Trait mindfulness as a moderator of green exercise and attention restoration

by

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Abstract

Attention Restoration Theory (ART) has been proposed as a potential approach to facilitate recovery from directed attention fatigue (DAF). The theory postulates directed attention is likely to replenish if permitted to 'rest'. One way to allow directed attention to rest is to promote the use of involuntary attention. Previous research suggests viewing images of natural environments captures involuntary attention while simultaneously limiting the need for directed attention. However, in our failed attempt to replicate findings of previous research, along with shortcomings found within previous research, there remains uncertainty regarding the efficacy of an ART-based intervention. For example, ART-based interventions may be bound by certain conditions. Therefore, the purpose of this research was to investigate potential inter-individual factors that may moderate the relationship between greenspace and directed attention restoration. Specifically, research aimed to investigate the boundary condition of trait mindfulness in relation to the effects of walking while exposed to restorative stimuli (i.e., 'green exercise'). The study examined whether trait mindfulness moderates the relationship between a 10-min bout of green exercise and attentional restoration from DAF. Results suggest that green exercise is inadequate for low or high trait mindful individuals' directed attention restoration or superior attentional capacity and cognitive control. Data suggest that ART is questionable, even when considered within a theoretically-driven boundary condition.

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Table of Contents

List of Tables

List of Figures

List of Abbreviations

ANT	Attention Network Test
ART	Attention Restoration Theory
BDS	Backwards Digit-Span
CR	Correct Response
DAF	Directed Attention Fatigue
D-P	D-prime
EEG	Electroencephalography
FFMQ	Five Facet Mindfulness Questionnaire
GLTEQ	Godin Leisure-Time Questionnaire
IR	Incorrect Response
PRS-11	Perceived Restorativeness Scale
PSS	Perceived Stress Scale
RT	Reaction Time
SART	Sustained Attention to Response Task

1. Introduction

1.1. Attention

Attention refers to the allocation of limited neural resources to internal or external stimuli (Schmidt & Wrisberg, 2008). Attention can be bifurcated into two characteristically different constructs: involuntary attention and voluntary (directed) attention (Kaplan & Berman, 2010). Involuntary attention involves the automatic allocation of neural resources to inherently interesting stimuli in an effortless bottom-up (stimulus-driven) manner. This form of attention implicates ventral-frontal and temporal cortices, as well as subcortical structures (Corbetta & Shullman, 2002; Fan et al., 2005). Conversely, directed attention involves the deliberate allocation of neural resources to stimuli in an effortful top-down (goal-driven) manner. This form of attention implicates dorsal-frontal and parietal cortices (Corbetta & Shullman, 2002; Fan et al., 2005). Importantly, as directed attention is goal-driven, it requires cognitive control (the ability to manage thoughts and behavior in accord with intentions) in order to monitor the status of performance goals (Koechlin, Ody, & Kouneiher, 2003).

1.2. Directed Attention Fatigue

Directed attention has been suggested to be a limited cognitive resource and susceptible to fatigue (Kaplan & Berman, 2010). Indeed, directed attention fatigue (DAF) is a term introduced to describe a decrease in ability to maintain attention on goals after prolonged use of directed attention. For example, Kaplan (1995) references "…scholars who need to concentrate for extended periods of time…" (p. 170) often experience DAF. Experimental evidence for DAF is provided by research on ego-depletion, described as the reduced ability to regulate behavior following periods of self-control (Baumeister, Bratslavsky, Muraven, & Tice, 1998; Tice, Baumeister, Shmueli, & Muraven, 2007). For example, participants were less effective at solving puzzles that employed executive functioning after completing a task requiring them to suppress their emotions (Baumeister et al., 1998). DAF and ego-depletion are related as they both involve failures of cognitive control (Kaplan & Berman, 2010); however, the ego-depletion effect has come under recent scrutiny. Specifically, a recent meta-analysis revealed little evidence for the ego-depletion effect (Carter, Kofler, Forster, & McCullough, 2015). Additionally, a multi-lab replication study found little evidence for ego-depletion (Hagger et al., 2015).

1.3. Attention Restoration Theory

A cognitive framework entitled Attention Restoration Theory (ART), originally constructed by Kaplan and Kaplan (1989), has been proposed as a potential approach to facilitate recovery from DAF. Specifically, the theory postulates directed attention is likely to replenish if permitted to 'rest' (Kaplan & Berman, 2010). One way to allow directed attention to rest may be to promote the use of involuntary attention. When utilizing involuntary attention, ventral-frontal, temporal, and subcortical areas are activated, while directed attention rests and its neural substrates are deactivated.

It is important to determine ways to promote the use of involuntary attention. Involuntary attention can be captured by environments with certain characteristics (Berto, 2005; Berman et al., 2008; Kaplan & Berman, 2010). First, the environment must elicit 'soft fascination', that is, the environment must contain stimuli that offer discovery as well as drive pleasant and unrestricted reflection. Second, the environment must offer 'extent', that is, contain a substantial amount of softly fascinating stimuli. Third, the environment should include stimuli that are compatible with personal preferences (i.e., 'compatibility'). Finally, the environment must be in a location, either physically or conceptually, away from daily stimuli that demand directed attention (i.e., 'being-away'). It is important to consider each characteristic when estimating the ability of an environment to capture involuntary attention and thus have a high restorative value. In sum, an environment is cognitively restorative when it is balanced with stimuli that draw upon involuntary attention while simultaneously limiting the need for directed attention (Kaplan & Berman, 2010).

Natural environments such as forests, mountain ranges, coastlines, and gardens (i.e., greenspace) are cognitively restorative as they integrate the characteristics of a cognitively restorative environment (Kaplan & Berman, 2010). First, the inherently interesting stimuli of greenspace have been suggested to stimulate enjoyable and unconstrained reflection (*soft fascination*). Second, greenspace contains a substantial amount of softly fascinating stimuli: nature-based ambient sounds of twittering birds, lightly gusting wind, and visual qualities associated with vistas, trees, and flowers (*extent*). Third, greenspace offers *compatibility* because it contains stimuli that our ancestors habitually experienced. Finally, greenspace is removed from daily work settings and, thus, absent from stimuli that demand directed attention (*being-away*).

In contrast, urban environments, such as busy streets and sidewalks (i.e., urbanspace) lack the aforementioned characteristics of a cognitively restorative environment. Specifically, urbanspace typically contains sensory stimuli (e.g., traffic sounds, advertising, and construction noise) that direct attention (i.e., ‘hard fascination’) and includes very few ‘softly fascinating’ stimuli (Berman et al., 2008). Additionally, urbanspace does not offer ‘compatibility’ because it contains stimuli unmatched to our evolutionary predispositions. Finally, urbanspace is similar to daily work settings and, thus, does not facilitate recovery from DAF. In sum, unlike greenspace, urbanspace does not allow directed attention to rest because it demands its use and does not facilitate involuntary attention. As suggested by Berto (2005), “In a restorative environment [greenspace], people do not have to focus on particular information, nor do they have to avoid attending to distractions.” (p. 254).

1.3.1. Evidence for Attention Restoration Theory

The extant literature provides evidence in support of ART. In Berman et al. (2008) Experiment 1, researchers aimed to investigate how interactions with greenspace and urbanspace influence directed attention restoration. First, 38 healthy young adults completed a laboratory-based cognitive task (backwards digit-span [BDS]), which was used to quantify changes in directed attention performance. The task protocol involved listening to strings of digits before attempting to verbally recite them backwards. Additionally, participants were required to complete a directed-forgetting task. The task involved the suppression of information in short-term memory and lasted 35 min. The directed-forgetting task was used to deplete directed attention further and, thus, increase sensitivity of the intervention. Next, participants were assigned to separate treatment groups: natural setting (arboretum) and urban setting (downtown). Participants were instructed to walk for 50- to 55-min in the assigned setting. Subsequent to the treatment condition, participants returned to the laboratory and completed the BDS. Participants returned one-week later and completed the same experimental procedure, assigned to the other treatment condition. Results revealed a significant Test (before walk vs. after walk) x Treatment Location (natural setting vs. urban setting) interaction, such that performance improvement on the BDS was significantly greater in the natural setting treatment condition compared to the urban setting treatment condition.

