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Attention Restoration Theory in Gaming as it Pertains to Subsequent Academic Learning

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ATTENTION RESTORATION THEORY IN GAMING AS IT PERTAINS TO SUBSEQUENT ACADEMIC LEARNING

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ABSTRACT

ATTENTION RESTORATION THEORY IN GAMING AS IT PERTAINS TO SUBSEQUENT ACADEMIC LEARNING

by Joseph D. Zoland

Past studies have conclusively shown that both immersion in natural settings and exposure to natural stimuli promote attention restoration, which involves renewal of the ability to focus attention on intrinsically uninteresting stimuli. This thesis addresses how attention restoration pertains to subsequent academic learning and whether natural video game settings facilitate attention restoration like physical environments. Each participant completed the Sustained Attention to Response Task (SART) to deplete attention and played a video game in a virtual nature or virtual urban environment for 5 or 15 min to restore attention. Afterwards, participants read a short text on beer brewing, took a test that assessed the quality of learning from the text, and completed the SART again to measure changes in attentional performance. The researcher hypothesized that participants who played in the virtual nature setting would perform better on the comprehension test and obtain greater improvements on the SART than the simulated urban group. In addition, the experimenter expected the nature group to perform better on both of the aforementioned measures when given 15 min to play rather than 5 min. Finally, it was hypothesized that improvement on the SART would be positively correlated with performance on the beer brewing document. However, these hypotheses were not supported by the results of this study. This thesis concludes with reasons for the lack of support, such as the apparent failure of the SART to adequately deplete participant attention, and offers several future directions for research.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF FIGURES

LIST OF TABLES

Introduction

Oftentimes, people must focus their attention on intrinsically uninteresting stimuli (e.g., textbooks) in order to be successful. According to Attention Restoration Theory (ART), this exertion leads to the depletion of the ability to focus attention, but restoration of this limited resource may occur via immersion in physical natural settings (Kaplan, 1995). The primary purpose of this study was to examine how virtual nature in gaming environments may facilitate attention restoration, subsequent learning, and ultimately academic achievement. Before investigating how this issue was addressed in the current effort, it is necessary to examine extensively the theory and the research that has already been conducted on ART.

Attention Restoration Theory: The Benefits of Nature

In his ART, Kaplan (1995) defined directed attention as having the will and ability to focus on important thoughts and stimuli in the presence of potential distractions. Directed attention is important for several activities in everyday life including the finding of appropriate strategies for problem-solving, inhibiting impulsive thoughts, being able to see the big picture, planning, and maintaining positive affect. Prolonged attention to any stimuli may result in exhaustion and depletion of the aforementioned capabilities.

According to ART, the existence of four qualities in an environment may lead to the restoration of directed attention: *fascination*, *being away*, *extent*, and *compatibility* (Kaplan, 1995). *Fascination* is synonymous with undirected attention, which refers to focus that requires little effort because the target thoughts and stimuli are intrinsically interesting; in contrast to directed attention, fascination requires little effort and motivation for persons to attend to given stimuli. In this way, greater levels of fascination are thought to be related to lesser usages of directed attention, allowing for much of directed attention to rest and become restored. *Being away* is linked to attention restoration because it allows persons to distance themselves from thoughts and stimuli that require effortful focusing. An environment that possesses *extent* is rich, coherent, and stimulating enough to facilitate undirected attention toward its stimuli. A setting with high *compatibility* fits a person's needs and desires, allowing that person to interact with its stimuli while expending low amounts of effort and little directed attention. In summary, the four factors of ART pertain to attention restoration indirectly by facilitating involuntary attention and/or directly by reducing the activation of directed attention; both processes allow directed attention to rest and return to satisfactory levels.

Hartig, Mang, and Evans (1991) empirically examined ART by randomly assigning participants to nature walk, urban walk, or relaxation (viz., sitting in a comfortable chair) conditions. After experiencing cognitive fatigue via the Stroop and binary classification tasks, each participant underwent one of the three conditions. The authors found that the nature group had significantly greater happiness, higher positive affect, lower anger/aggression, and greater attentional capacity after the intervention than did the other two groups. Hartig et al. concluded that physical immersion in nature brings about several benefits.

Rather than immersing participants in physical nature like Hartig et al. (1991), Tennessen and Cimprich (1995) examined exposure to nature via window views. The authors examined college dorm rooms and correlated the amount of nature in the window views with participating residents' scores on several measures of directed attention (e.g., Digit Span Test and Attentional Function Index). The authors found a significant positive correlation between the amount of nature in the window view and students' performance on cognitive tests. The authors concluded that those with views of nature from their dorm rooms may have a better capacity for directed attention and/or easier access to attention restoration than those without such views.

Like Hartig et al. (1991), Hartig, Book, Garvill, Olsson, and Garling (1996) included a control group in their Experiment 1. They exposed some participants to an attentional exhaustion task and then showed them nature slides, urban slides, or no slides; afterwards, they assessed their attentional performance on two 5-min blocks of the memory-loaded search task (SMT). The authors found that, although the nature group did not differ from the other groups in either individual block, it had a smaller increase in errors on the task between blocks 1 and 2 than the control group; however, there was no difference in search speed between the two groups. Upon further examination, the authors determined that the difference between the natural and urban groups was due to the no-task condition; whereas the natural task, control no-task, and control task groups had increases in error rate, the natural no-task group had a decrease in error rates from block 1 to block 2. There were no notable differences between the urban groups and the others on the SMT. The authors concluded that the nature no-task group may have possibly attained restoration as a result of the intervention.

In Experiment 2, Hartig et al. (1996) showed participants nature slides and urban slides (i.e., in a manner similar to that of Experiment 1) and tested their attentional capabilities with two 5-min blocks. In addition, the authors tested participant fascination by asking them questions during the slideshows and later inquiring how many times a particular question was asked. The authors found no significant differences between both groups on SMT search rates, error rates, and the recall of the correct number of questions. The authors concluded, in congruence with Experiment 1, that there were no major differences in attention between those who viewed either environment after the intervention.

Like Hartig et al. (1996), Hartig, Evans, Jamner, Davis, and Garling (2003) manipulated the level of attentional exhaustion. They tested the effects of natural and urban walks on participants who were exposed to extreme and moderate attentional fatigue in the task and no-task groups, respectively. Participants completed two measures of attention: the Necker Cube Pattern Control Task (NCPCT) and the SMT. Afterwards, they drove to a natural or urban site and completed two attentional fatigue tasks (i.e., Stroop and binary classification task) in the task group and nothing in the no-task group. Then, the participants sat in a room, walked in their environment and completed the NCPCT during the middle of it, and took the NCPCT and SMT again. There was an interaction between time and environment for the first and second administrations of the NCPCT: The natural group showed slight improvements and the urban group's performance worsened by the middle of the walk. The aforementioned interaction was found again when comparing scores on the first and third administrations of the NCPCT, but there were no differences between administrations 2 and 3; this occurred because the gaps in performance between environment conditions simply persisted from test 2 to test

3. The task and no-task groups did not differ on the NCPCT. The SMT data revealed no significant effects of environment or task during either of the two administrations; however, the authors noted that this attentional measure has not been demonstrated to be as sensitive as the NCPCT. The authors concluded that, presumably because the urban environment decreased attention or the natural setting alleviated attention depletion, the natural setting was linked to more positive psychological outcomes than the urban one.

Similar to the utilization of slides in Hartig et al. (1996), Berto (2005) examined attention restoration via pictures of environments. To deplete and measure attention, the researcher had participants engage in the Sustained Attention Response Task (SART) before and after viewing pictures of restorative or non-restorative environments, as defined by ART. The author found that those who viewed the restorative pictures had significantly greater sensitivity in detecting targets (i.e., higher d-prime scores), faster reaction times, and a greater number of correct answers for the posttest than the pretest; participants in the non-restorative condition did not show these improvements between tests. In terms of between-group comparisons on the SART posttest, the only difference that reached significance was faster reaction times for the restorative group. The author concluded that the restorative group had greater improvements between tests because the intervention restored their attention.

In a manner similar to Berto (2005), Experiment 2 of Berman, Jonides, and Kaplan (2008) tested whether exposure to natural pictures would facilitate attention restoration. Participants completed the backward digit span task and the Attention Network Task (ANT), which both depleted their attention. Then, participants viewed either natural or urban photos, and they performed the two aforementioned tasks again as posttest measures. After a week, participants returned and completed the same procedure again, except that the picture condition (i.e., natural or urban) was switched. In this way, each participant completed both picture conditions with the order of presentation counterbalanced.

Berman et al. (2008) found an interaction between time (i.e., pretest vs. posttest) and picture type (i.e., natural vs. urban) for the executive control portion of the ANT, with only the nature group showing improvement between tests. Though the authors did not find this interaction for the backward digit-span task, they found that time was only associated with improved performance on this test in the natural picture condition. The authors concluded that even brief interactions with nature can be beneficial to cognition.

Though past research directly investigated how ART pertains to attentional measures (e.g., Berto, 2005), Kjellgren and Buhrkall (2010) examined the effects of physical and simulated natural environments on altered states of consciousness (ASC) and energy. Participants, who were all suffering from extreme stress or burnout, sat in a park or watched a slideshow of pictures from that same park; afterwards, they completed measures of ASCs and energy. The authors found that those who sat in the park subsequently had higher energy levels and greater ASCs than those who watched the slideshow. As ASCs are associated with less use of directed attention, the authors concluded that physical natural environments may be particularly effective for evoking attention restoration by facilitating ASCs and thereby increasing energy levels.

Similarly to Kjellgren and Buhrkall (2010), Matsuoka (2010) did not directly measure attention; instead, he examined how exposure to nature pertains to education. The author noted that, surprisingly, few studies have examined the relationship between school environment and academic performance. The experimenter utilized linear and non-linear regression to examine the effects of nature after controlling for school socioeconomic status, ethnicity, enrollment, and age of the main classroom building. Matsuoka found that students from schools with better views of nature from the cafeteria and with landscapes that contained more trees and shrubs (i.e., rather than mowed lawns or parking lots) obtained higher scores on a standardized academic test. The author suggested that views of nature from the cafeteria may be more predictive of academic performance than classroom window areas (i.e., which represented students' access to nature during class) because students are better able to relax and restore attention during lunch than during class time.

Returning to the effects of nature on attention, Raanaas, Evensen, Rich, Sjostrom, and Patil (2011) investigated the idea that indoor plants may be restorative to attention. The authors had all participants complete a reading span task three times during the experiment: at baseline (time 1), after completing a proofreading task (time 2), and once more after a 5-min break (time 3). One group of participants had four plants present throughout the experiment, whereas the other did not. Raanaas et al. found that only the group with plants improved significantly on the reading span task from time 1 to time 2. However, both groups did not improve from time 2 to time 3; this may have occurred because the proofreading task was not very fatiguing and maximum restoration had already occurred before the 5-min break. The authors concluded that both groups benefited from practice at time 2, but the non-plant group suffered from fatigue at time 2 whereas the plants mitigated this effect for the plant group. Thus, this experiment demonstrated further support for ART.

Similarly, Johansson, Hartig, and Staats (2011) examined the effects of a walk down a street or through a park, with or without company, on attention restoration. In line with previous research, the authors hypothesized that the park would be associated with more attention restoration than the street walk, and the company would increase the restoration on the streets (viz., alleviating feelings of danger) but not in the park (viz., distracting participants from nature). The authors had all participants complete four walks that involved the four combinations of conditions described above; attention was measured before and after each walk. Interestingly, the authors found that all participants experienced declines in attention after the walks, and these declines were surprisingly most severe for those who walked through the park; there was no interaction between environment and social context. However, the authors noted that, before walking through the park, participants had significantly lower attention than walking down the streets; thus, after examining the data, Johansson et al. determined that regression to the mean seems to have caused the unexpected findings in the park condition. The authors concluded that these findings were inconclusive as to whether environment and company moderated attention restoration in this study.

W. S. Shin, C. S. Shin, Yeoun, and Kim (2011) examined the prospect that nature may mediate the enhancement of both attention and mood on a leisurely walk. The authors assessed participants' cognitive function and mood, assigned them to either a walk through a park or a street with several people and vehicles, and then assessed the two constructs again. The authors found that, whereas the park group improved their cognitive capacity after the walk, this did not occur for the street group. In addition, whereas the park group tended to have a better mood at the posttest than the pretest, the street group tended to have a worse mood. The authors concluded that their study supports the notion that nature is associated with psychological benefits.

Using the same dependent variables as the past study, Gatersleben and Andrews (2013) investigated the effects of visible or secluded natural areas on participants' mood and attention. In their first study, the authors showed pictures of natural areas and asked participants to rate the amount of restoration they would expect to gain from walks in those settings. Gatersleben and Andrews showed that imaginative walking through areas with high prospect (i.e., open and facilitative of wide views) and low refuge (i.e., few hiding places) was correlated with more perceived restoration, whereas low prospect and high refuge were associated with less perceived restoration. The authors also found that perceptions of danger and fear were highest in the low prospect and high refuge settings and lowest in the high prospect and low refuge settings; these variables, although highly correlated with each other, each mediated the effects of prospect and refuge via negative associations with perceived restoration. This demonstrated that prospect and refuge affect the perceived rate of attention restoration that is evoked by natural environments.

In their second study, Gatersleben and Andrews (2013) investigated the effects of either a physical or video walk through a high-prospect and low-refuge environment or a low-prospect and high-refuge environment. Participants underwent an attentional pretest, physically walked or participated in an interactive video walk through one of the two aforementioned settings, and then took the posttest. An interaction occurred in which attention did not differ between the two settings via video, but the high-prospect and low-refuge physical setting was much more facilitative of attention than the low-prospect and high-refuge condition. The authors concluded that the effects of prospect and refuge on attention restoration seem to be stronger in physical than video environments, presumably because the video simulations are not as realistic and do not contain as much sensory information as physical settings.

Rather than examining virtual nature's influence on attention, De Kort, Meijnders, Sponselee, and IJsselsteijn (2006) examined its effects on stress reduction. Participants who were randomly assigned to the low immersion condition watched a nature film that filled 31" of a 72" screen, whereas those in the high immersion condition viewed the entire 72" screen. The authors found evidence that the bigger screen caused more restoration from stress than the smaller screen. Thus, De Kort et al. concluded that the restorative effects of nature via various media may be mediated by the media's qualities. The authors also purported that interactive technological media (e.g., video games) may bring about greater attention restoration than static manifestations of natural settings (viz., pictures).

