contain much more redundant information than urban scenes, suggesting that natural environments are easier to process. For example, in a fern (plant), the leaves appear as scaled down replicas of the entire fern. Further, Hagerhall et al. (2004) used a geometric equation to calculate the fractal dimension, D, of silhouette outlines of various landscapes. They found a significant relationship between the fractal dimension and preference. This further implies that natural scenes are preferred because of their fractal-like structures.

These studies suggest that fluent stimuli, such as natural environments, are easier to process and therefore require less cognitive resource demands. If they lessen the demands of our cognitive resources, it can be hypothesized that fluent stimuli leave more space for replenishing attentional resources. This raised the question: would manipulating the fluency of a restorative environment prevent its restorative potential?

Current Study

The aim of the current study was to explore whether attention restoration is a by-product of fluent processing. To study this, participants were first mentally fatigued by completing a sustained attention task. After, they were instructed to view a natural scene photograph or an urban scene photograph, which was presented in various levels of processing ease (fluently, partially disfluent, or disfluently). Photographs were manipulated by degrading each photograph using computer software.

It was hypothesized that participants who viewed a disfluent image, whether it be natural or urban, would not experience directed attentional recovery. However, when presented fluently, it was hypothesized that participants in the nature scene condition would experience directed attentional recovery, whereas those in the urban scene condition would not.

Method

Participants

Seventy-eight undergraduate students (57 females, 21 males) from Indiana State University participated in this study. Students signed up through an online experiment management system, and were eligible to receive partial course credit. Previous research has found age-related declines in both reaction time and errors in sustained attention tasks (Carriere, Cheyne, Solman, & Smilek, 2010); therefore, the age range was restricted to 18 to 27 years (M = 19.1 years, SD = 1.3 years). Sixty-five percent were White/Caucasian, 31% Black/African American, 3% Hispanic, and 1% identified as multiracial. All participants gave informed consent as approved by the university's institutional review board.

Materials

Sustained Attention to Response Test (SART). The SART (Robertson, Manly, Andrade, Baddeley, & Yiend, 1997) is a construct used in previous ART studies (e.g., Berto, 2005). It measures attentional capacity and has also shown to be an effective way to deplete directed attention (Robertson, et al., 1997). The task asks participants to view a sequence of randomized stimuli (numbers and letters) on a computer screen and to press the 'space bar' for every stimulus except a predetermined target stimulus (the digit 3). Procedures for the SART used in the current study were adapted from a study by Berto (2005). A number or letter was presented on the computer screen every 250ms and remained on the screen for 1125ms. There was a total of 7 blocks, with 200 trials per block (32 of which presented the target stimulus). Blocks 1-5 were viewed prior to exposure to the environmental photograph and Blocks 6-7 were viewed after exposure to the photograph. Scores were calculated based on the number of correct responses (not responding) to the target stimulus for each block.

Positive Affect Negative Affect Schedule (PANAS). Winkielman and Cacioppo (2001) showed that fluent stimuli were associated with higher EMG activity of the zygomaticus major which are facial muscles related to positive affect; therefore the PANAS (Watson, Clark, & Tellegen, 1988) was used as a measure of affect. The PANAS is a self-report questionnaire, containing 20 different adjectives. Each adjective is rated on a 5-point Likert scale (1-*very slightly or not at all*, 2-*a little*, 3-*moderately*, 4-*quite a bit*, and 5-*extremely*). Ten items correspond with Positive Affect (PA) and the remaining ten items correspond with Negative Affect (NA). Scores are calculated by summing the scores for each subscale, which can range from 10 (low PA or NA) to 50 (high PA or NA). Cronbach's alpha (α) was calculated to check the reliability for each subscale for the current study and it was found that both the PA ($\alpha = 0.90$) and NA ($\alpha = 0.79$) subscales had high reliability. See Appendix A for the PANAS.

Questionnaire. Participants completed a questionnaire where they indicated their age, gender, and ethnicity. It also asked participants to rate the difficulty of detecting the image presented to them on a 7-point Likert scale (1-*not at all difficult* to 7-*extremely difficult*) and to identify what percent of an average day is spent viewing of nature. See Appendix B for full questionnaire.

