



An Investigation into the Stress-Buffering Effects of Nature Virtual Backgrounds in Video Calls

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Abstract. Videoconferencing technologies provided a lifeline for businesses and people to stay connected during the COVID-19 pandemic, but it also brought to light the unique stressors associated with video calls. This research explored the potential of utilizing virtual backgrounds as a strategy to mitigate against stress experienced during video calls. A between-subjects experiment was conducted ($N = 131$) where undergraduate research participants completed a 5-min mock job interview over Zoom. The interviewer's virtual background was manipulated to be a nature image or an office image (control). Results found no differences in physiological and behavioral stress between the conditions. However, among male participants, self-reported stress was marginally lower in the nature condition compared to the control condition. Based on these responses to the stress-induction task, our findings suggest that nature virtual backgrounds have the potential to buffer against stress during video calls. With video calls now a permanent fixture of modern life and workplaces, the findings contribute towards the nascent research into virtual backgrounds and have important theoretical and practical implications.

Keywords: virtual background · videoconferencing · nature · restoration · stress

1 Introduction

The growing use of videoconferencing tools in the first two decades of the 21st century was eclipsed by an exponential surge due to the global COVID-19 pandemic. Driven by the need for remote communication, video calls quickly became the primary means of staying connected while adhering to social distancing measures. Video calls offer important social and environmental benefits due to flexible work arrangements and reduced commuting. Nevertheless, concerns have been raised regarding the negative consequences that video calls have on stress and well-being. This is well captured by *Zoom fatigue*, a term that was widely used during the pandemic (Wiederhold, 2020).

S. H. M. Chan et al.—No conflicts of interest to disclose.

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B. Moore et al. (Eds.): SCAP 2023, SPBHS, pp. 169–180, 2024.

https://doi.org/10.1007/978-981-97-4802-0_10

Given the enduring “new normal” of video calls which remain a permanent feature of many workplaces today, it is imperative to examine ways to mitigate against its adverse impacts.

Zoom fatigue refers to the exhaustion uniquely associated with video calls (Nesher Shoshan & Wehrt, 2022) which are in part due to nonverbal overload (Bailenson, 2021). Compared to face-to-face interactions, video calls are associated with greater anxiety (Wegge, 2006) and cognitive load (Ferran & Watts, 2008). Several strategies have been suggested to reduce these negative impacts, such as hiding one’s self-view, reducing multitasking and notifications, optimizing physical movements and regenerating vision, among others (Bailenson, 2021; Peper et al., 2021). In this research, we explore a relatively new technical feature of video calls – virtual backgrounds. Virtual backgrounds use chroma key technology to replace a users’ physical background with an image. It is a recent development that was first launched by Zoom in 2016 (Lewis, 2016), and only introduced in Skype and Microsoft Teams in April 2020 (Ahmed, 2020). To date, only a handful of studies have investigated the effects of virtual backgrounds in video calls. One study examined the impact of virtual backgrounds on perceptions of users who use them (Hwang et al., 2021). The authors found that while users intuitively expect that their choice of virtual background could affect viewer’s perceptions of them (study 1), virtual backgrounds did not consistently predict viewer’s perceptions and instead resulted in muted ratings where there was a lack of very high or low scores (study 2). In another study conducted with 1283 teachers and 1018 students in Italy, students were positive about their teachers’ virtual backgrounds, with 46% reporting that they thought that the background improved their own levels of attention (de Maurissensa & Barbutib, 2021). Finally, another study conducted with 288 respondents in Norway found that over 90% notice the background (virtual or otherwise) of other users at least some of time, and that virtual backgrounds are generally not perceived to be distracting (Goethe et al., 2022). These studies highlight that users are familiar with the technical feature of virtual backgrounds and take notice of other users’ virtual backgrounds. In this research, we seek to explore how virtual backgrounds can be harnessed to mitigate against the harmful impacts of video calls on stress.

