Digital Nature Benefits Typical Individuals but not Individuals with Depressive Symptoms

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Abstract

Being in the natural environment has beneficial effects, including improved performance on subsequent mental tasks that require careful control over thought and action. This restorative effect has also been observed for individuals with depression after they experienced a 50 min walk in nature. While individuals without depression experienced this restorative effect even after brief exposure to low-intensity, digital nature stimuli, the negative thought biases associated with depressive symptomatology might interfere with the restorative effect during such brief exposures. The goal of this study was to assess whether brief exposure (4 min and 10 s) to two-dimensional digital nature images results in the restorative effect on a cognitive control task, the Sustained Attention to Response Task (SART), in individuals with depressive symptoms, compared to a control group without these symptoms. The results indicated that only typical individuals show improved performance after the low-intensity nature exposure, while individuals with significant depressive symptoms experienced no performance improvement. Thus, the findings imply that the salient negative self-focus associated with depression inhibits the restorative effect during such brief nature interventions. The results provide potential constraints for the scope of the restorative effect with digital nature and boundaries for its application in treatment of individuals with certain psychological states, such as depression. Key Words: Restorative natural environments—Cognitive—Environmental psychology—Emotions—Depression.

The beneficial restorative effect of nature has been reported for perceived self-regulation (Herzog & Rector, 2009; Kaplan, 2001) as well as performance of cognitive control tasks associated with certain subcomponents of executive functioning requiring directed attention. Directed attention, similar to top-down processing (Kaplan and Berman, 2010) is essential for accomplishing tasks of daily living. For example, when a graduate student is writing a difficult thesis, the natural urge to socialize with friends must often be inhibited. Such effortful tasks are mentally fatiguing for individuals, depleting their attentional resources. While both meditation and nature exposure have been recommended as a restorative technique to improve performance on cognitive control tasks (Kaplan, 1995; Tang & Posner, 2009), the latter is the focus of the current study.

Nature interventions for cognitive control tasks

A substantial body of research indicates that natural environments possess greater restorative potential than urban and indoor environments for typical individuals. For example, Ottosson and Grahn (2005) demonstrated that senior citizens performed better on cognitive control tasks after having spent one hour in a garden than after spending an hour inside. Similarly, research with college students indicated greater performance improvements on the backward digit span (DSB) after walking for 50–55 min in nature than after walking in an urban environment (e.g., downtown streets; see Berman et al., 2008). The restorative effect has also been observed for much briefer exposures to digital nature in typical individuals. Berman and colleagues (2008) indicated that viewing pictures of nature for

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approximately 6 min resulted in improved performance on the executive portions of the Attention Network Test as well as the DSB in typical individuals, and this did not occur for viewing digital urban environments. Likewise, Berto (2005) indicated that brief exposure (4–6 min) to digital nature images (but not digital urban images) resulted in improved performance on the Sustained Attention to Response Task (SART) in typical individuals.

Attention Restoration Theory (Kaplan, 1995) suggests that restorative environments may mitigate the depletion of specific attentional resources involved in directed attention via *soft fascination*. Soft fascination describes an attentional process that occurs when being in compatible restorative surroundings; in this context, attention is lightly attracted to the environment's features. Thus, there is no need to direct and control attention. This allows directed attention to rest and recuperate, reducing mental fatigue and generating positive affect. Furthermore, individuals who are dealing with persistent problems may have diminished attentional resources and enhanced mental fatigue and may then be unable to control their thoughts and constantly ruminate about their problems. Specifically, individuals with depressive symptomology have been shown to experience significantly higher levels of rumination or obsessive thoughts about their problems and symptoms. These thoughts may place demands on cognition (i.e., cognitive load), which is associated with the inability to mentally manage additional complex tasks (Matthews et al., 2000). Consistent with cognitive load, individuals with depressive symptomology have shown a disrupted ability to perform complex cognitive tasks that rely on directed attention (Watkins & Brown, 2002). Soft fascination, which allows attentional resources to replenish, might be hindered during brief exposure to nature imagery in individuals with depressive symptoms, as the strong negative thought biases and self-schemas might require more time and/or more salient external stimuli to engage in soft fascination.