In subsequent research on virtual nature, Mayer, Frantz, Bruehlman-Senecal, and Dolliver (2009) compared the effects of physical and simulated nature on attention restoration. Physical nature participants walked through an arboretum and the virtual nature group watched a video of a walk through the same area. The authors found that physical participants had more positive emotions, had greater ability to reflect on a problem, felt more connected to nature, and demonstrated greater environmental awareness than the virtual group. Despite these differences, the physical and virtual group did not differ in terms of attentional capacity; the authors also failed to find evidence that attentional capacity mediated the relationships between nature type (i.e., physical or virtual) and positive mood and between nature type and the ability to reflect on a problem. Mayer et al. concluded that physical nature is associated with benefits that are presumably absent in virtual nature, but both seem to bring about attention restoration.

Indeed, exposure to natural settings and stimuli does seem to be associated with many benefits, including attention restoration. Though many of these studies utilized physical immersion (e.g., Hartig et al., 1991) or pictures (e.g., Berto, 2005) to bring about benefits associated with nature, more sophisticated technologies like videos (e.g., De Kort et al., 2006) and video games also exist as possible media through which the effects of natural settings may be explored. Video gaming is a huge industry that has become extremely popular, especially among college students. According to Pew Research (Lenhart, Jones, & Macgill, 2008), 51% of persons that are at least 18 years old play video games (i.e., defined in these data as console, computer, or phone games); this percentage increases to 81% when specifically examining people between the ages of 18 and 29. In addition, 76% of students who are 18 years of age or older play video games.

Like immersion in natural settings, video games have been associated with several benefits in past research as well.

Video Games: Both Popular and Beneficial

Like Berman et al. (2008), Garcia, Nussbaum, and Preiss (2011) utilized the digit span task to measure cognitive ability. The authors used a correlational study to examine the relationship between technologies and memory. They recorded participants' usage of several technologies and then had those students perform both forward and backward digit span tasks. Garcia et al. found that those who played PC and video games had greater digit span scores than those who did not regularly play such games. The authors concluded that technologies like video gaming may lead to increases in cognitive abilities, or that persons with greater working memories may be more motivated to use such technologies.

Rather than using a correlational design like Garcia et al. (2011), Boot, Kramer, Simons, Fabiani, and Gratton (2008) manipulated video game exposure. The authors desired to examine differences between expert gamers, non-gamers, and trained gamers (non-gamers who played a total of 21.5 hr over the course of four to five weeks for this experiment) via a pretest-posttest design. By utilizing a composite measure of reaction time and accuracy, the researchers found that expert gamers performed significantly better on Tetris® than non-gamers. In addition, trained gamers who played Tetris improved significantly in reaction time on the mental rotation task between the beginning and end of the experiment. The authors concluded that participants in the training group acquired stronger mental rotation skills as a result of video game playing, which strongly suggests that gaming can improve certain cognitive abilities

Quiroga et al. (2009) also manipulated video game exposure and examined its relationship with increases in general intelligence (*g*). The experimenters had participants play three mini games (i.e., Train, Backward Memory, and Calculus) within a video game called Big Brain Academy®. Participants completed a measure of general intelligence (involving spatial ability, numerical ability, and short-term memory) before and after each of the two 50-game-trial sessions for each mini game. The authors found that Train, which involved guiding a train to a particular destination as quickly as possible, required and facilitated increases in *g*. The authors concluded that it is possible to identify elements in video games that may lead to benefits like increased intelligence. As different mini games were associated with differential gains in intelligence for the previous study, it should also be possible to identify elements of more complex video games (e.g.., natural stimuli) that may be associated with the benefit of attention restoration.

Unlike any of the other experiments, Valtchanov, Barton, and Ellard (2010) examined how ART pertains to video game settings. Participants experienced attention depletion, completed several pretest measures, were exposed to either virtual nature or the control condition, and then completed the posttest measures. The virtual nature group used a computer mouse to walk through a simulated natural environment that was created with a game graphics generator, whereas control participants watched a slideshow of abstract paintings. Of primary importance to the present study, the authors used two math tests (i.e., five multiplication and five division questions per test) to assess participants' attentional capabilities during the pretest and posttest phases.

Valtchanov et al. (2010) found a significant interaction between setting and time for stress reduction, with nature participants experiencing greater decreases in physiological stress than control participants after the intervention. However, the researchers did not find the expected interaction for math test scores; virtual nature participants did not show more improvement on this measure (i.e., representing attention restoration) than control participants. The authors concluded that virtual nature can bring about many of the same benefits as physical nature (e.g., reduced stress). Also, they noted that they may not have found the expected interaction for math scores because math performance may not adequately reflect attentional capacity and their math tests may have been too easy to sufficiently measure participants' attention.

Researchers have demonstrated that playing video games may be associated with several benefits, such as increased IQ (Quiroga et al., 2009). Nevertheless, no research has demonstrated that natural video game environments facilitate attention restoration. The only study to examine this possibility did not find an effect, although its measure of attentional capability was likely vulnerable to ceiling effects (Valtchanov et al., 2010).

Hypotheses

As can be seen in the review above, exposure to nature and the playing of video games are associated with many benefits. However, prior to this study, little research had examined how attention may be restored in natural video game settings (viz., Valtchanov et al., 2010) or how exposure to natural environments may facilitate academic learning

(Matsuoka, 2010). In addition, no study had investigated how virtual nature may facilitate academic learning. This experiment is important because it helped to fill the aforementioned gaps in the literature and demonstrated whether students may play natural video games to restore attention, facilitate learning, and consequently increase academic achievement.

For this study, participants completed an attentional exhaustion task, played a video game while being exposed to a simulated natural or urban environment for 5 or 15 min, read a short text, took a test that assessed their understanding of the aforementioned text, and completed the attentional exhaustion task again. Like an extensive period of intense studying, the first task was designed to mentally exhaust participants' attention, and the playing of the video game was utilized to simulate a study break. The subsequent reading of the document represented additional studying after a study break. The test was utilized to measure each student's ability to study after gaming. Finally, the first task was completed again as a posttest measure of student's attentional capabilities.

Five hypotheses were developed for this experiment. It was first hypothesized, in accordance with ART (Kaplan, 1995), that participants who were immersed in the simulated natural environments would experience greater attention restoration than the virtual urban group. For this experiment, attention restoration was defined as improvement in the attentional exhaustion task [i.e., the Sustained Attention Response Task (SART)] from the first administration to the second. The aforementioned hypothesis was theoretically justified because pictures of natural settings have been shown to increase attention more than urban settings (Berto, 2005; Berman et al., 2008), so it seemed appropriate to assume that virtual natural environments would bring about similar effects and consequently facilitate greater attention restoration than simulated urban settings. Secondly, although no research had examined the temporal duration that is necessary for attention restoration in natural video game settings, it was hypothesized that there would be an interaction between setting and time: In contrast to the urban condition, participants exposed to simulated nature were predicted to have greater attentional improvements when immersed for 15 min rather than 5 min. Because surrogate nature has been shown to restore attention (Berto, 2005; Berman et al., 2008), longer exposures to it were predicted to provide participants with greater opportunities to restore attention. In contrast, duration of exposure to the simulated urban settings was not expected to affect test scores because urban environments do not typically facilitate attention restoration (Kaplan, 1995).

As attention is necessary for academic achievement (Moreno, 2010, Chapter 6), the two constructs should be positively correlated. Thus, as virtual nature and longer periods of exposure to it were expected to be linked to greater levels of attention restoration, it was thirdly and fourthly hypothesized that both of these would also be linked to greater academic achievement. For the purposes of this experiment, academic achievement was defined as performance on a beer-brewing assessment. Finally, it was hypothesized that there would be a direct correlation between attention restoration and academic achievement.

Method

Participants

After IRB approval was obtained (Appendix A), participants were selected via convenience sampling. Students read a brief description and scheduled an appointment for this study online as part of a course requirement for their General Psychology course. Students were instructed not to participate if they had serious histories of seizures, motion sickness, and/or low tolerances for violence; gaming experience was not required. A total of 97 participants completed the entire experiment; cases were deleted on a case-by-case basis if they were outliers in a particular analysis (i.e., below the first quartile or above the third quartile by 1.5 interquartile ranges).

Approximately 42% of participants in the experiment were females and 58% were males. Participants were 19 years old on average. Most participants identified themselves as Asian (44%), White (25%), or Hispanic (14%), which closely mirrors the general student population of San José State University. As this study's participants were enrolled in General Psychology, the majority of participants were freshmen (54%), although several students were sophomores (27%) or juniors (13%).

Apparatus/Materials

Every phase of this experiment was completed in a computer lab at San José State University. Each participant's computer was equipped with a monitor that was approximately 17" in size. A computer mouse, keyboard, and a pair of headphones were also utilized by each participant for this experiment.

Participants completed the Sustained Attention Response Task (SART) on the aforementioned computers. For each trial, participants saw a digit from 0 to 9 and were told to press the spacebar unless the presented digit was a 3 (i.e., the target). The version of the SART in this study was designed to mimic Berto's (2005) design as closely as possible. In this way, each trial's duration was 1125 ms; each digit was displayed for the first 250 ms, and participants could respond at any time during the 1125 ms of each trial. Each of the 10 digits were presented an equal number of times; in this way, 10% of trials contained the target (i.e., the "3" digit) and 90% did not. Participants completed 20 practice trials before the first SART, and they completed 240 trials during each of the first and second SART administrations. Three measures of SART performance were utilized in this study: participants' reaction times in correctly pressing the spacebar for non-target trials, the number of target trials in which participants correctly inhibited their responses, and d-prime. D-prime is a measure of the ability to correctly discriminate between stimuli; it is computed by subtracting the z-transform of the false alarm rate from the z-transform of the hit rate. The false alarm rate was calculated as the number of times a participant incorrectly inhibited a response for a non-target trial divided by the total number of non-target trials, and the hit rate was the number of times a participant correctly inhibited a response for a target trial divided by the total number of target trials This SART task was programmed and run via PsychoPy, which is free and open-source software designed by Jonathan Peirce for psychology research (Peirce, 2007).

Participants were immersed in virtual nature or simulated urban settings of Morrowind® on their computers. Morrowind is a game that is well-known for its immersive environments and unrestricted, exploratory gameplay; it is the third installment in the Elder Scrolls® game series by Bethesda. Players of Morrowind can travel by foot for nearly endless amounts of time in an extraordinarily large virtual world that contains numerous natural and urban environments; they can also engage in combat with a variety of creatures and villains that are non-player characters (NPCs). For this experiment, participants in the natural condition started their exploration in the forest surrounding Seyda Neen and urban participants began in Vivec. To minimize fighting with NPCs so that participants could focus on interacting with their environments, a cheat code was used to make participants invisible to NPCs; in addition, participants' controls were largely restricted to simple movement. Participants only used their headphones during this portion of the study, and these headphones allowed them to hear the game's sound effects (viz., the sounds of one's own footsteps) and its soundtrack. Please see the attached pictures of the Morrowind natural and urban gaming environments that were utilized in this study (Appendices B and C, respectively).

All participants read an 1141-word document about the process of beer brewing that was compiled by Jonathan Boyajian (i.e., a graduate student of San José State University). Participants also completed a brief assessment designed by Boyajian to assess learning associated with the aforementioned document. This assessment was composed of 28 multiple choice questions (i.e., 14 factual and 14 conceptual items) with four possible answers each. Sample questions for this instrument include the following: "During malting, barley is steeped in water around… a.) 5-10° C; b.) 14-18° C; c.) 30-40° C; d.) 100-150° C" and "Beer is composed mostly of… a.) Malted barley; b.) Alcohol; c.)

Hops; d.) Water." From a larger item bank, Boyajian selected questions that had the strongest face validity and were the closest to being answered correctly by 50% of respondents; he compiled these items to create his beer brewing assessment (personal communication, August 15, 2012). The questionnaire is scored by determining each participant's number of correct answers. In this way, scores range from 0 to 28 and higher scores indicate greater understanding of beer brewing. The beer brewing assessment was found to have internal consistency reliability in this study, with a Cronbach's alpha of 0.76. Please see the attached beer brewing notes (Appendix D) and the beer brewing assessment (Appendix E).

Finally, a short form that was developed by the experimenter was used to gather demographic data and participants' reactions to the video game settings. Sample demographic items request that a participant indicates gender and ethnicity. In addition, this form utilizes the Perceived Restorativeness Scale (PRS) to record participants' responses to the video game environments. This is a short measure in which participants rate an environment's restorative capabilities in accordance with ART (Hartig, Kaiser, & Bowler, 1997). Individual ratings are made on a scale from 0 to 6 and the PRS contains 22 items (i.e., six reverse-scored items) after omitting the legibility subscale; thus, total ratings can vary from 0 to 154. A higher total rating indicates a setting that is perceived to be more restorative. Sample items for this instrument include the following: "My attention is drawn to many interesting things" and "I want to spend more time looking at the surroundings." Please see the attached survey for the demographic items (Appendix F) and Hartig et al. (1997) for the PRS items.

Design

The design for this study was a 2 X 2 factorial experiment. The independent variables (IVs) were virtual environment and time allotted to engage in the environment. First, virtual environment was a between-subjects IV and had two levels. Participants in the virtual natural environment wandered throughout the forests and plains of Morrowind while avoiding towns and cities; those in the simulated urban condition wandered throughout the town of Vivec. Time, the second IV, was also a between-subjects factor and had two levels. Participants were given 5 or 15 min to play Morrowind. The main dependent variables (DV) were scores on the SART and beer brewing assessment.

Participants were randomly assigned to conditions during the first few sessions of the experiment. In order to maintain an approximately equal number of participants per condition, the procedure for assignment to groups was subsequently different: The condition with the lowest number of participants at any given time was then assigned to the next session's participants.

