Natural Beauty Moves. Aesthetically Rewarding Nature Motivates to Work on a Mindless
Task – a Preregistered Study

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Abstract

In the present research, we propose and test the notion that nature, through its aesthetically rewarding qualities, can increase work motivation. In a preregistered study, we asked participants ($N = 219$) to watch a slideshow of either aesthetically rewarding (high reward condition) or relatively unrewarding nature scenes/elements (low reward condition), while also varying pre-slideshow workload (high vs. low workload). Following the slideshow, all participants had to perform a mindless routine task, i.e., clicking radio buttons. We found that under a low (vs. high) workload, participants who had watched aesthetically rewarding nature clicked more buttons, and reported to feel more motivated to click buttons compared to participants who had watched unrewarding nature. These findings testify to the motivational potential of aesthetically rewarding nature, and raise the possibility that cognitive nature benefits observed in restoration studies are not solely indicative of resource replenishment, but might also reflect increases in work motivation.

Keywords: nature; attention restoration; motivation; mindless work; aesthetic reward.

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One of the core assumptions of environmental psychology is that the way humans feel and behave is inextricably linked to, and influenced by the environments they find themselves in (Gifford, 2013; Steg, Van den Berg, & de Groot, 2013). Guided by this idea, the last decade has brought us a true explosion of psychology research into human-environment transactions, with researchers showing particular interest in learning how *natural* environments can yield beneficial effects (Hartig, Mitchell, De Vries, & Frumkin, 2014). To this day, one of the most widely studied topics in this research area is that spending time in nature, or even merely watching nature scenes, can improve cognitive functioning (Schertz & Berman, 2019). The present work is part and parcel of this research stream, and aims to propose and test a hitherto underexplored pathway through which nature might yield cognitive benefits: through increased motivation to work.

Research into nature's cognitive benefits is traditionally guided and inspired by Stephen and Rachel Kaplan's Attention Restoration Theory (ART; Kaplan & Kaplan, 1989; Kaplan, 1995; Kaplan & Berman, 2010; Schertz & Berman, 2019), which asserts that nature can be especially beneficial for the capacity to direct attention. People typically draw upon directed attention in situations and activities where they have to concentrate on a particular task that is often in itself not particularly interesting (e.g., proofreading), while at the same time ignoring or blocking out (external or internal) competing stimulation. In ART, the capacity to direct attention is regarded as a limited resource that can tire upon intensive and prolonged use, which might lead to directed attention fatigue (Kaplan & Kaplan, 1989, Kaplan, 1995; Kaplan & Berman, 2010; Schertz & Berman, 2019), and undesired states

and/or behavioral outcomes, such as increased distraction, aggression (Kuo & Sullivan, 2001; Wang et al., 2018), or impulsivity (Berry et al., 2015).

Just like tired muscles need rest to recover, ART states that a depleted capacity for directed attention needs rest to (self-)replenish (Kaplan & Kaplan, 1989, Kaplan, 1995, Kaplan & Berman, 2010; Schertz & Berman, 2019). One of the major contributions of ART-based research is that it has highlighted how physical environments can bolster this (self-)replenishment process, with such environments typically being referred to as “restorative environments”. Supported by a burgeoning research literature, the current consensus among restoration researchers is that having contact with (unthreatening) natural environments – and especially green and blue-space – provides a powerful means to combat and recover from directed attention fatigue, whereas “grey” urban environments tend to hamper replenishment of attentional resources (Schertz & Berman, 2019).

ART postulates that nature facilitates attention restoration because natural environments are rife with “soft fascinating” stimuli, such as “... clouds, sunsets, snow patterns, the motion of the leaves in the breeze...” (Kaplan, 1995, 139). Fascinating (natural) elements, settings and phenomena effortlessly draw and hold one’s attention in a gentle way, without putting any further demands on directed attention (Herzog, Black, Fountaine, & Knotts, 1997; Basu, Duvall, & Kaplan, 2019). When exposed to, or surrounded by natural fascinations, individuals thus function in another attentional channel than when using directed attention, leaving directed attention – if fatigued – an opportunity to rest and replenish itself. Urban environments, on the other hand, are often rife with “dramatic stimulation” that needs to be blocked out (e.g., cars, billboards; Berman, Jonides, & Kaplan, 2008), which makes that functioning in such settings requires directed attention rather than that it replenishes the capacity.

Nature Facilitates Resource Replenishment

To test nature's restorative potential, restoration studies usually adopt a three-step experimental paradigm (Stevenson, Schilhab, & Bentsen, 2018). In a first phase (at Time 1), participants have to execute a cognitively effortful task intended to fatigue directed attention. In a following phase (at Time 2), participants are shown, or immersed into natural (versus control/urban) environments, directly after which they need to perform a second cognitively taxing task (at Time 3) – with performance on the latter being the central outcome measure. Using this experimental paradigm, studies generally show that participants perform better on the task executed at Time 3 after seeing (images of) natural as opposed to urban (or control) environments. Advocates of ART generally assume that, inasmuch as the fatigue induction at Time 1 depletes directed attention, the nature advantage in task performance observed at Time 3 signals attentional resource replenishment facilitated by exposure to nature stimuli.

