Assessing the Impact of Nature for Reducing Cognitive Fatigue: A Validation Study

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Abstract

Attention is a limited resource that can become depleted after extensive usage. Exposure to nature stimuli can help recover attention depletion. More precisely, nature (vs. urban) benefits have been reported for working memory, attention control and cognitive flexibility, although these effects are the subject of debate. This study aims at assessing whether nature can help reduce cognitive fatigue as a consequence of attention depletion. Participants performed a pretest working memory and attention control task. Then, they went through a cognitive fatigue task, followed by exposure to either nature or urban images, and a posttest consisting of the pretest measures. Measures of subjective fatigue were also collected throughout the study. Pre- vs. posttest cognitive performance comparisons failed to raise differences across conditions. Yet, subjective fatigue was significantly improved by the nature intervention but not by the urban intervention. Results are discussed in terms of nature's positive impact on subjective experience.

Keywords: cognitive fatigue; attention restoration; nature; working memory; attention control; validation study

Introduction

Attention is a resource required for various tasks, including executive functioning and self-regulation (Kaplan & Berman, 2010). However, attentional resources are limited and can be depleted with usage, while cognitive efforts are deployed. Attention depletion is a frequent challenge experienced in many situations, across multiple domains, and can lead to mental fatigue. Operators from high-stake domains such as aviation (Dehais et al., 2014), command and control (Hodgetts et al., 2017), and defence (Cooke et al., 2004), as well as workers in more clerical jobs (Jett & George, 2003; Mak & Lui, 2012), often experience attention depletion because of the demands incurred by their work. The attentional fatigue induced, however, can increase risks of errors and, in cases of high-risk domains, may threaten the security of populations and infrastructure.

Exposure to nature stimuli, both in the lab and in real-life settings, has been shown to represent an efficient intervention to help recover attention resources following a period of cognitive depletion. The effects of this intervention have been demonstrated in many studies (e.g., Atchley et al., 2012; Berman et al., 2008; Berto, 2005; Duvall, 2011). According to the attention restoration theory (ART; Kaplan, 1995), nature's positive outcomes on attention ensue from the characteristics nature inherently possesses, more particularly because of its capacity to promote effortless attention capture and engagement, which in turn allows it to replenish (Marois et al., 2021). Although beneficial effects of nature on cognition represents a burgeoning fundamental research field, nature applied as an intervention to help recover attentional resources has great potential as a tool for multiple groups, including workers. Such a technique could provide an efficient alternative to provide workers with opportunities to replenish their attention in periods of fatigue and, in turn, to mitigate any negative effects on their work performance.

Some studies showed benefits for the integration of nature patterns or interventions into academic and professional settings (e.g., Craig et al., 2021; Gbetoglo, 2021; Marois, 2020). Still, no application has been developed to integrate such a technique as a countermeasure tool to mitigate the cognitive challenges experienced by workers, that is, when attentional fatigue is detected. Such user-tailored approach represents a key strategy for human factors and cognitive systems engineering practices and is deemed efficient at optimally supporting human activities in many domains and contexts (see, e.g., Dehais et al., 2011, 2020; Karran et al., 2019; Tejero Gimeno et al., 2006; Wang, Huang et al., 2014).

Performance improvements induced by nature attention restoration were observed on multiple cognitive functions including creative problem solving (Atchley et al., 2012), inhibitory control (Berman et al., 2008; Chung et al., 2018), memory (Berman et al., 2012; Shin et al., 2011; Szolosi et al., 2014), and sustained attention (Berto, 2005; Pasanen et al., 2018). A few meta-analyses, however, have raised questions regarding the actual effects of attention restoration and the type of cognitive tasks used to measure the behavioral effects of the intervention (Bowler et al., 2010; Ohly et al., 2016).