Negative thought biases, depressive states, and cognition

The cognitive theory of depression (Beck, 1976) posits that depressive symptoms generally result from negative thought biases rooted in dysfunctional self-schemas. Importantly, negatively biased thoughts or perceptions resulting from these maladaptive core beliefs are believed to reciprocally reinforce negative self-schemas, in turn creating a self-perpetuating depressive cognitive loop with continually reinforced negative thought biases in nearly all aspects of information processing, including perception, attention, and memory (e.g., Beck, 1976). For example, depressive symptoms have been linked to biased retrieval processes (Hamilton & Gotlib, 2008; Williams et al., 1997), selective attention to negatively valenced stimuli (e.g., Gotlib & McCann, 1984; Mathews et al., 1996; Mogg et al., 1992), and limited attention to positive stimuli (e.g., Gotlib et al., 1988; Mogg et al., 1991). Further, individuals experiencing depressive symptoms often demonstrate mental control decrements and other impairments in cognition (Elliott, 1998) and generate overactive brain activity when performing mentally demanding tasks relative to controls (Harvey et al., 2005). This finding is consistent with cognitive load imposed by the depressive loop (Watkins & Brown, 2002). High cognitive load has been associated with inferior cognitive task performance (Matthews et al., 2000). Will interventions utilizing restorative environments via digital nature effectively rejuvenate the depleted mental resources of individuals experiencing depressive states?

Depressive states and restoration

Research by Berman and colleagues (2012) indicated that depressed individuals exhibit improved cognitive control, as indicated by improved performance on the DSB task, after a one-hour walk through an arboretum versus downtown streets. This indicates that prolonged experience in actual nature has a positive influence on cognitive functioning in depressed populations (Berman et al., 2012). While the restorative effect on cognitive control tasks has also been previously observed for brief exposure to two-dimensional digital nature pictures for typical individuals (Berman et al., 2008; Berto, 2005), the negative thought biases typical of depressive symptomology may modify one's ability to benefit from brief restorative exposures. Specifically, the bias could interfere with the ability to focus on positive stimuli such as those found in natural landscapes during brief exposures to digital, low-intensity nature stimuli and consequently might hinder the effects of soft fascination. However, prior research has not assessed whether these findings extend to individuals with depressive symptoms.

Thus, the goal of the present study was to assess whether brief exposure to nature, particularly two-dimensional images presented in a digital format for several minutes, results in the restorative effect on a cognitive control task, the SART, in individuals with depressive symptomatology.

Method

Participants

Forty-eight individuals from a nonclinical population participated (22 women, 26 men), with an average age of 20.1 years. Participants took part in the study for course credit as part of the psychology research pool. Depressive symptoms were assessed using the Center for

Epidemiological Studies Depression Scale (CES-D; Radloff, 1991; see later description). For each condition (typical versus depressive symptoms), there were 24 participants; 12 participants were randomly assigned to the restorative condition, and 12 participants were randomly assigned to the nonrestorative (urban) condition. To recruit participants with depressive symptoms, the research team made use of a pre-screening tool administered to consenting participants at the beginning of each semester. This pre-screening survey included the CES-D. Participants received course credit as part of the psychology research pool for participating in the pre-screening. Those with heightened depressive symptomatology, as indicated by their CES-D score (described later), were contacted to participate in the present study. Participants were unaware as to why they were invited to participate.

Stimuli and measures

Center for Epidemiological Studies Depression Scale. Depressive symptoms were measured according to scores on the CES-D (Radloff, 1991). This scale was designed to measure depressive symptomatology in the general population. The CES-D is a 20-item self-report measure of depressive symptoms. The CES-D assesses various symptomatic aspects of depression including feelings of worthlessness and guilt, sadness, anhedonia, and helplessness. Acceptable levels of reliability and validity have previously been obtained in a sample of adolescents and college students (Radloff, 1991). Twenty-four participants were classified as typical and 24 as expressing depressive symptoms, as CES-D scores of 16 or above indexed significant depressive symptomology, consistent with previous literature (Radloff, 1977). The individuals scoring below this cutoff were classified in the present study as typical, as the scale was designed to assess depression in the general population, and these individuals are unlikely to have depression. The range of CES-D scores for typical individuals was 2–14 ($M = 8.13$, $SE = 0.75$), and 17–41 ($M = 24.36$, $SE = 1.43$) among individuals with depressive symptoms. There was no significant difference between typical individuals and individuals with depressive symptoms in age [$t\ (46) = -.455$, $p = .65$] or gender ($\chi^2 = 1.343$, $p = .247$).