Procedure

Participants scheduled appointments online prior to each session. The primary investigator and research assistants supervised groups of no more than five participants in a computer lab. To become eligible for participation, all participants consented via the signing of informed consent forms (Appendix G) at the beginning of each session. For the seven min following the delivery of consent, they completed the SART practice trials and the first administration of the SART. Next, they played the Morrowind video game in the virtual natural or urban setting for 5 or 15 min. In the natural condition, participants were instructed to explore their surroundings while avoiding towns and cities; urban participants were told to explore the city without wandering outside of it. Then, participants were told to study the beer-brewing document for the next 30 min. They were provided with scratch paper and told to take notes if they felt that it would help them to learn the material, but they were informed that the following test was not open-notes. Participants were also told that, if they got at least 60% of the questions correct on the following assessment, they would be entered into a gift card raffle for one of five $20 ITunes gift cards. After the 30 min had passed, the experimenter collected the scratch paper and verified that participants had closed their beer brewing notes pages. Then, participants were given a maximum of 20 min to complete the beer brewing assessment; in the event that a group finished early, the experiment proceeded to the next phase early. Afterward, participants completed the demographics and PRS form in approximately 5 min. Next, they completed the second administration of the SART in approximately 5 min. Finally, they were partially debriefed (viz., told that they would receive a thorough debriefing via email) and thanked for their participation. Altogether, each session lasted no longer than 90 min. After no more than one week, participants were debriefed thoroughly via email (Appendix H).

Results

Descriptive Statistics

To verify that the beer-brewing assessment is an adequate measure of academic achievement, the relationship between participants' self-reported GPAs and their total beer-brewing scores was examined. All tests of significance in this manuscript were tested via the traditional alpha level of .05. According to this aforementioned criterion, this positive correlation reached significance [$r(65) = .29$, $p = .016$]. Please see Table 1 for a correlation matrix that includes this correlation, as well as several others.

Table 1. Zero-Order Correlation Matrix.

	1	2	3	4	5	6	7	8	9	10
1. Gender	--									
2. Age	.20	--								
3. College GPA	.14	-.31 **	--							
4. Year in College	-.01	.72 ***	-.26 **	--						
5. Hours of Gaming per Week	-.14	-.14	.00	.01	--					
6. SART Restoration: Reaction Times	.09	.20	-.15	.12	-.12	--				
7. SART Restoration: Correct Answers	.03	-.02	.08	.03	.20 *	.13	--			
8. SART Restoration: D-Prime	.05	-.03	.16	.03	-.05	-.15	.80 ***	--		
9. Academic Achievement: Beer Brewing Score	.00	.06	.29 **	.22 *	.05	-.10	.03	.15	--	
10. PRS Score	.00	.13	.03	.19	.03	-.12	##	.11	.23 *	--

Note: *N* = 67.

* p < .10
** p < .05
*** p < .01

As nature should be associated with greater perceived attention restoration than urban environments, an independent-samples *t* test was conducted to examine whether those who were immersed in virtual nature had higher PRS ratings than those who were exposed to the simulated urban environments. However, those immersed in simulated nature did not rate their environments significantly higher on the PRS than those in the virtual urban settings (M_{Nat} = 82.10, SD_{Nat} = 28.35, N_{Nat} = 49, M_{Urb} = 79.04, SD_{Urb} = 22.62, N_{Urb} = 48; $t(95) = 0.587$, $p = .559$, Hedges' $g = 0.12$). This indicates that participants did not perceive differences between virtual environments in the elements of attention restoration, as measured via the PRS.

Main Analyses

It was hypothesized that participants who were immersed in virtual nature environments would have greater attentional improvements than those in simulated urban environments, and longer playing time would contribute to greater increases for those in virtual nature but not in the urban settings. Attention was measured in three ways via the SART: average reaction times for go trials (i.e., correctly hitting the spacebar when the stimulus was not a 3), number of correct responses to no-go trials (i.e., correctly inhibiting a response when the stimulus was the target, 3), and d-prime. Each participant's attentional improvement scores were obtained by subtracting each of the three aforementioned scores on the first performance of the SART from the second SART. Thus, three 2 X 2 factorial ANOVA's were conducted to examine the relationship between virtual environment and game time on attentional improvement. As can be seen in Figures 1-3, no significant effects of Environment, Time, or the

Environment X Time interaction on attentional improvement were observed via reaction times [$F_{Env}(1, 90) = 0.02$, $p = .904$, $g = -0.03$; $F_{Time}(1, 90) = 0.36$, $p = .550$, $g = -0.12$; $F_{Env\ X\ Time}(1, 90) = 0.01$, $p = .932$], correct responses [$F_{Env}(1, 93) = 0.00$, $p = .989$, $g < .01$; $F_{Time}(1, 93) = 0.57$, $p = .451$, $g = -0.15$; $F_{Env\ X\ Time}(1, 93) = 0.30$, $p = .586$], and d-prime [$F_{Env}(1, 86) = 0.07$, $p = .793$, $g = -0.07$; $F_{Time}(1, 86) = 0.40$, $p = .530$, $g = -0.14$; $F_{Env\ X\ Time}(1, 86) = 1.40$, $p = .240$]. Consequently, the aforementioned hypotheses were not supported.

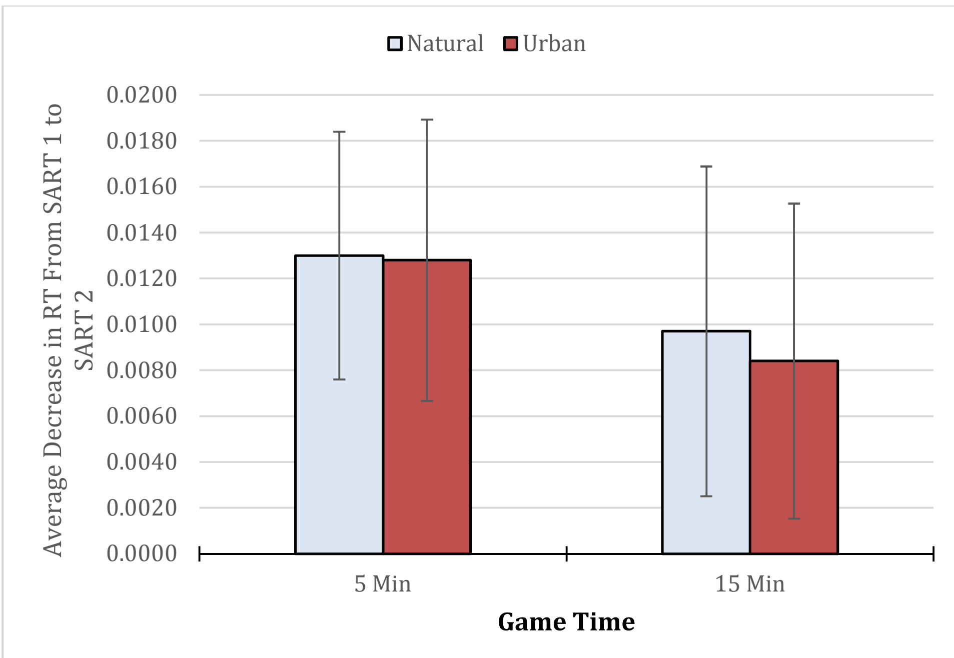

Figure 1. Average decrease in reaction times from the SART 1 to the SART 2 by virtual environment and game time. Error bars represent ±1 *SE*; $M_{Nat\text{-}5} = 0.0130$ (0.0270), $n_{Nat\text{-}5} = 25$, $M_{Urb\text{-}5} = 0.0128$ (0.0294), $n_{Urb\text{-}5} = 23$, $M_{Nat\text{-}15} = 0.0097$ (0.0352), $n_{Nat\text{-}15} = 24$, $M_{Urb\text{-}15} = 0.0084$ (0.0322), $n_{Urb\text{-}15} = 22$. The main effects of virtual environment and game time, as well as the interaction between them, did not reach significance.

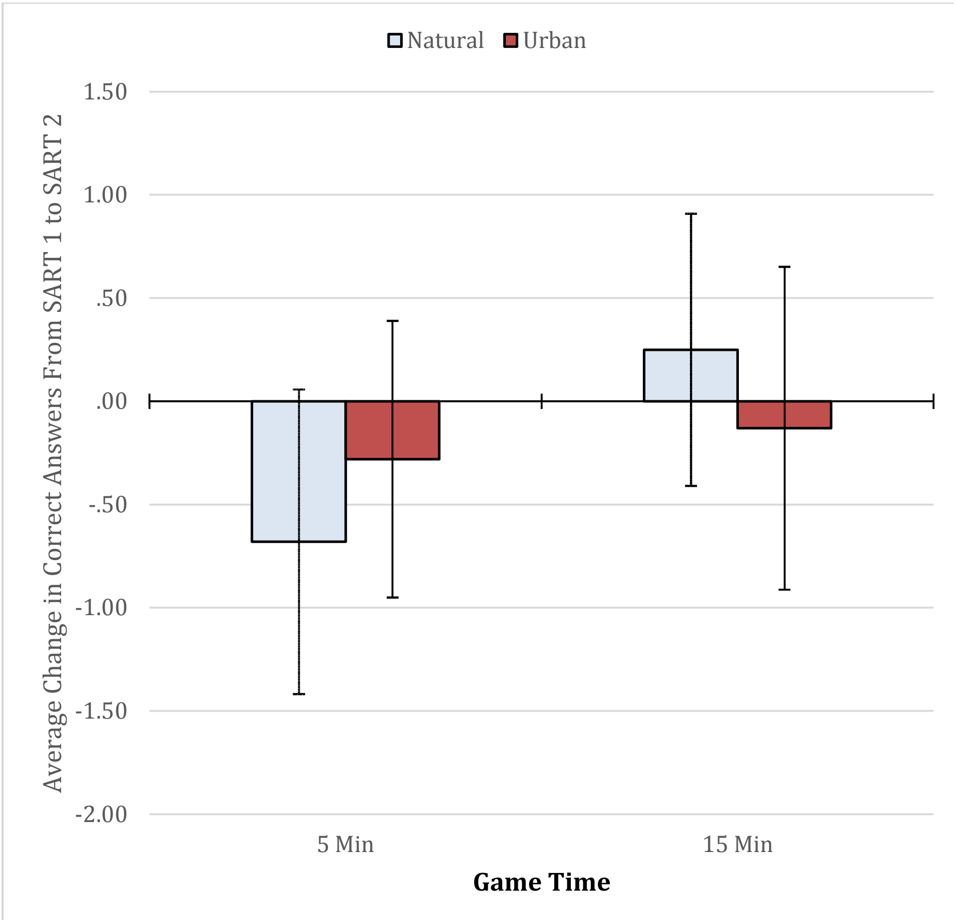

Figure 2. Average change in number of correct responses from the SART 1 to the SART 2 by virtual environment and game time. Error bars represent ±1 *SE*; $M_{\text{Nat-5}}$ = -0.68 (3.69), $n_{\text{Nat-5}}$ = 25, $M_{\text{Urb-5}}$ = -0.28 (3.35), $n_{\text{Urb-5}}$ = 25, $M_{\text{Nat-15}}$ = 0.25 (3.23), $n_{\text{Nat-15}}$ = 24, $M_{\text{Urb-15}}$ = -0.13 (3.75), $n_{\text{Urb-5}}$ = 23. The main effects of virtual environment and game time, as well as the interaction between them, did not reach significance.

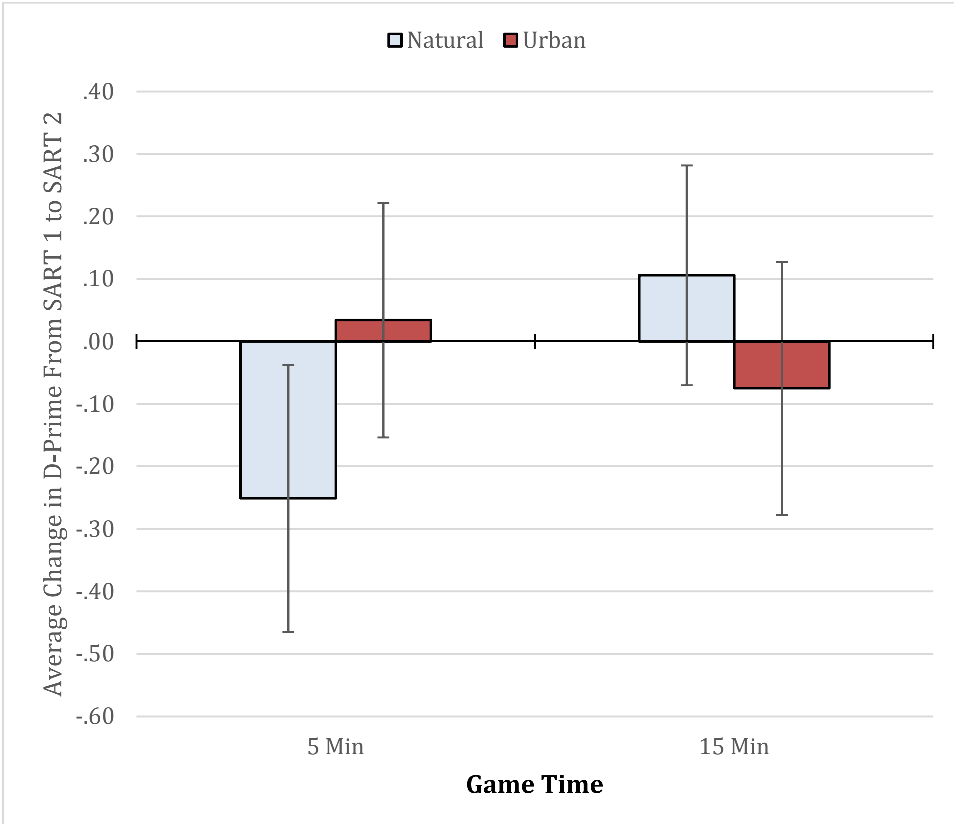

Figure 3. Average change in d-prime from the SART 1 to the SART 2 by virtual environment and game time. Error bars represent ±1 *SE*; $M_{\text{Nat-5}}$ = -0.25 (1.05), $n_{\text{Nat-5}}$ = 24, $M_{\text{Urb-5}}$ = 0.03 (0.92), $n_{\text{Urb-5}}$ = 24, $M_{\text{Nat-15}}$ = 0.11 (0.83), $n_{\text{Nat-15}}$ = 22, $M_{\text{Urb-15}}$ = -0.08 (0.91), $n_{\text{Urb-15}}$ = 20. The main effects of virtual environment and game time, as well as the interaction between them, did not reach significance.

Similar to the first hypotheses, it was expected that those who were immersed in simulated nature would have greater academic achievement than those in the urban environments, and greater playing time would contribute to greater academic achievement for those in virtual nature but not in the urban condition. Academic achievement was defined as each participant's total score on the beer-brewing assessment. As Figure 4 illustrates, a 2 X 2 factorial ANOVA was conducted to investigate the relationship between virtual environment and game time on academic achievement. Mirroring the results of the analysis on attentional gains, participants' academic achievement did not differ as a result of Environment [$F(1, 93) = .1.79$, $p = .185$, $g = -0.27$], Time [$F(1, 93) = 0.89$, $p = .347$, $g = 0.19$], or the Environment X Time interaction [$F(1, 93) = 0.23$, $p = .634$].