A well-established finding from environmental psychological research is that nature exposure exerts beneficial effects on stress by facilitating restoration (Haluza et al., 2014; Hartig et al., 2014). Restoration describes “processes through which people recover resources that they have diminished in their efforts to meet the demands of everyday life” (Hartig et al., 2011, p. 148). Two main theories underlie nature’s restorative effects. First, the stress recovery theory (Ulrich, 1983; Ulrich et al., 1991) posits that humans have evolved to respond positively to natural elements (e.g., water, vegetation) that signalled better survival for our ancestors. Second, the attention restoration theory (Kaplan & Kaplan, 1989; Kaplan, 1995) argues that natural environments restore the fatigue of directed attention, a cognitive resource that is typically depleted in urban environments. The theories are considered complementary and together explain nature’s beneficial effects on mitigating against stress (Berto, 2014). In line with the theories’ predictions, nature exposure has consistently been found to reduce psychophysiological stress (Mygind et al., 2019). Importantly, nature’s restorative effects have been found both in-situ (i.e., exposure to physical nature) and in laboratory experiments through the use of

images, videos, or simulations of nature in Virtual Reality (VR) (Menardo et al., 2019). For example, after a stress induction, participants who watched a video of a natural environment reported lower stress and better mood, compared to those who watched a video of an urban environment (van den Berg et al., 2003). Comparing between being in a natural environment and watching a video of that environment, Kjellgren and Buhrkall (2010) found that both conditions elicited comparable reductions in physiological and self-reported stress levels. These studies are further supported by an fMRI study which showed that neural activity associated with behavioral stress-related responses varied with the amount of nature that was present in pictures viewed by participants (Chang et al., 2021).

Given its restorative effects, nature exposure has the potential to address stress-related issues associated with video calls. Virtual backgrounds provide one such opportunity to increase nature exposure. Extending beyond the traditional view of nature exposure enabling restoration (i.e., reducing stress levels), we are interested to examine if nature exposure can buffer against stress such that the stress response is moderated, resulting in a lower peak stress level. Although closely related, this distinction is important to make. A stress restoration perspective focuses on how nature promotes faster recovery *after* a stressor, whereas a stress-buffering perspective focuses on how nature minimizes stress levels *during* a stressor. Limited studies have directly tested the stress-buffering effects of nature. In one VR study, participants who walked through a stressful urban environment with nature showed a smaller increase in physiological stress during the VR exposure, compared to those who walked in the urban environment without nature (Chan et al., 2021). In another study, male participants in an office with nature posters reported lower anger and stress when completing provoking tasks on a computer, compared to participants in an office without any posters (Kweon et al., 2007). Lastly, the peak physiological stress levels during a stress induction were lower among participants who had watched a prior nature video of nature compared to those who watched a prior urban video (Parsons et al., 1998). Together, these studies suggest that nature exposure can strengthen one's immunity against stressors. In the context of virtual backgrounds, a nature background may therefore ameliorate stress during a video call.

To explore this possibility, we conducted a between-subjects experiment to test the stress-buffering effects of nature virtual backgrounds in video calls. Zoom fatigue from video calls can arise from a wide range of circumstances such as excessive cognitive processing due to diminished nonverbal cues, prolonged online presence, and worries concerning communication technologies, among others. In this research, we zoom in and focus on acute stress experienced during a video call. To this end, a stress-induction task was administered through a video call during the experiment. Participants, who were undergraduates, completed a 5-min mock job interview over Zoom while interacting with a confederate who had a virtual background depicting either a nature scene or a home office scene which served as the control condition. We hypothesized that participants in the nature condition would show a weaker stress response compared to participants in the control condition. Notwithstanding the limitations of our specific experimental paradigm and sample, the current study contributes towards the paucity of research done on the impacts of virtual backgrounds and provides an empirical base that can inform further studies.

2 Methodology

2.1 Participants

Based on an effect size of $\eta_p^2 = .035$ obtained from past research examining the stress buffering effects of nature on physiological stress (Chan et al., 2021), a power analysis performed with G*Power 3.1. (Faul et al., 2009) with alpha = 0.05 and power = 0.95 indicated a required sample size of $N = 92$. A total of 131 undergraduate participants were recruited from a large university in Singapore and were granted 1 course credited for their participation. Participants were randomly assigned to the nature ($n = 64$) or control ($n = 67$) condition and completed the study individually.

