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# Attentional Effort of Beginning Mindfulness Training Is Offset With Practice Directed Toward Images of Natural Scenery

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## Abstract

Mindfulness involves curious and detached attention to present experience. Long-term mindfulness practice can improve attentional control capabilities, but practice sessions may initially deplete attentional resources as beginners struggle to learn skills and manage distractions. Without using skills or effort, people can have mindful experiences in pleasant natural environments; natural scenery may therefore facilitate mindfulness practice. Twenty-seven participants completed an 8-week mindfulness course; 14 served as waiting-list controls. We tested participants' attention every other week before and after 15-min sessions of conventional mindfulness practice, mindfulness practice with nature images, or rest with nature images (controls). Mindfulness practice incurred attentional effort; it hampered performance gains seen in controls during practice/rest sessions, and attentionally weak participants completed fewer course exercises. Viewing nature images during practice increasingly offset the effort of mindfulness practice across the 8 weeks. Bringing skill-based and nature-based approaches together


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offers additional possibilities for understanding and facilitating mindfulness and restorative states.

**Keywords**
mindfulness, nature, attention, restoration, environment

Mindfulness practice has been studied and promoted as a method to improve the conscious regulation of one's emotions, thoughts, and behaviors (Brown, Ryan, & Creswell, 2007; Chiesa, Serretti, & Jakobsen, 2013; Holzel et al., 2011). Among other things, the practice is thought to make individuals more attentive to present experience during and shortly after practice sessions. With continued practice, attentional enhancements are thought to generalize beyond practice sessions. These potential effects have sparked interest among researchers who see attention as a basis for self-regulation and stress management (e.g., Kaplan, 2001; Lutz, Slagter, Dunne, & Davidson, 2008; Tang, Holzel, & Posner, 2015). These researchers consider that by enhancing attentional and self-regulatory ability through mindfulness practice, people can become more capable of managing the demands of everyday life and so improve their psychological health.

Evidence affirms that regular mindfulness practice eventually improves aspects of attentional functioning, but for novices, the initial practice sessions are believed to require self-regulatory effort and thus potentially tax attentional resources (Chiesa, Calati, & Serretti, 2011; Lutz, Dunne, & Davidson, 2007; Tang et al., 2015). Attentionally weak individuals may thus struggle to acquire practice habits before benefits are realized. The present experiment addresses this possibility; it tracks attentional effects of practice in beginning meditators. It also tests a means to facilitate practice by directing it toward images of pleasant natural scenery thought to support an effortless mindful state. Thus, we test a novel combination of the training approach to management of self-regulatory resources, as described in the mindfulness literature, with an environment-based approach, described in the literature on restorative effects of nature experience (Kaplan, 2001; Von Lindern, Lymeus, & Hartig, in press).

## Attention, Effort, and Mindfulness

To voluntarily direct attention is to selectively process some stimuli (external or internal) and accordingly inhibit processing of other stimuli that may be more salient (Kahneman, 1973). Also covered by terms such as *selective attention* and *executive attention* (Diamond, 2013), directed attention enables self-regulated action that is goal-directed and controlled rather than reactive and automatic (Rueda, Posner, & Rothbart, 2011). Because directing attention involves effort, the capacity to direct attention is limited (Cohen, 1980; Kahneman, 1973; Kaplan & Berman, 2010). High concurrent self-regulatory demands compete for attentional resources, increasing distractibility, impairing performance (Choi, van Merriënboer, & Paas, 2014; Lavie, 2005), and provoking acute psychophysiological stress (e.g., Dickerson & Kemeny, 2004). Prolonged efforts to sustain attention can deplete attentional resources, increasing distractibility and self-regulatory deficits (Langner & Eickhoff, 2013; Schmeichel & Baumeister, 2010), and contributing to chronic stress until resources recover (Cohen, 1980; Kaplan, 1995).

Mindfulness meditation has been proposed as a means to strengthen attentional control capabilities (e.g., Holzel et al., 2011), and to help people reduce attentional effort (e.g., Posner, Rothbart, Rueda, & Tang, 2010) and mitigate the depletion of directed attention capacity as a self-regulatory resource (e.g., Kaplan, 2001). Mindfulness involves attending to one's present experience in a particular way (Kabat-Zinn, 1990). Considered as a state (rather than a trait), mindfulness can be described as *intentional curiosity*; that is, connecting with openness and acceptance with any and all experience in the moment, including its cognitive and emotional aspects (Bishop et al., 2004; Lau et al., 2006). Mindfulness also involves *detachment*; that is, psychological distance from the experiential process, which allows one to notice and gently let go of habitual reactive patterns that arise with experience, including thoughts, emotions, and actions that would distract and diminish one's connectedness with the present moment (see also Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006; Brown et al., 2007; Holzel et al., 2011; Lutz et al., 2007).

Mindfulness is often construed as a volitional practice. During practice sessions, beginning practitioners typically try to maintain mindfulness toward a chosen object of practice (e.g., sensations with breathing), and toward any distractions and difficulties they encounter (e.g., worries, negative emotions). When they notice that their attention has wandered away from the object of practice, they try to calmly return to it (Bishop et al., 2004; Kabat-Zinn, 1990). With more meditation training (often several months or years), practitioners increasingly turn to open monitoring meditation exercises in which no object of practice is chosen (Lutz et al., 2008). Instead, they practice mindfulness of the changing stream of ongoing experience and attentional shifts from moment to moment. With open monitoring exercises, mindfulness practitioners thus engage with both external and internal aspects of experience as they come and go in awareness.