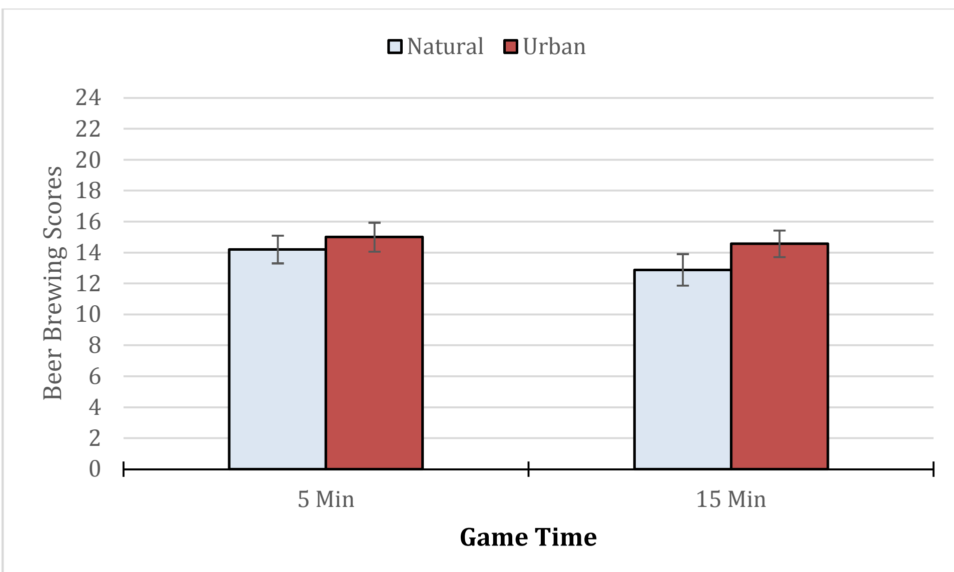

Figure 4. Average score on the beer brewing assessment by virtual environment and game time. Error bars represent ±1 *SE*; $M_{\text{Nat-5}} = 14.20$ (4.48), $n_{\text{Nat-5}} = 25$, $M_{\text{Urb-5}} = 15.00$ (4.67), $n_{\text{Urb-5}} = 25$, $M_{\text{Nat-15}} = 12.88$ (5.01), $n_{\text{Nat-15}} = 24$, $M_{\text{Urb-15}} = 14.57$ (4.11), $n_{\text{Urb-15}} = 23$. The main effects of virtual environment and game time, as well as the interaction between them, did not reach significance.

Finally, it was hypothesized that attentional improvement would be positively related to greater academic achievement. However, there were no significant relationships between total beer brewing scores and improvements in SART reaction times [$r(65) = -.10$, $p = .441$], correct responses [$r(65) = .03$, $p = .790$], and d-prime [$r(65) = .15$, $p = .224$]. Thus, the final hypothesis was not supported. Please refer again to Table 1 for further details.

Subsequent Analyses

As the hypotheses were not supported, it was possible that participants may not have experienced attentional depletion after the first SART administration and were consequently unable to subsequently experience attention restoration. Thus, Pearson correlations were conducted to investigate the relationships between trial number and the three aforementioned measures of SART performance for both the first and second SARTs. As the SART is supposed to lead to attentional exhaustion, participants' performance should worsen as they progress into the later trials of the SART and their attention continues to deplete. However, there were no significant relationships between trial number and mean reaction times [$r(238) = .07$, $p = .297$], correct answers [$r(238) = .09$, $p = .148$], and d-prime [$r(238) = .05$, $p = .471$] for the first administration of the SART. In contrast, trial number had a weak negative correlation with reaction times that was trending toward significance [$r(238) = -.124$, $p = .054$], a significant weak negative correlation with correct answers [$r(238) = -.164$, $p = .011$], and a strong negative correlation with d-prime for the second SART [$r(238) = -.434$, $p < .001$]. Please refer to Figures 5-10. In sum, participants' performance did not decrease as trial number increased for the first administration of the SART, but participants' performance did deteriorate as trial number increased during the second SART.

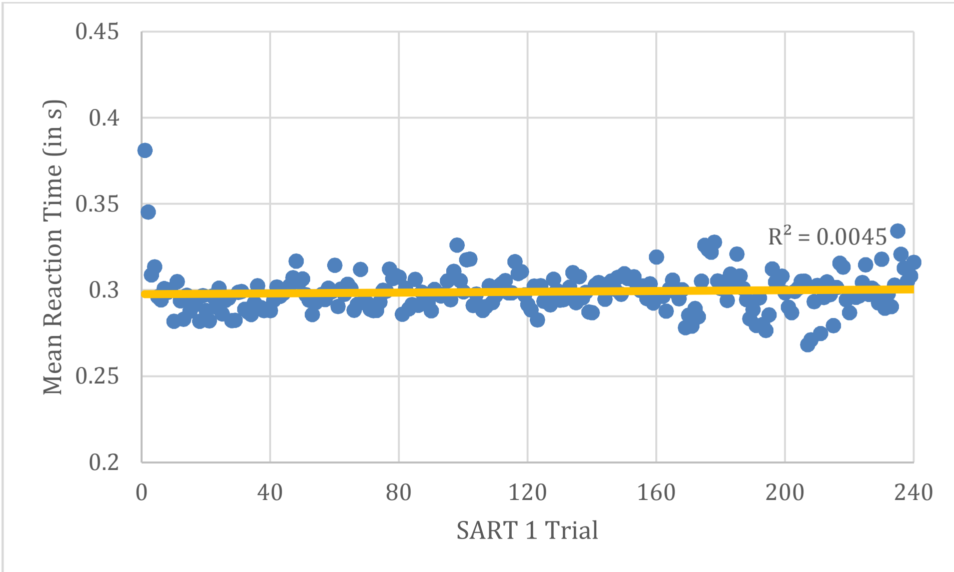

Figure 5. Mean reaction time by trial for the SART 1. Means calculated from 97 participants. There was no significant linear relationship between trial number and reaction time for the first SART.

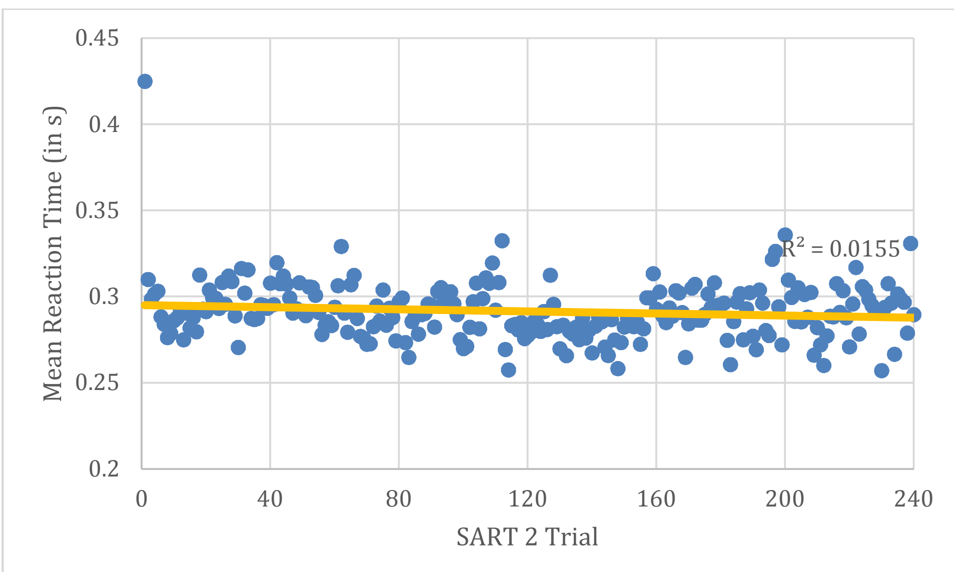

Figure 6. Mean reaction time by trial for the SART 2. Means calculated from 97 participants. The relationship between trial number and reaction time for the second SART was trending towards significance.

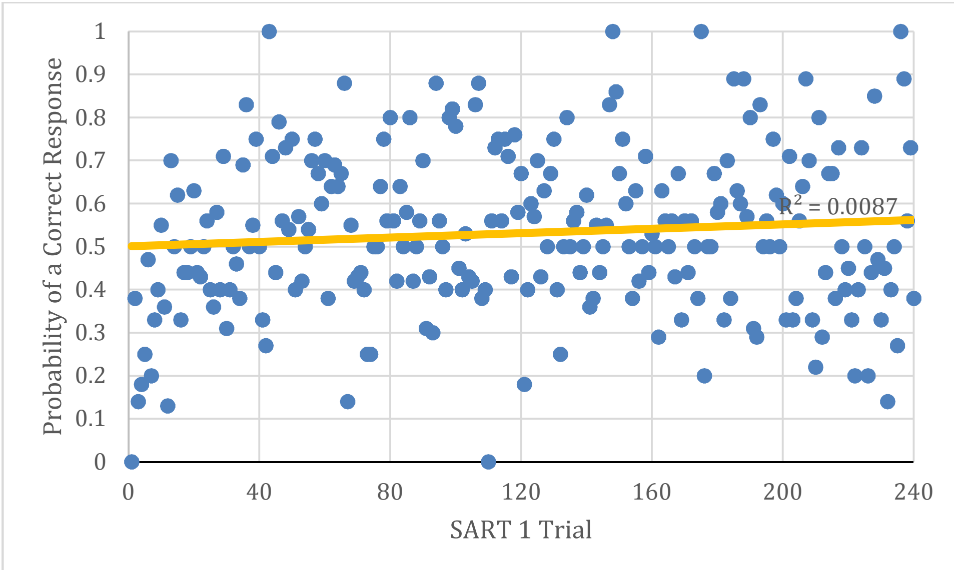

Figure 7. Probability of a correct response by trial for the SART 1. Means calculated from 97 participants. There was no significant linear relationship between trial number and probability of a correct response to a no-go trial for the first SART.

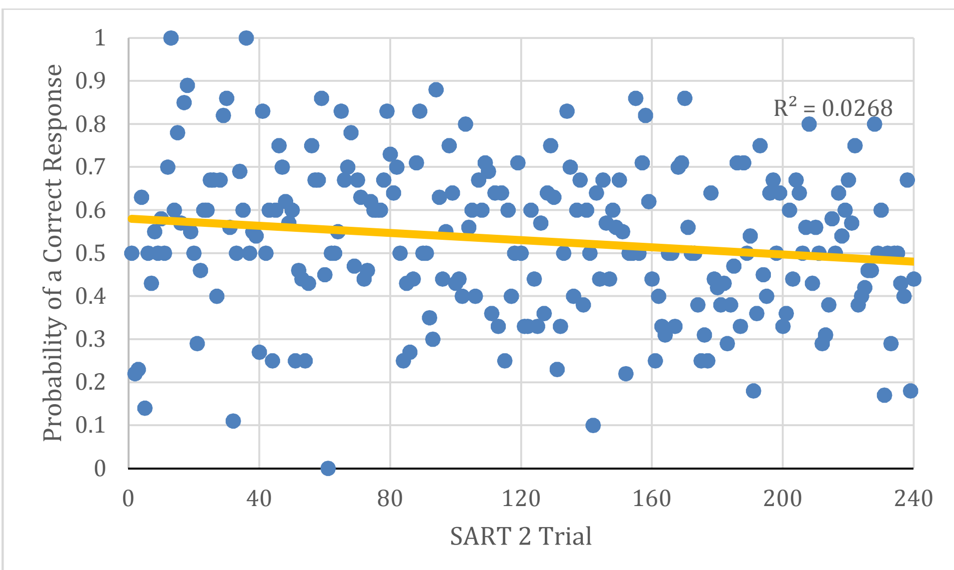

Figure 8. Probability of a correct response by trial for the SART 2. Means calculated from 97 participants. There was a weakly significant negative relationship between trial number and probability of a correct response to a no-go trial for the second SART.

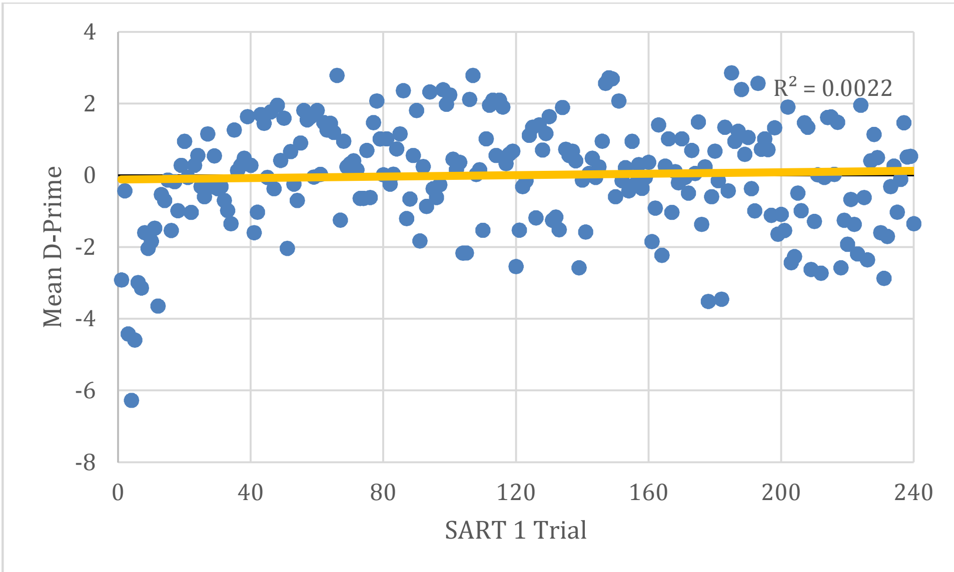

Figure 9. Mean d-prime by trial for the SART 1. Means calculated from 97 participants. There was no significant linear relationship between trial number and the ability to discriminate between stimuli for the first SART.