In Berman et al. (2008) Experiment 2, ART was tested utilizing BDS and the Attention Network Test (ANT). ANT categorizes three attentional functions: alerting, orienting, and executive function. It was predicted that interactions with nature would improve only executive functions as this form of attentional function implicates cognitive control. The ANT required participants ($N = 12$) to respond to an arrow presented in the center of a computer screen. The executive attention portion of the test consisted of 192 trials: 96 congruent arrows and 96 incongruent arrows (see Berman et al., 2008, Fig.

1.). Similar to the flanker task (e.g., Eriksen & Eriksen, 1974), participants were required to respond only to the middle arrow (target arrow) and withhold the tendency to respond to the surrounding stimuli (flanking arrows). During congruent trials, the target arrow pointed in the same direction as the flanking arrows. During the incongruent trials, the target arrow pointed in a different direction from the flanking arrows. Unlike the treatment conditions used in Experiment 1, the treatment conditions in Experiment 2 consisted of images detailing environmental settings. Participants completed the ANT and BDS prior to the treatment conditions. During the treatment conditions, participants viewed 50 pictures of either greenspace or urbanspace. Following the treatment condition, participants completed the ANT and BDS. Participants completed the same experimental protocol one-week later and viewed the opposite set of environmental images. Results revealed a significant Condition (nature vs. urban) x Time (before picture viewing vs. after picture viewing) interaction, such that exposure to nature pictures significantly improved executive functions of ANT compared with exposure to urban pictures. Additionally, results revealed BDS performance significantly improved after exposure to nature pictures, but this improvement was not reliably different from the improvement after exposure to urban pictures (i.e., there was a non-significant Condition x Time interaction).

Berto (2005) supports the ART-based intervention postulation. Specifically, she aimed to investigate how brief exposure (approximately 10 min) to photographs of greenspace affects attention performance. To this aim, in Experiment 1, participants (*N* = 32) were cognitively fatigued by performing the Sustained Attention to Response Task (SART). SART is a prolonged and repetitive cognitive task that requires participants to control distractions through the use of inhibitory mechanisms. The task design presents repetitive and temporally predictive numerical stimuli that require a response via keyboard entry. Specifically, a series of stimuli consisting of numerical values, digits 1 through 9, appeared in the middle of a computer screen. Participants were asked to respond as quickly and accurately as possible to each of the digits by pressing the 'SPACEBAR' as the digits appeared. However, when a digit '3' appeared, they were required to withhold response. Two-hundred forty digits, numbers 1 to 9, *excluding* number '3', with 24 targets (i.e., number '3') served as the total number of trials in the experimental paradigm. Performance was assessed in consideration of the following variables: d-prime, a measurement of participant's sensitivity to target detection (D-P); mean reaction time, a measurement of the latency to press the spacebar when a non-target appeared (RT); correct responses, a measurement of the number of times spacebar was not pressed when the target appeared (CR); and incorrect responses, a measurement of the number of times spacebar was pressed although the target was present (IR). Following completion of the SART, participants viewed a series of 25 environmental images, either greenspace or urbanspace, for 15 s each. Finally, participants completed the SART again after exposure to the images. The SART performance score, D-P, showed a significant improvement in Session 2 compared to Session 1 for the greenspace group. However, there was no Group (greenspace/urbanspace) x Session (1/2) interaction reported, nor did groups differ from each other in either session. Furthermore, the greenspace group showed significantly faster mean RT in Session 2 compared to Session 1. Additionally, the greenspace treatment group showed significantly faster mean RT in comparison to the urbanspace treatment group in Session 2. However, there was no Group x Session interaction reported. Further, the greenspace group showed significantly more correct responses (CR) in Session 2 compared to Session 1. However, there was no Group x Session interaction reported, nor did groups differ from each other in either session. Finally, the urbanspace group showed significantly more incorrect responses (IR) in Session 2 compared to Session 1. There was no Group x Session interaction reported, nor did groups differ from each other in either session.

In Berto (2005), Experiment 2 was designed to investigate the influence of nonenvironmental images on cognitive performance. Unlike the treatment condition stimuli used in Experiment 1, the treatment condition stimuli in Experiment 2 consisted of images of geometrical patterns. The data of Experiments 1 and 2 were evaluated together, comparing the influence of the three different stimuli on cognitive performance: restorative environments, nonrestorative environments, and geometrical patterns. It is important to note that non-randomized sampling was involved in this comparison. The experimental procedure was identical to Experiment 1: SART was used to induce a state of cognitive fatigue. During the treatment condition, participants (N = 32) viewed 25 colored images of geometrical patterns (see Berto, 2005, Fig. 2). Following the treatment condition, participants completed the SART. Performance was assessed in consideration of the following variables: D-P, RT, CR, and IR. No significant differences emerged with respect to SART performance measures between Session 1 and Session 2. Results suggest that the stimuli used in Experiment 2 did not stimulate cognitive restoration. Berto concluded, "Perhaps the stimuli were not innately interesting and did not generate enough [soft] fascination to serve a restorative function" (p. 255).

In Berto (2005), Experiment 1 participants viewed environmental images for 15 s each during the treatment condition. According to the author, Experiment 3 was a systematic replication of Experiment 1. However, participants (N = 32) in Experiment 3 decided the amount of time each environmental image was viewed (i.e., self-selected pace). It was expected that the greenspace images would be viewed longer in comparison to the urbanspace images. Additionally, it was anticipated that participants exposed to the greenspace images in the self-paced condition would perform better than those exposed to the greenspace images in the standard time condition (15 s). The experimental procedure was identical to Experiment 1: SART was used to induce a state of cognitive fatigue, 25 greenspace or 25 urbanspace images served as the treatment condition stimuli, and finally, cognitive performance was tested again subsequent to treatment. However, the viewing time of treatment stimuli was not fixed. That is, unlike in Experiment 1, images were viewed at a self-selected pace. Participants advanced each image by pressing a key on a computer keyboard; total viewing time was recorded. Performance was assessed in consideration of the following variables: D-P, RT, CR, and IR. Data collected from Experiments 1 and 3 were considered together using a 2 (Group: nonrestorative/restorative) x 2 (Exposure Time: standard/self-paced) x 2 (Sessions: pre/post) MANOVA, with D-P, RT, CR and IR serving as the dependent variables. It is important to note that non-randomized sampling was involved in this comparison. The SART performance score, D-P, showed a significant improvement in Session 2 compared to Session 1 for the greenspace group. However, there was no Group x Session interaction reported, nor did groups differ from each other in either session. Furthermore, the greenspace group showed significantly more correct responses (CR) in Session 2 compared to Session 1. However, there was no Group x Session interaction reported, nor did groups differ from each other in either session. Additionally, the greenspace group did not show reliable differences in RT or IR between Session 1 and Session 2. Furthermore, the urbanspace group showed no significant differences with respect to SART performance. Notably, there was no main effect for exposure time nor was there a significant Group x Exposure Time interaction for any of the dependent variables. Finally, self-paced exposure time was considered; results revealed that the greenspace images were viewed significantly longer in comparison to the urbanspace images.

Previous research suggests viewing images of natural environments captures involuntary attention while simultaneously limiting the need for directed attention (Berto, 2005; Berman et al., 2008, Experiment 2). However, directed attention restoration in both studies was measured at the behavioral level (i.e., improvements on task performance). Therefore, the purpose of our preliminary study was to quantify directed attention restoration at the neuronal level, as indexed by electroencephalography (EEG)

(Dyke, Rhoads, O'Neil, & Miller, unpublished data). EEG was recorded while participants (*N* = 40) completed the SART. Subsequently, participants assigned to either Green or Urban treatment groups viewed images of greenspace or urbanspace, respectively. Post-treatment procedures were identical to pre-treatment procedures. Psychophysiological (EEG) and behavioral (SART) data were assessed with Group (Green/Urban) x Test (Pre-treatment/Post-treatment) interactions. Results revealed non-significant differences in the magnitude of neural resources allocated to evaluating targets and non-targets; non-significant differences in the magnitude of neural resources allocated for cognitive control (i.e., inhibiting responses to targets); and non-significant differences in the magnitude of neural resources allocated for evaluating incorrect responses (i.e., responses to targets). Behavioral results revealed non-significant differences in all SART performance measures (RT, CR, and IR). In sum, results from Dyke, et al. (unpublished data) failed to support the ART-based intervention hypothesis.