2.2 Procedure and Stress Induction

At the start of the study, participants were greeted by a female experimenter and shown to a small office where they remained for the rest of the study. The same experimenter was present for all sessions and was positioned outside the office with the door closed. After providing consent, participants were provided instructions to correctly attach the electrocardiogram (ECG) electrodes for measuring cardiovascular activity. Participants then completed a pre-test survey on a computer. Next, they received instructions to remain seated for the next 3 min during which their baseline heart rate would be recorded. After 3 min, participants received a prompt on the computer that they have the next 2 min to prepare for an online job interview where they must introduce themselves to a staff manager and convince her to hire them. Participants were further told that the interview would be recorded, and that the hiring manager was specially trained to monitor nonverbal behaviour. After the preparation time, participants joined a Zoom (version 5.4.7) video call with a confederate who introduced herself as the staff manager. For consistency, the same female confederate interviewed all participants. The video call was set to be viewed in full screen with the 'gallery view' which displayed participants' self-view alongside the staff manager's. Depending on the experimental condition, the staff manager had a virtual background that depicted a nature scene or home office scene. Participants themselves had no virtual background. The mock interview lasted 5 min, after which participants completed a post-test survey and were debriefed. The online mock interview was an adapted version of the Trier Social Stress Test (Kirschbaum et al., 1993) which is a well-established stress induction paradigm (Allen et al., 2017).

2.3 Stimuli

The images used in the manipulation of virtual background are shown in Fig. 1. Past research on nature's restorative effects have mostly focused on green (vegetation) and blue (water) features of nature (Twedt et al., 2019; White et al., 2010). Moreover, nature has often been contrasted with built outdoor environments like cityscapes (van den Berg et al., 2003). In our experiment, we selected an autumn nature scene that composed of red-orange color tones and contrasted this with an indoor office scene for the control condition. The images were rated in a pilot test by 33 raters on attractiveness (1 = extremely unattractive; 7 = extremely attractive), complexity (1 = extremely simple;

7 = extremely complex), and likelihood of being used as a virtual background (1 = extremely unlikely; 7 = extremely likely). The nature and control images were rated to be comparable on all attributes – attractiveness (nature: $M = 5.85$, $SD = 0.94$, control: $M = 5.64$, $SD = 1.22$; $t(32) = .89$, $p = .38$), complexity (nature: $M = 4.03$, $SD = 1.74$; control: $M = 4.18$, $SD = 1.51$; $t(32) = .50$, $p = .62$), and likelihood (nature: $M = 5.15$, $SD = 1.54$; control: $M = 4.48$, $SD = 1.82$; $t(32) = -1.49$, $p = .15$).

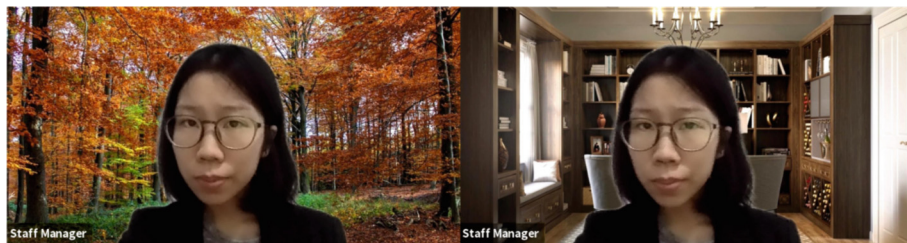


Fig. 1. Screen capture of the confederate using the nature (left) and control (right) virtual backgrounds during the Zoom video call

2.4 Measures

Stress levels were assessed through a triangulation of three methods – self-report, physiological measurements, and nonverbal behavior.

Participants completed the short, state version of the State-Trait Anxiety Inventory (STAI; Marteau & Bekker, 1992; Spielberger, 1983). The self-report measure includes 6 items (e.g., “I am worried”) and were rated on a 4-point scale (1 = not at all, 4 = very much so). The scale showed good reliability (pre-test $\alpha = .83$; post-test $\alpha = .80$).