Sustained Attention to Response Task. Sustained attention was measured using the SART (Robertson et al., 1997). The SART was administered on a Mac OSX computer with a 20 in. monitor (17½ in. horizontal, 10¾ in. vertical). This no-go task requires participants to abstain from responding to critical signals (the number 3) while rapidly responding to noncritical signals by pressing the space bar (all other digits, 1 through 9). Poor performance on this task has been linked to both attentional failures and neurocognitive dysfunction, as one must keep the task goals in mind with directed attention and infrequently interrupt the impulse to respond (Robertson et al., 1997). Each number was presented quickly (250 ms) and then covered by a mask (a number sign, #) for a restricted period of time (885 ms). Participants had the entire stimulus and mask presentation time to respond or not respond to a stimulus (1135 ms). There were a total of 240 trials, with 24 of them (10%) being target trials (the number 3). The digits (1–9) were presented in 48 pt, 72 pt, 94 pt, 100 pt, and 120 pt font, in order to reduce reliance on physical cues. The stimuli were black on a white background. SART performance, particularly the metric of the rate of responses to the target number, has been associated with attentional errors, lapses, and frontal lobe dysfunction (Robertson et al., 1997).

Restoration condition. Restorative images and nonrestorative images were taken from previous research utilizing similar research methods (Berto, 2005). These digital images were originally compiled after an extensive survey using a scale of perceived restorativeness (Korpela & Hartig, 1996), with the highest- and lowest-scoring images used as stimuli for restorative and nonrestorative environments, respectively, with a cutoff score of 6.5 or greater for restorative pictures and 3 or less for nonrestorative pictures (see Berto, 2005, for details). Restorative images were nature scenes, primarily consisting of grasslands, rivers, and landscapes. Nonrestorative images were pictures of city streets, neighborhoods, and factories. Pictures were displayed digitally on a 20 in. monitor.

Procedure

After arriving at the experiment, participants signed consent and completed the CES-D (Radloff, 1977). Participants then performed the first iteration of a 5 min SART. After the first execution of the SART, participants in the restorative condition viewed nature pictures, while those in the nonrestorative condition viewed urban environment pictures. Participants assigned to both conditions were informed that they could relax when viewing the pictures and that they would not have to use the pictures for a later task. In both viewing conditions, 25 digital pictures were displayed in random order at a speed of 10 s per picture, resulting in a total viewing time of 4 min and 10 s. After viewing the images, participants immediately completed the second administration of the 5 min SART. The parameters of the second iteration of the SART were identical to the initial SART.

Results

Sustained Attention to Response Task performance was measured using the percentage of correct responses to the critical target

(number 3), which required abstaining from pressing the space bar. The number of correct responses to the target number (3) was divided by the total number of target trials and multiplied by 100 to calculate a percentage of hits. Lower percentages indicate more errors. The percent correct response to the target in the SART (see Fig. 1) was analyzed using a 2 (SART administrations) × 2 (Restorative condition) × 2 (Depressive symptoms) mixed ANOVA. Restorative condition (restorative vs. nonrestorative) and depressive symptoms (typical vs. depressive) served as between-group variables, and SART administration (before and after the administration of the restorative condition) served as the repeated-measures variable. Mauchly's test of sphericity indicated that the sphericity assumption was met.