Taken together, our failed attempt to replicate findings of Berto (2005) Experiment 1, along with the shortcomings found within previous research (Berto, 2005; Berman et al., 2008) (unreported a priori power analyses, lack of tested interactions, not controlling for pre-test measures, non-randomized sampling procedures), there remains uncertainty regarding the efficacy of an ART-based intervention. For example, ART-based interventions may be bound by certain conditions. Therefore, the purpose of this research was to investigate potential inter-individual factors that may moderate the relationship between greenspace and directed attention restoration.

1.4. The Psychological Construct of Mindfulness

Many of the core processes of cognitive control (a prerequisite for directed attention) are interrelated within the working definition of the psychological construct of mindfulness (e.g., attention and awareness). In fact, Jon Kabat-Zinn, a leader in the field of Western mindfulness-based research, operationally defines this construct as, “the awareness that emerges through paying attention on purpose, in the present moment, and non-judgmentally to the unfolding of experience moment by moment” (Kabat-Zinn, 2003, p. 145). Additionally, mindfulness often involves the self-regulation of attention in order to bring a quality of nonelaborative awareness to current experience (Bishop et al., 2004). As long as attention is purposively active during an experience, mindfulness will be maintained; when attention is no longer regulated, mindfulness may subside.

1.4.1. The Psychological Construct of Trait Mindfulness

It is important to note that human beings are all mindful to some degree as it is an inherent human capacity (Brown & Ryan, 2003). However, some people are more mindful than others; that is, they have higher levels of trait mindfulness. Five factors that have been suggested to characterize trait mindfulness as it is currently conceptualized are (1) observing, (2) describing, (3) acting with awareness, (4) non-judging of inner experience, and (5) non-reactivity to inner experience (Baer et al., 2006). *Observing* involves recognizing internal and external experiences, such as sensations, cognitions, and environmental stimuli (e.g., sights, sounds, and smells). *Describing* involves relating experiences to words. *Acting with awareness* involves identifying and attending to events of the present moment. *Non-judging of inner experience* involves possessing a nonevaluative perspective toward feelings and thoughts formed in the present moment. *Non-reactivity to inner experience* involves understanding that feelings and thoughts ebb and flow, allowing for reflection without distractive rumination. In sum, trait mindful individuals often exhibit these five factors.

1.4.2. Trait Mindfulness as a Moderator of Attention Restoration

There are two primary reasons why trait mindful people should benefit from the restorative qualities of greenspace significantly more than their less mindful counterparts. First, people who are inherently mindful tend to be more receptive of their environment. This follows because trait mindfulness implicates recognizing environmental stimuli (observing), attending to present moment experiences (acting with awareness), and possessing a nonevaluative perspective (non-judgment). Importantly, receptiveness may promote the use of involuntary attention, thereby reducing the need for directed attention and, thus, facilitating attention restoration. Second, trait mindful people utilize present moment awareness significantly more than their less mindful counterparts. Conversely, low trait mindful individuals routinely engage in mind-wandering, the mind's drift from the present moment to thoughts about the past or future (Mrazek, Smallwood, & Schooler, 2012). Critically, rumination of the past or concern about future events implicates directed attention (Mrazek, et al., 2012); thus, mind-wandering in greenspace precludes attention restoration. As such, low trait mindful individuals may be insensitive to the effects of an ART-based intervention. In sum, high trait mindful individuals may benefit from restorative environments, whereas low trait mindful individuals may not.

Despite the potential relationship between attention restoration and trait mindfulness, to our knowledge this relationship has yet to be tested. This research aimed to investigate the boundary condition of trait mindfulness in relation to the effects of walking while exposed to restorative stimuli ('green exercise'). Specifically, the study examined whether trait mindfulness moderates the relationship between a 10-min bout of green exercise and restoration from DAF.

2. Methods

2.1. Participants

Sixty healthy, young adults (27 females, M_{age} = 22.6, *SD* = ±3.65 years; see Table 1, p. 24 for detailed descriptive data) completed the experiment after providing informed written consent to an institution-approved research protocol. Sample size was determined with an a priori power calculation providing 80% power (α ≤ .05) to detect a moderate-sized effect (f^2 = .15) of the interaction between trait mindfulness and treatment group on post-treatment directed attention, controlling for baseline directed attention, trait mindfulness, and treatment group in a multiple linear regression model (Faul et al., 2007). Participants were conveniently recruited by word-of-mouth from a variety of departments directly associated with Auburn University, Auburn, AL. Participants were compensated with course credit when possible and/or received a monetary award, contingent upon cognitive testing performance (refer to section 2.2.2., p. 13 for details).

2.2. Tasks

2.2.1. Directed-Attention Reducing Battery

To elicit directed attention fatigue, two separate tasks were implemented: Subtraction of Serial Sevens Test and Spelling Words Backwards (Rogerson & Barton, 2015). During the Subtraction of Serial Sevens Test, participants verbally subtracted seven from a randomly generated number between 100 and 999, counting down until reaching six or less before restarting with a new number. This first part of the battery lasted 2 min and 30 s. Next, during the Spelling Words Backwards Task, participants listened to the experimenter read and spell an eight-letter word, before verbally spelling that word in reverse. For example, the experimenter said "*chipmunk*… c-h-i-p-m-u-n-k." After verbal delivery and spelling of the word, the participant was immediately asked to spell the word backwards (i.e., "k-n-u-m-p-i-h-c"). In order to avoid learning effects, each word was used only once. This final part of the battery lasted 2 min and 30 s. The directed-attention reducing battery was utilized to deplete participants' directed attention, and thus induce DAF, prior to subsequent task completion.

2.2.2. Backwards Digit-Span Test (BDS)

The BDS test is used to measure individuals' number storage capacity (i.e., short-term working memory). Test performance is contingent upon directed attention abilities (e.g., Taylor, Kuo, & Sullivan, 2002; Berman et al., 2008; Kaplan & Berman, 2010). The testing protocol involves listening to strings of single digits before attempting to verbally recite them in reverse order (Berman et al., 2008). Modification of the BDS test was utilized for this experimental paradigm. Specifically, participants were presented with a series of digits (e.g., '7, 2, 5'), one at a time, and recalled them via computer keyboard entry after the series was presented. Successful performance of two correct series subsequently generated more difficult stimuli; that is, participants were presented with an extended list (e.g., '8, 2, 5, 3'). The length of the number-string continually increased by 1-digit until participants inaccurately recalled a string of the specified length; a 12-digit number string served as the longest possible length. For each numerical string, digits were presented on a computer screen, for 1 s each, via Presentation® version 18.3, a stimulus delivery and experiment control program for neuroscience. Participants were required to initiate their response within 5 s of the final digit of the number string presented. Additionally, participants were required to complete their response within 10 s. Participants were seated 1-m away from a 48-cm computer monitor; researchers provided verbal instructions of the task protocol prior to testing. The BDS test provided an objective behavioral measure of participants' directed attention. Testing performance was incentivized to promote engagement and motivation in the task. Specifically, participants' BDS performance scores were ranked in order of highest to lowest; a monetary incentive of $60, $40, and $20 was awarded to 1st, 2nd, and 3rd place, respectively.

2.2.3. Sustained Attention to Response Task (SART)

The SART is a prolonged and repetitive cognitive task that requires participants to control distractions using inhibitory mechanisms (for more details, refer to section 1.3.1., p. 5-6). The task consisted of 300 trials. Two-hundred seventy trials included a non-target stimulus (digits 1 – 9; excluding number '3'), and 30 trials included a target stimulus (i.e., number '3'). Stimuli were presented for 250 ms with an interstimulus interval of 1125 ms (see Berto, 2005, Experiment 1). All stimuli were presented in the color white against a black background screen. Participants sat 1-m away from a 48-cm computer monitor; the screen displayed instructions of the task protocol prior to testing. Task instructions included the following: "*During this task you will be presented with a series of stimuli consisting of numerical values, digits 1 through 9, in the middle of the screen. You will be asked to respond as quickly and accurately as possible to each of the digits by pressing the SPACEBAR. However, when a digit '3' appears, withhold your response (i.e., simply DO NOT press the SPACEBAR and wait for the next digit). The task takes approximately 7 min to complete*". All participants used the index finger of their dominant hand when responding to the numerical stimuli. In accord with Berto (2005), successful test performance involved participants remaining adequately attentive to their manual responses, such that in the appearance of the target stimulus (digit '3') they withheld pressing down the spacebar. A 10-trial practice period familiarized participants with the experimental paradigm (Lee et al., 2015); practice scores were excluded from participants' overall SART performance. SART was implemented by way of Presentation® version 18.3. Prior experimental testing has revealed SART as an ecologically-valid measure of attentional capacity and cognitive control, which are prerequisites for directed attention (Smilek et al., 2010). Thus, SART performance is an effective metric of the capability to utilize directed attention.