Stevenson et al. (2018) conducted a meta-analysis that evaluated the different processes to restore and the tasks that showed potential to demonstrate such restoration. They also

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considered aspects related to pre-intervention fatigue, baseline individual differences, and type of exposure. They showed that attentional control (via the Necker Cube Pattern Control, Attention Network Task, Multi-Source Interference Task, and Stroop Task), working memory (using the Digit Span Backward Task, Digit Span Forward Task, Forward Spatial Span, and Reading Span Task), and cognitive flexibility (measured with the Trail Making Task B and Stroop Task) represented the three main processes that showed benefit from nature exposure. The authors also outlined that higher engagement toward a nature setting (e.g., exposure to real environments, potentially driven by exposure duration/level of engagement, see, e.g., Browning et al., 2020; Duvall, 2011; Lin et al., 2014; Marois et al., 2021; Pasanen et al., 2018; Szolosi et al., 2014) were likely to enhance restoration effects, especially for attentional control and cognitive flexibility. Controlling for baseline differences, when comparing nature and urban exposure conditions, reduced the effects over attentional control, and effects were diminished when a period of cognitive fatigue preceded the intervention for working memory studies.

Overall, it seems that attentional control, working memory and cognitive flexibility mostly profit from nature exposure, but some confounding variables must be considered. Such a conclusion however needs further empirical support. Besides, the concept of cognitive fatigue remains quite vague, and it is not clear whether the importance of cognitive fatigue prior to nature interventions suggests that perceived fatigue can be restored by nature stimuli. In that regard, a recent study by Johnson et al. (2022) suggested that subjective reports of restoration as well as markers of cognitive alertness could be improved by exposure to nature environments. Reports of restored state were higher for participants exposed to nature compared with urban exposure. Objective measures of alertness (i.e. performance on the sustained attention to response task and pupillary dilation), however, did not improve. Nonetheless, the study lacked self-reports of fatigue, which may have been more sensible and appropriate for assessing the subjective impact of nature. To better understand the effects of nature interventions, there is a need for such assessments using a variety of cognitive measures.

Study Goal

The present study represents a first step towards a more holistic assessment of the potential of nature interventions to mitigate cognitive fatigue through the combination of objective and subjective measures of cognitive functioning and fatigue. More precisely, the goal is to provide preliminary proof-of-concept validation for examining the impact of a nature intervention on cognitive functioning following a period of cognitive resource depletion. Such depletion serves to control for any difference in baseline, ensuring that all participants are facing cognitive fatigue before being exposed to the intervention (cf. Stevenson et al., 2018). To reach this goal, participants performed a pretest measure of their working memory and attention control abilities before having to carry out a repetitive task imposing cognitive demands upon them. Following this fatigue stage, they were exposed to either nature or urban images. After the intervention, they performed a posttest measure using the same set of tests used at pretest. Across all these steps, they were asked approximately every 10 min on their subjective fatigue level. We hypothesized that participants exposed to nature would experience lower subjective fatigue as well as improvements on the working memory and attention control tests following the intervention relative to urban images exposure.

Method

Participants

Forty-seven participants (M_{age} = 26.17, SD = 7.54; 33 men, 12 women, 2 not disclosed) took part in this study. All reported normal or corrected-to-normal vision and audition. The study was approved by the Université Laval Research Ethics Committee (2022-352 / 22-09-2022).

Apparatus and Material

Participants performed the experiment in a dimly lit room. A PC computer running E-Prime 3.0 (Psychology Software Tools) was used for presenting the instructions, controlling the tasks and measures, and presenting the intervention.

Working Memory and Attention Control Measures At the beginning (pretest) and end (posttest) of the experiment, measures of working memory capacity and attention control were collected (Figure 1). Working memory capacity was assessed using the Automated Operation Span task (OSPAN; Unsworth et al., 2005). Participants were presented a series of letters of various lengths with each letter being interleaved with simple mathematical operations. Each letter was presented for 1,000 ms. For each mathematical operation, participants had to select if the suggested outcome was true or false within a maximum of 3,000 ms. Once all the letters of the series were presented, participants were asked to recall them in their presentation order. OSPAN scores represent the sum of all perfectly recalled sets for the 15 trials.