Skilled mindfulness practitioners can likely meditate with little self-regulatory effort (Tang et al., 2015). In contrast, a growing body of research indicates that the beginning stages of mindfulness practice can be effortful. Among others, Chiesa et al. (2011), Holzel et al. (2011), and Lutz et al. (2008) assert that the initial practice of attempting to sustain attention and repeatedly returning attention to a chosen object can train the brain. Called attention network training, this practice is thought to strain the capacity limits of the involved neural networks and thereby stimulate the development of functional capabilities to better meet heavy attentional demands (Posner, Rothbart, & Tang, 2015; Rabipour & Raz, 2012). Also in line with the notion that beginning mindfulness practice requires effort, Bishop et al. (2004), Kaplan (2001), and Linehan (1993), among others, conceptualize mindfulness practice as skills training, which presumably requires effort as meditators learn to override old habits with new cognitive–behavioral abilities (e.g., intentional curiosity, detachment). The supposed demands of beginning mindfulness practice have even prompted adaptations for people with clinical self-regulation deficiencies (e.g., in dialectical behavior therapy [Linehan, 1993] and in a treatment for people with attention deficit disorder [Zylowska et al., 2008]). If mindfulness practice is initially effortful, practice sessions presumably will tax self-regulatory resources and temporarily impair attentional performance due to the limitations of directed attention outlined above.

We are not aware of any studies that have assessed the short-term effects on attentional performance of single meditation practice sessions. However, some have reported improved attention test performance shortly after the last of a short series of practice sessions. Tang et al. (2007) measured improved executive performance with the Attention Network Test in beginner meditators shortly after the last of five daily 20-min sessions of mindfulness practice in an integrative body–mind training course, compared with relaxation training. Zeidan, Johnson, Diamond, David, and Goolkasian (2010) measured improvements indicative of enhanced sustained and executive attention with the Symbol-Digit Modalities Test, Controlled Oral Word Association Test, and an n-back task in beginner meditators shortly after the last of four weekly 20-min sessions with mindfulness of breath practice, compared with listening to audio books. These findings apparently contrast with predictions based on the understanding that beginning mindfulness practice improves attention gradually through regular training with exercises that require participants to effortfully sustain and direct attention. Although research has not yet determined the necessary frequency and duration of meditation practice before any substantial attention network training benefits can be realized, improvements would likely appear over the course of several weeks to months of regular practice. The brief meditation courses used in these studies may instead have improved attention in the short term through low-effort, open monitoring practice (i.e., through attention state training, rather than through attention network training; Posner et al., 2010; Posner et al., 2015; Tang et al., 2015; see also Chiesa et al., 2011; Lutz et al., 2008). In fact, many strained individuals may have more to gain from beginning with regular, low-effort practice sessions that promote restoration from acute stress and attentional fatigue before considering effortful attention network training or attention skills training. To facilitate the acquisition of mindfulness skills in the beginning stages of mindfulness practice, this line of reasoning can be integrated with ideas about the involuntary and effortless engagement of attention in contacts with natural environments.

## Effortless Attention, Nature, and Mindfulness

In contrast to directed attention, involuntary attention involves attention being drawn to salient experiences in the moment (external or internal) without effort (Kaplan, 1995). For example, some stimuli that are common in urban and crowded environments, like sudden sounds and angry faces, tend to evoke automatic orienting accompanied by fight-or-flight responses, including negative emotions, increased arousal, and automatic reactions (Lang & Davis, 2006; Öhman, Flykt, & Esteves, 2001). In addition to the acute responses, self-regulatory efforts to avoid or overcome such experiences demand directed attention resources and can prolong stress responses (Berman, Jonides, & Kaplan, 2008; Brosschot, Gerin, & Thayer, 2006). Conversely, pleasantly interesting experiences tend to evoke effortless attention characterized by openness and curiosity, and accompanied by positive emotions, relaxation, and flexible behavior and cognition (e.g., exploration, creativity; e.g., Ashby, Isen, & Turken, 1999; Fredrickson & Branigan, 2005).

The experience that people have with objects and processes that draw attention softly and effortlessly is called “soft fascination” by Kaplan and Kaplan (1989; Kaplan, 1995). Their attention restoration theory (ART) builds on observations that experiences in safe and scenic nature are often rich in soft fascination. ART also asserts that nature can support a sense of being away—psychological distance—from worries and other routine mental contents, and from demands on directed attention (e.g., to regulate one’s behavior). These and related aspects of experience in turn support stress reduction and restoration of attentional self-regulatory resources that have been taxed by previous demands (e.g., Berman et al., 2008; Hartig, Evans, Jamner, Davis, & Gärling, 2003; for a review, see Von Lindern et al., in press).

Many people visit nature to experience mindfulness-like states; however, that connection has attracted little interest in the meditation literature (Tang & Posner, 2009, is one exception). In contrast, environmental psychologists have long studied mindfulness-like experiences in nature within the framework of restorative environments research (Hartig et al., 2011). That literature has, however, rarely considered any practice-based contributions (e.g., meditation) that individuals can apply to facilitate and enhance restorative experiences. One notable exception is Kaplan's (2001) theoretical exploration of how experiences in nature can support meditative states through soft fascination, being away and related aspects of experience described in ART, and how meditation practices in turn can help people become positively engaged with stress-reducing and attentionally restorative environmental conditions.