A significant condition × SART administration interaction was observed, $F(1, 44) = 19.77$, $p < .001$, $n_p^2 = .31$. Furthermore, a significant condition × depressive symptoms × SART administration interaction was observed, $F(1, 44) = 11.90$, $p = .001$, $n_p^2 = .21$. None of the other main-effects and interactions were significant. The condition × depressive symptoms × SART administration interactions were further analyzed using restrictive error terms, which are solely based on the data involved in a given effect/comparison (see Myers and Well, 2003). The analysis of this three-way interaction indicated that participant's SART performance at the first iteration did not differ across the restorative ($M = 63.37$, $SE = 4.21$) and the nonrestorative ($M = 65.45$, $SE = 3.79$) condition, $t(46) = 0.37$, $p = .715$, 95% CI [-13.490, 9.322], $d = .11$ (using pooled SD). Further, those with depressive symptoms ($M = 64.76\%$, $SE = 4.73$) and typical individuals ($M = 64.06\%$, $SE = 3.13$) did not differ on their initial SART performance, $t(39.90) = -0.122$, $p = .903$, 95% CI [-12,163, 10.774], $d = .035$ (using pooled SD). The three-way interaction was further analyzed to determine if the impact of the two conditions (restorative vs. nonrestorative) on SART performance differed for depressive and typical participants. The analysis of typical participants assigned to the restorative condition revealed improved SART performance on the second SART iteration ($M = 76.74\%$, SE = 5.41) compared to the initial SART performance ($M = 63.54\%$, SE = 3.81), $t(11) = -2.99$, $p = .012$, 95% CI [-22.894, −3.495], $d = .864$ (this and all subsequent d were derived using the SD of the difference scores). However, SART performance of typical participants assigned to the nonrestorative condition deteriorated from the first iteration ($M = 64.58\%$, $SE = 5.14$) to the second iteration ($M = 47.57\%$, $SE = 4.98$), $t(11) = 7.00$, $p < .001$, 95% CI [11.664, −22.364], $d = 2.021$.

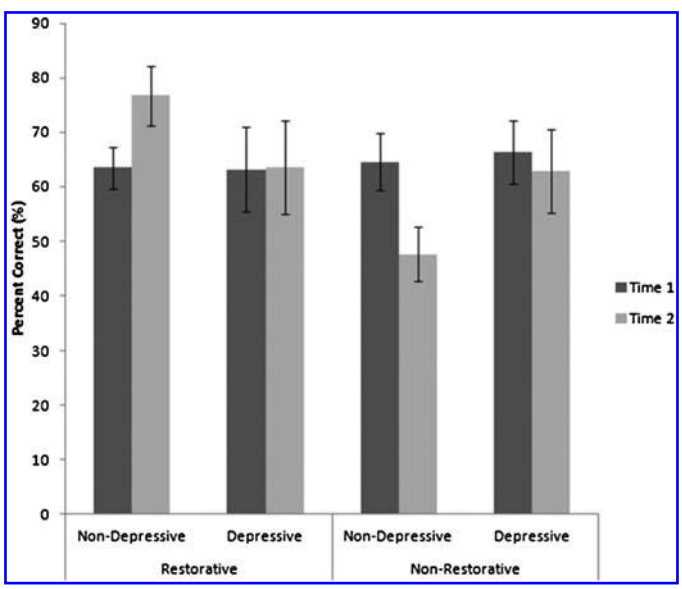

Fig. 1. Percent correct withholding of response to target (3) for each condition. Error bars represent standard error.

Among the group with depressive symptoms, SART performance tended to remain the same from the first iteration ($M = 63.19\%$, $SE = 7.72$) to the second iteration ($M = 63.54\%$, $SE = 8.52$) for the restorative condition $t(11) = -.079$, $p = .938$, 95% CI [-9.956, 9.262], $d = .022$. Similarly, SART performance among participants with depressive symptoms assigned to the nonrestorative condition did not significantly differ between the first iteration ($M = 66.32\%$, $SE = 5.79$) and the second iteration ($M = 62.84\%$, $SE = 7.59$), $t(11) = .923$, $p = .376$, 95% CI [-4.810, 11.755], $d = .266$.

Discussion

The purpose of this study was to investigate if brief, low-intensity, digital nature exposure has similar effects on typical individuals as those with depressive symptoms. Individuals performed a 5 min SART, briefly observed two-dimensional nature or urban pictures, and then performed the 5 min SART again. The results indicated that typical participants demonstrated improved performance on the SART after viewing two-dimensional, digital nature scenes, an indication of restored cognition for the typical sample. This finding is generally consistent with previous literature, demonstrating an improvement in attention and cognitive control after individuals briefly observe digital, two-dimensional natural environments (Berman et al., 2008; Berto, 2005). Thus, mere exposure to digital nature scenes may serve as a source of soft fascination for typical individuals, leading to the initial stage of the restorative effect. Therefore, even seemingly insignificant nature elements added to an environment, such as digital images, may serve to restore attentional control

for typical individuals (Taylor & Kuo, 2009). However, it is important to remember that technological nature interfaces offer some but not all of the benefits associated with exposure to actual nature (Kahn, 2011; Kahn et al., 2009). Thus, soft fascination and the restorative effect induced by digital nature stimuli might not be as effective as those induced by actual nature exposure.