2.3. Questionnaires

2.3.1. Five Facet Mindfulness Questionnaire (FFMQ)

Baer et al. (2006) created the Five Facet Mindfulness Questionnaire (FFMQ) as an instrument based on a factor analysis of five independently developed mindfulness questionnaires (The Mindful Attention Awareness Scale, The Freiburg Mindfulness Inventory, The Kentucky Inventory of Mindfulness Skills, The Cognitive and Affective Mindfulness Scale, and The Mindfulness Questionnaire). The factor analysis generated five facets that characterize elements of mindfulness as it is presently conceptualized. As previously detailed, the five facets include (1) observing, (2) describing, (3) acting with awareness, (4) non-judging of inner experience, and (5) non-reactivity to inner experience. The FFMQ uses 39 items to measure these facets of trait mindfulness, each rated on a 5-point scale (1 = never or very rarely true, 2 = rarely true, 3 = sometimes true, 4 = often true, 5 = very often or always true). Subsets of the items are allocated into the following order: *observing* (e.g., "I pay attention to sensations, such as the wind in my hair or sun on my face"); *describing* (e.g., "I can usually describe how I feel at the moment in considerable detail"); *acting with awareness* (e.g., "When I do things, my mind wanders off and I'm easily distracted"); *non-judging of inner experience* (e.g., "I make judgments about whether my thoughts are good or bad"); *non-reactivity to inner experience* (e.g., "In difficult situations, I can pause without immediately reacting"). Instructions are as follows: "*Write the number in the blank that best describes your own opinion of what is generally true for you*". In the proposed study, the FFMQ was utilized as a metric of trait mindfulness to explore its moderating role on attention restoration. Importantly, participants completed the FFMQ during recruitment (≥ 48 hours prior to testing) to avoid potential priming effects of mindfulness on thoughts during the treatment or task performance.

2.3.2. Perceived Restorativeness Scale (PRS-11)

The PRS-11 measures individuals' perceptions of the four restorative qualities of an environment: fascination, being-away, extent (coherence and scope) and compatibility (Pasini, Berto, Brondino, Hall, & Ortner, 2014, Appendix A., p. 296-297). The PRS-11 uses eleven items to measure these features of an environment, each rated on a 7-point scale (0 = Not at all … 6 = Completely). Subsets of the items are allocated into the following order: *fascination* (e.g., "In places like that, my attention is drawn to many interesting things"); *being-away* (e.g., "To get away from things that usually demand my attention I like to go to similar places"); *coherence* (e.g., "There is a clear order in the physical arrangement of places like that"); *scope* (e.g., "In places like that, there are few boundaries to limit my possibility for moving about"). Subset *extent* is comprised of the two elements, *coherence* and *scope.*

2.3.3. Perceived Stress Scale (PSS 4-Item)

The PSS provides a measurement of the degree to which situations in one's life are evaluated as stressful (Cohen, Kamarck, & Mermelstein, 1983). The PSS (4-Item) uses four items to measure how often participants perceive their lives as unpredictable, uncontrollable, and overloaded. The PSS (4-Item) was utilized to measure changes in perceived stress during data collection. The PSS (4-Item) served as a secondary analysis to examine changes in participants' (pre- and post-treatment) perceived stress. This analysis was of interest as bouts of green exercise have been revealed to reduce individuals' perceived levels of stress (e.g., Ulrich et al., 1991; Hansmann, Hug, & Seeland, 2007). In the present study, participants completed the PSS (4-Item) directly after the first BDS test (pre) and after completion of the treatment condition (post). Each question (e.g., "How often have you felt difficulties were pilling up so high that you could not overcome them?") was rated on a 5-point scale (0 = Never, 1 = Almost Never, 2 = Sometimes, 3 = Fairly often, 4 = Very often).

2.3.4. Godin Leisure-Time Exercise Questionnaire (GLTEQ)

The GLTEQ is a self-report questionnaire for measuring individuals' exercise behavior (Godin & Shephard, 1997). The questionnaire is a brief four-item query of participants' leisure-time exercise habits. Importantly, participants completed the

GLTEQ during recruitment to provide researchers with an understanding of participants' overall exercise behavior, which could relate to their experience of the walking exercise.

2.3.5. Rating of Perceived Exertion (RPE)

Participants' RPE provided a quantitative measure of individuals' perceived exertion during the treatment condition. This analysis was of interest as bouts of green exercise have been revealed to reduce individuals' perceived ratings of perceived exertion (e.g., Ceci & Hassmén, 1991). In the present study, participants completed the RPE scale immediately following the treatment condition. The RPE scale included 6 levels of perceived exertion (1 = Very Light Activity, 2-3 = Light Activity, 4-5 = Moderate Activity, 6-7 = Vigorous Activity, 8-9 = Very Hard Activity, and 10 = Max Effort).

2.4. Experimental Procedure

2.4.1. Recruitment

Recruitment preceded data collection by ≥ 48 hrs. No participant had prior experience with the experimental procedure. During recruitment, all participants provided informed written consent to an institutional-approved research protocol. Next, participants completed The American College of Sports Medicine (ACSM) Physical Activity Readiness Questionnaire (PAR-Q^+). The PAR-Q^+ was administered prior to the commencement of data collection to determine contraindications of physical activity. Individuals were eligible to participate in the study if they answered 'NO' to *all* (1-7) of the general health questions. However, if participants answered 'YES' to one or more of the general health questions, they were instructed to complete pages 2 and 3 of the document. Upon completion, participants read page 4 and signed the participant declaration. Finally, participants completed the GLTEQ and FFMQ.

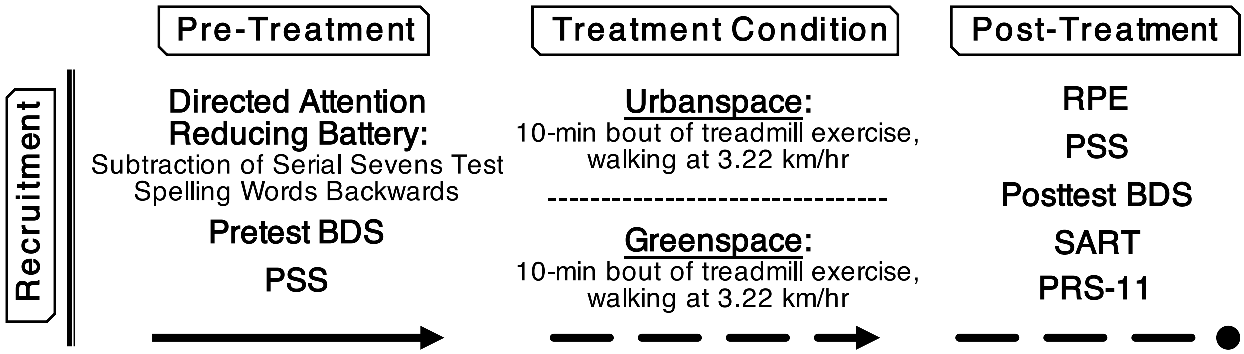

Fig. 1. Timeline of the experimental procedure, including: questionnaires administered; tests conducted; treatment condition protocol; and data collected. During recruitment, all participants provided informed written consent, and completed the PAR-Q$^+$, GLTEQ and FFMQ.