A largely separate line of research has recently provided indirect support for the notion that mindfulness can enhance contacts with nature, and vice versa. Some cross-sectional studies indicate that a tendency to attend mindfully to experiences in everyday life (i.e., with intentional curiosity) is related to a stronger general sense of connectedness with nature, whereas aspects of mindfulness more related to detachment may not be (e.g., Barbaro & Pickett, 2016; Howell, Dopko, Passmore, & Buro, 2011). Also, Unsworth, Palicki, and Lustig (2016) reported an experiment in which students provided reports of mindfulness and connectedness with nature on the first and last days of a 3-day nature camp that either included or lacked daily 15-min sessions of mindfulness of breath meditation in nature. Participation in the nature camp was attended by increase in mindfulness ratings regardless of the meditation sessions. However, participants who also meditated in nature reported greater increase in connectedness with nature. Barbaro and Pickett (2016) suggest that the general sense of connectedness with nature may be strengthened through instances of intense, mindful connection with nature.

Natural features can thus support effortless attention toward present experience. Reciprocally, practicing intentional curiosity can enhance practitioners' ability to connect with different stimuli, in effect making them more fascinating. Presence in a safe natural environment can also relieve worries and other strains on self-regulatory capabilities. Reciprocally, practicing mindful detachment can further relieve worries and mitigate problematic habitual reactions that arise when present experience (internal or external) is difficult (e.g., Arch & Craske, 2006; Delgado et al., 2010).

If beginning mindfulness practice requires attentional effort and natural scenery supports effortless mindfulness-like states, then directing the practice toward nature scenes could offset that effort. This study addressed that possibility as well as conventional claims that mindfulness meditation can enhance psychological health (e.g., Brown et al., 2007). Its objectives were as follows:

1. to track long-term changes in attentional performance and psychological health (in terms of depression, anxiety, and stress) in beginning meditators over an 8-week mindfulness course;

2. to assess the short-term effects of mindfulness practice sessions on attentional performance in beginning meditators compared with controls who rest with images of natural scenery;
3. to track change in short-term attentional effects as mindfulness practitioners gradually gain experience;
4. to determine whether directing the mindfulness practice toward images of natural scenery offsets the supposed effort of practice sessions;
5. to explore how initial attentional performance and psychological health relates to the amount of mindfulness practice completed during the course.

# Method

## *Participants and Design*

University students without meditation experience and without current psychiatric diagnoses or treatment were recruited through posters that advertised a study involving a mindfulness training course. Given the time and other resources available, it was anticipated that, at most, 60 participants could initially be accommodated in the study. In practice, 51 eligible individuals volunteered for the study. With expectations that data collection from 20% to 30% of the participants could be incomplete due to dropout or single missed measurement occasions across the 8-week period (e.g., due to illness), we proceeded with awareness that the study was not powered to reliably detect small effects on the main outcomes. The participants ($M_{\text{age}}$ = 25.00 years, *SD* = 5.46 years; 14 males) were randomly assigned to the 8-week course (and to two different groups within the mindfulness training condition) or to a waiting-list control group. As compensation, mindfulness training group participants were offered the course (including instruction and materials) free of charge. Control group participants were offered four cinema tickets if they completed all measurements during the study, and they were offered mindfulness training after the study.

Measures were collected before and after a 15-min practice/rest session on each of five occasions: Before the first mindfulness class (pretest) and before the start of instruction for subsequent classes at 2-week intervals. The classes (and so the measurement occasions) were scheduled on weekdays at 5:00 p.m., when participants were likely to have some need for attentional restoration (cf. Hartig & Staats, 2006). On each measurement occasion following pretest, one group of mindfulness training participants spent the 15-min session practicing mindfulness with no nature stimuli (mindfulness-only group; $n$ = 17), the other group practiced mindfulness while viewing nature images (mindfulness/nature group; $n = 16$), and control participants rested while viewing nature images (control/nature group; $n = 18$). Our design thus includes two within-subjects factors, occasion (five levels: pretest and Weeks 2, 4, 6, and 8), and session (two levels: pre- and post-15-min practice/rest session), together with the between-subjects factor (assignment to one of the three groups).

## *Mindfulness Course*

The mindfulness course was modeled on Mindfulness-Based Stress Reduction (MBSR; Kabat-Zinn, 1990). It had weekly 90-min classes with mindfulness-only and mindfulness/nature participants together. Participants chose to attend classes either every Tuesday (18 beginning participants) or every Thursday (15 beginning participants). Participants received weekly readings (ca. three pages) and instructions to do guided formal exercises 6 days a week. The exercises consisted variously of 10 min of mindfulness of breath (Weeks 1 and 2), a 45-min body scan (Weeks 1 to 3), up to 30 min of sitting meditation (Weeks 3 and 4), 45 min of sitting meditation or hatha yoga (Week 5), and their own choice of exercises (Weeks 6 and 7). They were additionally instructed to do informal practice in everyday situations.

## *Images of Natural Scenery*

Images of rural and wild nature common in the hemiboreal areas of Scandinavia and North America were obtained from several amateur and professional photographers. Based on unanimous judgment between the first and third authors, both familiar with rating scale measurement of the components of restorative experience described in ART, 62 images were selected as likely to be perceived by participants as high in restorative quality. The set included full landscape scenes (e.g., a green field with tree-lined horizon), scenes with focal point and moderate depth (e.g., a grove of trees covered in snow), and semi-proximal motifs (e.g., a tree branch reflected in water surface). No close-up shots were included. Of the images, 56 featured trees and 32 water; 22 included grassy, uniform ground; 11 included paths, gravel roads, bridges, or boats; 3 included fences or embankments; 7 pictured coastal landscapes; 9 showed snow and 6 rain or fog; 7 showed twilight scenes and the rest daytime scenes. None included people or buildings. Images from the set were selected randomly by a computer and projected onto a 2.5 × 2.5 m screen for 120 s with a brief fading effect between images. Interested readers can contact the first author for example images or discussion of possibilities to use the images for replication purposes.