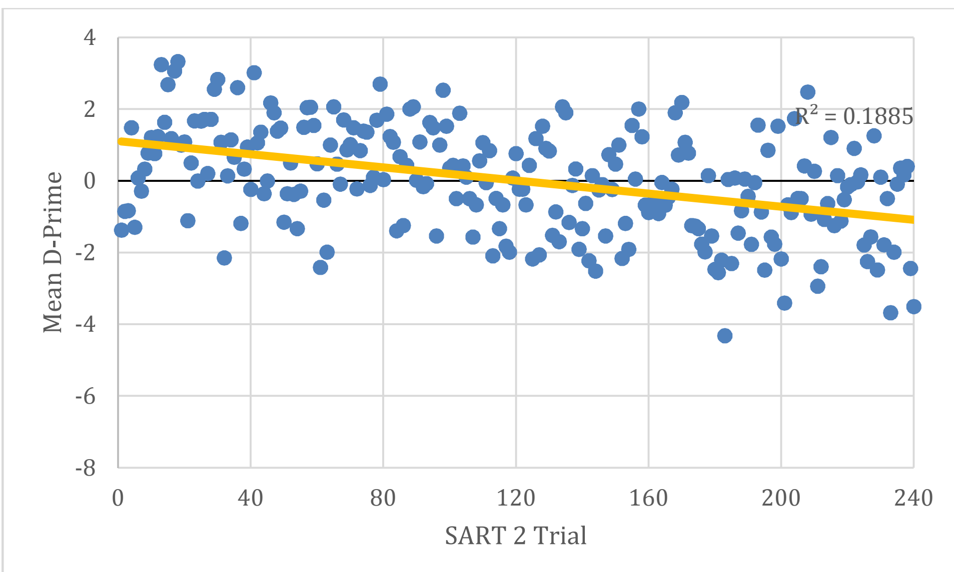

Figure 10. Mean d-prime by trial for the SART 2. Means calculated from 97 participants. There was a strongly significant negative relationship between trial number and the ability to discriminate between stimuli for the second SART.

In addition, because restoration did not differ between the virtual environment and playing time groups, the possibility that participants experienced attention restoration within groups was examined. Three paired-samples *t* tests (i.e., on reaction times, correct answers, and d-prime) were conducted for each of the four groups to identify whether participants obtained better SART scores on the second administration of the SART than the first. As Figure 11 illustrates, although virtual nature participants had significantly lower reaction times during the second SART than the first SART [$t(47) = 2.88$, $p = .006$, $g = 0.30$], this did not occur for the simulated urban group [$t(46) = 1.33$, $p = .191$, $g = 0.17$]. As shown in Figure 12, although those who played for 5 min had significantly lower reaction times during the second SART than the initial SART [$t(48) = 2.51$, $p = .015$, $g = 0.26$], this did not occur for the 15 min group [$t(45) = 1.61$, $p = .114$, $g = 0.19$]. Nevertheless, none of the groups obtained significantly more correct answers or higher d-prime scores on the second SART than the first (see Figures 13-16).

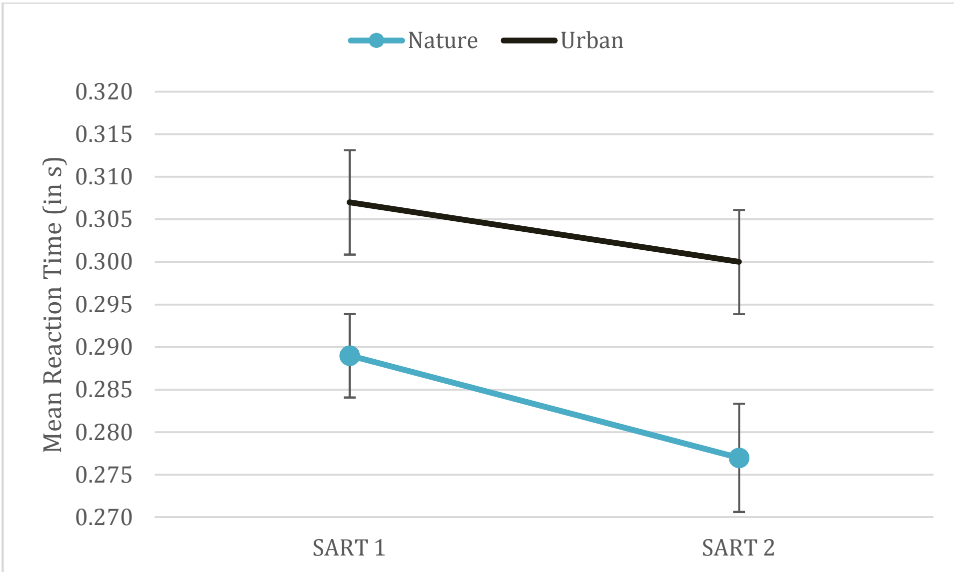

Figure 11. Average reaction time for the SART 1 and SART 2 by virtual environment. Error bars represent ±1 *SE*; $M_{Nat\text{-}1}$ = 0.289 (0.034), $M_{Nat\text{-}2}$ = 0.277 (0.044), n_{Nat} = 48, $M_{Urb\text{-}1}$ = 0.307 (0.042), $M_{Urb\text{-}2}$ = 0.300 (0.042), n_{Urb} = 47. The change from SART 1 to SART 2 in the natural ($p < .01$), as well as the difference between natural and urban groups during both the SART 1 ($p < .05$) and SART 2 ($p < .01$), reached significance.

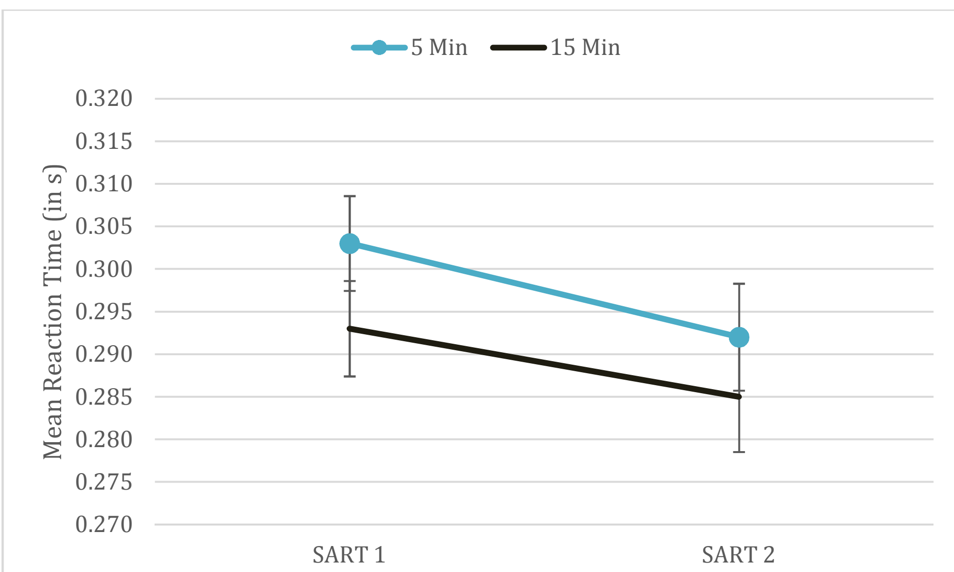

Figure 12. Average reaction time for the SART 1 and SART 2 by gameplay time. Error bars represent ±1 *SE*; $M_{5\text{-}1}$ = 0.303 (0.039), $M_{5\text{-}2}$ = 0.292 (0.044), n_5 = 49, $M_{15\text{-}1}$ = 0.293 (0.038), $M_{15\text{-}2}$ = 0.285 (0.044), n_{15} = 46. The change from SART 1 to SART 2 in the 5 min group ($p < .05$) reached significance.

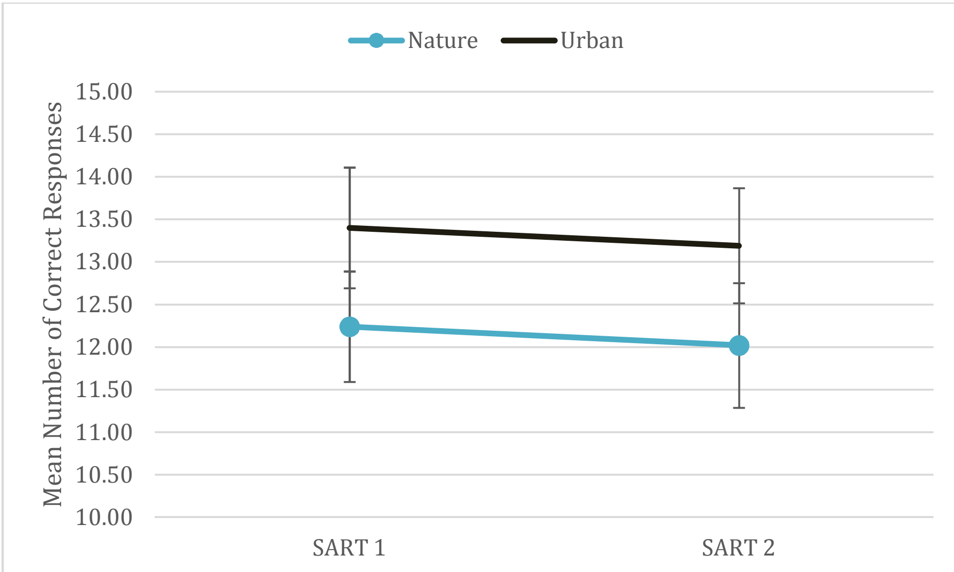

Figure 13. Average number of correct responses for the SART 1 and SART 2 by virtual environment. Error bars represent ±1 *SE*; $M_{\text{Nat-1}}$ = 12.24 (4.54), $M_{\text{Nat-2}}$ = 12.02 (5.13), n_{Nat} = 49, $M_{\text{Urb-1}}$ = 13.40 (4.91), $M_{\text{Urb-2}}$ = 13.19 (4.68), n_{Urb} = 48. There were no significant differences between the SART 1 and SART 2, as well as between either individual test, in both the natural and urban groups.

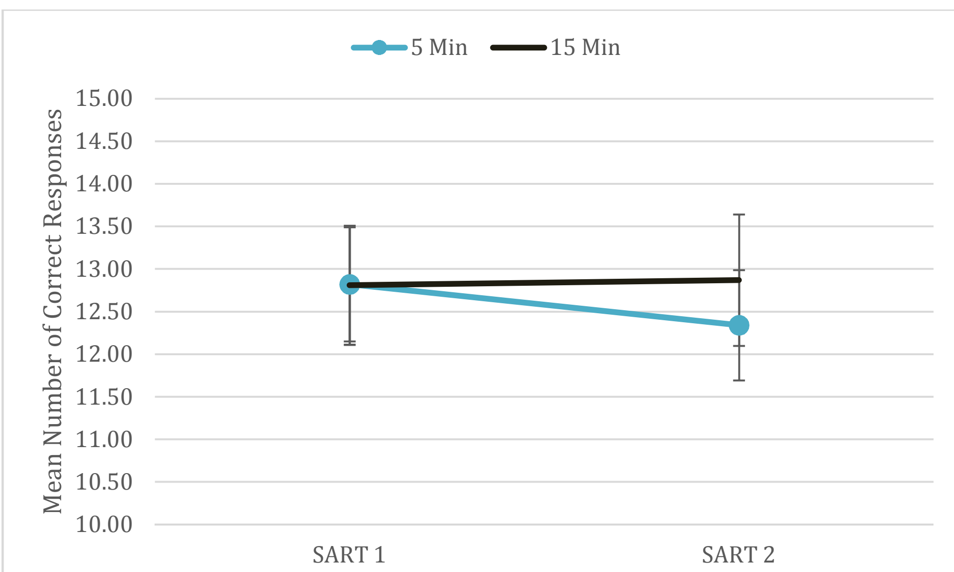

Figure 14. Average number of correct responses for the SART 1 and SART 2 by gameplay time. Error bars represent ±1 *SE*; $M_{5\text{-}1}$ = 12.82 (4.74), $M_{5\text{-}2}$ = 12.34 (4.58), n_5 = 50, $M_{15\text{-}1}$ = 12.81 (4.79), $M_{15\text{-}2}$ = 12.87 (5.29), n_{15} = 47. There were no significant differences between the SART 1 and SART 2, as well as between either individual test, in both the 5 min and 15 min groups.

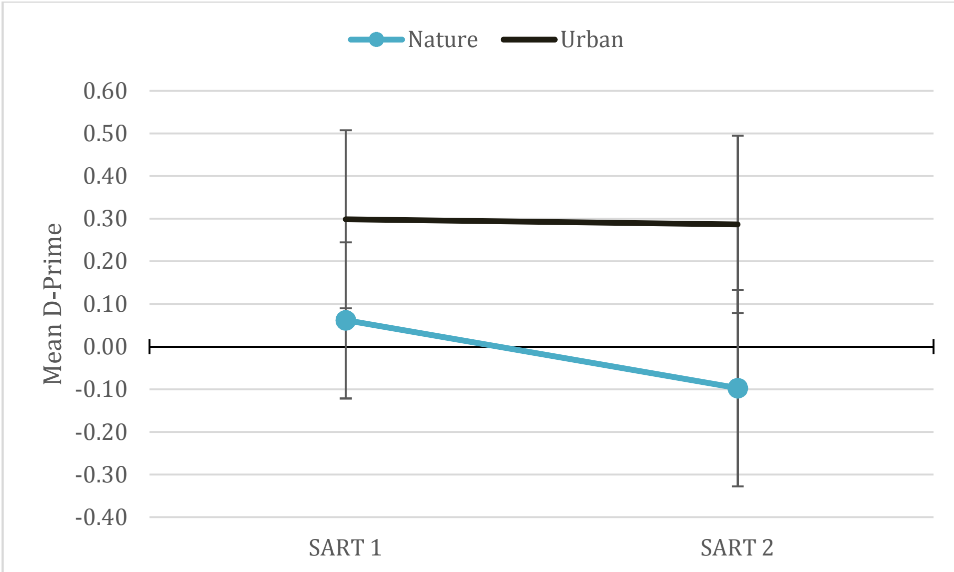

Figure 15. Average d-prime for the SART 1 and SART 2 by virtual environment. Error bars represent ±1 *SE*; M_{Nat-1} = 0.06 (1.26), M_{Nat-2} = -0.10 (1.58), n_{Nat} = 47, M_{Urb-1} = 0.30 (1.42), M_{Urb-2} = 0.29 (1.41), n_{Urb} = 46. There were no significant differences between the SART 1 and SART 2, as well as between either individual test, in both the natural and urban groups.