Participants’ cardiovascular activity was also recorded continuously through a portable ECG device from BITalino (<https://bitalino.com/en/>) at a sampling rate of 1000 Hz. Customized algorithms generated with Python (Bizzego et al., 2019; Gabrieli et al., 2020) were used to pre-process the ECG data. First, R peaks were detected and used to determine the inter-beat interval (IBI). A higher IBI is indicative of lower stress levels and has been used in past research examining the effects of nature exposure on physiological response (Park et al., 2010; Ulrich et al., 1991). From IBI, the root mean square of successive differences (RMSSD) – a time-domain measure of heart rate variability – was computed. RMSSD reflects parasympathetic activation (Shaffer & Ginsberg, 2017) of the autonomic nervous system which regulates relaxation and restoration of the human body (Andreassi, 2010). A higher RMSSD reflects lower stress levels (Delaney & Brodie, 2000).

Finally, participants’ blinks were counted to compute their blink rate (number of blinks/minute) as a behavioral measure of stress. Past research has found higher blink rates to be indicative of greater stress levels (Giannakakis et al., 2017; Harrigan & O’Connell, 1996). Blink rate was counted independently by two coders who were blind to the study hypothesis and conditions. The coders showed high interrater reliability ($\alpha = .92$).

2.5 Data Screening and Analysis

After pre-processing and screening the ECG recordings, data from 97 out of 131 participants were accepted for analyses. IBI and RMSSD were extracted for every 10 s, with 5 s overlapping with the next data point. Baseline physiological stress was computed as the mean IBI and RMSSD during the 3-min rest period before receiving the interview preparation instructions. Physiological stress level during the interview was computed as the mean IBI and RMSSD during the 5-min mock interview.

To examine the effectiveness of our stress induction, a paired samples *t*-test was conducted on self-reported and physiological stress indicators. To examine differences between conditions, a change score was first computed for self-reported stress (post-test minus pre-test) and the physiological indicators of IBI and RMSSD (interview minus baseline). Then, independent samples *t*-tests were performed on these change scores and blink rate.

3 Results

Self-reported stress increased from pre-test to post-test ($t(130) = 10.06, p < .001$). Likewise, IBI and RMSSD decreased – indicating increased stress levels – from baseline to interview (IBI: $t(96) = -12.09, p < .001$; RMSSD: $t(96) = -4.61, p < .001$). This provided evidence that the stress induction was successful.

Summary statistics and bivariate correlations of the variables are reported in Table 1. Blink rate was negatively correlated with IBI during the interview (lower IBI reflects higher stress), which shows consistency between physiological and behavioral measures of stress. However, post-test self-reported stress was negatively correlated with blink rate and not significantly associated with IBI or RMSSD, suggesting a divergence between subjective stress levels and the other two measures.

Table 1. Summary statistics by condition and bivariate correlations

	Nature			Control			Correlation coefficient					
	<i>M</i>	<i>SD</i>	<i>n</i>	<i>M</i>	<i>SD</i>	<i>n</i>	(1)	(2)	(3)	(4)	(5)	(6)
(1) STAI_1	2.35	0.60	64	2.16	0.55	67						
(2) STAI_2	2.83	0.61	64	2.83	0.53	67	.33**					
(3) Blink rate	37.11	17.82	64	36.93	13.87	67	-.02	-.18*				
(4) IBI_1	0.731	0.11	43	0.719	0.10	54	-.10	-.05	-.16			
(5) IBI_2	0.658	0.10	43	0.656	0.11	54	.07	.02	-.20*	.85**		
(6) RMSSD_1	0.039	0.04	43	0.036	0.02	54	-.13	-.05	-.10	.73**	.60**	
(7) RMSSD_2	0.028	0.02	43	0.030	0.02	54	-.02	-.01	-.12	.63**	.76**	.76**

Note. * $p < 0.05$, ** $p < .01$, *** $p < 0.001$. Correlations computed with pairwise deletion. STAI = self-reported stress; _1 = pre-test/baseline; _2 = post-test/interview

Comparing between the conditions, no statistically significant differences were found for any of the stress indicators – change in self-reported stress: $t(129) = 1.56, p = .12$;

blink rate: $t(129) = -0.07, p = .95$; change in IBI: $t(95) = 0.90, p = .37$; change in RMSSD: $t(95) = 1.00, p = .32$.