2.4.2. Tasks and Measurements

First, participants completed the 5-min directed-attention reducing battery. Next, participants completed the BDS test. Following completion of the pre-treatment testing protocol, participants completed the laboratory-based exercise treatment condition, quasi-randomly assigned to either Greenspace (i.e., restorative images and auditory stimuli) or Urbanspace (i.e., non-restorative images and auditory stimuli). Quasi-randomization was based on FFMQ Total Scores, with participants scoring below 131 on the FFMQ randomly assigned to one of the two treatment groups, and participants scoring equal to or above 131 randomly assigned to one of the two treatment groups. (One-hundred thirty-one was selected based on previous data collected in our laboratory [Thompson, 2016, *dissertation*]). The treatment condition (i.e., ART-based intervention) involved treadmill exercise; specifically, walking at 3.22 km/hr (e.g., a "casual stroll") on a treadmill positioned approximately 2-m from a large projector screen. Participants' RPE was assessed immediately post-treatment. Participants were required to walk continuously for 10 min in the respective treatment condition.

The restorative environment (Greenspace) consisted of visual stimuli detailing vistas, vegetation, variations in topography, and ambient sounds characteristically produced in those settings (e.g., nature-based sounds of twittering birds, lightly gusting wind). In contrast, the non-restorative environment (Urbanspace) consisted of visual stimuli of skylines, thoroughfares, automobiles, and auditory soundscapes (e.g., traffic sounds, emergency vehicles' sirens and horns, construction noise, human commotion). Visual and auditory stimuli were presented by way of PowerPoint Presentation, displayed through a Panasonic Projector on a 310 cm screen and ceiling-mounted digital surround sound system, respectively. In accordance with Berto (2005), visual stimuli were presented via single-picture-format (Berto, 2005, Experiment 1); dimensions for each of the photographs were as follows: 142 cm (height) X 149 cm (width). A total of 36 photographs were presented for 16 s each with an interstimulus interval of 1.5 s (i.e., transition to ensuing image); auditory stimuli were delivered at approximately 75 decibels. Importantly, auditory stimuli loudness for each treatment condition were established by way of field-recordings from local greenspace and urbanspace.

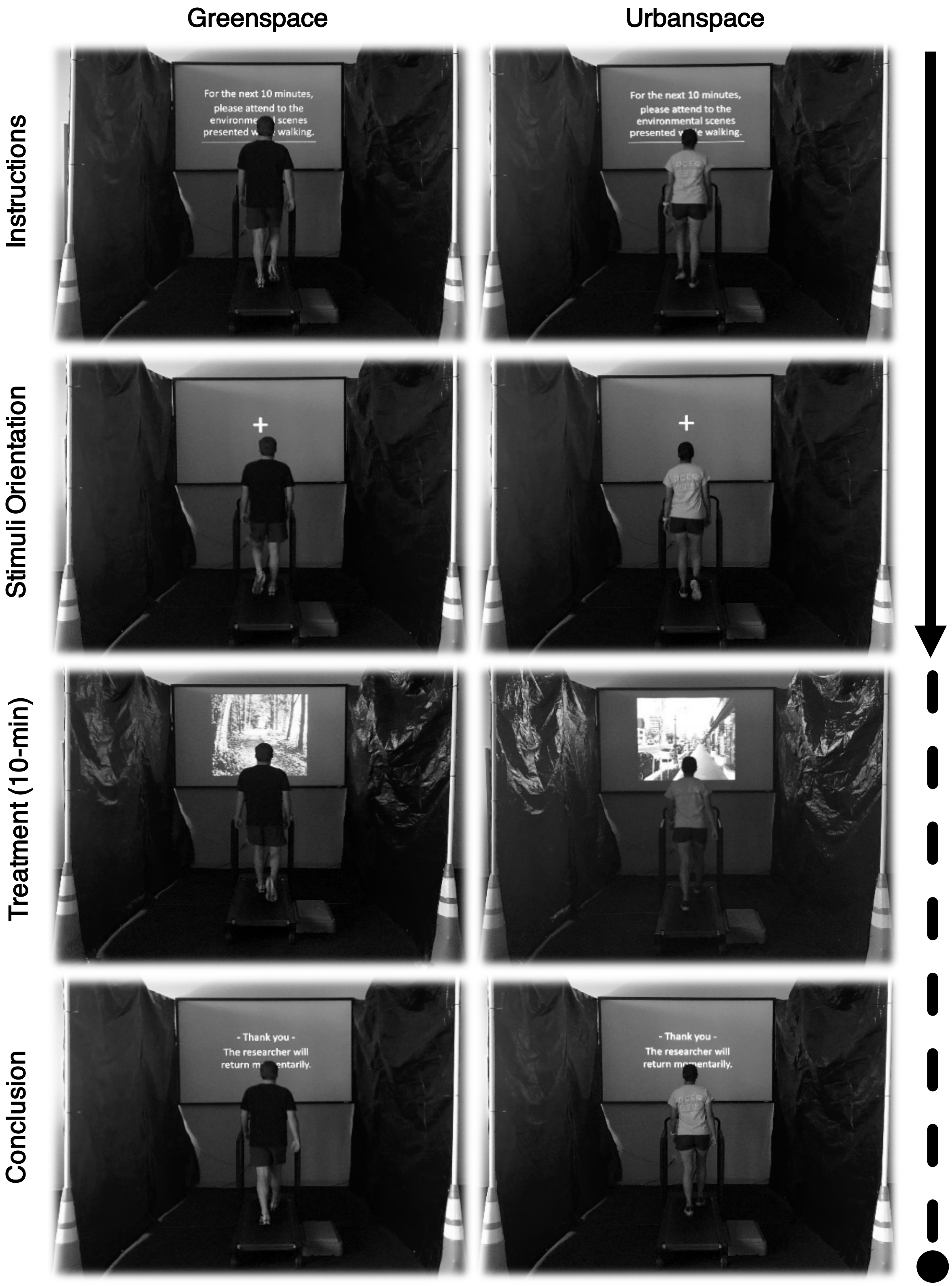

Fig. 2. Pictorial representation of the laboratory setup for the experimental treatment condition protocol, including sample images from both treatment conditions (Greenspace and Urbanspace). Instructions included the following information: "For the next 10 minutes, please attend to the environmental scenes presented while walking". Conclusion read: "Thank you. The researcher will return momentarily."

Immediately following conclusion of the treatment condition protocol, participants provided their RPE. Next, participants completed the BDS test followed by the SART. Importantly, SART testing was not implemented during pre-treatment procedures because SART has been correlated with trait mindfulness (Mrazek et al., 2012); so including a pre-treatment measure of SART in the statistical model could have resulted in multicollinearity. Next, participants completed the PRS-11. At the conclusion of data collection, the Principal Investigator and/or Research Assistant acknowledged each participant for his/her willingness to participate in the experiment. After data from all participants had been collected, participants were notified if they earned a monetary award for their cognitive testing performance. All data collection procedures were completed in the Exercise Adherence and Obesity Prevention Laboratory, room 149 at Auburn University, School of Kinesiology.

2.5. Data Processing

2.5.1. Backwards Digit-Span Test (BDS)

To measure directed attention capacity, the maximum string-length accurately recalled twice served as each participant's digit-span. These data were manually extracted from Presentation® log files.

2.5.2. Sustained Attention to Response Task (SART)

To index attentional capacity and cognitive control, SART performance was assessed by way of a speed/accuracy composite score. Speed was quantified as latency to press the spacebar once a non-target appeared, measured by way of participant median RT in milliseconds. Accuracy was calculated as total number of correct target responses (i.e., the participant did not press the spacebar when the target digit '3' appeared). Correctly withheld responses are of greater interest than correctly made responses, as the former relates to cognitive control, specifically, impulse inhibition. The total number of possible correct target responses was 30. The RT and correctly withheld responses were converted into zScore values. These values were subtracted to generate the speed/accuracy composite score (zScore Accuracy - zScore Speed). Composite scores accounted for potential speed-accuracy trade-offs in SART performance (Dyke et al., unpublished data).

2.5.3. Five Facet Mindfulness Questionnaire (FFMQ)

To assess trait mindfulness, FFMQ Total Score was calculated from all five subset scores.

2.5.4. Perceived Restorativeness Scale (PRS-11)

To assess the perceived restorativeness of the assigned treatment environment, PRS-11 Total Score was generated from the average of the four subsets.

2.5.5. Perceived Stress Scale (PSS)

PSS (4-Item) Total Scores (pre- and post-treatment) were obtained to measure participants' perceived stress.