While this three-step experimental paradigm is widely used in restoration research, it has recently been criticized on the grounds that it fails to provide a rigorous test of one of the most central tenets of ART, i.e., its replenishment idea (Joye & Dewitte, 2018). Specifically, the widespread practice to fatigue *all* participants at Time 1 does not permit one to ascertain that superior task performance at Time 3 is driven by nature (versus urban) scenes facilitating the replenishment of directed attention, or whether nature can also have beneficial effects through processes operating independent of resource depletion. In the absence of a control group of relatively unfatigued individuals, better task performance at Time 3 after seeing nature is *both* consistent with a depletion/replenishment account as with accounts centering on mechanisms that operate independent of a state of depletion.

This methodological consideration leads us to believe that there is currently only a weak empirical basis to conclude that nature-driven performance benefits reflect attentional resource replenishment; what happens between Time 1 and Time 3 – the supposed

(restorative) process – remains a black box. Guided by this issue, and by further conceptual and methodological difficulties with ART (Joye & Dewitte, 2018), we decided to take a step back, and to look at whether nature might set in motion processes – other than soft fascination facilitating/driving replenishment – that might also plausibly account for nature's benefits. With the present work, we specifically aim to both theoretically elucidate and empirically test the notion that the aesthetically rewarding qualities of natural scenes and elements makes individuals plainly more motivated and persistent on a given task.

Nature Motivates to Work by Fulfilling Hedonic Goals

In restoration research, various experimental procedures are employed to test nature's restorative effects, including (but not limited to) such tasks as the digit span forward/backward (Berman et al., 2008), the Stroop task (Beute & De Kort, 2014), the sustained attention to response task (Berto, 2005; Lee, Williams, Sargent, Williams, & Johnson, 2015), or the attention network task (Berman et al., 2008; Gamble, Howard, & Howard, 2014). Because a common denominator between these and other tasks is that their execution relies on directed attention, a nature (versus urban) advantage on these tasks is seen as evidence that nature specifically operates on this attentional capacity. There are however other common denominators between these tasks, and – at the current stage of research – we cannot exclude that nature also operates on these.

What might those other common denominators be? At a basic level (independent from attention), a shared ground between many, if not all tasks used in restoration research is that participants are expected to fulfill the goal to *work*. They have to perform a task that, for many of them, is not particularly rewarding or personally meaningful, and might even be boring (e.g., SART; Pattyn, Neyt, Henderickx, & Soetens, 2008) or frustrating (e.g., Stroop task; Filipas, Mottola, Tagliabue, & La Torre, 2018). When participants are sufficiently

motivated to fulfill the required work, they will invest effort and show persistence in the work, leading to better task performance than when work motivation would be comparatively lower.

Crucially, the goal of working does not take place in a vacuum but is part of a goal system: people hold multiple other goals (of varying importance) at the same time (Kruglanski et al., 2002), and, given that it can be maladaptive to only narrowly focus on one goal (Kurzban, Duckworth, Kable, & Myers, 2013), they try to reach and preserve an equilibrium between these multiple goals. The upshot is that as a work episode progresses, other goals might become increasingly more salient, some of which may even start competing with the goal of working. While there might be a myriad of competing goals, we suspect that the goal to engage in something pleasurable/rewarding – i.e., pursuing hedonic goals – will become particularly attractive in work situations (especially if the work itself is not rewarding or meaningful; Inzlicht & Schmeichel, 2012). The increasing importance of hedonic goals can interfere with work, and eventually even hurt work performance.

We thus propose a dynamic interplay between goals, where progressive engagement in the goal to work increases the attractiveness of hedonic goals (Inzlicht & Schmeichel, 2012). The point at which hedonic goals become salient and start to conflict/interfere with the goal to work is most probably influenced by what happens immediately before the work episode. If people have experienced something non-rewarding before work, hedonic goals will more quickly become salient during work than when having experienced something comparatively more rewarding before work. This is simply because hedonic goals have remained unfulfilled for a longer time in the former situation compared to the situation where a rewarding stimulus immediately preceded work. If hedonic goals remain unfulfilled, performance can suffer, which can be evident from lower persistence, slacking off, or from lapses in concentration during work.