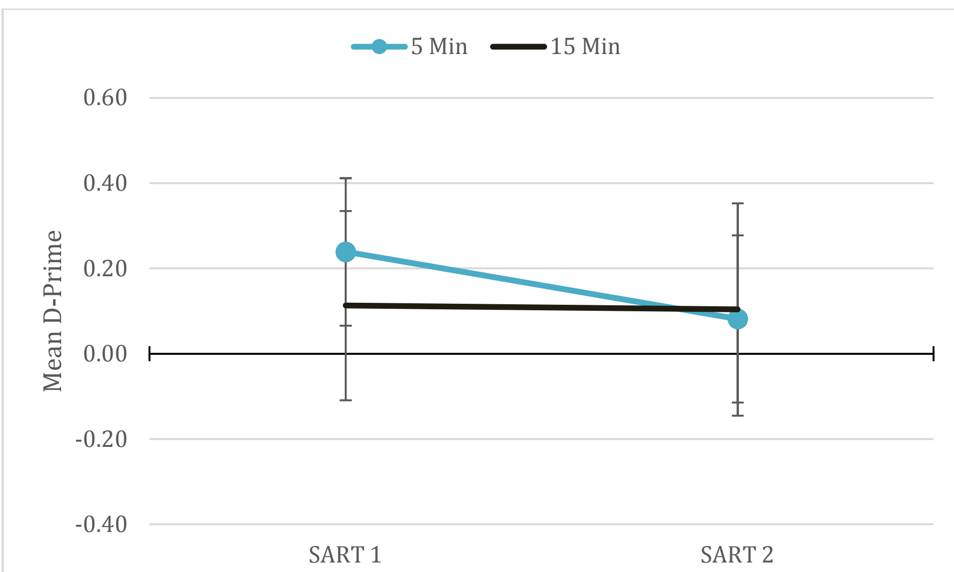

Figure 16. Average d-prime for the SART 1 and SART 2 by gameplay time. Error bars represent ±1 *SE*; M_{5-1} = 0.24 (1.21), M_{5-2} = 0.08 (1.37), n_5 = 49, M_{15-1} = 0.11 (1.47), M_{15-2} = 0.10 (1.65), n_{15} = 44. There were no significant differences between the SART 1 and SART 2, as well as between either individual test, in both the 5 min and 15 min groups.

Although the amount of restoration between the two administrations of the SART did not differ between groups, it was highly possible that performance on one of the tests differed between conditions. Of primary interest was whether nature participants did better on the second SART, presumably due to higher levels of attention, than the urban group. To investigate the possibility that performance on either of the SART administrations differed between the virtual environment or between the game time conditions, one 2 X 2 factorial ANOVA was conducted for each of the three aforementioned SART measures for both the first SART and the second SART. As shown in Figure 11, the only significant findings were that the natural group had significantly faster reaction times on both the SART 1 [$F(1, 92) = 3.98$, $p = .049$, $g = -0.47$] and the SART 2 [$F(1, 91) = 6.90$, $p = .010$, $g = -0.53$] than the urban group; there were no interactions between virtual environment and gameplay time.

Because only the natural and the 5-min groups had faster reaction times on the second SART than the first, it seemed prudent to investigate whether a particular combination of environment and time were primarily responsible for these findings. To better understand whether a particular combination of conditions lead to attention restoration, three additional paired-samples *t* tests were conducted on the four combinations of groups. Although those who played in virtual nature for 15 min [$t(22) = 1.70$, $p = .104$, $g = 0.29$], simulated urban for 5 min [$t(23) = 1.26$, $p = .220$, $g = 0.22$], and virtual urban settings for 15 min [$t(22) = .61$, $p = .550$, $g = 0.12$] did not have significantly different reaction times on the second SART than the first, those who played in virtual nature for 5 min had significantly faster reaction times on the latter SART

[$t(24) = 2.41$, $p = .024$, $g = 0.33$]. Please see Figures 17-18. As can be seen in Figures 19-22, none of the combinations of conditions had significantly more correct answers or higher d-prime scores on the second SART than the first.

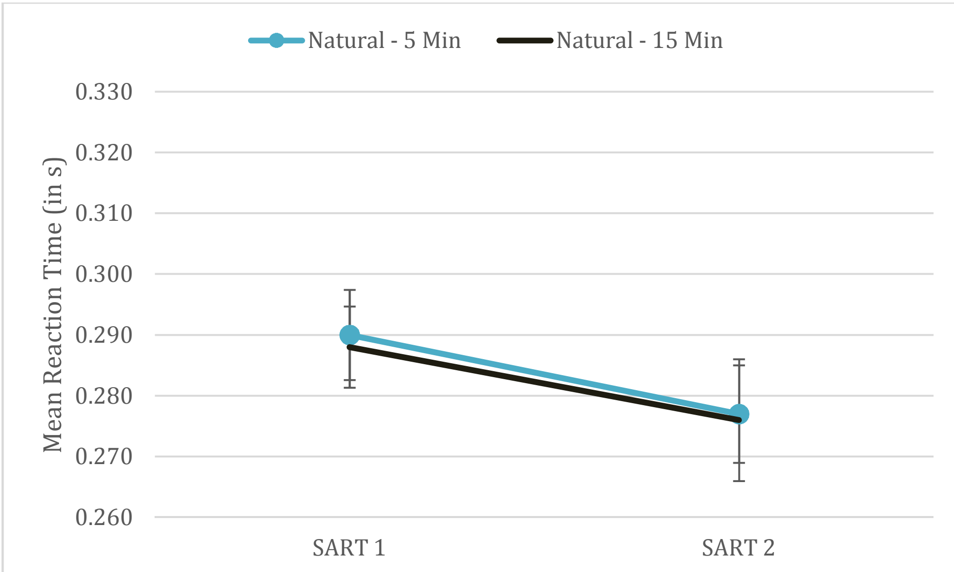

Figure 17. Change in average reaction time from the SART 1 to the SART 2 for simulated natural settings for 5 or 15 min. Error bars represent ±1 *SE*; $M_{\text{Nat-5-1}}$ = 0.290 (0.037), $M_{\text{Nat-5-2}}$ = 0.277 (0.040), $n_{\text{Nat-5}}$ = 25, $M_{\text{Nat-15-1}}$ = 0.288 (0.032), $M_{\text{Nat-15-2}}$ = 0.276 (0.048), $n_{\text{Nat-15}}$ = 23. The change from SART 1 to SART 2 in those who played in the virtual natural environment for 5 min reached significance ($p < .05$).

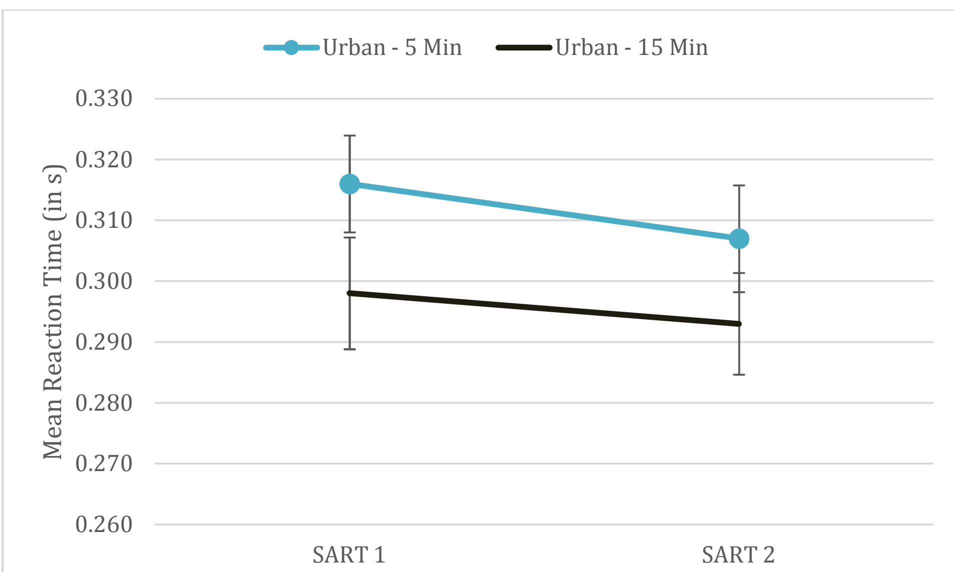

Figure 18. Change in average reaction time from the SART 1 to the SART 2 for simulated urban settings for 5 or 15 min. Error bars represent ±1 *SE*; $M_{\text{Urb-5-1}}$ = 0.316 (0.039), $M_{\text{Urb-5-2}}$ = 0.307 (0.043), $n_{\text{Urb-5}}$ = 24, $M_{\text{Urb-15-1}}$ = 0.298 (0.044), $M_{\text{Urb-15-2}}$ = 0.293 (0.040), $n_{\text{Urb-15}}$ = 23. The change from SART 1 to SART 2 did not reach significance in either group.

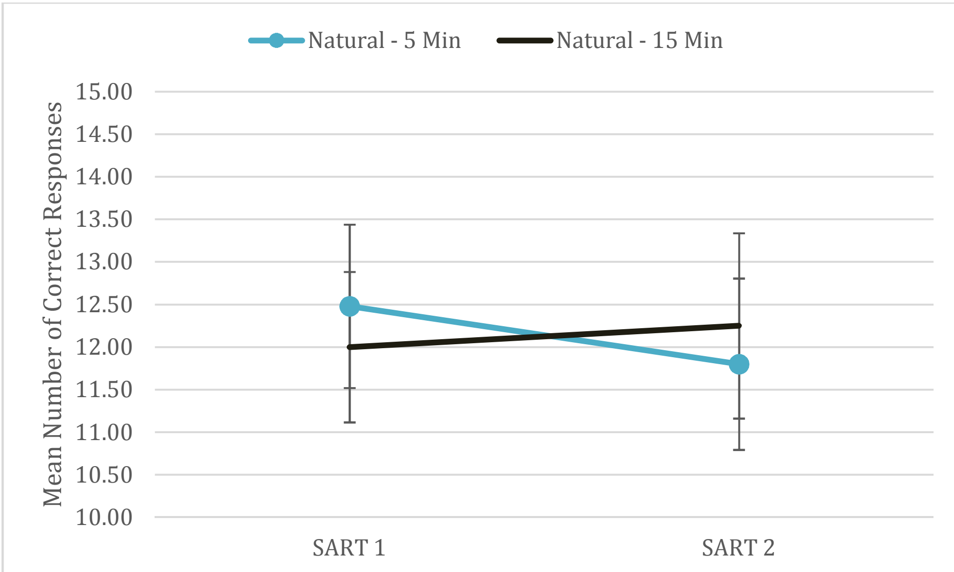

Figure 19. Change in average number of correct answers from the SART 1 to the SART 2 for simulated natural settings for 5 or 15 min. Error bars represent ±1 *SE*; $M_{\text{Nat-5-1}}$ = 12.48 (4.80), $M_{\text{Nat-5-2}}$ = 11.80 (5.03), $n_{\text{Nat-5}}$ = 25, $M_{\text{Nat-15-1}}$ = 12.00 (4.33), $M_{\text{Nat-15-2}}$ = 12.25 (5.33), $n_{\text{Nat-15}}$ = 24. The change from SART 1 to SART 2 did not reach significance in either group.

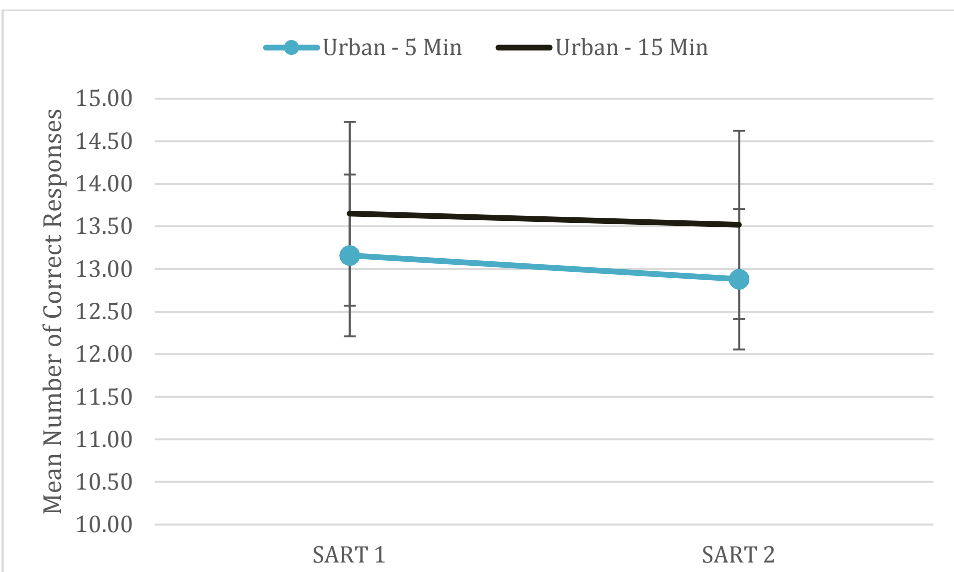

Figure 20. Change in average number of correct answers from the SART 1 to the SART 2 for simulated urban settings for 5 or 15 min. Error bars represent ±1 *SE*; $M_{\text{Urb-5-1}}$ = 13.16 (4.75), $M_{\text{Urb-5-2}}$ = 12.88 (4.12), $n_{\text{Urb-5}}$ = 25, $M_{\text{Urb-15-1}}$ = 13.65 (5.18), $M_{\text{Urb-15-2}}$ = 13.52 (5.30), $n_{\text{Urb-15}}$ = 23. The change from SART 1 to SART 2 did not reach significance in either group.