In their study, Kweon et al. (2007) found stress-buffering effects among male participants only and not female participants. To further explore our results, we therefore conducted a *a posteriori* analysis for males and females separately. Among males, the difference in change scores for self-reported stress approached statistical significance ($t(24) = 2.04, p = .053$). Males in the nature condition showed a marginally smaller increase in self-reported stress ($M = 0.33, SD = 0.60, n = 12$) compared to males in the office condition ($M = 0.75, SD = 0.44, n = 14$). There were no statistically significant differences among males for blink rate, IBI, or RMSSD ($p > .36$). Among females, no statistically significant differences emerged across all of the stress indicators ($p > .23$).

4 Discussion

This study aimed to test the stress-buffering effects of nature virtual backgrounds in video calls. Participants underwent a mock job interview over Zoom with a confederate that had a virtual background depicting either a nature or office scene. The overall results did not find support for the stress-buffering effects of nature backgrounds on physiological and behavioral stress. However, there is some evidence that nature backgrounds reduced self-reported stress among male participants.

For the male participants of this study, those in the nature condition showed a smaller increase in self-reported stress from pre-test to post-test, compared to those in the control condition. The nature virtual background thus appears to have buffered against the adverse impacts of the interview. This aligns with the large body of research which demonstrates nature's restorative effects on stress (Berto, 2014; Mygind et al., 2019), and further contributes to the small pool of studies which specifically show that nature can ameliorate negative responses to external stressors (Chan et al., 2021; Kweon et al., 2007; Parsons et al., 1998). It is noteworthy that we only found this effect among males, which corresponds to the study by Kweon and colleagues which found that only male participants, but not female participants, reported lower anger and stress responses when completing a series of provoking tasks in an office with nature posters (vs. no posters). Another study examining the restorative effects of tree cover density found that men showed changes in physiological stress which varied according to tree density whereas females showed no relationship between stress recovery and tree cover density (Jiang et al., 2014). Past research has also found gender differences in stress reactivity to the Trier Social Stress Test (Kelly et al., 2008; Liu et al., 2017). This aligns with research that show gender differences in stress and coping styles (Matud, 2004). A promising area for future research is to investigate the interaction between gender, stress, coping styles, and nature's stress-buffering effects.

A possible explanation for why the nature background failed to exert stress-buffering effects is that participants may not have even noticed or paid attention to the confederate's virtual background. It is common for people to spend a significant portion of their time looking at themselves during video calls. A study conducted with 115 daily users of video calls found that a majority of participants (44%) reported looking at their self-views very frequently or frequently, 38% occasionally, and only 17% reported rarely

or never (Balogova & Brumby, 2022). In another study conducted with 438 women, participants reported spending an average of 40% of the time looking at themselves during video calls (Pfund et al., 2020). Furthermore, the context of a job interview is likely to have increased participants' self-focus, leading to heightened attention on their self-view. Without much attention being paid to the confederate's background, it is thus possible that the nature exposure was not strong enough to elicit stress-buffering effects. Following this logic, an additional explanation for the gender differences in self-reported stress discussed in the preceding paragraph may be that female participants spent more time looking at their self-views and thus were even less likely to have paid attention to the nature background. This is supported by research which shows that women have a greater tendency to self-focus than men (Ingram et al., 1988). As an extension, future studies can consider manipulating participants' own virtual backgrounds instead to examine if a nature background in one's self-view can buffer against stress. On a visual level, the participant would view themselves to be "in nature". This may therefore lead to stronger stress-buffering effects.