The mechanism we put forward might point to an alternative pathway through which nature can yield a performance advantage on cognitive tasks used in restoration research. Ample environmental psychology research has shown that natural landscapes and elements (more so than urban settings) are widely considered to be aesthetically rewarding (Biederman & Vessel, 2006; Yue, Vessel, & Biederman, 2007; Vessel, Maurer, Denker, & Starr, 2018), with researchers tracing this aesthetic preference back – amongst others – to our shared evolutionary past (Wilson, 1984) or to differences in processing demands imposed by natural versus urban scenes (Joye, Steg, Ünal, & Pals, 2016). Inasmuch as executing cognitive tasks in restoration studies is experienced as work, viewing nature might provide an aesthetic reward before engaging in that work. In that capacity, nature is better able to satisfy hedonic goals than comparatively less rewarding stimuli (such as urban settings), and can thereby delay or buffer against the interference/conflict that can arise between working (on cognitive tasks) and the need for hedonic stimulation.

The Current Study

Guided by the previous theoretical framework, we expected that experiencing aesthetically rewarding nature (versus relatively unrewarding stimuli) would have motivational influence, such that after/during watching such nature, participants would be more willing to work.

To provide a first test of this notion, we conducted a pre-registered lab study in which participants had to watch a slideshow consisting of fifteen photos of natural scenes/elements. We manipulated the reward value of the slideshow images (between-subjects) by showing them either aesthetically attractive nature images (high reward condition) or nature images where the aesthetic qualities had been removed through pixilation (low reward condition). We subsequently tested the effect of this manipulation on participants' motivation to work by

monitoring their performance on a very simple and mindless “clicking task” consisting of freely clicking radio buttons.

In addition to manipulating the aesthetic reward value of the nature images, we also varied participants’ workload (between-subjects), to gauge if the main effect of aesthetic reward on the central clicking task would be affected by the amount of work performed. In the high workload condition, participants not only did the clicking task after, but also *before* the nature slideshow, whereas in the low workload condition participants only had to click buttons after the nature slideshow.

We submitted two preregistered hypotheses. First, guided by the notion that aesthetically attractive nature scenes/stimuli constitute a visual reward (Biederman & Vessel, 2006; Yue et al., 2007), and that providing a reward before work increases work motivation, we hypothesized that participants in the high reward nature condition would click more buttons than participants in the low reward condition (Hypothesis 1). At the time of the preregistration, we believed that this effect would take place irrespective of level of workload. Second, based on the notion that motivation dwindles upon repeating a mindless task, we expected that participants who only had to perform one clicking task would click more buttons than participants who received a higher workload (by also doing the task *before* the nature slideshow; Hypothesis 2).

Methodology

Preregistration

For the present study, we preregistered the theoretical rationale and main hypotheses, the calculation of sample size, exclusion criteria, as well as the target analyses. The preregistration document can be accessed via <https://osf.io/439um>.

Participants and Design

Two-hundred and nineteen participants (age: $M = 44.43$, $SD = 12.94$; 122 females) participated in this lab study, which was part of a multi-study experimental session. Sample size for the present study was determined before data collection using G*Power (Faul, Erdfelder, Lang, & Buchner, 2007), recommending a required sample size of 210, based on a medium effect size ($f = 0.25$), an alpha-level of .05, and a power of .95. We sampled somewhat above this sample size to account for sample attrition. We used a 2 by 2 between-subjects design, with “reward value” (high reward vs. low reward) and “workload” (high workload vs. low workload) as the between-subjects factor, and (the measures for) work motivation as the dependent variable. In the Appendix we list additional measures taken for the present study, including descriptives per condition.

Manipulations and Measures

Slideshow of High Reward Versus Low Reward Nature Photos.

We collected fifteen high-resolution photographs of aesthetically appealing natural settings/elements/phenomena using *Google Images*. The photo set included images of mountains views, sunsets, and forests, but also of small beautiful natural elements, such as tiny glistening water droplets on leaves. In the high reward condition, we showed participants the original (but resized) photographs (see Figure 1 for sample images, and the full image set in the Appendix), whereas in the low reward condition, we used the same pictures as in the high reward condition, but pixelated each photo using an online pixilation application (accessible via www.onlinepngtools.com; pixilation size was set at a value of 30). As low-level structure/detail of images is known to contribute to the aesthetic qualities of pictures (Valtchanov & Ellard, 2015; Van den Berg, Joye, & Koole, 2016), and as pixilating removes that low-level structure/detail, we expected that pixelating would substantially reduce the

aesthetic qualities of the photos, while at the same time preserving general color information, global scene properties, and content information. In other words, pixelating allowed us to isolate and specifically manipulate the aesthetic reward value of the photos. We preferred this method over comparing (images of) natural with urban scenes (common in restoration research; Stevenson, Schilhab, & Bentsen, 2018), as these scene categories differ on countless other dimensions than their aesthetic value (e.g., signs of human presence, presence of artefacts, differences in color).

Aesthetic Ratings of the Slideshow Photos.

To verify whether participants indeed perceived the high versus low reward slideshow photos as aesthetically rewarding, we asked them to rate how “beautiful”, “fascinating”, “rewarding”, and “ugly” they considered the entire set of nature photos¹ (scored from 1 = strongly disagree, to 7 = strongly agree). We created an aesthetic reward index by averaging the first three items ($\alpha = .90$; we left out the item “ugly”, because – after reverse-coding – it turned out to reduce the scale’s reliability, although not affecting results in any way).