2.5.6. Godin Leisure-Time Exercise Questionnaire (GLTEQ)

To index participants' leisure-time exercise behavior, participants' weekly frequencies of strenuous, moderate, and light activities were multiplied by nine, five, and three, respectively (Godin & Shephard, 1997). Total weekly leisure activity was calculated in arbitrary units by summing the products of the separate components.

2.5.7. Rating of Perceived Exertion (RPE)

To assess participants' post-treatment rating of perceived exertion, a modified Borg's category-ratio (1-10) RPE scale was used (e.g., Zamunér et al., 2011).

2.6. Statistical Analysis

2.6.1. Directed Attention Restoration

To measure directed attention restoration, one multiple linear regression was conducted for Posttest BDS Performance. The first step of the model controlled for Pretest BDS Performance. The second step added Treatment Group (Green/Urban) and FFMQ Total Score. Finally, the third step added the Treatment Group (Green/Urban) x FFMQ Total Score interaction.

2.6.2. Attentional Capacity and Cognitive Control

To assess attentional capacity and cognitive control, another multiple linear regression was conducted for Posttest SART Performance (Composite Score). The first step of the regression consisted of Treatment Group (Green/Urban) and FFMQ Total Score. The second step added the Treatment Group (Green/Urban) x FFMQ Total Score interaction.

2.6.3. Secondary Analyses

2.6.3.1. Perceived Restorativeness Scale (PRS-11)

An independent sample *t*-test compared the perceived restorativeness of the Greenspace treatment condition and the Urbanspace treatment condition stimuli. The PRS-11 served as a manipulation check for the ART-based treatment condition.

2.6.3.2. Perceived Stress Scale (PSS)

To assess changes in participants' perceived stress levels (pre- to post-treatment), an ANCOVA was conducted with Post-Treatment PSS serving as the dependent variable, Treatment Group (Green/Urban) serving as the between-subjects factor, and Pre-Treatment PSS serving as the covariate.

2.6.3.3. Godin Leisure-Time Exercise Questionnaire (GLTEQ)

An independent sample *t*-test (Treatment Group) compared participants' leisure-time exercise behavior.

2.6.3.4. Rating of Perceived Exertion (RPE)

An independent sample *t*-test (Treatment Group) compared participants' post-treatment RPE.

3. Results

3.1. Descriptive Data

Table 1
Descriptive data for each group. *CI* is 95%.

Descriptive data by group

	Green (*n* = 30; 12 females)		Urban (*n* = 30; 15 females)	
	M	*CI*	*M*	*CI*
Age	23.2	21.6–24.7	22.1	21.0–23.2
FFMQ Total	135	130.2–140.3	131	125.7–135.7
GLTEQ	47.1	38.2–55.9	59.5	50.5–68.4
BDS Pre	3.40	2.97–3.83	3.16	2.86–3.46
BDS Post	3.93	3.57–4.30	3.73	3.46–4.01
SART Comp. Score	0.18	-0.999–0.460	-0.18	-0.462–0.102
PSS Pre	6.33	5.23–7.44	5.73	5.00–6.47
PSS Post	6.13	5.08–7.19	5.50	4.56–6.44
RPE	1.83	1.51–2.16	2.03	1.78–2.28
PRS-11	4.10	3.80–4.40	3.01	2.70–3.31

3.2. Perceived Restorativeness Scale (PRS-11)

Results indicated that the Greenspace treatment condition was perceived as more restorative, denoted by higher scores ($t(58) = 5.26$, $p < .001$, $d = 1.35$). Specifically, the Green Treatment Group perceived the respective environmental stimuli as more restorative ($M = 4.10$, $CI = 3.80–4.40$) compared to the Urban Treatment Group ($M = 3.01$, $CI = 2.70–3.31$).

3.3. Directed Attention Restoration

The first step of the analysis revealed a significant main effect of Pretest BDS Performance predicting Posttest BDS Performance ($p = .002$). The second step of the analysis revealed no main effects of Treatment Group (Green/Urban) or FFMQ Total

Score on Posttest BDS Performance (p = .531 and p = .712, respectively). Additionally, no Treatment Group (Green/Urban) x FFMQ Total Score interaction was present in the final step of the analysis (p = .413).

Table 2

Details of regression models testing the hypotheses that directed attention restoration (as indexed by higher Posttest BDS Performance) occurs as a function of green exercise and trait mindfulness, including the following predictors: Pretest BDS Performance (Model 1); Treatment Group (Green/Urban) and FFMQ Total Score (Model 2); the interaction term was added (Model 3). Regression coefficients are not standardized and are thus interpretable in their natural units. For the Group variable, Green = '1' and Urban = '-1'. *CI* is 95%.

Model 1: Posttest BDS Performance ~ Pretest BDS Performance

	SS	*Df*	*MS*	*F*	R^2 *Change*
Regression	6.76	1	6.76	10.4	.152
Residual	37.6	58	0.648		
Coefficients	β	*CI*	*t*-value	*p*-value	
Intercept	2.71	1.99 – 3.44	7.50	< .001	
Pretest BDS	0.341	0.130 – 0.552	3.23	.002	

Model 2: Posttest BDS Performance ~ Pretest BDS Performance + Treatment Group + FFMQ Total Score

	SS	*Df*	*MS*	*F*	R^2 *Change*
Regression	7.07	3	2.36	3.54	.007
Residual	37.3	56	0.665		
Coefficients	β	*CI*	*t*-value	*p*-value	
Intercept	3.13	0.882 – 5.38	2.79	< .001	
Pretest BDS	0.333	0.117 – 0.549	3.09	.003	
Group	0.068	-0.148 – 0.283	0.631	.531	
FFMQ	-0.003	-0.019 – 0.013	-0.372	.712	

Model 3: Posttest BDS Performance ~ Pretest BDS Performance + Treatment Group + FFMQ Total Score + Treatment Group x FFMQ Total Score

	SS	*Df*	*MS*	*F*	R^2 *Change*
Regression	7.53	4	1.88	2.81	.010
Residual	36.8	55	0.669		
Coefficients	β	*CI*	*t*-value	*p*-value	
Intercept	3.08	0.818 – 5.34	2.73	.009	
Pretest BDS	0.348	0.128 – 0.567	3.17	.002	
Group	-0.818	-2.98 – 1.35	-0.758	.452	
FFMQ	-0.003	-0.019 – 0.013	-0.381	.902	
Group x FFMQ	0.007	-0.010 – 0.023	0.825	.413	