The current findings contribute to the scant literature on the impacts of virtual backgrounds. It is interesting to note that nature as a theme for background images features in previous studies. For example, 12% of over 2,000 participants used a nature-related virtual background in the study done by de Maurissensa and Barbutib (2021). In the study by Hwang et al. (2021), nature images emerged as the top 2 most selected backgrounds out of 90 images when participants wished to convey openness and agreeableness. This reflects people's general positivity towards natural landscapes and aligns with the evolutionary framework of the stress recovery theory (Ulrich, 1983; Ulrich et al., 1991). However, nature scenes are not all equally preferred nor do they confer equal restorativeness (Meidenbauer et al., 2020). The nature image used in our study depicted an autumn scene that is predominantly orange-red. This differs from most past research on nature's restorative effects which involved mainly green (vegetation) and blue (water) features of nature (Twedt et al., 2019; White et al., 2010). Research on visual features suggest that color-related properties commonly found in nature scenes like blue-green hue are associated with aesthetic preference (Kardan et al., 2015). Moreover, a study showed that participants who exercised while watching a video of tree-lined route with a green filter reported lower perceived exertion and anger, compared to those who watched the same video with a red filter (Akers et al., 2012). An alternative reason for the null findings in this research may therefore be related to the specific nature image we used as experimental stimuli. In a similar vein, the office image used in the control condition may have been perceived by participants to be more congruent in the context of an interview. In their study, Hwang and colleagues (2021) showed that interior (e.g., office room, living room) and workplace images were most commonly selected as virtual backgrounds for video calls with colleagues, and particularly so with a supervisor. The match between the confederate's background and the context of an interview may thus have been perceived as coherent and compatible – two features identified by the attention restoration theory as conducive for restoration (Kaplan & Kaplan, 1989; Kaplan, 1995). Future studies can utilize a broader and more diverse range of images to investigate if image content and context interacts to impact stress in video calls.

Our study contained several limitations that should be acknowledged. First, we did not include a manipulation check to assess if participants had noticed the confederate's background. An interesting possibility for future studies is to employ eye-tracking techniques. This would provide insights on where users pay the most attention to. Second, the use of a 5-min mock interview in this study differs in many ways from naturalistic video calls that users are exposed to in the real-world. Moreover, participants were undergraduates who completed the study in exchange for course credits. The short duration of the interview and the absence of any actual consequences therefore limits the generalizability of the current research. For example, it remains unknown if virtual backgrounds will have an impact on professionals who spend long periods of time in video calls. The undergraduate research participants were also all comfortable and familiar with videoconferencing technologies. An important area for future research is to test the stress-buffering effects of virtual backgrounds in other contexts and explore if familiarity with technology or age plays a role in stress-related outcomes of video calls. Finally, to ensure consistency, all participants interacted with the same two female experimenters. Particularly noteworthy is that all participants were interviewed by a female staff manager. It is therefore possible that there may be interpersonal gender effects since female participants interacted with the same gender whereas male participants interacted with the opposite gender. Future studies can attempt to disentangle the gender effects which would shed greater light on the underlying reasons for the gender differences in self-reported stress found in our study.

In summary, this research investigated the stress-buffering effects of a nature virtual background during a mock job interview over Zoom. Our findings show that the nature background ameliorated self-reported stress to a small degree among male participants. Beyond hiding a messy background, virtual backgrounds have the potential to provide additional psychophysiological benefits for users.

References

- Ahmed, A.: Skype copies zoom's feature by introducing custom virtual backgrounds for video conversations. *Digital Information World* (2020). <https://www.digitalinformationworld.com/2020/04/skype-copies-zoom-s-feature-by-introducing-custom-virtual-backgrounds-for-video-conversations.html>
- Akers, A., Barton, J., Cossey, R., Gainsford, P., Griffin, M., Micklewright, D.: Visual color perception in green exercise: positive effects on mood and perceived exertion. *Environ. Sci. Technol.* **46**(16), 8661–8666 (2012). <https://doi.org/10.1021/es301685g>
- Allen, A.P., Kennedy, P.J., Dockray, S., Cryan, J.F., Dinan, T.G., Clarke, G.: The trier social stress test: principles and practice. *Neurobiol. Stress* **6**, 113–126 (2017). <https://doi.org/10.1016/j.ynstr.2016.11.001>
- Andreassi, J.L.: The nervous system and measurement of its activity. In Andreassi, J.L. (Ed.) *Psychophysiology: Human Behavior and Physiological Response*. Psychology Press (2010). <https://doi.org/10.4324/9780203880340>
- Bailenson, J.N.: Nonverbal overload: a theoretical argument for the causes of zoom fatigue. *Technol. Mind Behav.* **2**(1) (2021). <https://doi.org/10.1037/tmb0000030>
- Balogova, K., Brumby, D.: How do you zoom?: A survey study of how users configure video-conference tools for online meetings. In: *Proceedings of the 1st Annual Meeting of the Symposium on Human-Computer Interaction for Work*, Durham, NH, USA (2022). <https://doi.org/10.1145/3533406.3533408>