## Measures

Participants rated their psychological health with the Depression Anxiety Stress Scales (DASS; Lovibond & Lovibond, 1995). That instrument measures depression, anxiety, and stress as distinct constructs. It has shown sensitivity to change in symptom severity (Ronk, Korman, Hooke, & Page, 2013). Participants rated the degree to which 21 different symptom descriptions applied to them during the past week, using a scale ranging from 0 (*not at all*) to 3 (*very much or most of the time*). Scores were doubled for comparability with the respective subscales of the 42-item DASS, giving possible scores of 0 to 42 on each subscale. The subscales generally had adequate to good internal consistency, with the mean Cronbach's alphas of the groups all > .7 across the measurements (pretest and Weeks 2, 4, 6, and 8; see Table 1 in the online appendix); however, alpha values < .7 were noted on some assessments, especially for the anxiety scale. These low alpha values were apparently due to floor effects with very low variance in several anxiety items.

Attention was assessed with the Letter-Digit Substitution Test (LDST; van der Elst, van Boxtel, van Breukelen, & Jolles, 2006). The LDST was chosen over technologically sophisticated assays because of its suitability for brief group administration. Substitution tests are typically classified as measures of information processing capability. They are sensitive to variations in mental acuity, tapping the selective and executive components of attention (Davis & Pierson, 2012; Lezak, 2004; Mirsky, Anthony, Duncan, Ahearn, & Kellam, 1991; van der Elst et al., 2006). They have previously shown responsiveness to brief mindfulness inductions (Zeidan et al., 2010) and time spent in a garden rather than indoors (Ottosson & Grahn, 2005). We thus anticipated that participants' LDST performance would change both with any cumulative attention network training or attention skills training effect over the 8 weeks and as a function of transient attention state changes related to any attentional effort or restoration during practice/rest sessions. The participants were instructed to quickly and accurately fill in digits (1-9) in blank spaces corresponding to randomly assigned letters, guided by a code key. The score is the number of correct responses completed in 60 s. Two practice runs preceded the presession measure on each occasion. No practice runs were used post session. All trials used new versions, counterbalanced across participants.

## Procedures

Thirty minutes before the mindfulness classes at pretest and Weeks 2, 4, 6, and 8, the control/nature and mindfulness training participants were seated together in a small classroom with curtains closed to prevent outside views.

They completed the practice runs of the LDST, then the DASS, and then the presession LDST. Mindfulness/nature and control/nature participants remained in that room while the slideshow of nature images was projected onto a screen. Control/nature participants received instructions to "just rest and view the images" on all occasions. Mindfulness/nature participants received instructions at pretest to just rest and view the images and, on subsequent occasions, to "practice what you have learned in mindfulness training while you view the images." They received no further practice guidance. Mindfulness-only participants went to a similar adjoining classroom where no images were projected. They received instructions at pretest to "just rest" and, on subsequent occasions, to "practice what you have learned in mindfulness training," without instruction to direct their practice toward any particular stimuli and without further practice guidance. The ceiling lights were slightly dimmed in both rooms during these sessions. After 15 min, all participants gathered again in the one room, where they completed the postsession LDST. Mindfulness training participants then attended their class. After the last class, the mindfulness training participants completed an evaluation that included questions about how much homework practice they had completed.

## Results

### Group Comparability and Participation

Prior to the analyses bearing on the study objectives, we considered the initial comparability of the three groups on the outcome measures and in terms of participation in the study. Four of the 51 participants fell from these analyses because they failed to provide complete data on the first measurement occasion. The groups performed similarly on the attention test (LDST) at the initial assessment (pretest, presession); for the one-way ANOVA, $F(2, 44) = 1.39$, $p = .259$, $\eta_p^2 = .060$. Initial (pretest) DASS ratings showed similar levels of depression, anxiety, and stress in the groups—depression: $F(2, 44) = 1.23$, $p = .302$, $\eta_p^2 = .053$; anxiety: $F(2, 44) = 0.48$, $p = .624$, $\eta_p^2 = .021$; stress: $F(2, 44) = 0.48$, $p = .623$, $\eta_p^2 = .021$—with means for all three variables corresponding to Ronk et al.'s (2013) psychiatric outpatient categories. Descriptive statistics for all tests and measurement occasions are provided in Table 1 in the online appendix.

Over the five measurement occasions with pre- and postsession assessments, the 51 participants missed 105 of 510 assessments (21%). Ten participants attended fewer than three measurement occasions or missed two consecutive ones; they were considered dropouts. Attendance rank scores

(0 = dropout; 1-3 = attended occasions above the dropout criterion) were subjected to ordinal regression with initial LDST and DASS scores as predictors. Explanation of attendance by these predictors was significantly greater than chance, $\chi^2(4, N = 47) = 10.04$, $p = .040$, Nagelkerke pseudo-$R^2 = .212$; however, only initial LDST performance positively predicted subsequent attendance, coefficient = .128, 95% confidence interval (CI) = [0.033, 0.222], $p = .008$. The DASS ratings did not contribute significantly—$p$s > .175; coefficients: depression = .122, 95% CI = [−0.055, 0.298]; anxiety = .026, 95% CI = [−0.156, 0.207]; and stress = −.062, 95% CI = [−0.211, 0.086].