Validation of Environmental Stimuli. To assess the relative fluency of the stimuli to be used in the main study, a pilot study was conducted in which 51 participants randomly viewed either a nature or urban photograph under conditions of distortion. Using the Gaussian Blur effect in Microsoft PowerPoint (version 12.1.0), each image was subjected to eight levels of distortion ranging from 70% to 0 (in increments of 10%). Participants began by viewing the most severely degraded version of the assigned photograph and were asked to identify the image. After 10 seconds, participants could move on to view the next slightly less distorted image and were again asked to identify the image. This was repeated until participants reached the non-distorted image. Participants' responses were examined to determine at what point participants could accurately identify the content of the image. Point of recognition was quantified by recording a number 1 through 8 for each participant (1 if they recognized the photograph at the most severely degraded version to an 8 if the point of recognition was the non-distorted image).

The average point of recognition varied between urban and nature conditions, $F(1, 49) = 4.03$, $p < .05$ with the nature photograph typically recognized sooner ($M = 5.26$) than the urban scene photograph ($M = 6.08$), signifying that the nature scene photograph was processed more fluently.

Environmental Stimuli. The environmental stimuli (a natural scene photograph and an urban scene photograph) consisted of the same two photographs used in the validation pilot study. The nature photograph was of a heavily wooded trail and the urban photograph was of a downtown city. Both photographs were presented in color. Using Microsoft PowerPoint, each photograph was subjected to a blurring manipulation (0%, 10%, and 30%) to represent various degrees of fluency and were presented to the participants for 2 minutes. See Figure 1 for the environmental stimuli.

Procedure

Participants arrived in the psychology laboratory where they were sequentially assigned to one of the six conditions. After completing the consent form (Appendix C), the participants were given a participant number, which was recorded on the SART, the PANAS, and the demographic questionnaire in order to match data without compromising confidentiality. The participants were seated in front of a 14-in IBM laptop computer approximately 22 inches from the screen. The lights in the laboratory were dimly lit to minimize distractions and encourage focus on the tasks and environmental stimuli presented on the computer. The experiment began with the instructions, which were read aloud by the experimenter (Appendix D). When the participant had no questions, the experimenter left the room and the participant began the trials of the SART.

After 1,000 trials a second set of instructions appeared on the screen, informing the participant that they would be viewing an image. They were encouraged to look freely at the image and asked to try to picture him- or herself within the scene. The image was approximately 8 x 11 inches and appeared in the center of the screen. After viewing the photograph for 2 minutes, the participant was instructed to complete the PANAS, which was located on the desk where they were seated. When this was completed, they were asked to complete the remaining 400 trials of the SART. Once the participant was finished, one last set of instructions appeared on the screen directing them to tell the experimenter they had completed the task. The experimenter then asked the participant to answer the questions on the demographic questionnaire. After this was completed, they were debriefed (Appendix E).

Results

Attentional Capacity. Scores on the SART were calculated by averaging the number of correct responses to the target stimulus for each block. The means and standard deviations for each block are presented in Table 1. To explore the hypothesis that perceptual fluency is involved in the restorative potential of natural environments, a 2x3x7 mixed factor analysis of variance design was used. There were two between subjects factors, including environment (nature or urban) and level of fluency (fluent, partially disfluent, or disfluent) and one within subjects factor, which was time (blocks 1-7).

The test of between-subjects effects revealed no significant main effect for environment nor for fluency. The interaction between environment and fluency was also non-significant. Given the repeated measures nature of the current study, these tests were not of main interest and were not explored further. The *F*-values and their corresponding significance levels for the between-subjects effects are provided in Table 2.