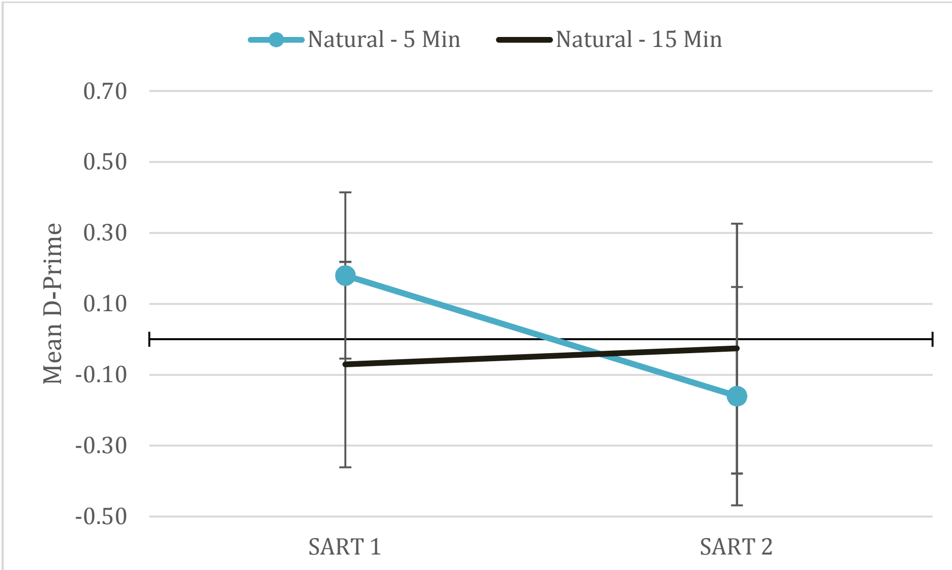

Figure 21. Change in average d-prime from the SART 1 to the SART 2 for simulated natural settings for 5 or 15 min. Error bars represent ±1 *SE*; $M_{Nat\text{-}5\text{-}1}$ = 0.18 (1.17), $M_{Nat\text{-}5\text{-}2}$ = -0.16 (1.54), $n_{Nat\text{-}5}$ = 25, $M_{Nat\text{-}15\text{-}1}$ = -0.07 (1.36), $M_{Nat\text{-}15\text{-}2}$ = -0.03 (1.65), $n_{Nat\text{-}15}$ = 22. The change from SART 1 to SART 2 did not reach significance in either group.

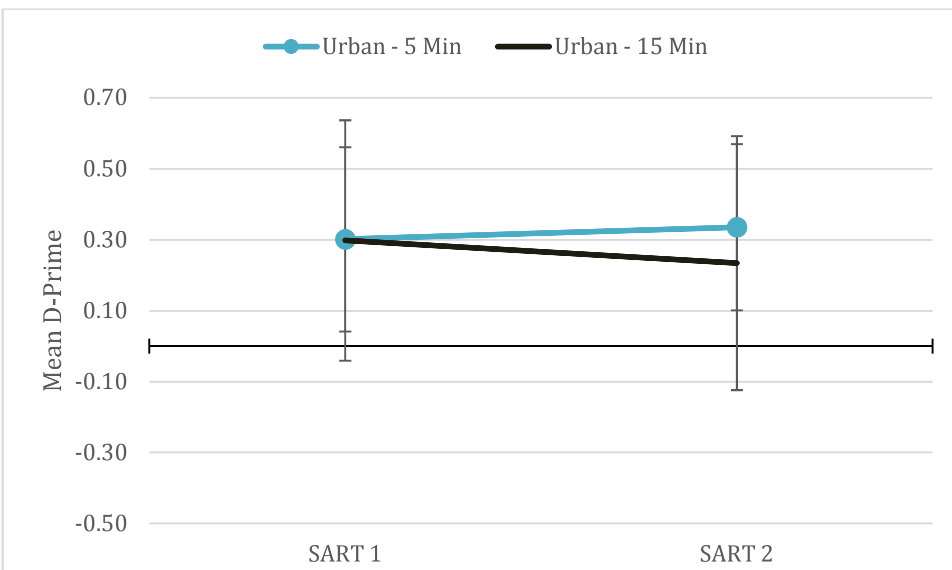

Figure 22. Change in average d-prime from the SART 1 to the SART 2 for simulated urban settings for 5 or 15 min. Error bars represent ±1 *SE*; $M_{Urb\text{-}5\text{-}1}$ = 0.30 (1.27), $M_{Urb\text{-}5\text{-}2}$ = 0.34 (1.15), $n_{Urb\text{-}5}$ = 24, $M_{Urb\text{-}15\text{-}1}$ = 0.30 (1.59), $M_{Urb\text{-}15\text{-}2}$ = 0.23 (1.68), $n_{Urb\text{-}15}$ = 22. The change from SART 1 to SART 2 did not reach significance in either group.

Discussion

Prior to this experiment, a plethora of research on Attention Restoration Theory (ART) had shown that natural environments tend to bring about more attention restoration than urban ones (e.g., Hartig et al., 1991; Raanaas et al., 2011). I examined the prospect that virtual natural environments may be more facilitative of attention restoration than simulated urban settings. Unfortunately, the results of the study did not support this notion. There were no significant differences in SART improvement scores between those who were immersed in virtual nature or urban environments, regardless of the duration of exposure to these settings. Thus, the first two hypotheses were not supported.

In addition, as attention is thought to be necessary for academic learning and achievement (Moreno, 2010, Chapter 6), I expected to find that those who were immersed in simulated natural environments would study better and thus score higher on the beer brewing test than those who were exposed to virtual urban settings. Unfortunately, paralleling the findings on attention restoration, there were no significant differences in beer brewing exam scores between the virtual nature and simulated urban groups, regardless of the duration of exposure to these environments. Consequently, the third and fourth hypotheses were not supported.

Again, as attention is thought to be required for academic learning and achievement, I hypothesized that there would be a positive relationship between attention restoration and academic achievement. However, there were no significant relationships between beer brewing exam scores and improvements in SART reaction times, correct responses, or d-prime. Thus, the fifth hypothesis was not supported.

Unfortunately, the five hypotheses of this experiment were not supported. Upon subsequent analyses, I determined that the expected negative correlations between trial number and the SART performance measures did not occur for the first administration of the SART, but they did exist in the second administration. In addition, there was substantial variation within the individual environment and gameplay time conditions, as can be seen by the large standard deviations within groups on both the SART improvement and beer brewing scores (see Figures 1-4). Thus, one plausible explanation for the lack of significance is that participants entered the experiment with different levels of available attention, which was not adequately depleted during the five minutes of the first SART administration. Consequently, the unchecked attentional differences within groups contributed to error variance and decreased the statistical power of the analyses.

Although Berto's (2005) study and this study utilized an identical SART procedure, the two experiments resulted in findings that were quite different. The only major similarity was that only those who were exposed to natural environments, rather than urban ones, had faster reaction times during their second SART than the first. Whereas Berto found that those who viewed restorative pictures had faster reaction times than the non-restorative group on the second SART but not the first, the results of this study revealed that the natural group had significantly faster reaction times than the urban group on both the first and second SARTs; this suggests that the natural group was more proficient at the SART than the urban group before being exposed to the gaming intervention. Although the natural group in this study was the only environment condition that obtained significantly faster reaction times on their second SART than the first, the significant difference on the first SART suggests that the natural group was more proficient and possibly more capable of improvement between SART administrations than the urban group. In other words, it is impossible to say with certainty that virtual nature caused the simulated nature group to obtain greater reaction time improvements because the groups were different at the start. Berto found that nature participants had improvements in reaction times, correct answers, and d-prime from the first SART to the second SART but the urban group did not, whereas the only change I found for the natural group was the aforementioned improvement in reaction times. Although Berto's study strongly suggested that exposure to natural environments brings about greater attention restoration than urban ones, this idea was not supported in this study.

It should be noted that, contrary to expectations, there was no significant difference in ratings on the Perceived Restorativeness Scale (PRS) between the virtual nature and simulated urban conditions. As mentioned previously, the PRS was designed to measure the amounts of ART elements that are present in environments to gauge their potentials for attention restoration (Hartig et al., 1997). Thus, it is possible that, as the virtual nature environments were not linked to higher PRS scores than the urban ones, there was no difference in restorative qualities between the two settings. This provides an additional explanation for the lack of significant differences in this study. However, it should be noted that the PRS had never before been used to gauge the restorative qualities of virtual environments; it may not be a satisfactory measure of restorative potential for simulated settings. Indeed, some of the questions seem awkward when applied to virtual environments (e.g., "Being here helps me to relax my focus on getting things done"). Future research should further examine the applicability of the PRS to simulated environments.

Another caveat to this study is that the beer-brewing measure may not have been a truly accurate proxy of academic achievement. This study utilized a beer-brewing measure, rather than a traditional math exam for example, because something like a math exam may be largely influenced by students' individual backgrounds. In other words, this measure was utilized to minimize unexplainable variance in participants' test scores by choosing a topic that was relatively unfamiliar to the majority of young college students. Although some may consider a beer brewing test to be an inadequate measure of academic achievement, there was a significant positive correlation between the beer brewing scores and GPA in this study. It is possible that a more traditional measure may have been more sensitive to students' academic learning and achievement. However, as attention is necessary for academic achievement and there were no differences in attention restoration as the result of my intervention, it is extremely unlikely that performance on a different measure would have significantly differed between the gaming conditions.

After weighing all of the evidence, I conclude that the virtual environments of Morrowind do not seem to have notably different effects on students' attention and academic achievement. Although the first SART did not fully deplete participants' attention, there presumably still would have been differences if Morrowind's natural settings had much stronger positive effects on attention restoration and academic achievement than its urban environments. However, this conclusion does not undermine the notion that physical natural and urban environments have differing effects on attention as described by ART, nor does it purport that such physical settings have negligibly differential effects on students' academic achievement. Instead, I suggest that the benefits of nature on these constructs are reduced when simulated in virtual environments that resemble those in this study. It is possible that factors such as more realistic graphics may increase the restorative potential of virtual natural environments, by causing these settings to more closely resemble physical nature. As much research has been done to investigate the effects of physical environments on attention restoration, further studies such as this one are needed to better understand the best media through which surrogate nature can facilitate attention restoration and academic achievement. After such research has been completed, researchers may be capable of identifying games that are both fun to play and strongly beneficial to attention and academic achievement.

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IRB Approval Form (Appendix A)

SAN JOSÉ STATE
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To: Joseph Zoland

From: Pamela Stacks, Ph.D.
Associate Vice President
Graduate Studies and Research

Date: October 16, 2012

The Human Subjects-Institutional Review Board has approved your request to use human subjects in the study entitled:

"Attention Restoration in Gaming as it Pertains to Subsequent Academic Learning"

This approval is contingent upon the subjects participating in your research project being appropriately protected from risk. This includes the protection of the confidentiality of the subjects' identity when they participate in your research project, and with regard to all data that may be collected from the subjects. The approval includes continued monitoring of your research by the Board to assure that the subjects are being adequately and properly protected from such risks. If at any time a subject becomes injured or complains of injury, you must notify Dr. Pamela Stacks, Ph.D. immediately. Injury includes but is not limited to bodily harm, psychological trauma, and release of potentially damaging personal information. This approval for the human subject's portion of your project is in effect for one year, and data collection beyond October 16, 2013 requires an extension request.

Please also be advised that all subjects need to be fully informed and aware that their participation in your research project is voluntary, and that he or she may withdraw from the project at any time. Further, a subject's participation, refusal to participate, or withdrawal will not affect any services that the subject is receiving or will receive at the institution in which the research is being conducted.

If you have any questions, please contact me at (408) 924-2427.

Protocol #S1204069

cc. Ron Rogers 0120

Morrowind Nature Pictures (Appendix B)

Morrowind Urban Pictures (Appendix C)

Beer Brewing Notes (Appendix D)

The Basics of Beer Brewing

Barley

Fundamentally beer is the product of the alcoholic fermentation by yeast of extracts of malted barley. While malt and yeast contribute substantially to the character of beers, the quality of beer is at least as much a function of the water and, especially, of the hops used in its production.

Barley starch supplies most of the sugars from which the alcohol is derived in the majority of the world's beers. Historically, this is because, unlike other cereals such as wheat, barley retains its husk on threshing and this husk traditionally formed the filter bed through which the liquid extract of sugars was separated in the brewery.

The starch in barley is enclosed in cell wall and proteins and these wrappings are stripped away in the malting process (essentially a limited germination of the barley grains), leaving the starch essentially preserved. This softens the grain and makes it more readily milled. Not only that, but unpleasant grainy and astringent characters are removed during malting.

Malting/Kilning

Malting commences with steeping of barley in water at 14-18° C for up to 48 hours, until it reaches a moisture content of 42-46%. This is usually achieved in a 3-stage process, with the steeps being interspersed with 'air rests' that allow the barley to get some oxygen (to 'breathe').

Raising the moisture content allows the grain to germinate, a process that usually takes 3-5 days at 16-20° C. In germination, the enzymes break down the cell walls and some of the protein in the starchy endosperm, which is the grain's food reserve, rendering the grain friable. Amylases are produced in germination and these are important for the mashing process in the brewery.

After the malt is steeped, it is placed inside of a kiln. Progressively increasing the temperature during kilning arrests germination. Regimes that progressively increase temperatures over the range 50 to perhaps 110° C are used to dry the malted barley to less than 5% moisture, while preserving heat-sensitive enzymes. The more intense the kilning process, the darker the malt and the more roasted and burnt are its flavor characteristics.

Mashing

In the brewery, the malted grain must first be milled to produce relatively fine particles, which are for the most part starch. The particles are then intimately mixed with hot water in a process called mashing. The water must possess the right mix of salts. For example fine ales are produced from waters with high levels of calcium. Famous pilsners are from waters with low levels of calcium. Typically mashes have a thickness of three parts water to one part malt and contain a stand at around 65° C, at which temperature the granules of starch are converted by gelatinization from an indigestible granular state into a "melted" form which is much more susceptible to enzymatic digestion.

The enzymes that break down the starch are called the amylases. They are developed during the malting process, but only start to act once the gelatinization of the starch has occurred in the mash tun. Some brewers will have added starch from other sources, such as maize or rice, to supplement that from malt. These other sources are called adjuncts.

Lautering/Boiling

After perhaps an hour of mashing, the liquid portion of the mash, known as the wort, is recovered, either by straining through the residual spent grains (lautering) or by filtering through plates. The wort is run to the kettle (sometimes known as the copper, even though they are nowadays fabricated from stainless steel) where it is boiled, usually for 1 hour. Boiling serves various functions, including sterilization of wort, precipitation of proteins (which would otherwise come out of solution in the finished beer and cause cloudiness), and the driving away of unpleasant grainy characters originating in the barley. Many brewers also add some adjunct sugars at this stage, at which most brewers introduce at least a proportion of their hops.

Hopping

The hops have two principal components: resins and essential oils. The chemical composition of the resins (so-called alpha-acids) are changed ("isomerized") during boiling to yield iso-alpha-acids, which provide the bitterness to beer. This process is rather inefficient. Nowadays, hops are often extracted with liquefied carbon dioxide and the extract is either added to the kettle or extensively isomerized outside the brewery for addition to the finished beer (thereby avoiding losses due to the bitter substances' tendency to stick on to yeast).