¹ We also asked participants how much “awe” the images provoked in them, but due to a translation error we were unable to use this item.

Figure 1: Sample images of an original (left; high reward condition) and a pixelated nature image (right; low reward condition) used in the present study.

Behavioral Measure of Work Motivation: Clicking Radio Buttons.

As the central behavioral measure of participants' motivation to work, we chose a task that was easy to implement and execute on the survey platform we used (i.e., *Qualtrics*), while at the same time permitting us to straightforwardly quantify participants' motivation and effort investment. We opted for participants to click radio buttons. Participants were presented with a matrix of 500 clickable buttons (organized in 50 rows of 10 buttons; see Figure 2) and their task was simply to click as many buttons as they wanted. We considered the act of clicking to be routine-like and “mindless” work, without any obvious reward value, and requiring little to no directed attention or any other cognitive resources. If aesthetically rewarding nature photos would positively affect performance on such a simple task, then this would lend support to the notion that beautiful nature has motivating potential.

Self-Reported Motivation to Work.

In addition to behaviorally assessing participants' motivation through a clicking task, we also gauged motivation using three self-report measures. We asked them how much effort they had put into the clicking task (“effort index”; scored from 1 = very little effort, to 5 = very much effort), how motivated they were to perform the clicking task (“motivation index”; scored from 1 = very unmotivated, to 7 = very motivated), and whether or not they had

clicked more buttons than they had intended to do (“surplus clicking”; scored from 1 = yes, 2 = no, to 3 = I don’t know). For the statistical analyses of surplus clicking, we excluded participants who selected (the uninformative) score 3.

Procedure

Participants were randomly assigned to the experimental conditions. For participants in the high workload condition, the study began with the clicking task. After a general introduction to the study, we informed them that they would be shown a matrix of 500 clickable radio buttons on the next page, and instructed them that they had to click buttons (using the mouse) until they no longer felt like it, at which point they could click away to the next page of the survey. We explicitly communicated to them that they were free to click as many (or as little) buttons as they wanted, to ensure that clicking would reflect work motivation rather than satisficing.

After briefing these participants about the clicking task, they could click away to the next page where they were presented with the matrix of 500 radio buttons, all of which could be clicked. Not all 500 buttons were simultaneously visible on the computer screen, so participants had to scroll down during the clicking task (computers and computer settings were identical across participants). For each participant, we counted the number of buttons clicked as the central behavioral measure of his/her motivation. Participants could stop and click away to the next page at any point. Because of limitations in allocated study time, the length of the clicking task was limited to four minutes, after which the page showing the radio buttons automatically advanced.

Figure 2: Schemas of the experimental procedure used in the present study, for participants in the high workload (top) and low workload (bottom) condition. Each participant either saw the original nature photos (high reward condition), or their pixelated counterparts (low reward condition).

After this first clicking task, participants in the high workload condition were invited to watch the slideshow of nature photos. Participants in the low workload condition did not

have to perform a pre-slideshow clicking task; after receiving a general introduction to the study, for them the experiment started off with the slideshow. Across both workload conditions, participants were randomly assigned to the slideshow showing either the original (high reward condition) or the pixelated photos (low reward condition) of natural scenes/stimuli.

For the slideshow, we instructed participants to closely watch each photograph, and to be aware of their feelings and thoughts while watching. Each slideshow image was displayed on the screen for 10 seconds, after which the page auto-advanced to the next picture. Photo presentation order was identical for all participants.

After the slideshow, all participants had to perform the clicking task – this was the second clicking task for participants in the high workload condition, and the first one for participants in the low workload condition. The instructions were identical to the instructions given to participants who had to perform a pre-slideshow clicking task. We again counted the total numbers of buttons clicked, and treated this as our central behavioral index for work motivation. After clicking, we measured participants' self-reported motivation (i.e., effort index, motivation index, and surplus clicking), asked them to rate the aesthetically rewarding character of the slideshow images (i.e., aesthetic reward index), and ended the study by debriefing and thanking participants.

Results and Discussion

Preliminary Analyses

To check whether the original versus pixelated nature photos were indeed experienced as aesthetically more rewarding, we conducted an independent samples *t*-test (with degrees of freedom corrected for violation of homogeneity of variances) with reward value (high vs. low reward) as the independent variable, and the aesthetic reward index as the dependent variable.

This analysis revealed a statistically significant effect of reward value, $t(183.29) = -11.19, p < .001$, Cohen's $d = 1.51$, such that participants indeed experienced the high reward slideshow images to be more aesthetically rewarding ($M = 5.59, SD = 1.09$) than their low reward counterparts ($M = 3.40, SD = 1.74$). Thus, our manipulation of aesthetic reward value was successful.