Of primary interest in this study is the effect of environment by fluency across time (blocks), that is, the 3-way interaction. The within-subjects effects test revealed that Mauchly's test of sphericity had been violated χ^2 (20) = 41.10, $p < .01$, therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = .82$). There was a significant effect of time, $F(4.94, 356.11) = 17.16$, $p < .01$. A significant linear trend confirmed that, as expected, participants' performance grew progressively worse over Blocks 1-5, F (1,72) = 83.17, $p < .01$, demonstrating that they were experiencing fatigue. There was no significant environment by time interaction, F (4.95, 356.11) = 1.40, *ns,* and no significant fluency by time interaction, F (9.90, 356.11) = .77, *ns*. The three-way interaction between environment, fluency, and time was also non-significant, F (9.90, 356.11) = .51. *ns*. This implies that the number of correct responses on the SART over time were not influenced by an interaction of environment and fluency levels.

The omnibus tests above examined an unspecified change in responses over time but the potentially-restorative stimulus was presented at a specific point (between Blocks 5 and 6). Therefore, a contrast was performed to test the more precise prediction that there would be a change occurring between these blocks (that would vary by environment, fluency, or their interaction). A significant environment by time (contrast) interaction emerged in this analysis, F (1,72) = 4.77, $p < .05$. The means revealed that a more dramatic increase in scores from block 5 to block 6 was observed for those who saw the natural environment photographs (M_{Block5} = 21.82; M_{Block6} = 24.69) compared to those who saw the urban environment photographs (M_{Block5} = 22.23 M_{Block6} = 23.00). But neither the fluency by time (contrast) interaction, F (2, 72) = 1.26, *ns*, nor the three-way interaction between environment, fluency, and time (contrast) were significant, F (2, 72) = .03, *ns*.

Mood Ratings. Scores on the Positive Affect (PA) and Negative Affect (NA) subscales of the PANAS were summed and analyzed separately. The means and standard deviations for each subscale are provided in Table 3. Scores were collected once after participants viewed the environmental photograph, therefore data were entered into a 2 (environment) x 3 (fluency) between-subjects ANOVA. Results revealed no significant main effect for environment, F (1, 72) = .67, *ns*; no significant main effect for level of fluency, F (1, 72) = 1.23, *ns*; and no significant nature by fluency interaction, F (2, 72) = .55, *ns,* on positive affect. This suggests that positive affect was not influenced by the type of environment or the level of fluency.

A 2 x 3 ANOVA examining negative affect scores showed that there was a marginally significant main effect for environment, $F(1, 72) = 3.75$, $p < .10$. Examining the means of the NA subscale indicated that the Nature condition reported *higher* levels of NA ($M = 17.46$) than the Urban condition ($M = 14.90$). There was no significant main effect for level of fluency, $F(1, 72) = .06$, *ns,* and no significant nature by fluency interaction, $F(2, 72) = 1.22$, *ns*. However, these results appeared to reflect the response of one participant who scored 7.5 standard deviations above the average NA score in the fluent/nature condition. A reanalysis excluding this participant showed no effects approaching significance. *F*-values for environment, fluency, and the environment by fluency interaction were 2.69, .143, and .430, respectively.

Discussion

Attention Restoration Theory has repeatedly shown that natural environments contain certain properties that allow for directed attention recovery or 'restorative experiences' (Kaplan, 1995). However, the mechanisms underlying these restorative experiences are largely unexplained. The purpose of this study was to examine processing fluency as a potential explanation. Previous research has found that natural environments have more fluent features than urban environments (Redies, 2007) and given that fluent stimuli are lower on cognitive resource demands, there is more room for replenishing attentional resources. With this in mind, the current study was designed to discover whether natural environments are more restorative than urban environments because of their relatively greater fluency. To do this, I depleted participants' attention and then presented them with a natural or urban photograph during a "restorative" break. Fluency was further manipulated through varying levels of distortion in the presented photos (none, moderate, high).

In accord with ART's claim that directed attention can become fatigued after prolonged mental effort (Kaplan, 1995), there was a general decline in number of correct responses in each condition from Blocks 1-5. Also, as expected, results showed that after the environmental image was presented, participants who saw the nature photograph had a larger increase/recovery during Block 6 than participants who saw the urban photograph. This happened, however, regardless of manipulated fluency levels. Taken together, the present findings add to the ART literature, which states that natural environments lead to restorative experiences; however, it does not speak to *why* this happens. A possible explanation for the non-significant fluency findings is offered below.