The oils are responsible for the "hoppy nose" on beer. They are very volatile and if the hops are all added at the start of the boil then all of the aroma will be blown up the chimney. In traditional lager brewing a proportion of the hops are held back and only added towards the end of boiling, which allows the oils to remain in the wort. For obvious reasons, this process is called late hopping. In traditional ale production, a handful of hops is added to the cask at the end of the process, enabling a complex mixture of oils to give a distinctive character to such products. This is called dry hopping. Liquid carbon dioxide can be used to extract oils as well as resins and these extracts can also be added late in the process to make modifications to beer flavor.

Fermentation

After the precipitate produced during boiling has been removed, the hopped wort is cooled and pitched with yeast. There are many strains of brewing yeast (Saccharomyces Cerevisiae), and brewers jealously guard and look after their own strains because of their importance in determining brand identity. Fundamentally brewing yeast can be divided into ale and lager strains, the former type collecting at the surface of the fermenting wort and the latter settling to the bottom of a fermentation (although this differentiation is becoming blurred with modern fermenters). Both types need a little oxygen to trigger off their metabolism, but otherwise the alcoholic fermentation is anaerobic. Ale fermentations are usually complete within a few days at temperatures as high as 20° C, whereas lager fermentations at as low as 6° C can take several weeks. Fermentation is complete when the desired alcohol content has been reached and when an unpleasant butterscotch flavor which develops during all fermentations has been mopped up by yeast. The yeast is harvested for use in the next fermentation.

Conditioning

Nowadays, the majority of beers, both ales and lagers, receive a relatively short conditioning period after fermentation and before filtration. This conditioning is ideally performed at –1° C for a minimum of three days, under which conditions more proteins drop out of solution, making the beer less likely to go cloudy in the package or glass.

The filtered beer is adjusted to the required carbonation before packaging into cans, kegs or glass or plastic bottles. Much of the carbonation in beer is a natural result (CO_2 byproducts) of the fermentation process.

Beer Brewing Assessment (Appendix E)

Please do not start this assessment until the researcher instructs you to do so. If you opened this page by accident, please press the minimize button in the upper right hand corner and select the correct program instead. Thank you for your cooperation.

Please write your participant ID number in the box below. You can refer to the sticky note program by pressing the minimize or restore down button in the top right hand corner. Please verify that the number is correct, as an incorrect entry will both hinder data collection and make it impossible to enter you into the raffle.

Participant ID Number:

After you have verified that the ID number is correct, please maximize this window (make this page cover the whole screen) and do not refer to any outside materials for the rest of the assessment period. Please wait until the experimenter tells you to begin before starting the test.

Instructions: Please electronically mark your responses on this form. Remember, you are not allowed to use any outside materials. This test contains a total of 28 questions and you will have 20 minutes to complete it. Have fun and good luck!

What is the most common source of the sugars used in beer?
- ❍ Hops (1)
- ❍ Barley (2)
- ❍ Wheat (3)
- ❍ Yeast (4)

The “melting” of starch during mashing is called
- ❍ Isomerization (1)
- ❍ Malting (2)
- ❍ Precipitation (3)
- ❍ Gelatinization (4)

What is the purpose of raising the temperature during kilning?
- ❍ To boil the mash (1)
- ❍ To break down the cell wall and proteins surrounding the starch (2)
- ❍ To stop the germination of the barley sprouts (3)
- ❍ To melt the barley starch and cause gelatinization (4)

Isomerization refers to
- A change in chemical structure (1)
- The removal of ions from the Barley extract (2)
- The building of maltose molecules (3)
- A process that can usually take 3-5 days (4)

Alcoholic fermentation is primarily
- Anaerobic (does not use oxygen) (1)
- Aerobic (uses oxygen) (2)
- Both A and B (3)
- None of the above (4)

Why are the barley sprouts germinated?
- To break down the cell wall and proteins surrounding the starch (1)
- To increase the amount of barley in the malt (2)
- To break down the starch before gelatinization (3)
- To increase the amount of adjuncts in the mash (4)

Lautering is the process whereby
- Fresh barley is boiled in water (1)
- The composition of the oils and resins from the hops are changed (2)
- The liquid portion of the mash is strained (3)
- Granules of starch are converted into simple sugars (4)

Which of the following beer brewing steps are in the right order?
- Mashing, Lautering, Malting, Conditioning (1)
- Kilning, Lautering, Hopping, Fermentation (2)
- Malting, Hopping, Mashing, Conditioning (3)
- Malting, Kilning, Fermenting, Boiling (4)

In beer brewing, adjuncts are defined as
- Enzymes that break down starch (1)
- Seasonings added with the hops (2)
- Salts added to the water to produce the right mix (3)
- Additional sources of starch (4)

'Air rests' during malting
- Keep the barley from burning (1)
- Allow the barley to dry (2)
- Give the barley oxygen (3)
- Give the malt yeast (4)

The malt sugar solution is boiled with hops in order to
- ❍ Increase the alcohol content (1)
- ❍ Provide seasoning (2)
- ❍ Release enzymes in the hops (3)
- ❍ Filter unwanted organic waste (4)

Kilning usually removes around _____ of the moisture from the malted barley
- ❍ 5% (1)
- ❍ 25% (2)
- ❍ 75% (3)
- ❍ 95% (4)

The two main products of the fermentation process in beer brewing are
- ❍ Yeast and barley (1)
- ❍ Amylase and alcohol (2)
- ❍ O2 and alcohol (3)
- ❍ CO2 and alcohol (4)

Which of the following are the most crucial to the beer brewing process?
- ❍ Water, barley, yeast (1)
- ❍ Hops, Yeast, O2 (2)
- ❍ O2, water, amylases (3)
- ❍ Yeast, salt, barley (4)

The enzymes that break down the cell walls and expose the starch are called
- ❍ Yeasts (1)
- ❍ Adjuncts (2)
- ❍ Saccharomyces Cerevisiae (3)
- ❍ Amylases (4)

Fine ales are typically produced from waters with
- ❍ High levels of Sodium (1)
- ❍ Low levels of Sodium (2)
- ❍ High levels of Calcium (3)
- ❍ Low levels of Calcium (4)

During malting, barley is stepped in water around
- ❍ 5-10°C (1)
- ❍ 14-18°C (2)
- ❍ 30-40°C (3)
- ❍ 100-150°C (4)

Kilning is similar to which process?

- Thickening a liquid (1)
- Sprouting seeds (2)
- Roasting coffee (3)
- Boiling water (4)

The carbonation in beer

- Is added after the beer has fermented (1)
- Is due primarily to the addition of hops during boiling (2)
- Is what eventually kills off the yeast (3)
- Is a natural result of fermentation (4)

The two principal components of the hops are the

- Yeast and sugar (1)
- Yeast and amylase (2)
- Starch and maltose (3)
- Resins and essential oils (4)

Kilning usually occurs around

- 0-50°C (1)
- 20-60°C (2)
- 50-110°C (3)
- 100-150°C (4)

Lagers generally have yeast that

- Collect at the top of the fermenting wort (1)
- Collect at the bottom of the fermenting wort (2)
- Do not collect in any particular area (3)
- Produce lower amounts of alcohol compared to ales (4)

Conditioning is ideally performed at

- 15°C for at least 5 days (1)
- 5°C for at least 3 days (2)
- -5°C for at no more than 5 days (3)
- -1℃ for at least 3 days (4)

Beer is composed mostly of

- Malted barley (1)
- Alcohol (2)
- Hops (3)
- Water (4)

During winemaking, grapes are often crushed in order to free the contents of the berries. This process is most similar to

- Mashing (1)
- Malting (2)
- Lautering (3)
- Kilning (4)

What is most likely the correct set of steps for winemaking?

- Crush grapes, mix with sugar and water, strain liquid, add yeast, ferment, bottle (1)
- Crush grapes, mix with sugar and water, add yeast, ferment, boil, strain liquid, bottle (2)
- Crush grapes, mix with sugar and water, add yeast, ferment, strain liquid, bottle (3)
- Sprout grapes, mix with sugar and water, boil, add yeast, ferment, bottle (4)

Malting is similar to which process?

- Thickening a liquid (1)
- Sprouting seeds (2)
- Roasting coffee (3)
- Boiling water (4)

Yeast is added to the hopped wort in order to

- Provide seasoning (1)
- Activate the enzymes for mashing (2)
- Begin fermentation (3)
- Produce CO_2 (4)

You have reached the end of the assessment. Please feel free to check and modify your answers until the time is up; you may return to previous pages by clicking the arrow facing to the left. Otherwise, mark the box below and click the arrow facing to the right in order to submit your answers.

- Yes, I have completed the assessment. If I have finished early, I will wait quietly for everyone else to finish. (1)

Demographics Form (Appendix F)

Please do not start this survey until the researcher instructs you to do so. If you opened this page by accident, please press the minimize button in the upper right hand corner and select the correct program instead. Thank you for your cooperation.

Instructions: Please click the answer that best describes you and type in your answer when a blank is provided. Again, please refer to the sticky note to write your participant ID number and verify that it is correct before beginning the survey. Thank you!

Participant ID Number:

Gender
- ❍ Male (1)
- ❍ Female (2)
- ❍ Other (Please Specify Below) (3) ____________________

Age

Ethnicity
- ❍ Asian (1)
- ❍ Black (2)
- ❍ White (3)
- ❍ Hispanic (4)
- ❍ Native American (5)
- ❍ Pacific Islander (6)
- ❍ Other (Please Specify Below) (7) ____________________

College Major

College GPA (0.00 - 4.00)

College Year
- ❍ Freshman (1)
- ❍ Sophomore (2)
- ❍ Junior (3)
- ❍ Senior (4)
- ❍ Super Senior (5+ Years) (5)

Total Hours of Console, Computer, + Phone Games per Week

How Much Had You Played Morrowind Before Today?

- None (6)
- Not Much (7)
- Some (8)
- Quite a Bit (10)
- A Lot (9)

Level of Interest in the Beer Brewing Process

- Not interested (1)
- Slightly interested (2)
- Moderately interested (3)
- Quite interested (4)
- Extremely interested (5)

Previous Knowledge About Beer Brewing

- Knew nothing (1)
- Knew very little (2)
- Knew some things (3)
- Knew a lot (4)
- Knew most things (5)

Informed Consent Form (Appendix G)

Agreement to Participate in Research

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Responsible Investigator(s): Joseph Zoland (SJSU M.A. Student) and Dr. Ron Rogers (Department Chair, SJSU Psychology Department)
Title of Protocol: Gaming and Learning

1. You have been asked to participate in a research study investigating the effects of computerized activities on the acquisition of knowledge.
2. You will be asked to perform a computerized task of cognition twice, play a computer game, read some notes on beer brewing, and complete both an assessment on beer brewing and a short survey. This study's estimated duration is 1.5 hr and it will be conducted in a Dudley Moorhead Hall (DMH) computer lab at SJSU.
3. Please do not participate if you have a history of seizures while playing video games (viz., photosensitive epilepsy or video game-induced seizures), as there is a possibility that the tasks of this study may invoke a seizure for those with such a history. There is a slight chance that the playing of the video games may cause motion sickness or discomfort due to minimal violence that has been deemed acceptable for teens, so please do not participate if these have been serious issues in your past. Other possible minor discomforts include minimal levels of cognitive strain and test-taking anxiety while completing the aforementioned tasks. No additional risks or discomforts are anticipated.
4. You may benefit from learning about beer brewing in this experiment.
5. Although the results of this study may be published, no information that could identify you will be included. During data collection, participant numbers that are not directly linked to their identities will be used to classify the data. Afterward, consent forms will be stored in a locked file cabinet in the DMH building at SJSU, and the remaining data will be stored in the primary investigator's password-protected computer.
6. You will receive course credit if you participate in this experiment as part of a course requirement. In addition, all participants who correctly answer 60% of the assessment questions will have the chance to win one of five $20 iTunes gift cards in an upcoming raffle.
7. Questions about this research may be addressed to Joseph Zoland [redacted] Complaints about the research may be presented to Ronald Rogers, Department Chair of psychology, at (408)924-5652**.** Questions about a research subjects' rights, or research-related injury may be presented to Pamela Stacks, Ph.D., Associate Vice President, Graduate Studies and Research, at (408) 924-2427.
8. No service of any kind, to which you are otherwise entitled, will be lost or jeopardized if you choose not to participate in the study.
9. Your consent is being given voluntarily. You may refuse to participate in the entire study or in any part of the study. You have the right to not answer questions you do not wish to answer. If you decide to participate in the study, you are free to withdraw at any time without any negative effect on your relations with San Jose State University.
10. At the time that you sign this consent form, you will receive a copy of it for your records, signed and dated by the investigator.

- The signature of a subject on this document indicates agreement to participate in the study.
- The signature of a researcher on this document indicates agreement to include the above named subject in the research and attestation that the subject has been fully informed of his or her rights.

_______________________________	______________
Participant's Signature	Date
_______________________________	______________
Investigator's Signature	Date

Debriefing Form (Appendix H)

Recently, you completed an experiment examining the effects of a study break on the acquisition of knowledge. In the beginning of the experiment, you completed the Sustained Attention to Response Task (SART). We had participants complete this task to exhaust their attention; this was done to simulate how one's attention becomes depleted after studying for a long period of time. Afterward, you played a video game called Morrowind, which acted as the study break. Later, you read some notes and completed an assessment. We included five $20 iTunes gift cards to motivate participants to try their very best when studying for and completing the assessment. We were interested in examining elements of the video games that may restore attention and facilitate subsequent learning, as measured by the beer brewing examination.

The primary investigator of this experiment is Joseph Zoland, an MA student in the Experimental Psychology Program at San Jose State University. If you have any questions or concerns about this study that were not addressed in this debriefing, you may email Joseph Zoland.

If you require them, the SJSU Student Health Center and SJSU Counseling Services are available to you as resources. The SJSU Student Health Center is located directly behind the Event Center, phone: (408)924-6122. The SJSU Counseling Services is located in the Administration Building room 201, phone: (408)924-5910.

We could not inform you of this research's purpose before your completion of the experiment because it may have influenced your actions and/or responses. Please do not tell other students about this experiment's purpose because we would not want potential future participants to become biased from their knowledge of this debriefing information.

Thank you for your cooperation and participation!