Note furthermore that the number of buttons clicked correlated positively and significantly with the motivation index, $r(219) = .48, p < .001$, and with the effort index, $r(219) = .26, p < .001$, and that the effort index and motivation index correlated positively with each other, $r(219) = .47, p < .001$. For surplus clicking we only found a significant relationship with the effort index, with an independent samples t-test revealing that participants who had clicked more buttons than intended ($M = 2.35, SD = 1.04$) reporting to have expended more effort on the clicking task than participants who had not clicked more buttons than intended ($M = 1.96, SD = 0.97$), $t(175) = 2.55, p = .012$, Cohen's $d = 0.39$ (all other p 's $> .117$). Taken together, these findings generally confirm that clicking buttons captures motivation.

Preregistered Analyses

Effects of Reward Value and Workload on Buttons Clicked.

To test the effect of aesthetically highly rewarding (vs. low rewarding) nature on participants' work, we ran a two-way ANOVA with reward value of the images (high reward vs. low reward) and workload (high vs. low workload) as the independent variables, and the number of post-slideshow buttons clicked as the dependent variable. We excluded participants from all analyses ($n = 4$) who had an outlying value for the average number of buttons clicked (i.e., $+3$ SD s from the mean; $M = 129.07, SD = 121.55$).

While this analysis did not reveal a significant main effect of reward value on numbers of buttons clicked (cf., Hypothesis 1), $F(1, 211) = 1.44, p = .232, \eta_p^2 = .01$, it yielded a significant main effect of workload (cf., Hypothesis 2), $F(1, 211) = 4.00, p = .047, \eta_p^2 = .02$, showing that participants clicked more buttons in the low workload than in the high workload condition. There was furthermore a significant reward value by workload interaction, $F(1, 211) = 4.56, p = .034, \eta_p^2 = .02$, suggesting that the effects of high reward (vs. low reward) nature on button clicking might actually be a function of level of workload (see Figure 3).

In line with our first pre-registered hypothesis (Hypothesis 1), planned comparisons revealed that within the low-workload condition, participants indeed clicked significantly more buttons, $F(1, 211) = 5.53, p = .020, \eta_p^2 = .03$, when they had watched high reward, ($M = 162.07, SD = 125.74$) rather than low reward nature images ($M = 112.15, SD = 83.22$). In contrast, under a high workload, there was no significant difference between the high reward ($M = 100.15, SD = 107.44$) and low reward condition ($M = 114.17, SD = 117.52$) for number of buttons clicked, $F(1, 211) = 0.44, p = .508, \eta_p^2 = .00$. Thus, partly in line with our preregistered hypothesis, participants who were under a relatively low workload worked more on a mindless routine task after seeing rewarding nature than relatively unrewarding nature².

² Note that the higher number of clicks in the high reward (versus low reward) nature conditions cannot be explained by faster clicking, due to – say – increased arousal after seeing beautiful nature. Because we had time recordings of how long it took participants to click buttons, we could calculate the average clicking time per button for each participant. There were no significant differences in average clicking speed per button between all conditions (all F 's < 1), suggesting that differences in number of buttons clicked did not merely reflect increased response speed.

Figure 3: Number of buttons clicked as a function of level of reward and workload (error bars represent 95% confidence intervals).

Effects of Reward Value and Workload on Self-Reported Motivation and Effort.

We tested whether the effects obtained for clicking buttons would also hold for the motivation index and effort index. We again conducted a 2 (high vs. low reward) by 2 (high vs. low workload) ANOVA, now with both self-report measures of motivation as the dependent variables.

These analyses yielded no significant main effect of reward value on both the effort and motivation index (both p 's $> .404$), but revealed a (marginally) significant main effect of workload (high vs. low) on the motivation index, $F(1, 211) = 3.38, p = .068, \eta_p^2 = .02$. There was no significant main effect of workload on the effort index, $F(1, 211) = 2.32, p = .130, \eta_p^2 = .01$, although the effect was directionally similar as for the motivation index. Consistent with the results for clicking buttons there was a significant reward value by workload

interaction for both the motivation index, $F(1, 211) = 6.93, p = .009, \eta_p^2 = .03$, and the effort index $F(1, 211) = 6.25, p = .013, \eta_p^2 = .03$ (see Figure 4).

Figure 4: Scores on the motivation index (left) and effort index (right) as a function of level of reward and workload (error bars represent 95% confidence intervals).

Planned comparisons revealed that under a low workload, participants felt (marginally) significantly more motivated, $F(1, 211) = 2.78, p = .097, \eta_p^2 = .01$, and reported to have invested significantly more effort, $F(1, 211) = 5.54, p = .020, \eta_p^2 = .03$, in the high reward (motivation index: $M = 4.43, SD = 1.41$; effort index: $M = 2.39, SD = 1.00$) than in the low reward condition (motivation index: $M = 3.87, SD = 1.70$; effort index: $M = 1.94, SD = 0.91$).