Based on participants' comments, it was found that many individuals visualized various objects (e.g., a snowman) and scenes (e.g., rainforest) that were not intended or expected. Also, some participants commented on personal experiences. For example, one participant stated that the urban photograph reminded him of downtown Chicago, where he lived previously. It is plausible that a deeper cognitive process is occurring. To explain further, it's important to remember that both the theories of restoration and processing fluency stress the importance of effort. That is, when an individual does not need to make a strong effort to attend to the surrounding environment, he or she has more room for, what ART states as, replenishing attentional resources. However, this 'extra room' may alternatively provide individuals the ability to imagine what he or she deems as restorative.

Related to this reasoning, it is worth noting that there was an increase in SART scores from Block 5 to Block 6 for every group except the fluent/urban condition. Even though the 3-way interaction was not significant, it appears that the unrecognizable photographs had similar effects to nature, actually freeing participants from attending to particular features, and thereby enabling restoration. This may suggest that ART's heavy focus on the restorative effects of natural environments is somewhat misguided. When our attention is fatigued, our 'default' reaction may be to engage in restoration unless prevented. In line with the ART literature, the urban environment did not show restoration effects; it may have prevented the 'default' restoration seen in the other conditions. Therefore, the real issue may be that urban environments are *preventing* the 'default' restorative experience.

Furthermore, it was found that not only did the nature conditions display more restoration than the urban conditions, but even the most disfluent nature condition showed more restoration than the most fluent urban condition. Given that the current study used color images, a factor that may contributed to this observed difference is the influence of the color green. A recent study found that participants who viewed the color green before performing a creativity task demonstrated more creativity than those who viewed white, gray, red, or blue prior to the task (Lichenfeld, Elliot, Maier, & Pekrum, 2012). The nature photograph used in the current study had a great deal of green in the image possibly promoting creative and/or restorative thoughts.

Somewhat surprising was the non-significant findings regarding the PANAS scores. Previous research has found that not only do people prefer natural environments (van den Berg, Koole, & van der Wulp, 2003), but that restorative environments are linked with positive affect (Hartig, Evans, Jamner, Davis, & Garling, 2003). It's possible that introducing the PANAS prior to (and with participants' awareness that they were going to) complete additional trials of the SART were responsible for this lack of effect. Previous ART studies that have measured affect (e.g. Berman et al., 2008) have typically done so after completion of the attention tasks. Although one might have expected a stronger mood effect when measured more proximate to environmental exposure, it seems plausible that anticipation of more SART suppressed affective reactions. Furthermore, some other researchers have failed to find a mood effect in an ART paradigm (e.g., Tennessen & Cimprich, 1995).

Limitations and Future Research

There are several limitations that may qualify the current findings. Despite previous research (Felsten, 2009) showing that using computerized images is ecologically valid, the current study was a simulated laboratory experiment. Therefore, it cannot be stated with complete confidence that the images viewed by the participants replicated real-world effects. Consequently, it also does not necessarily provide information about directed attention recovery in real-world environments. However, when exploring directed attention recovery in real-world environments, an issue of control becomes a factor. Variables such as weather, traffic and other people introduce the risk of generating confounds that could only be eliminated in a laboratory setting.

Kaplan (2001) noted the importance of intrinsic motivation in real-world restorative experiences. In other words, in the real-world, individuals seek out restorative environments because they are dealing with demanding situations. For most (if not all) participants, participation in the current study was likely motivated by extrinsic reasons (i.e., class credit), thus restoration may be more difficult to find in experimental settings. However, avoiding the study of individuals who took their own initiative to spend time in a natural or urban setting provided the advantage of controlling for self-selection.

The use of college students between the ages of 18-27 might raise a concern about the generalizability of the findings to other age groups. On the one hand, directed attention fatigue may be a more relevant experience to college-age students who spend much of their time in classrooms and study settings; it is also possible that that because of this, they have trained themselves to control attention better than non-college students. It is worth noting, however, that prior studies have demonstrated ART effects in broader groups (e.g., Harig, Mang, & Evans, 1991).