As with the initial sample, the 41 nondropout participants in the different groups (mindfulness training group, $n = 27$, divided between mindfulness-only group, $n = 12$, and mindfulness/nature group, $n = 15$; control/nature group $n = 14$) performed similarly on the initial LDST; for the one-way ANOVA, $F(2, 35) = 1.37$, $p = .269$, $\eta_p^2 = .072$. Participants with perfect attendance who provided complete data on all measures (mindfulness training group, $n = 16$, divided between mindfulness-only group, $n = 7$, and mindfulness/nature group, $n = 9$; control/nature group $n = 8$) also performed similarly on the initial LDST across groups, $F(2, 21) = 0.73$, $p = .930$, $\eta_p^2 = .007$. As with the full initial sample, the initial similarity between the groups on levels of depression, anxiety, and stress also held for the nondropout participants—depression: $F(2, 35) = 0.15$, $p = .859$, $\eta_p^2 = .009$; anxiety: $F(2, 35) = 0.08$, $p = .923$, $\eta_p^2 = .005$; stress: $F(2, 35) = 0.03$, $p = .967$, $\eta_p^2 = .002$—and participants with perfect attendance—depression: $F(2, 21) = 0.69$, $p = .515$, $\eta_p^2 = .061$; anxiety: $F(2, 21) = 2.07$, $p = .151$, $\eta_p^2 = .165$; stress: $F(2, 21) = 0.23$, $p = .977$, $\eta_p^2 = .002$. Because data "missingness" was related to the main dependent variable, attentional performance as assayed with LDST, we proceeded without imputation of missing data. Descriptive statistics are provided in Table 1 in the online appendix, separately for those nondropout participants who provided measures on the given occasions and participants with perfect attendance.

## *Effects of the Mindfulness Training Course on Psychological Health and Attention*

The first objective of the study was to track long-term changes in attentional performance and psychological health in beginning meditators over an 8-week mindfulness course. Toward this end, we compared the combined mindfulness training groups with the control/nature group on the DASS ratings and LDST scores obtained before the practice/rest sessions on the five measurement occasions (pretest and Weeks 2, 4, 6, and 8). The postsession LDST scores were not included in these analyses, which thus treated only

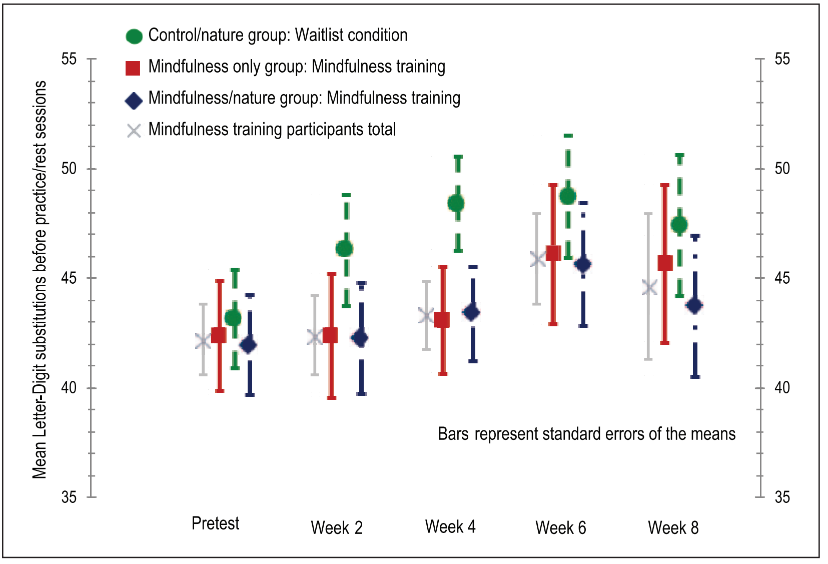


**Figure 1.** Letter-digit substitution performance before practice/rest sessions on the five measurement occasions over the 8 weeks of the study.
*Note.* Scores are the number of correct substitutions completed in 60 s. Higher scores indicate better performance.

occasion as a within-subjects factor (i.e., a two-factor mixed or repeated-measures analysis of variance [RM ANOVA]).

The depression ratings did not show consistent decline over the duration of the course; for the linear trend, $F(1, 23) = 1.95$, $p = .176$, $\eta_p^2 = .078$. In contrast, both anxiety and stress declined from the start of the course, as reflected in significant linear trends—anxiety: $F(1, 23) = 7.35$, $p = .012$, $\eta_p^2 = .242$; stress: $F(1, 23) = 8.76$, $p = .007$, $\eta_p^2 = .276$. The degree of linear improvement did not, however, differ between the mindfulness training and control/nature groups on any of the three DASS measures—depression: $F(1, 23) = 0.60$, $p = .446$, $\eta_p^2 = .026$; anxiety: $F(1, 23) = 1.31$, $p = .250$, $\eta_p^2 = .057$; stress: $F(1, 23) = 0.02$, $p = .904$, $\eta_p^2 = .001$.

For LDST performance, the analysis showed a main effect of time that comprised linear improvement across the occasions—$F(1, 23) = 19.66$, $p < .001$, $\eta_p^2 = .461$—and a quadratic trend component—$F(1, 23) = 4.98$, $p = .036$, $\eta_p^2 = .178$—that reflects a dip in performance on the last occasion (see Figure 1). The groups did not differ significantly in terms of these linear—$F(1, 23) = 0.34$, $p = .568$, $\eta_p^2 = .014$—and quadratic trends—$F(1, 23) = 3.11$, $p = .091$, $\eta_p^2 = .119$.