- Berto, R.: The role of nature in coping with psycho-physiological stress: a literature review on restorativeness. *Behav. Sci. Sci.* **4**(4), 394–409 (2014). <https://doi.org/10.3390/bs4040394>
- Bizzego, A., Battisti, A., Gabrieli, G., Esposito, G., Furlanello, C.: pyphysio: A physiological signal processing library for data science approaches in physiology. *SoftwareX* **10** (2019). <https://doi.org/10.1016/j.softx.2019.100287>. Article 100287
- Chan, S.H.M., Qiu, L., Esposito, G., Mai, K.P.: Vertical greenery buffers against stress: Evidence from psychophysiological responses in virtual reality. *Landscape Urban Plann.* **213**, 104127 (2021). <https://doi.org/10.1016/j.landurbplan.2021.104127>
- Chang, D.H.F., Jiang, B., Wong, N.H.L., Wong, J.J., Webster, C., Lee, T.M.C.: The human posterior cingulate and the stress-response benefits of viewing green urban landscapes. *Neuroimage* **226**, 117555 (2021). <https://doi.org/10.1016/j.neuroimage.2020.117555>
- de Maurissensa, I., Barbutib, N.: Ontology of backgrounds in distance learning. Correlations between virtual backgrounds and educational relationship. In: Proceedings of the First Workshop on Technology Enhanced Learning Environments for Blended Education, Foggia, Italy (2021). <https://ceur-ws.org/Vol-2817/paper2.pdf>
- Delaney, J.P.A., Brodie, D.A.: Effects of short-term psychological stress on the time and frequency domains of heart-rate variability. *Percept. Mot. Skills* **91**(2), 515–524 (2000). <https://doi.org/10.2466/pms.2000.91.2.515>
- Faul, F., Erdfelder, E., Buchner, A., Lang, A.-G.: Statistical power analyses using G*Power 3.1: tests for correlation and regression analyses. *Behav. Res. Methods* **41**(4), 1149–1160 (2009). <https://doi.org/10.3758/BRM.41.4.1149>
- Ferran, C., Watts, S.: Videoconferencing in the field: a heuristic processing model. *Manage. Sci.* **54**(9), 1565–1578 (2008). <https://doi.org/10.1287/mnsc.1080.0879>
- Gabrieli, G., Azhari, A., Esposito, G.: PySiology: a Python package for physiological feature extraction. In: Esposito, A., Faundez-Zanuy, M., Morabito, F.C., Pasero, E. (eds.) *Neural Approaches to Dynamics of Signal Exchanges. Smart Innovation, Systems and Technologies*, vol. 151, pp. 395–402. Springer, Singapore (2020). https://doi.org/10.1007/978-981-13-8950-4_35
- Giannakakis, G., et al.: Stress and anxiety detection using facial cues from videos. *Biomed. Signal Process. Control* **31**, 89–101 (2017). <https://doi.org/10.1016/j.bspc.2016.06.020>
- Goethe, O., Sørnum, H., Johansen, J.: The effect or non-effect of virtual versus non-virtual backgrounds in digital learning. In: Ahram, T., Taiar, R. (Eds.) *Human Interaction, Emerging Technologies and Future Systems V. HIET 2021. Lecture Notes in Networks and Systems*, vol. 319, pp. 274–281. Springer International Publishing, Cham (2022). https://doi.org/10.1007/978-3-030-85540-6_35
- Haluza, D., Schönbauer, R., Cervinka, R.: Green perspectives for public health: a narrative review on the physiological effects of experiencing outdoor nature. *Int. J. Environ. Res. Public Health* **11**(5), 5445–5461 (2014). <https://doi.org/10.3390/ijerph110505445>
- Harrigan, J.A., O’Connell, D.M.: How do you look when feeling anxious? facial displays of anxiety. *Personality Individ. Differ. Individ. Differ.* **21**(2), 205–212 (1996). [https://doi.org/10.1016/0191-8869\(96\)00050-5](https://doi.org/10.1016/0191-8869(96)00050-5)
- Hartig, T., Mitchell, R., de Vries, S., Frumkin, H.: Nature and health. *Annu. Rev. Public Health. Rev. Public Health* **35**(1), 207–228 (2014). <https://doi.org/10.1146/annurev-publhealth-032013-182443>
- Hartig, T., van den Berg, A.E., Hagerhall, C.M., Tomalak, M., Bauer, N., Hansmann, R., Ojala, A., Syngollitou, E., Carrus, G., van Herzele, A., Bell, S., Podesta, M.T.C., Waaseth, G.: Health benefits of nature experience: psychological, social and cultural processes. In: Nilsson, K., Sangster, M., Gallis, C., Hartig, T., de Vries, S., Seeland, K., Schipperijn, J. (eds.) *Forests, Trees and Human Health*, pp. 127–168. Springer Netherlands, Dordrecht (2011). https://doi.org/10.1007/978-90-481-9806-1_5