Furthermore, the relatively limited sample size may have influenced the results. This likely was not an issue for the measure of attention, given the repeated-measures nature of this measure; however; the measure of affect appeared to be sensitive to the small sample size. As demonstrated above, removing an outlier from one of the conditions impacted the results. Thus, a larger sample size is recommended in future research.

Finally, it is important to consider whether photographic distortion constitutes an adequate manipulation of fluency. The validation study conducted before the current study was used to ensure that the chosen nature photograph was, in fact, categorized quicker than the chosen urban photograph, which is a sign of ease of processing. Further, other studies have manipulated visual clarity with intent to manipulate fluency (Alter & Oppenheimer, 2008). However, Redies (2007) found that natural environments contain more fractal, or self-similar, characteristics which in turn cause them to be more fluent. It is unclear whether the distortion would have influenced this; thus, even the "disfluent" natural setting may have contained more fractals, resulting in the obtained greater restoration in natural settings, regardless of fluency levels. A manipulation of the number of fractals may be selected as a better indicator of fluency.

Future research might explore the degree to which the subjective perception of the environment influences restoration. As mentioned earlier, participants appeared to perceive or imagine various objects and events occurring within the environmental image. Perhaps in environments that don't require effortful processing, there is more room to imagine "restorative" thoughts. It would be worthwhile to analyze the thoughts that arise while viewing various types of environments and examine whether this mediates or enhances the nature-restoration relationship.

Conclusion

It has been argued that because our environment is becoming increasingly urbanized, people have fewer opportunities for contact with nature, and thus are being deprived of the possible psychological benefits of restorative environments. Key theories on restoration are still relevant but they leave certain questions unanswered. Although the current study did not find that processing fluency influenced restoration, I hope it will open new avenues of research regarding the specific mechanisms underlying restorative environments. Based on this type of research, findings may offer landscape designers and spatial planners a more grounded theoretical basis for green interventions, especially in areas that lack regular access to restorative settings. This may also offer employers warranted justification for including these green interventions in the workplace to promote psychological health, positive affect, and overall human sustainability.

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Table 1

Means (SDs) for Number of Correct Responses on the SART Each Block[a] (32 Max)

	Prior to Environmental Exposure					Post Environmental Exposure	
Distortion	Block1	Block2	Block3	Block4	Block5	Block6	Block7
None							
Nature	25.77 (3.66)	23.85 (5.61)	22.31 (5.31)	23.15 (4.49)	22.15 (6.34)	24.08 (7.08)	21.92 (6.81)
Urban	23.85 (6.61)	22.77 (7.06)	21.39 (6.35)	22.23 (5.90)	21.77 (5.64)	21.46 (6.65)	19.85 (7.00)
Moderate							
Nature	26.39 (4.11)	24.54 (4.48)	23.92 (4.44)	22.62 (3.69)	21.77 (4.50)	24.92 (5.06)	22.31 (4.73)
Urban	28.08 (2.78)	26.62 (3.15)	25.77 (3.44)	24.54 (4.88)	24.77 (5.15)	25.62 (3.78)	24.77 (5.26)
High							
Nature	25.85 (3.58)	23.15 (5.67)	23.77 (5.18)	22.23 (4.97)	21.54 (4.37)	25.08 (5.50)	22.92 (5.37)
Urban	25.39 (5.40)	24.46 (5.41)	21.62 (5.82)	20.85 (7.11)	20.15 (6.34)	21.92 (7.25)	20.69 (7.67)

[a]$n = 13$.

Table 2

Environment x Fluency Analysis of Variance for SART Scores—Between Subjects Results

Source	*Df*	*F*	*p*
(A) Environment	1	0.06	.80
(B) Fluency	2	1.62	.21
A x B (interaction)	2	1.08	.35
Error (within groups)	72		

Note. N = 78.

Table 3

PANAS Scores (SDs) for Each Condition[a]

Distortion	PA	NA
None		
Nature	22.85(10.77)	19.23(8.84)
Urban	24.15(11.03)	13.77(3.75)
Moderate		
Nature	23.15(8.53)	16.77(5.05)
Urban	19.77(5.72)	15.31(4.94)
High		
Nature	21.08(8.90)	16.39(5.90)
Urban	18.31(6.05)	15.62(5.32)

Note. PA = Positive Affect; NA = Negative Affect; scores range from 10 (low PA or NA) to 50 (high PA or NA)
[a]$n = 13$.