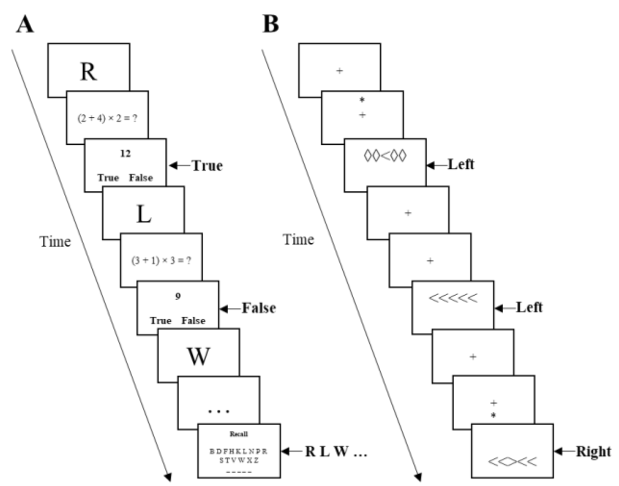

Figure 1: Depiction of the OSPAN task (A) and the ANT (B) performed at pretest and posttest.

To measure attention control, the attention network test (ANT; Fan et al., 2002; Wang, Cui et al., 2014) was used. On each trial (*n* = 120), after presenting a fixation cross for 1,000 ms, a cue could be presented either at the center, on the upper part or the lower part of the screen for 1,000 ms. Following a delay of 1,000 ms, the target (an arrow pointing either left or right) appeared where the cue was presented or randomly above or below the fixation cross if no cue was presented. The target was surrounded with flankers (either neutral or pointing to a congruent or incongruent direction with respect to the target). Participants had to respond using the keyboard, within 2,000 ms, depending on the direction of the target. We employed Wang, Cui et al.'s (2014) method and computed the following scores: a) mean accuracy; b) alerting effect; c) orienting effect; d) conflict effect; e) alerting with conflict effect; f) orienting with conflict effect; g) conflict with alerting effect; and h) conflict with orienting effect.

Cognitive Fatigue Task The AX-CPT task was used to induce fatigue. As shown in Figure 2, participants were presented a 1,000-ms fixation, followed by a letter (the cue) for 200 ms. Then, another fixation cross was presented for 1,000 ms followed by another letter (the potential target). Participants had to press a specific key only when the cue was an *A*, followed by the target letter (an *X*). In other cases, they had to press another key. All 324 trials (comprised of the two fixation crosses, the cue and the letter) were followed by an interstimulus interval of either 1,500, 2,000 or 2,500 ms, randomly generated.

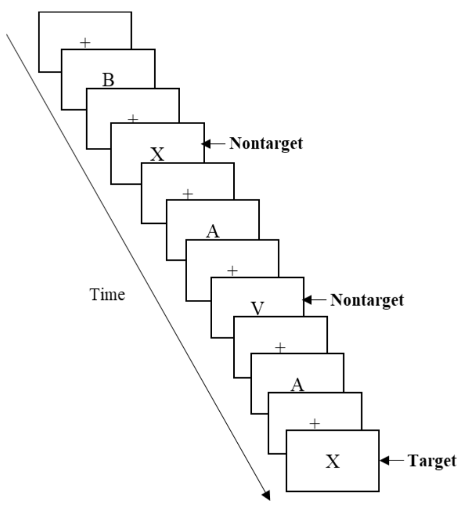

Figure 2: Depiction of the AX-CPT task.

Restoration Intervention Following the fatigue task, participants were exposed to the restoration intervention. Half were assigned to the Nature condition and the other half to the Urban condition. They were presented a series of 30 images, split into two blocks of 15 images. In the Nature condition, nature images were presented, whereas images of cities were presented in the Urban condition (images selected from royalty-free websites (https://isorepublic.com/ and https://unsplash.com/fr). Images across both conditions were controlled for many properties: the season (Summer, Fall or Winter), the type of view (straight, from above or from below), the orientation (portrait vs. landscape) and the type of visual effects (visual effects or not). This was to ensure that visual properties would not impact their restorative properties differently across groups (Berman et al., 2014).