In the high workload condition, there was no significant difference on the effort index between the high reward ($M = 1.85, SD = 1.05$) and low reward condition ($M = 2.08, SD = 0.95$), $F(1, 211) = 1.39, p = .239, \eta_p^2 = .01$, whereas participants scored significantly lower on the motivation index in the high reward ($M = 3.37, SD = 1.96$) than low reward condition ($M = 4.06, SD = 1.81$), $F(1, 211) = 4.23, p = .041, \eta_p^2 = .02$. Thus, taken together, these findings

show that participants who were under a relatively low workload reported to be more motivated to work on the clicking task after seeing rewarding versus unrewarding nature. These results are in line with the results found for the actual clicking behavior.

Effects of Reward Value and Workload on Surplus Clicking.

Using a chi-square test of independence, we tested the relation between reward value and the questionnaire item “surplus clicking”, while controlling for level of workload (high vs. low). Paralleling the results of our previous analyses, this analysis revealed that in the low workload condition, the relation between these variables was significant, $\chi^2(1, N = 76) = 5.30, p = .021$. Thus, participants were more likely to report that they had clicked more buttons than anticipated after seeing the high reward than after seeing the low reward nature photos. In the high-workload condition the relationship between reward value and surplus clicking turned out not to be significant, $\chi^2(1, N = 97) = 0.02, p = .888$.

Exploratory, Non-Preregistered Analyses

Changes in Clicking Behavior as a Function of Reward Value.

In the previous analyses we considered the pre-slideshow clicking task as a manipulation of workload. Of course, for participants who did the clicking task twice (i.e., participants in the high workload condition, $n = 108$, after removal of outliers), we might also examine whether their clicking behavior changed over time, and whether those changes – if any – might be a function of the level of reward value of the slideshow. For these participants, we therefore conducted a mixed-design ANOVA with time of the clicking task (pre-slideshow vs. post-slideshow) as the within-subjects variable, slideshow reward value (high vs. low reward) as the between-subjects variable, and number of buttons clicked as the dependent variable. Consistent with the notion that participants loose motivation upon

repeating routine tasks, this analysis revealed a significant general decrease in buttons clicked from the pre-slideshow clicking task ($M = 122.94$, $SD = 103.27$) to the post-slideshow clicking task ($M = 107.16$, $SD = 112.28$), $F(1, 106) = 6.21$, $p = .014$, $\eta_p^2 = .06$. There was no significant time of the clicking task by reward value interaction, $F(1, 106) = 0.34$, $p = .562$, $\eta_p^2 = .00$, showing that in this particular workload condition, the change in clicking behavior remained unaffected by the reward value of the slideshows.

Exploring the Direction of the Motivational Effect.

While the results from the preregistered analyses point to the existence of differences in motivational potential between high reward and low reward nature under a low workload, at the same time our analyses remain inconclusive about whether it is high reward nature that motivates, low reward nature that demotivates, or whether both processes operate simultaneously. Recall however, that all participants in the high workload condition ($n = 108$) began the study with a clicking task, only after which they saw the nature slideshow – either the rewarding or unrewarding version. So, clicking behavior on this first (pre-slideshow) clicking task can function as a control condition, against which post-slideshow clicking behavior in the high reward and low reward condition for participants who are under a low workload can be compared.

To test this, we merged participants' clicking performance (i.e., number of buttons clicked) on the pre-slideshow clicking task with the post-slideshow clicking performance of participants in the low workload condition into one new dependent variable. After also creating a new independent variable to code for the type of slideshow participants had to watch before clicking (i.e., no slideshow [= control condition], high reward, or low reward condition) a one-way ANOVA revealed a significant effect, $F(2, 212) = 3.53$, $p = .031$, $\eta_p^2 = .03$, with participants clicking significantly more buttons in the high reward ($M = 162.07$, SD

= 125.74) than in the control condition ($M = 122.94$, $SD = 103.27$; $p = .026$), while there was no significant difference ($p = .541$) between the control and the low reward condition ($M = 112.15$, $SD = 83.22$; see Figure 5).

In sum, the fact that participants clicked significantly more buttons in the high reward than control condition, and that there was no difference on the number of buttons clicked between the low reward and control condition, seems to suggest that motivational differences between the slideshow conditions are especially driven by watching aesthetically rewarding nature images.

Figure 5: A comparison of the number of buttons clicked between the high reward, low reward and control condition, within the low-workload condition (error bars represent 95% confidence intervals).

General Discussion

In the present work, we proposed and tested the notion that nature can function as an aesthetic reward that increases people's motivation to work. In a preregistered study, we asked participants to perform a task whose execution would put little to no demands on attentional/cognitive resources, namely clicking radio buttons. Consistent with the hypothesis

that aesthetically rewarding nature can have motivating potential, we found that – under a relatively low workload – participants clicked more buttons, reported to feel more motivated, and to have expended more effort on the clicking task after seeing rewarding versus unrewarding nature. Additional exploratory analyses showed that it was especially the high reward nature condition that gave participants a motivational “push”, rather than that low reward nature pulled motivation down.