### *Effects of Sessions With Mindfulness Practice and/or Nature Images on Attention*

Three further objectives of the study were as follows: (a) to assess the short-term effects of mindfulness practice sessions on attentional performance in beginner meditators compared with controls who rested with images of natural scenery, (b) to track change in short-term attentional effects as practitioners gradually gained experience, and (c) to determine whether directing the mindfulness practice toward images of natural scenery offset the supposed effort of practice sessions. For these objectives, we compared the mindfulness-only, mindfulness/nature, and control/nature participants on LDST scores obtained before and after the practice/rest sessions on the five measurement occasions (pretest and Weeks 2, 4, 6, and 8). The within-subjects design component thus included both occasion and a second factor representing the pre- to postsession change in attention within each occasion (i.e., a three-factor mixed or RM ANOVA). Our primary interest was in group differences in change in LDST performance during sessions, collapsed across occasions (i.e., the Group × Session interaction) and as they developed across the five measurement occasions (i.e., the Group × Session × Occasion interaction). The Group × Session interaction was not significant—$F(2, 21) = 1.43$, $p = .262$, $\eta_p^2 = .120$—meaning that averaged across the five measurement occasions, including the pretest, the amount of pre- to postsession change in LDST performance was similar across the three groups. In contrast, the Group × Session × Occasion linear trend was statistically significant—$F(2, 21) = 4.25$, $p = .028$, $\eta_p^2 = .288$. Control/nature and mindfulness/nature participants achieved increasingly positive session change in LDST performance across the 8 weeks, whereas mindfulness-only participants gradually fared worse (see Figure 2). Repeating the RM ANOVA with just the mindfulness/nature and mindfulness-only groups, we confirmed that their linear trends differed; $F(1, 14) = 10.12$, $p = .007$, $\eta_p^2 = .420$: Mindfulness/nature participants had a more beneficial development than did mindfulness-only participants in session change in LDST performance across the 8 weeks.

Because the psychological health ratings with DASS and the LDST performance assessments obtained before the practice/rest sessions had changed across the weeks of the study, the starting points varied on the different weeks for any change in LDST performance from before to after the practice/rest sessions. We tested whether presession DASS ratings or LDST performance were related to session change in LDST performance. This analysis compared mindfulness-only, mindfulness/nature, and control/nature participants' average session change scores in LDST performance from Weeks 2, 4, 6, and 8, when some mindfulness training had been realized (thus omitting the pretest). It included

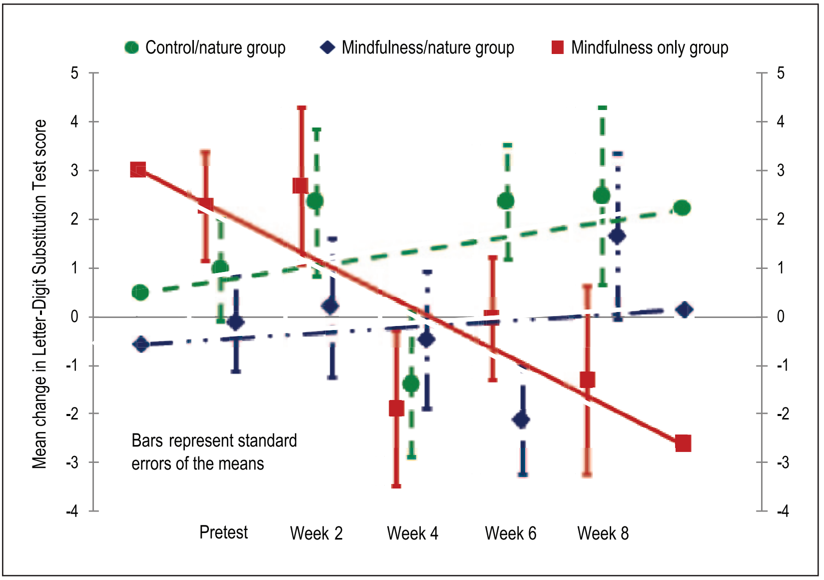


**Figure 2.** Effects on letter-digit substitution performance of 15 min of mindfulness practice with or without images of natural scenery versus simply resting while viewing images of natural scenery. Assessments were obtained at 2-week intervals while mindfulness/nature and mindfulness-only participants attended a mindfulness training course.

*Note.* At pretest, control/nature and mindfulness/nature participants rested with images of natural scenery, and mindfulness-only participants rested with no nature stimuli. Positive scores reflect improved performance from before to after the practice/rest session (i.e., increase in the number of correct substitutions completed in 60 s). Ordinary least squares regression lines based on the displayed means for pre- to postsession change illustrate the Group × Session × Occasion linear trend.

the average presession DASS ratings and LDST scores as covariates (i.e., a two-factor mixed ANCOVA). The analysis revealed that the presession DASS ratings were unrelated to session change in LDST performance on average—$ps > .503$; depression: $B = -.099$, 95% CI = [−0.404, 0.206]; anxiety: $B = .038$, 95% CI = [−0.290, 0.365]; stress: $B = .049$, 95% CI = [−0.213, 0.311]. Presession LDST performance was negatively related to improvement in LDST performance on average; $B = -.169$, 95% CI = [−0.280, −0.059], $F(1, 17) = 10.52$, $p = .005$, $\eta_p^2 = .382$; participants with weaker presession LDST performance thus improved more during sessions, overall, regardless of their psychological health otherwise. Because they were unrelated to session change in LDST performance, we excluded the presession DASS ratings from the ANCOVA and