For each image, participants completed the shortened perceived restoration scale (PRS). It contained the following statements: "*This place has qualities that fascinate me*", "*I would like to spend more time looking at the surroundings here*", and "*My attention is drawn to many interesting things here*". Typically, higher scores on the PRS are linked with restorative nature while lower scores are associated with low restorative or nonrestorative environments (Korpela, 2013). Figure 3 provides an example of the restoration intervention.

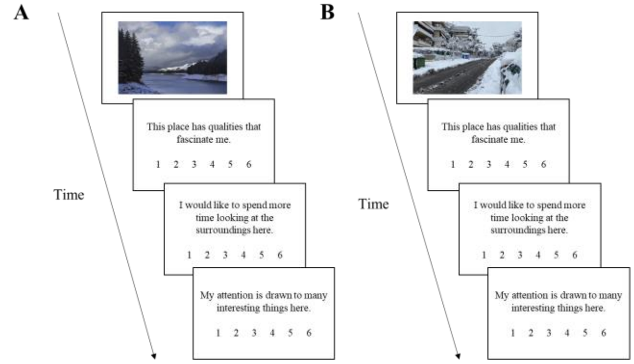

Figure 3: Depiction of attention restoration intervention with the PRS questions (A: Nature intervention; B: Urban intervention).

Self-Reported Measures of Fatigue Participants were asked to answer the Karolinska Sleepiness Scale (KSS), a 10-point sleepiness subjective scale (Åkerstedt & Gillberg, 1990). Scoring goes from "*Extremely alert*" (1) to "*Extremely sleepy, can't keep awake*" (10). Higher KSS values indicate higher fatigue levels.

Procedure

After having provided informed consent, participants were explained the procedure. Then, they were asked to go through the pretest tasks (task order was counterbalanced across participants). After, they performed the cognitive fatigue task followed by the intervention, either with nature or urban images. After the intervention, participants performed the posttest tasks (counterbalanced order). At the end of the experiment, participants were debriefed, thanked and received monetary compensation for their participation. The KSS was completed as follows: (T1) prior to the pretest; (T2) after the first task of the pretest; (T3) following the last task of the pretest; (T4) after the first block of the cognitive fatigue task; (T5) after the second block of the cognitive fatigue task; (T6) after the last block of the fatigue task; (T7) after the first block of the intervention; (T8) after the second block of the intervention; (T9) following the first task of the posttest; and (T10) after the last task of the posttest. Figure 4 summarizes the experimental design.

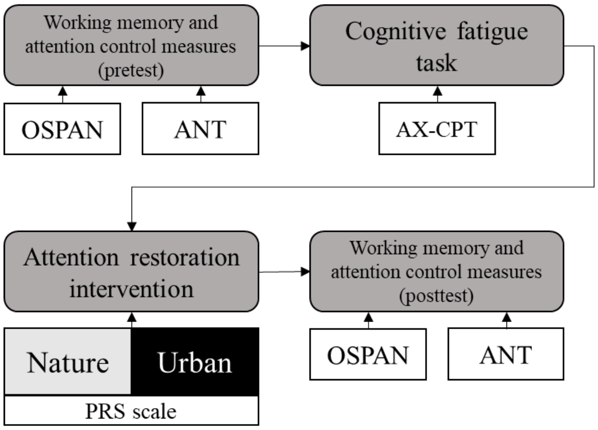

Figure 4: Stages of the experiment. Participants went through either the Nature or Urban intervention. Note that the KSS was completed approximately each 10 min through the different stages.