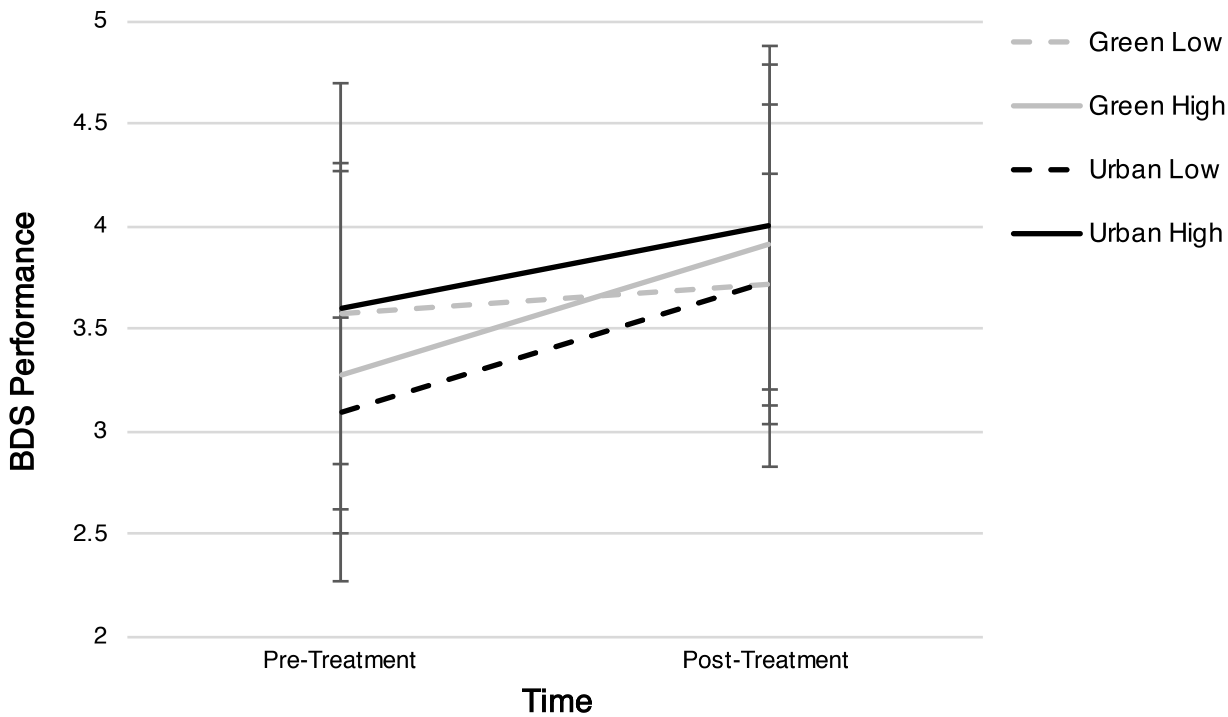

Fig. 3. BDS Performance as a function of Treatment Group (Green/Urban), FFMQ Total Score (High FFMQ = Top 25%, Low FFMQ = Bottom 25%), and Time (Pre-Treatment/Post-Treatment). Higher values on the y-axis represent better performance. Error bars represent 95% *CI*s.

3.4. Attentional Capacity and Cognitive Control

The first step of the analysis revealed no main effects of Treatment Group (Green/Urban) or FFMQ Total Score on Posttest SART Performance (p = .100 and p = .285, respectively). Additionally, no Treatment Group (Green/Urban) x FFMQ Total Score interaction was present in the final step of the analysis (p = .472).

Table 3

Details of regression models testing the hypotheses that superior attentional capacity and cognitive control (as indexed by higher Posttest SART Performance) occurs as a function of green exercise and trait mindfulness, including the following predictors: Treatment Group (Green/Urban) and FFMQ Total Score (Model 1); the interaction term was added (Model 2). Regression coefficients are not standardized and are thus interpretable in their natural units. For the Group variable, Green = '1' and Urban = '-1'. *CI* is 95%.

Model 1: Posttest SART Performance (Composite Score) ~ Treatment Group + FFMQ Total Score

	SS	*Df*	*MS*	*F*	R^2 *Change*
Regression	2.65	2	1.32	2.35	.076
Residual	32.2	57	0.564		
Coefficients	β	*CI*	*t*-value	*p*-value	
Intercept	-1.05	-3.00 – 0.907	-1.07	.288	
Group	0.164	-0.033 – 0.361	1.67	.100	
FFMQ	0.008	-0.007 – 0.023	1.08	.285	

Model 2: Posttest SART Performance (Composite Score) ~ Treatment Group + FFMQ Total Score + Treatment Group x FFMQ Total Score

	SS	*Df*	*MS*	*F*	R^2 *Change*
Regression	2.95	3	0.983	1.73	.009
Residual	31.9	56	0.569		
Coefficients	β	*CI*	*t*-value	*p*-value	
Intercept	-1.05	-3.01 – .915	-1.07	.289	
Group	-0.541	-2.51 – 1.42	-0.552	.583	
FFMQ	0.008	-0.007 – 0.022	1.06	.293	
Group x FFMQ	0.005	-0.009 – 0.020	0.723	.472	

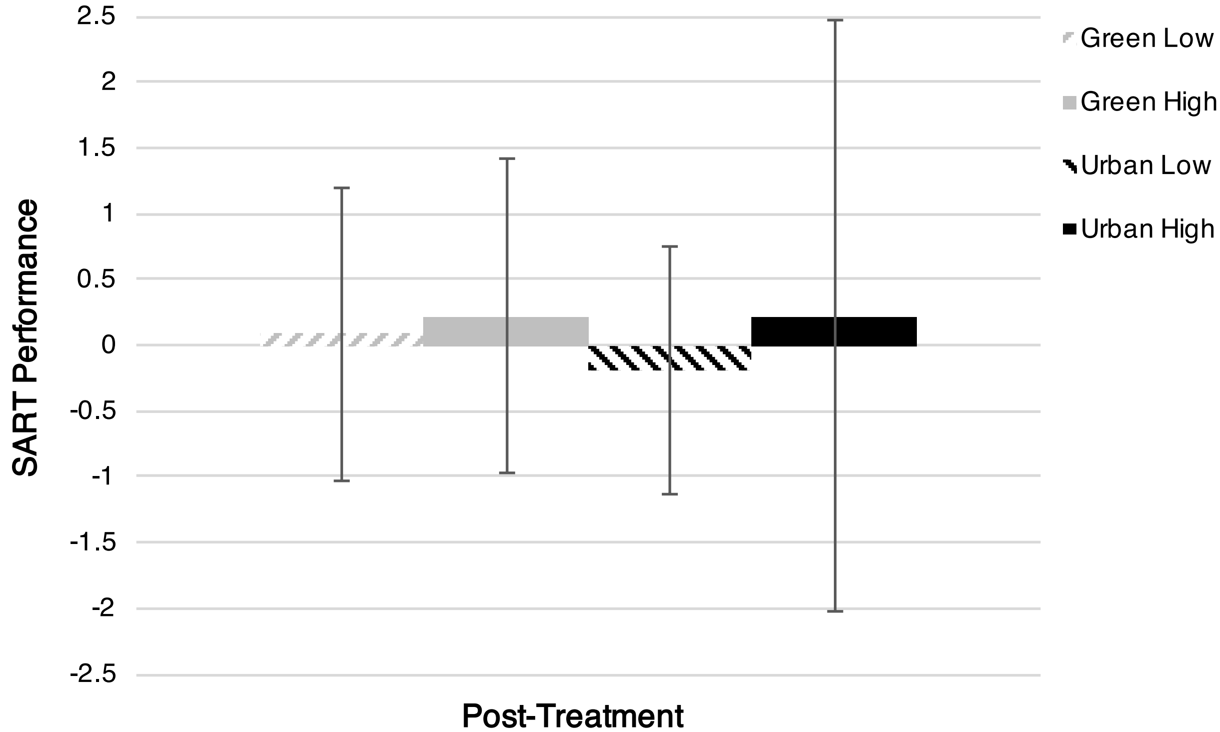

Fig. 4. SART Performance (Composite Score) as a function Treatment Group (Green/Urban) and FFMQ Total Score (High FFMQ = Top 25%, Low FFMQ = Bottom 25%). Higher values on the y-axis represent better performance. Error bars represent 95% *CI*s.

3.5. Perceived Stress Scale (PSS)

Results revealed no significant differences in Post-Treatment PSS scores as a function of Treatment Group (p = .835), controlling for Pre-Treatment PSS scores. Specifically, individuals' perceived stress did not change as a function of Greenspace treatment (Pre-Treatment M = 6.33, CI = 5.23–7.44 and Post-Treatment M = 6.13, CI = 5.08–7.19). Furthermore, individuals' perceived stress did not change as a function of Urbanspace treatment (Pre-Treatment M = 5.73, CI = 5.00–6.47 and Post-Treatment M = 5.50, CI = 4.56–6.44).

3.6. Godin Leisure-Time Exercise Questionnaire (GLTEQ)

Results indicated that participants assigned to the Greenspace treatment condition reported less leisure-time exercise behavior, denoted by lower scores (t(58) =

-2.01, p = .04). Specifically, the Greenspace treatment group's GLTEQ scores were lower (M = 47.1, CI = 38.2–55.9) compared to the Urbanspace treatment group's GLTEQ scores (M = 59.5, CI = 50.5–68.4). Therefore, it was appropriate to control for GLTEQ scores in both statistical models. Adding GLTEQ to the primary regression did not cause Treatment Group, FFMQ, or Treatment Group x FFMQ to become significant (ps ≥ .151) predictors of attention restoration/ attentional capacity and cognitive control.

3.7. Rating of Perceived Exertion (RPE)

Results revealed non-significant differences for participants' Post-Treatment RPE and treatment condition assignment (t(58) = -1.00, p = .320). Specifically, Green Treatment Group RPE was lower (M = 1.83, CI = 1.51–2.16) compared to Urban Treatment Group RPE (M = 2.03, CI = 1.78–2.28).