Our results contribute to a growing body of research into the beneficial psycho-social effects of natural settings, such as reducing stress (Ulrich et al., 1991), improving mood (Beute & De Kort, 2014) and mental health (Bratman, Hamilton, Hahn, Daily, & Gross, 2015; Cox et al., 2017), increasing prosociality (Piff, Dietze, Feinberg, Stancato, & Keltner, 2015; Joye & Bolderdijk, 2015), and improving cognitive function (Berman et al., 2008). Importantly, inasmuch as the successful execution of the attentional/cognitive tasks used in restoration research depends on motivation to work, our results suggest that superior performance after seeing natural versus urban scenes might – at least partly – also reflect motivational differences stemming from differences in reward value between both scene types. While this account has already been hinted at (Joye & Dewitte, 2018), we think it deserves further consideration in restoration research.

Critical readers might notice that the methods and stimuli we used in the present research deviate in essential ways from those employed in ART-based research. We for example compared photos of nature scenes/phenomena (original versus pixelated) in *both* reward conditions, rather than contrasting (images of) natural with urban scenes, and used a task – i.e., clicking buttons – that did not specifically tap into attentional capacity. One might therefore be left wondering what the current research can say about attention restoration. Let us make clear, however, that our main goal was not to critically assess aspects of ART, nor to

try to refute the framework. Rather, we selected these methods and stimuli because they specifically allowed us to test the motivational potential of nature.

Our study provides initial support for the motivating effects of aesthetically rewarding nature, but also yielded some unexpected results. While we were able to show that participants clicked more buttons after seeing high rewarding nature, we only found this effect in the low workload condition. A possible explanation is that the reward value of the nature slideshow was simply not high enough in the high workload condition. In this condition participants experienced *both* something unrewarding (i.e., a first, pre-slideshow clicking task) and rewarding (i.e., beautiful nature) before the post-slideshow clicking task. It might be that the combined effect of something rewarding and unrewarding carried too little total reward value to play a significant role in the post-slideshow clicking task. Future research might look at the minimal dose of “natural reward” required to observably affect participants’ motivation.

There might also be alternative explanations for our findings. One such explanation is that increased button clicking and motivation reflect a prosocial act. In line with research that shows that nature can increase prosocial inclinations (Piff et al., 2015; Joye & Bolderdijk, 2015), viewing aesthetically rewarding nature could have prompted participants to do the experimenter a favor, leading to increased clicking. While we have tried to prevent participants from engaging in satisficing (by explicitly communicating to them that they were completely free to click as many buttons as they wanted), prosocial impulses might still have operated outside participants’ conscious awareness. Future research might try to disentangle whether increased work motivation observed in the current study stemmed from reward, from an increase in prosocial tendencies, or even from both. Note however that this alternative explanation would not fundamentally change the main message of the current paper, i.e., that nature yields (cognitive) benefits through an increased motivation to work. In addition to

stemming from the fulfillment of hedonic goals, work motivation might as well get a boost from activating prosocial values.

A second alternative explanation is that differences in clicking behavior between the high reward and low reward nature conditions might still reflect the replenishment of attentional resources. Most probably, participants did not start this lab study in a fully rested state, and advocates of ART might therefore argue that watching high reward (vs. low reward) nature might have partly resolved attentional fatigue. Because of this, in the high reward condition, participants had more resources available to withstand the impulse to prematurely abandon the boring clicking task compared to participants in the low reward condition, translating into more clicking in the former condition. If true, then this effect should especially hold for participants in the high workload condition, because they have done the task twice. Our data however show that the strongest effects are there for participants who have not done a pre-slideshow clicking task, which makes it unlikely that our findings reflect resource replenishment.

Although ART has been hugely influential as an explanatory framework for nature's cognitive benefits, there currently exists only little direct evidence for the notion – central to ART – that cognitive restoration reflects a replenishment process operating via soft fascination (Joye & Dewitte, 2018). In the present work we were able to give a first glimpse of an underexplored effect of nature, which might point to an alternative pathway through which natural environments/stimuli can yield, what appear to be, “cognitive” benefits. While ART has traditionally centered on nature's capacity to engage effortless attention (or: “fascination”), our results show that aesthetically attractive nature can also simply motivate participants to work. We hope that future studies will further explore increased work motivation as an alternative viable driver of nature's cognitive benefits.

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Appendix

Below we disclose all the additional measures we have taken in the current study, and in Table A1 we provide the descriptives of those measures across the reward (high vs. low reward) and workload (high vs. low workload) conditions.