Statistical Analysis

A manipulation check was performed by comparing the mean PRS scores in both conditions using an independent samples *t*-test to assess whether nature images provided more perceived restoration. Then, performance measures on the OSPAN and ANT tasks were compared between groups and between pretest and posttest using a 2 × 2 mixed ANOVA with the between-subjects factor Condition (Nature vs. Urban) and the within-subject factor Time of measurement (pretest vs. posttest). Performance on the AX-CPT was not analyzed as it only served to induce fatigue. Reports of fatigue were compared between conditions and across times of reporting. Raw mean scores were reported, but baseline-corrected KSS scores (i.e. corrected from the first KSS level prior to the pretest) were compared using a 2 × 10 mixed ANOVA with the between-subjects factor Condition (Nature vs. Urban) and the within-subject factor Time of measurement (T1 to T10). All alpha levels were set at 0.05 and Bonferroni corrections were used for multiple comparisons. Bayesian-equivalent analyses performed with JASP are also presented (van den Bergh et al., 2020). Four participants were removed due to missing data, resulting in 23 participants in the Nature condition and 20 in the Urban condition.

Results

Manipulation check

A first analysis assessed whether nature images were perceived as more restorative than the urban ones according to the mean PRS scores. On average, nature images were rated at a level of 3.51 points out of 6 (SD = 1.09) while urban images reached a mean level of 2.59 (SD = 0.86). An independent samples *t*-test confirmed that nature images were considered significantly more restorative than urban images, $t(41) = 3.20$, $p = .003$, Cohen's $d = 0.99$ ($BF_{01} = 0.07$, providing strong evidence against the null hypothesis).

Working Memory and Attention Control

Scores on the pretest for the OSPAN task were, on average, of 39.22 (SD = 15.45) for the Nature condition and of 39.25 (SD = 12.59) for the Urban condition. At posttest, the Nature condition reached a mean score of 43.70 (SD = 13.69) and the Urban condition a score of 48.45 (SD = 16.12). The mixed ANOVA revealed a main effect of Time of measurement, $F(1, 41) = 15.88$, $p < .001$, $\eta^2_p = .279$, but no effect of Condition nor any two-way interaction ($Fs < 1.90$, $ps > .175$). Multiple comparison tests showed that, in both conditions, participants performed better at posttest. A Bayesian analysis supported these results, suggesting strong probability for the effect of Time of measurement given the data ($p = .553$), and strong evidence against the null model ($p = .009$, $BF_{01} = 61.92$, relative to the Time of measurement model).

Table 1 depicts all generated ANT scores. For all scores but one, the mixed ANOVA raised no main effect of Time of measurement, $Fs(1, 41) < 1.59$, $ps > .214$, $\eta s^2_p < .038$, of Condition, $Fs(1, 41) < 2.20$, $ps > .146$, $\eta s^2_p < .050$, nor any interaction, $Fs(1, 41) < 3.45$, $ps > .070$, $\eta s^2_p < .079$. The Condition effect on the orienting score reached significance, $F(1, 41) = 5.33$, $p = .026$, $\eta^2_p = .115$. Overall, the Nature condition (M = -0.01) had a higher score than the Urban condition (M = -0.05). Bayesian analyses confirmed this pattern, as supported by very strong evidence against the full model comprised of both factors and their interaction ($ps < .068$, $BFs_{01} < 0.287$, relative to the null model).

Table 1: Mean scores (SD) collected from the ANT task across conditions and times of measurement.

ANT scores	Time of measurement	Condition	
		Nature	Urban
Mean accuracy	Pretest	97.54 (3.61)	96.13 (5.98)
	Posttest	96.85 (4.09)	96.33 (3.86)
Alerting	Pretest	-0.02 (0.04)	0.01 (0.07)
	Posttest	-0.01 (0.07)	0.00 (0.08)
Orienting	Pretest	-0.02 (0.05)	-0.05 (0.08)
	Posttest	0.00 (0.07)	-0.04 (0.07)
Conflict	Pretest	0.28 (0.07)	0.32 (0.20)
	Posttest	0.31 (0.13)	0.29 (0.15)
Alerting with conflict	Pretest	0.72 (7.18)	-0.21 (7.56)
	Posttest	-1.00 (7.59)	-0.60 (2.04)
Orienting with conflict	Pretest	-0.74 (14.77)	-0.63 (1.39)
	Posttest	-1.74 (4.51)	-0.65 (2.02)
Conflict with alerting	Pretest	0.08 (0.26)	0.07 (0.48)
	Posttest	0.28 (0.90)	0.17 (0.53)
Conflict with orienting	Pretest	-0.07 (0.35)	0.28 (1.29)
	Posttest	-0.12 (0.37)	0.15 (0.39)