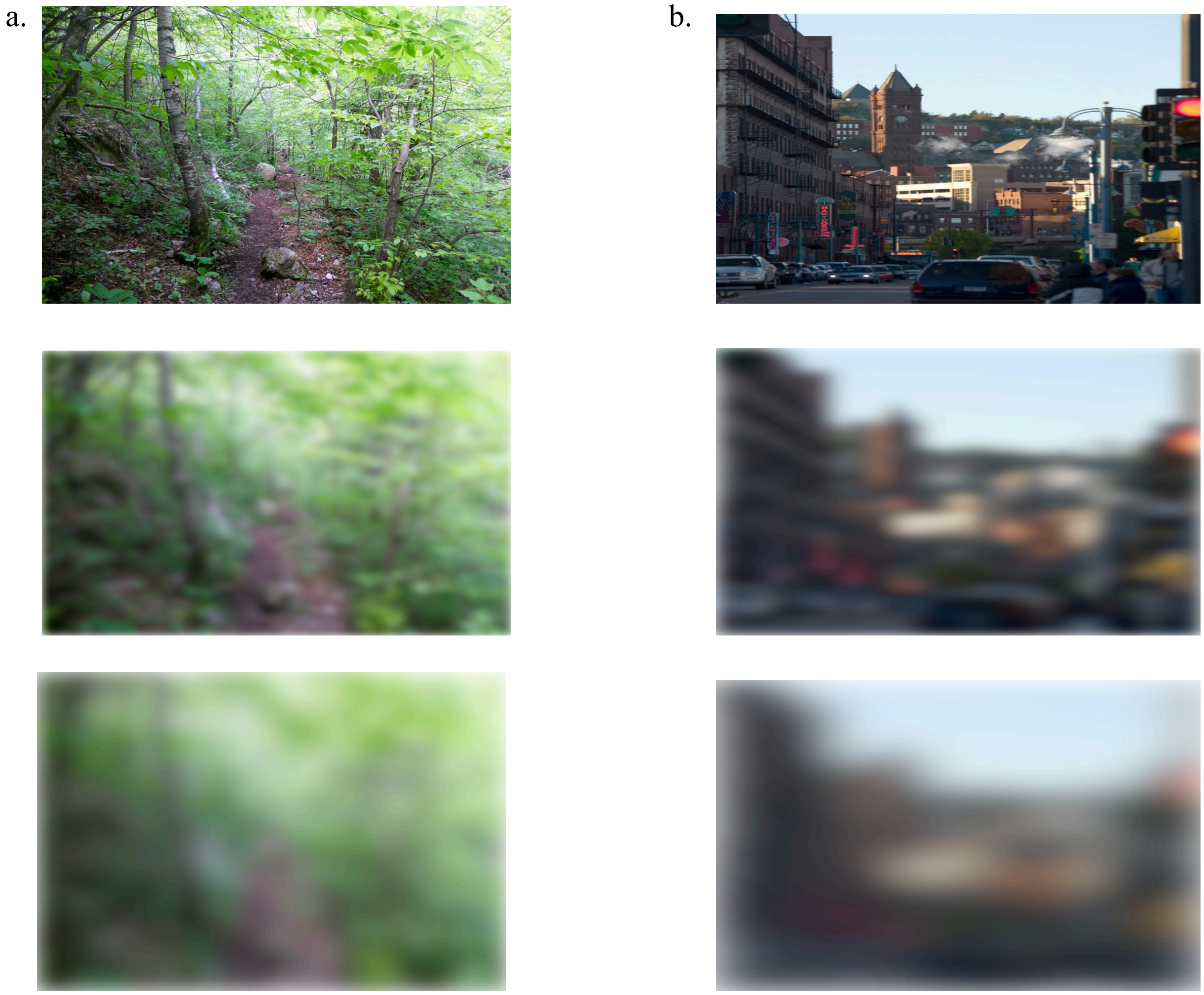

Figure 1. Environmental stimuli. The first column (a) contains the stimuli used in the nature conditions. The second column (b) contains the stimuli used in the urban conditions.