Feelings Associated With the Clicking Task

Immediately after finishing each clicking task, we asked participants how “bored”, “interested”, “annoyed”, “happy”, “sad”, “motivated”, “energized”, and “tired” they felt at that very moment (scored from 1 = strongly disagree, to 7 = strongly agree). Note that participants in the high-workload condition took these measures two times, because they had to do the clicking task twice (before, and after the slideshow).

Ratings of the Slideshow Images

In addition to measuring aesthetic emotions provoked by the slideshow images, at the end of the survey we also asked participants to evaluate the images on several other dimensions. The items participants had to rate were: “The images ... excited me”, “... made me happy”, “... energized me”, “... relaxed me”, “... bored me”, “... confused me”, and “... tired me” (scored from 1 = strongly disagree, to 7 = strongly agree).

Need for (Less or More) Monetary Compensation

As an exploratory measure, we asked participants whether they thought the payment they were receiving for their participation in the study (i.e., 12 euro) was appropriate, or whether they thought they needed to be paid more, or less. We gave them the following three answer options:

- Option 1: “The amount of money I receive for my participation is too much” (if this choice was selected, participants had to indicate how much they wanted to be paid for participating in the study, in euros).
- Option 2: “The amount of money I receive for my participation is just right”.
- Option 3: “The amount of money I receive for my participation is too little” (if this choice was selected, participants had to indicate how much they wanted to be paid for participating in the study, in euros).

Control Measures

We took two control measures, namely the short Nature Relatedness Scale (NR-6; taken from Nisbet & Zelenski, 2013), and participants’ engagement with natural beauty (taken from: Diessner, Solom, Frost, Parsons, & Davidson, 2008).

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Table A1

Descriptives of the additional measures taken in the present study.

		low workload		high workload	
		high reward <i>M(SD)</i>	low reward <i>M(SD)</i>	high reward <i>M(SD)</i>	low reward <i>M(SD)</i>
	<i>n</i> (participants)	55	55	54	55
feelings CT 1	bored	-	-	3.20 (1.64)	2.60 (1.56)
	interested	-	-	5.02 (1.35)	5.33 (1.40)
	annoyed	-	-	1.85 (1.28)	2.20 (1.43)
	happy	-	-	4.59 (1.25)	4.85 (1.50)
	sad	-	-	1.69 (1.13)	2.00 (1.35)
	motivated	-	-	4.54 (1.49)	4.85 (1.47)
	energized	-	-	4.35 (1.38)	4.87 (1.31)
	tired	-	-	2.30 (1.22)	2.85 (1.77)
feelings CT 2	bored	2.98 (1.72)	3.47 (1.71)	3.67 (1.75)	4.00 (1.96)
	interested	5.09 (1.32)	5.16 (1.27)	4.57 (1.70)	4.53 (1.79)
	annoyed	2.15 (1.46)	2.33 (1.41)	1.85 (1.11)	2.58 (1.67)
	happy	4.95 (1.30)	4.56 (1.20)	4.52 (1.53)	4.69 (1.60)
	sad	1.75 (1.11)	2.36 (1.38)	1.78 (1.08)	2.25 (1.48)
	motivated	4.87 (1.44)	4.35 (1.25)	4.30 (1.50)	4.44 (1.66)
	energized	4.51 (1.39)	3.96 (1.44)	4.39 (1.45)	4.20 (1.87)
	tired	2.98 (1.89)	3.18 (1.71)	2.72 (1.60)	3.09 (1.90)
image ratings	excited	3.80 (1.70)	2.78 (1.33)	3.43 (1.91)	2.65 (1.67)
	happy	5.33 (1.29)	3.58 (1.71)	4.96 (1.67)	3.33 (2.05)
	energized	4.80 (1.61)	3.11 (1.56)	3.93 (1.86)	2.69 (1.67)
	relaxed	5.42 (1.47)	3.65 (1.66)	5.19 (1.83)	3.27 (1.82)
	bored	2.29 (1.50)	3.98 (1.89)	2.43 (1.59)	4.16 (2.18)
	confused	1.56 (1.03)	3.47 (1.82)	1.72 (1.27)	3.44 (1.70)
	tired	1.13 (0.47)	2.33 (1.50)	1.07 (0.26)	2.47 (1.69)
control measures	ENB	5.26 (1.02)	5.28 (0.90)	4.91 (1.24)	5.47 (1.15)
	NR	3.62 (0.68)	3.65 (0.67)	3.62 (0.64)	3.68 (0.87)
	MC	14.02 (5.14)	14.09 (5.83)	14.04 (6.20)	13.89 (4.75)

Notes: feelings CT1 (and CT2) = feelings reported after the 1st clicking task one (or after the 2nd clicking task); ENB = engagement with natural beauty; NR = nature relatedness; MC = monetary compensation. There were some missing values for "monetary compensation": for this measure, the number of participants per condition was: low workload, low reward: $n = 54$; low workload, high reward: $n = 53$; high workload, low reward: $n = 53$, high workload, high reward: $n = 53$.

Images

High Reward Condition

Low Reward Condition