Self-Reported Measures of Fatigue

Mean levels of the KSS across conditions and times of measurement are reported in Table 2. A decrease in KSS scores was observed after the T6 for the Nature condition, i.e. in the middle of the attention restoration intervention. In contrast, the KSS level remained similar throughout the experiment in the Urban condition.

Table 2: KSS mean raw level (and *SD*) across conditions and times of measurement (T1 to T10).

KSS time of measurement	Condition	
	Nature	Urban
T1	4.35 (1.67)	3.90 (1.61)
T2	4.70 (1.61)	4.57 (1.69)
T3	5.43 (1.90)	5.33 (1.93)
T4	6.04 (1.64)	6.10 (2.02)
T5	6.70 (1.69)	5.76 (2.47)
T6	7.22 (1.62)	6.33 (2.58)
T7	6.00 (1.62)	6.00 (2.02)
T8	5.96 (1.87)	6.05 (2.11)
T9	5.70 (1.92)	6.14 (1.98)
T10	5.83 (1.61)	6.71 (1.59)

A correction was then applied to each KSS score using the score collected before the pretest to account for the baseline fatigue level reported (i.e. at T1). Figure 5 presents the corrected KSS scores from T1 (i.e. baseline, score = 0) to T10. The 2 × 10 mixed ANOVA raised a significant main effect of Time of measurement, $F(9, 369) = 16.88$, $p < .001$, $\eta^2_p = .292$, no effect of Condition, $F(1, 41) = 0.96$, $p = .333$, $\eta^2_p = .023$, and a significant two-way interaction, $F(9, 369) = 1.98$, $p = .041$, $\eta^2_p = .046$. A Bayesian analysis provided positive evidence for the full model ($p = .157$, $BF_{01} = 3.84$, relative to the Time of measurement model), suggesting also that this model was 2.41×10^{19} times more likely to be observed than the null model.

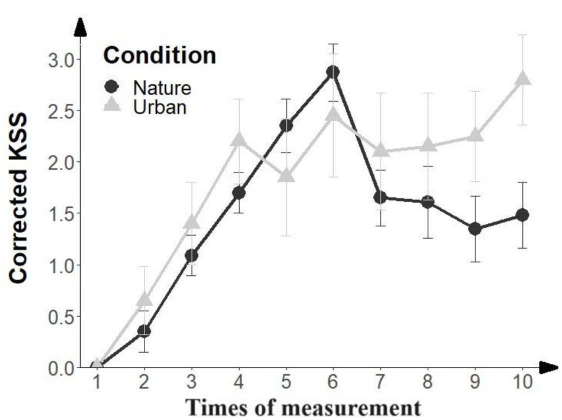

Figure 5: Mean values of the corrected KSS across times of measurement (T1 to T10) for both Nature and Urban conditions. Error bars represent the standard errors of the mean. Higher scores represent higher fatigue. The intervention is presented after T6 up to T8.