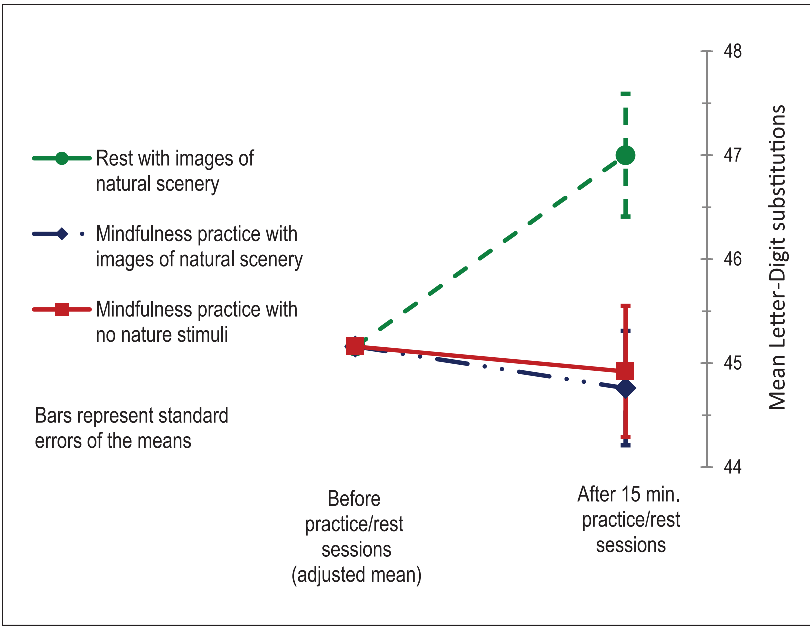


**Figure 3.** Letter-digit substitution performance after practice/rest sessions, averaged for the four assessments obtained after mindfulness/nature and mindfulness-only participants had started mindfulness training.
*Note.* Scores are the number of correct substitutions completed in 60 s. Higher scores indicate better performance. Adjustment has been made for variation in letter-digit substitution performance before the practice/rest sessions.

retained only the presession LDST score as a covariate. Again, we analyzed data averaged for Weeks 2, 4, 6, and 8, when mindfulness-only and mindfulness/nature participants practiced mindfulness during the sessions (i.e., omitting pre-test data). Comparing session change in LDST performance between the groups with the adjustment for presession LDST performance—$F(2, 20) = 4.38$, $p = .026$, $\eta_p^2 = .305$—we saw that only the control/nature participants improved on average (mean change = 1.84, 95% CI = [0.60, 3.08]; see Figure 3). Mean session change in LDST performance tended toward the negative for the mindfulness/nature (−0.39, 95% CI = [−1.55, 0.76]) and mindfulness-only participants (−0.24, 95% CI = [−1.55, 1.06]). Control/nature participants' average session change in LDST performance differed from that of mindfulness/nature (postsession mean group difference = 2.23, 95% CI = [0.52, 3.94], $p = .013$) and mindfulness-only participants (postsession mean group difference = 2.08, 95% CI = [0.27, 3.89], $p = .026$).

### The Role of Amount of Mindfulness Practice

Finally, we addressed the fifth objective of the study: to explore how initial attentional performance and psychological health relate to the amount of mindfulness practice completed during the course. Mindfulness training participants who did not drop out reported completing on average 6.37 ($SD$ = 1.26) formal and informal mindfulness exercises per week, including in-class practice. Mindfulness-only and mindfulness/nature participants completed similar amounts of practice, mean difference = 0.58, 95% CI = [−0.51, 1.66], $t(21) = 1.11$, $p$ = 281. The completed amount of practice was not strongly related to change from pretest to Week 8 in LDST performance ($r = .021$, $p = .927$) or DASS ratings ($r$s from −.288 to −.016, $p$s > .205). We explored with regression analysis whether initial attention affected mindfulness training participants' subsequent tendency to practice. Because practice had apparently taxed attentional resources during sessions, we anticipated in this analysis that already attentionally weak participants had engaged in course exercises to a lesser degree than had those with stronger initial attention. Initial LDST performance positively predicted mindfulness practice—$F(1, 19) = 12.15$, adjusted $R^2 = .358$, $p = .002$; $B = .138$, $SE = .040$, $\beta = .625$. The model was not substantially changed by entering initial DASS ratings, $\Delta F(3, 16) = 1.83$, $\Delta R^2 = .074$, $p = .183$. It appears that attentionally weaker participants practiced substantially less than did those with already strong attention, regardless of their psychological health otherwise.

## Discussion

Our results indicate that for beginning meditators, mindfulness practice incurs self-regulatory effort and negatively affects LDST performance. That effort can be offset to a degree by directing the practice toward natural scenery.

Resting with nature images for 15 min supported short-term attentional improvement on average. Overall, participants with weaker attention before the sessions benefited most during sessions, as expected when people with different needs for restoration get an opportunity to rest. However, mindfulness practice, with or without nature images, hampered attentional improvement on average. Although our mindfulness practicing participants did not decidedly deteriorate in LDST performance during the sessions, they had relatively disadvantageous change, especially on Weeks 4 and 6. Also, mindfulness training participants who were relatively attentionally weak before the course subsequently completed substantially fewer mindfulness exercises during the 8 weeks than did those with already stronger attention, regardless of depression, anxiety, and stress levels. These findings are, to our knowledge, the first that substantiate with a performance assay that beginning mindfulness practice can incur a cost in the form of attentional effort. This result is apparently in line with notions previously put forth by Chiesa et al. (2011), Holzel et al. (2011), Kaplan (2001), Lutz et al. (2008), and others. However, it contrasts with previous empirical findings by Tang et al. (2007) and Zeidan et al. (2010) who reported positive outcomes of brief mindfulness training on assays of sustained and executive attention. The reason for this discrepancy may be the timing of postpractice measurements: Signs of attentional effort may dissipate shortly after practice. Alternatively, the discrepancy could be related to differences in the meditation practices that are taught to beginners in more conventional mindfulness courses like MBSR compared with some brief interventions like Tang et al.'s integrative body–mind training, which has been described as involving low-effort, open monitoring practice already in early stages.