Appendix A

Positive Affect Negative Affect Schedule

Participant Number: ___________

The list below consists of a number of words that describe different feelings and emotions. Using the following scale, please rate each word to the extent to which you feel each emotion **right now**, that is, **at this present moment**.

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

Again, please rate each word to the extent you feel the emotion **at this present moment**.

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

Appendix B

Questionnaire

Participant Number: ______

Please answer the following:

1. How difficult was it for you to make out the image presented to you?
(Use the scale below to circle your response).

1 ———— 2 ———— 3 ———— 4 ———— 5 ———— 6 ———— 7

Not at all difficult	*moderately difficult*	*extremely difficult*

2. Age: ______

3. Gender: ___Female
___Male
___Other

4. Race/Ethnicity:

___ White/Caucasian	___ Black/African American
___ Hispanic/Latino(a)	___ Native American/Am. Indian
___ Asian/Asian Am.	___ Multiracial
___ Other	

5. Please imagine an average day. What percent of that day is spent with a view of nature?
(Use the scale below to circle your response).

0% ———— 20% ———— 40% ———— 60% ———— 80% ———— 100%

Appendix C

Informed Consent

You are being asked to participate in a research study on attention. This study is being conducted by Andrea Ahles and Dr. Virgil Sheets from the Psychology Department at Indiana State University. Your participation in this study is entirely voluntary. Please read the information below and ask questions about anything you do not understand, before deciding whether or not to participate.

If you volunteer to participate in this study, you will be asked to do the following:

You will be asked to complete a computerized attention task. During this task, various numbers and letters will appear on the computer screen. Before this begins, you will be given instructions to press a specific key on the keyboard for some of these numbers or letters, but not others. Following this, you will view a photograph and complete a questionnaire that evaluates your mood. You will then return to the attention task. After you have completed the attention task, you will be asked to complete a second questionnaire about characteristics about yourself. This study will take approximately 45 minutes to complete.

Your name will be recorded to verify both participation and consent; however, no identifying information will be stored with your data. Instead, your data will be labeled with a number making it impossible to link your data with your name. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind. You may also refuse to answer any questions you do not want to answer.

If you have any questions or concerns about this research, please contact Andrea Ahles at aahles@sycamores.indstate.edu or Dr. Virgil Sheets at virgil.sheets@indstate.edu .

If you have any questions about your rights as a research subject or if you feel you've been placed at risk, you may contact the Indiana State University Institutional Review Board (IRB) by mail at Indiana State University, Office of Sponsored Programs, Terre Haute, IN, 47809, by phone at (812) 237-8217, or by e-mail at irb@indstate.edu.

I confirm that I am at least 18 years old. I understand the procedures described above. My questions have been answered to my satisfaction, and I agree to participate in this study.

____

Printed Name

____________________________________ __________________

Signature Date

Appendix D

SART Instructions

When the test starts, you will see numbers or letters appearing one at a time. Your task is to press the spacebar key every time you see a number or a letter, EXCEPT when you see the number 3. Just let 3s pass without pressing any key.

Appendix E

Debriefing

We know that as a college student, you spend a lot of time engaging in sustained, or prolonged, attention. After awhile, *mental fatigue* can begin to negatively influence your mood as well as other cognitive abilities such as appropriate decision making. Research has shown that there are certain environments that can actually help us recover from mental fatigue.

The computerized task you completed today was used to fatigue your attention. During the two minute break period, you were randomly given one of six environmental images. We are interested in which environments assisted in the recovery of fatigued attention and which environments did not.

We ask that you to maintain confidentiality about the purpose of the experiment since any pre-knowledge of the purpose will bias the data for that person and thus cannot be used.

Thank you for your participation in this study. If you have any questions or if you are interested in the results of the study please contact Andrea Ahles, Department of Psychology, at aahles@sycamores.indstate.edu.