Bonferroni-corrected decomposition of the interaction raises differences across groups and times of measurement. First, across both groups, a significant increase in KSS score was observed from T1 to T6, that is, after the cognitive fatigue task (AX-CPT; *p*s < .001). Both groups were at similar KSS levels at T6 ($p = .511$). However, for the Nature condition, a significant reduction in KSS score was observed from T6 ($M = 2.81$, $SD = 1.36$) to T7 ($M = 1.65$, $SD = 1.30$), that is, from the end of the AX-CPT to the middle of the attention restoration intervention ($p = .003$). Such a decrease in KSS scores was not found for the Urban Condition (T6: $M = 2.43$, $SD = 2.67$; T7: $M = 2.10$, $SD = 2.53$; $p > .999$). Although mean values in the Urban condition seemed to increase from T6 up to T10, no significant difference was found, and values remained as high as those collected at T6 (*p*s > .999). In the Nature condition, KSS scores remained lower than T6 at T8 ($p = .007$) and T9 ($p = .023$). These scores were also similar to T3 (i.e. pre-fatigue task level) at T8, T9 and T10 (*p*s > .999). Although the KSS score at T10 for the Nature condition did not significantly differ from the one collected at T6 ($p = .324$), it was significantly lower than the one observed for the Urban condition at T10 ($p = 0.18$). This means that, at the end of the posttest, participants from the Nature condition reported lower fatigue levels on the KSS.

Discussion

As a first step towards a more holistic assessment of the potential of nature interventions to mitigate cognitive fatigue, this study assessed the effects of exposure to nature on objective measures of cognitive functioning and subjective measures of cognitive fatigue following a fatigue-inducing period. Results showed that nature images, which were perceived as more restorative than urban images, induced no improvement in cognitive functioning, i.e. on working memory and attention control. However, analysis of the KSS showed that exposure to nature images significantly improved subjective reports of fatigue. For the Nature condition, reports of fatigue even remained at the pre-fatigue task level following the intervention. Overall, these results outline how nature exposure can provide subjective positive effects for self-reports of fatigue.

The higher restorative evaluations reported for nature images as well as the positive benefits raised for the KSS are consistent with previous studies interested in subjective measures of attention restoration including perceived restoration (e.g., Chung et al., 2018; Yap et al., 2022; for a meta-analysis, see Menardo et al., 2021) and mood and affective measures (e.g., Hartig et al., 2003; Meidenbauer et al., 2020; for a meta-analysis, see McMahan & Estes, 2015). To our knowledge, however, self-reported improvements in fatigue have scarcely been reported. For instance, Johnson et al. (2022) compared KSS reports before and after exposing participants to either urban, meadow or ocean images. They failed to find any difference across groups while the KSS scores increased in all conditions from pre- to post-intervention measurement. The same absence of effect on subjective fatigue, measured by the visual analog scale (VAS; Ahearn, 1997), can be seen in Sun et al. (2022) for participants being exposed to a 12-min viewing of natural scenes. Imamura et al. (2022), reported improvements in the VAS following an indoor forest bathing intervention, but also failed to reach significant differences. Although our findings will need to be replicated, they represent new evidence that perceived fatigue may profit from exposure to nature.

The improved rates of perceived fatigue are coherent with how restorative nature engages one's attention (Duvall, 2011; Marois et al., 2021; Szolosi et al., 2014) without necessarily imposing further attentional demands. Nature may encourage one to actively explore and engage toward the exposed setting, while properties inherent to nature (e.g., soft fascination; see Berman et al., 2008; Kaplan & Berman, 2010) may facilitate this engagement. Contrary to urban environments that contain bottom-up stimulation that automatically captures attention and requires directed attention to resist, nature's "soft fascination" attracts attention in a way that does not incur resistance nor inhibition, given that it is coherent with top-down intentions (Kaplan, 1995; Pearson & Craig, 2014). Such an absence of effortful inhibition to "compete" with attraction driven by nature may promote restoration of cognitive resources, in turn improving self-reported measures and experience of fatigue.