In contrast to typical participants, those with depressive symptoms did not significantly benefit from brief, digital, two-dimensional (low-intensity) nature exposure. Although previous research showed restorative benefits for depressed participants with prolonged actual nature interaction (Berman et al., 2012), the lack of significance of this effect for brief, digital, two-dimensional nature exposure by participants with depressive symptomatology in the present study is due to the low observed effect size ($d = 0.022$) rather than low power caused by a small sample size. Sample size estimation indicated that for observing a power of .80, more than 16,000 participants with depressive symptomology would be required for the restorative (nature) condition.

The discrepancy between our results and those observed by Berman and colleagues (2012) might be due to actual nature being essential for the experience of the restorative effect by participants who endorse depressive symptomatology. Specifically, individuals with depressive symptoms experience internal negative bias and restricted information processing (Gotlib et al., 2004). Because the population with significant depressive symptomatology is more likely to remain focused on negative thoughts and feelings at the expense of positive elements in their external environment, this group may not readily attend to the restorative cues of digital natural environments in the same way as typical populations. Thus, the internal distracters experienced by individuals with depressive symptoms might have to be made relatively less significant by the external stimuli for restoration to result; brief exposure to digital, two-dimensional nature pictures might not be sufficient to overcome these salient internal distracters.

Further, besides experiencing actual natural environments, the study by Berman and colleagues (2012) also differed from the present study in the length participants were exposed to nature. Thus, the difference observed between the results of the present study may be due not only to intensity (actual nature versus viewing digital, two-dimensional pictures) but also to the actual length of nature exposure. The current sample was exposed to digital nature pictures for less than 5 min, and each image was presented for 10 s, while participants in the Berman et al. (2012) study physically walked in a nature park for almost an hour. Prolonged exposure (25 min walk) to actual nature has been associated with EEG profiles consistent with meditative states as well as reduced arousal and fatigue (Aspinall et al., 2015). Thus, actual exposure to natural environments might provide the context essential for individuals with depression to reassess their situation via relaxation and meditative reflection (Berman et al., 2012). Note that depressed participants in Berman and colleagues' (2012) study experienced the restorative effect while being within actual nature for a prolonged period of time while thinking about unpleasant memories (Berman et al., 2012). Thus, it is important to note that that negative thought bias and actual experienced negative affect are not necessarily synonymous and that such negative thought biases might disrupt the restorative process during brief exposure to digital nature images.

Implications for theory

Attention Restoration Theory's account of restoration describes an attentional process that is elicited by environments that have certain (restorative) characteristics (Kaplan, 1995), with an attentional reflective component described in later elaborations of the theory (Kaplan & Berman, 2010). The present findings suggest certain boundary conditions to this process, in that mental states (e.g., negative biases) may interfere with the ability for restorative environments to capture attention. Although the present results are linked only to limited digital exposures, this constraint suggests that even environments that are restorative for most of the population may not be effective for a percentage of individuals. If the restorative effect eventually occurs for individuals with depressive states because of an increased capacity to adaptively reassess their own negative thoughts and situation (Berman et al., 2012), then the time needed for reflection to occur is likely not met by brief exposures to restorative environments. However, medication use and comorbidity might potentially impact the restorative effect in individuals with depressive symptoms; it is important to note that the present study did not control for these factors.

Implications for intervention

Unlike the longer actual nature exposure described by Berman and colleagues (2012), brief exposure to small elements such as office plants, screen savers, office decorations, nature photography, art, or even proximity to restorative locales such as courtyards and parks may be of value for typical individuals, particularly for improving cognitive performance and self-control. This finding has implications for high-stress environments such as workplaces, childcare centers, hospitals, doctors' offices, or other places where typical workers or clients are likely to be cognitively depleted.

This study also has implications for individuals with some level of depressive symptomatology. For these individuals, brief exposure to

low-intensity digital elements, like two-dimensional pictures, is unlikely to have a restorative effect. When individuals experience strong negative internal intensity, such internal stimuli that may overwhelm the ability to experience soft fascination and reflection, prolonged experience in actual nature may be necessary for the restorative signal to occur. Environments such as neonatal ICUs, funeral homes, and military bases may benefit from an on-site arboretum, greenhouse, or garden.

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