3.8. Exploratory Analyses

It was hypothesized that trait mindful people would benefit from the restorative qualities of greenspace significantly more than their less mindful counterparts. Justifications centered around the idea that people who are inherently mindful tend to be more receptive of their environment. This follows because trait mindfulness implicates recognizing environmental stimuli (observing), attending to present moment experiences (acting with awareness), and possessing a nonevaluative perspective (non-judgment). Therefore, exploratory analyses were conducted to assess the relationship between these specific facets of trait mindfulness (observing, acting with awareness, and non-judgment) and directed attention restoration/ attentional capacity and cognitive control.

To measure directed attention restoration, a multiple linear regression was conducted for Posttest BDS Performance. The first step of the model controlled for Pretest BDS Performance (p = .002). In the second step of the model, FFMQ Total Score was replaced with the sum of all three facets (Observing + Acting with awareness

+ Non-judgment) ($p_{\text{Treatment Group}}$ = .469, $p_{\text{FFMQ Sum}}$ = .371). In the third step, the sum of the three facets by Treatment Group interaction was added (*p* = .762). Similarly, to assess attentional capacity and cognitive control, another multiple linear regression was conducted for Posttest SART Performance (Composite Score). In the first step of the model, FFMQ Total Score was replaced with the sum of all three facets (Observing + Acting with awareness + Non-judgment) ($p_{\text{Treatment Group}}$ = .078, $p_{\text{FFMQ Sum}}$ = .831). In the second step of the model, the sum of the three facets by Treatment Group interaction was added (*p* = .745). In sum, the exploratory analyses yielded non-significant results.

4. Discussion

Results revealed that trait mindfulness does not moderate the relationship between a 10-min bout of green exercise and directed attention restoration. Further, trait mindfulness does not moderate the relationship between a 10-min bout of green exercise and individuals' attentional capacity and cognitive control. Thus, results failed to support the current hypothesis.

However, PRS-11 results indicated that the Green Treatment Group perceived the environmental stimuli as more restorative compared to the Urban Treatment Group. Therefore, PRS-11 results served as a methodological factor in the current study. That is, the designed treatment manipulation generated perceptual changes in individuals' ratings of perceived restorativeness; however, unreliable behavioral changes were detected (i.e., individuals' pre- to post-treatment cognitive performance was similar). The unreliable behavioral result is potentially due to the relatively short treatment duration (10-min). Therefore, future research could implement a longer treatment condition (e.g., Berman et al., 2008, Experiment 1), which may elicit changes in cognitive performance that align with perceived restoration.

With respect to shortcomings of the study design, treatment condition instructions may have caused a limitation. Specifically, prior to commencement of the 10-min exercise bout, participants were told the following: “For the next 10 minutes, please attend to the environmental scenes while walking.” Generally speaking, these instructions may have impacted participants in two ways that interacted with variables of interest (Treatment Group and FFMQ). First, the instructions may have promoted directed attention instead of allowing for involuntary attention in the Green Treatment Group. Participants were instructed “[to] attend”, which may imply directing of attention. Second, it was hypothesized that participants high in trait mindfulness would be more likely to attend to the environmental scenes than their less mindful counterparts. However, the instructions may have mitigated the differences in attentional state between the high and low mindful participants by priming the latter to be attentive (resembling their high mindful counterparts). Therefore, future studies should not provide *any* specific instructions prior to and/or during the treatment condition to avoid priming effects.

Another observation is that the BDS testing paradigm may have confounded directed attention with motor response speed and accuracy. Specifically, the BDS paradigm required participants to manually enter responses on a keyboard within a fixed (10 s) duration. Conversely, other BDS paradigms employed in studies similar to the present have asked participants to make verbal responses without any time constraint (e.g., Berman et al., 2008, Experiment 1). An alternative study design could implement BDS testing by utilizing verbal response instead of manual keyboard entry, thus better isolating directed attention effects.

An alteration to the study design could implement a baseline measurement of BDS prior to the directed-attention reducing battery in order to assess the changes from baseline BDS to pre-treatment/post directed-attention reducing battery BDS and pre-treatment BDS to post-treatment BDS. This study design would, first, provide a measurement for directed-attention reducing battery effectiveness, and, second, generate a more precise measurement of attention restoration. Ultimately, this may yield a clearer depiction as to the efficacy of the ART-based intervention.

Although it has been suggested that BDS test performance is contingent upon directed attention abilities (e.g., Taylor et al., 2002; Berman et al., 2008; Kaplan & Berman, 2010), BDS reflects a *single* element associated with directed attention (short-term working memory). Other elements related to directed attention such as cognitive flexibility may not be captured by BDS testing. Thus, the BDS test may not be a *global* measurement of directed attention. Therefore, it may be worthwhile to investigate how the application of alternative directed attention tasks may influence future results.

Additionally, the directed-attention reducing battery that was implemented to induce DAF in the present study lasted for a total of 5 min. This total time is relatively short in comparison to other directed-attention reducing tasks employed in similar studies (e.g., 35 min, [Berman et al., 2008, Experiment 1]). Therefore, it may be important to utilize a longer directed-attention reducing battery. This would first, potentially augment the onset of DAF, and, second, increase the sensitivity to the effects of the ART-based treatment condition.

Beyond methodological shortcomings of the present study, there may have been theoretical shortcomings. Specifically, the general consensus within the extant literature centers around the idea that urbanspace does not allow directed attention to rest. Unlike greenspace, urbanspace demands the use of directed attention and does not facilitate involuntary attention. However, the boundary condition of trait mindfulness may play a role in "protecting" individuals from the demand urbanspace places on directed attention. Trait mindful individuals possess the ability to uphold a non-judgmental perspective (e.g., open-mindedness toward internal or external experiences, regardless of the situation [Kabat-Zinn, 2003]). Therefore, this perspective may have reduced the degree to which high mindful participants in the Urban Treatment Group perseverated on the environmental stimuli designed to demand directed attention. Alternatively, it is possible participants in the Green Treatment Group who were high in trait mindfulness may have failed to utilize involuntary attention. This follows because high trait mindfulness is associated with operating in a cognitive mode of directed attention (e.g., Mrazek et al., 2012). In summary, the hypothesis regarding the interactions between treatment group and trait mindfulness could have been incorrect.

Finally, beyond the methodological and theoretical shortcomings of the present study, ART may be limited. Specifically, our ancestors lived amid an outdoor natural environment for numerous generations. This form of lifestyle may provide present day humans with an innate connection to greenspace. However, people have resided in urbanspace (e.g., cities, towns, and metropolitan areas) for nearly 7000 years (The Ancient City, Retrieved from: http://www.ancient.eu/city). As a result, a potential shift in our environmental predispositions may have occurred. Specifically, people may now perceive greater *'compatibility'* with urban areas. Greenspace may contain stimuli, such as insects, reptiles, or other animals, that demand directed attention from urban-dwellers who may be uncomfortable around such animals. Additionally, people may now find storefronts and skylines inherently interesting (*'soft fascination'*), and urban areas contain a large amount of such potentially fascinating features (*'extent'*). Further, people often travel to urbanspace to get away from everyday demands (*'being-away'*). Thus, it may be important to consider the evolution of our predilections when estimating the restorative value of an environment. In particular, the present study revealed greenspace was perceived as more restorative than urbanspace, but this perception did not manifest itself behaviorally. Perhaps ART is efficacious for behavior, but its effect is small, due to weak individual preferences for greenspace. If this is the case, then future research will need to be powered to detect a small ART effect.

5. Conclusions

Consolidating our initial failure to replicate Berto (2005) Experiment 1 (Dyke et al., unpublished data), the shortcomings found within previous research (unreported a priori power analyses, lack of tested interactions, not controlling for pre-test measures, non-randomized sampling procedures [e.g., Berto, 2005; Berman et al., 2008]), and present results suggest uncertainty regarding the efficacy of an ART-based intervention. An indication of present results is that a 10-min bout of green exercise is not efficacious for low or high trait mindful individuals' directed attention restoration. Additional results suggest that a 10-min bout of green exercise does not facilitate the restoration of attentional capacity and cognitive control. In conclusion, data suggest that ART is questionable, even when considered within a theoretically-driven boundary condition. Accordingly, as future research aims to investigate ART as a potential approach to facilitate recovery from directed attention fatigue, investigators may consider the findings of the present study.

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