The absence of effect on working memory and attention control suggests, however, that nature images failed to exert objective restorative effects. Such an absence of effect on objective measures of cognitive functioning is not unheard of (Johnson et al., 2022; Kimura et al., 2021; Ohly et al., 2016; Yap et al., 2022). According to Stevenson et al. (2018), nature exposure can induce improvements for working memory tasks such as the Digit Span Backward and Forward Tasks, as well as attention control effects on the ANT. Yet, these effects may be moderated by multiple factors. Stevenson et al.'s meta-analysis showed that higher engagement and pre-intervention cognitive fatigue tend to augment restorative impacts. Participants from our study had no specific task to perform other than having to complete the PRS after each 20-s image while being exposed to the nature or urban settings on the computer. One could perhaps contend that participants' engagement toward nature images was relatively low, as opposed to interventions with real restorative environments such as forests and trails (Berman et al., 2008; Browning et al., 2020) or interventions characterized by increased awareness toward the setting (Duvall, 2011; Lin et al., 2014; Macaulay et al., 2022). This could explain the absence of objective restorative effects.

An alternative explanation could be that the tasks used failed to either induce the desired effects of fatigue or that they do not allow to measure cognitive fatigue properly and objectively. It could indeed be the case that the AX-CPT was not strong enough to exert objective effects that could be measurable through the pre-post intervention differences. The tasks used to measure the objective effects of fatigue, that is the ANT and the OSPAN, might also be impervious to such manipulation. Despite Stevenson et al.'s (2018) suggestions that the ANT and that working memory tasks such as the Digit Span Backward Task and the Digit Span Forward Task can benefit from nature exposure, such tasks may be insensitive to fatigue effects. Future studies should consider alternative tasks that rely on similar cognitive mechanisms (i.e., working memory and attentional control).

Overall, our results have implications for supporting subjective fatigue in operational environments. As stated earlier, fatigue is experienced in many situations including high-stake domains (Cooke et al., 2004; Dehais et al., 2014; Hodgetts et al., 2017), and even among clerical jobs (Jett & George, 2003; Mak & Lui, 2012). Given the evidence provided herein that nature can help improve perceived fatigue, it seems that interventions with nature could represent an interesting avenue to help replenish depleted resources among these operational populations (cf. Marois, 2020). This aspect speaks to the domain of cognitive augmentation, a domain interested in techniques and interventions that promote improvements in cognitive measures (Marois & Lafond, 2022). Although no improvement in (objective) working memory or attentional functioning has been observed, boosts on subjective fatigue still suggest that nature interventions may represent a technique of value for this field.

However, full benefits of nature on measures of cognitive functioning must be better understood. Indeed, although subjective experience may be improved, the absence of effect on behavioral performance may represent a problem. A risk may lie where an operator would feel (over)confident about their performance capacity—due to improvements in subjective fatigue—while not necessarily experiencing improvements in their performance behavior. Such could become a problem, especially for high-stakes domains where errors can have dire consequences. As such, the development of technologies equipped with cognitive state assessment capacities could represent a great asset. For instance, physiological sensing technologies could be used. This would allow providing further (objective) evaluation of the actual state of the person, as well as providing more information about one's mental state during nature exposure.

Conclusion

The study provides preliminary evidence that exposure to nature images can help reducing cognitive fatigue, at least from a subjective perspective. Interestingly, it also serves as a manipulation check for the two types of images used (nature vs. urban) to raise differences in perceived restoration. No evidence of actual improvements in cognitive benefits were, however, shown. The next step will aim at improving statistical power in order to reach a closer sample size to other studies interested in assessing the effects of nature interventions over subjective and objective measures of cognitive fatigue (e.g., up to 76 subjects in total, i.e. the average sample size for all the studies reported by Stevenson et al., 2018). Analyses of the physiological data collected during the study will also represent an interesting avenue given previous evidence that nature exposure can induce changes in neurophysiological activity and that nature vs. urban exposure differences across these measures may be more detectable (e.g., Hartig et al., 2003; Hopman et al., 2020; Imamura et al., 2022; Johnson et al., 2022; Kimura et al., 2021; Marois et al., 2021; Olszewska-Guizzo et al., 2018). Such could allow to investigate more thoroughly how nature can influence one's cognitive activity and how ultimately such an intervention could be better harnessed.

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