In addition to demonstrating that beginning conventional mindfulness practice involves attentional effort, our results indicate that natural scenery can be used to counter that effort. The average session effect of mindfulness practice on attention was similar whether with or without nature images: Average session change among mindfulness-only and mindfulness/nature participants tended toward the negative, with confidence intervals overlapping 0. The trends over time, however, show that participants who only practiced mindfulness had increasingly negative session effects over the 8 weeks. In contrast, participants who viewed nature images while practicing mindfulness had a positive trend of development. Toward the end of the 8 weeks, mindfulness/nature participants appeared to be improving during sessions: The natural scenery apparently supported their mindfulness practice and offset some of the effort otherwise incurred. This finding is in line with theory outlined by Kaplan (2001) suggesting that softly fascinating and otherwise restorative features of natural environments can facilitate and enhance meditative states. It also indicates a potentially fruitful path for clinical and environmental psychologists to explore together. Combinations of mindfulness and nature interventions may, for example, help individuals with attention problems achieve mindful states through mindfulness practices directed toward softly fascinating environmental features that help hold attention to present experience with little effort. Given the stress and heavy attentional demands that many people face in their everyday lives, we see value in discovering ways to bolster self-regulatory capabilities without imposing additional strain on already vulnerable individuals. Environment-based approaches have this advantage over many training interventions.

Participation in the study appeared to improve attentional performance and reduce anxiety and stress in the full sample, as seen in linear change across measurements obtained at pretest and on Weeks 2, 4, 6, and 8 of the study. However, we could not confirm greater long-term benefits of mindfulness training on attention or psychological health relative to a waiting-list condition; the degree of improvement was similar in the groups. Participants in the waiting-list condition did, however, regularly participate in rest sessions with nature images that appear to have yielded short-term attentional benefits, so they were not completely without treatment. The quadratic pattern in attentional performance seen in both mindfulness training and waiting-list controls, with improvement from pretest across Weeks 2, 4, and 6 but a dip on the last occasion, presumably reflects influences over and above any cumulative effect of mindfulness practice, like seasonality or history, which could be mistaken for practice effects with simple pre–post designs or uncontrolled studies.

### *Limitations of the Study*

The study had several limitations. Obviously, a relatively small sample size was one of these. Although the obtained sample was sufficient to detect important effects as reported above, we recognize that with a larger sample, we could have more confidence in the reliability of results reported. The reported results from low-powered studies sometimes show inflated effect estimates, a phenomenon called the "winner's curse" (Button et al., 2013). They also replicate successfully less often than do results from more powerful studies. Replication is thus important to verify our results. Researchers seeking to replicate the study should ensure high initial power.

Another limitation involved attrition. The mindfulness training and waiting-list control participants had comparable LDST performance and depression, anxiety, and stress ratings in the initial assessment, whether considering the originally randomized sample, the nondropout sample partition, or the sample partition with perfect attendance. However, the attrition dampens confidence in the initial equivalence on unmeasured variables of the sample partitions ultimately analyzed. Also, the resulting reduction of statistical power with an already small sample may have further hindered detection of some outcomes, like small differences between mindfulness training and waiting-list control participants' LDST performance or change in psychological health ratings across the 8 weeks. Researchers seeking to replicate the study should therefore consider additional means to mitigate problems with dropout and missing data.

Procedurally, the control/nature participants differed from the mindfulness training participants in that they were not anticipating a mindfulness training class or a specified control activity after the practice/rest session measurements. Also, the mindfulness-only group went to another room during sessions, whereas the other two groups remained in the one room. These differences could have affected participants' attention in unknown ways.

The use of a single, brief attention assay (LDST) has practical advantages but constrains our conclusions to those attentional processes that are jointly involved in substitution test performance (i.e., information processing, selective attention, and executive attention). Other important aspects and correlates of attentional functioning may also have varied across the 8 weeks and with the practice/rest session conditions. For instance, beyond the tests concerned with attrition, we did not consider participants' motivation to participate in assessments or mindfulness training.

Our design does not allow conclusions that viewing natural scenery improves attention or supports mindfulness practice more than other potentially relevant types of pleasant stimuli. We also did not assess participants' affective or experiential state as a function of the practice/rest sessions or measurement procedures, which could otherwise have allowed analyses of complementary or mediating processes related to attentional effort and restoration during mindfulness practice and/or viewing images of natural scenery. Related to that, the nonspecific instructions to practice mindfulness or rest during sessions presumably bolstered ecological validity of the conditions but preclude conclusions about which specific practices and processes underlie their respective outcomes.

## *Directions for Future Research*

We have shown that change in attentional performance in connection with mindfulness training can occur over the course of minutes as well as weeks. We have also shown that such change can be influenced by factors in addition to the mindfulness training as such. Single time point assessments of attention can be influenced by systematic variation in practice experience as well as other activity patterns, motivations, and environmental factors. Our study illustrates why future studies on the attentional outcomes of mindfulness training would do well to use strong experimental designs that consider developmental trajectories rather than single time point performance.

We anticipate that mindfulness training with tailored exercises in actual natural settings can relieve the attentional strain of practice, and that its outcomes may be mediated by processes common to both mindfulness and attentionally restorative experiences. Future studies could benefit from the measurement of state mindfulness and perceived restorativeness in connection with specific mindfulness practice sessions and/or encounters with nature. They could also benefit from measurement of change in participants' general tendency to be mindful and to have restorative experiences in everyday life through regular mindfulness practice and/or encounters with nature over several weeks or longer spans of time.

## Authors' Note

This article is based on work completed by Freddie Lymeus in 2008 for a professional degree in counseling psychology and MSc in psychology from Uppsala University.

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