- Hwang, A.-C., Wang, C.Y., Yang, Y.-Y., Won, A.S.: Hide and seek: choices of virtual backgrounds in video chats and their effects on perception. *Proc. ACM Hum. Comput. Interact.* **5**(CSCW2), 1–30 (2021). <https://doi.org/10.1145/3476044>
- Ingram, R.E., Cruet, D., Johnson, B.R., Wisnicki, K.S.: Self-focused attention, gender, gender role, and vulnerability to negative affect. *J. Pers. Soc. Psychol.* **55**(6), 967–978 (1988). <https://doi.org/10.1037/0022-3514.55.6.967>
- Jiang, B., Chang, C.-Y., Sullivan, W.C.: A dose of nature: tree cover, stress reduction, and gender differences. *Landsc. Urban Plan.. Urban Plan.* **132**, 26–36 (2014). <https://doi.org/10.1016/j.landurbplan.2014.08.005>
- Kaplan, R., Kaplan, S.: *The Experience of Nature: A Psychological Perspective*. Cambridge University Press (1989)
- Kaplan, S.: The restorative benefits of nature: toward an integrative framework. *J. Environ. Psychol.* **15**(3), 169–182 (1995). [https://doi.org/10.1016/0272-4944\(95\)90001-2](https://doi.org/10.1016/0272-4944(95)90001-2)
- Kardan, O., et al.: Is the preference of natural versus man-made scenes driven by bottom-up processing of the visual features of nature? *Front. Psychol.* **6**, 471 (2015). <https://doi.org/10.3389/fpsyg.2015.00471>
- Kelly, M.M., Tyrka, A.R., Anderson, G.M., Price, L.H., Carpenter, L.L.: Sex differences in emotional and physiological responses to the trier social stress test. *J. Behav. Ther. Exp. Psychiatry/Behav. Ther. Exp. Psychiatry* **39**(1), 87–98 (2008). <https://doi.org/10.1016/j.jbtep.2007.02.003>
- Kirschbaum, C., Pirke, K.M., Hellhammer, D.H.: The ‘trier social stress test’—a tool for investigating psychobiological stress responses in a laboratory setting. *Neuropsychobiology* **28**, 76–81 (1993). <https://doi.org/10.1159/000119004>
- Kjellgren, A., Buhrkall, H.: A comparison of the restorative effect of a natural environment with that of a simulated natural environment. *J. Environ. Psychol.* **30**, 464–472 (2010). <https://doi.org/10.1016/j.jenvp.2010.01.011>
- Kweon, B.-S., Ulrich, R.S., Walker, V.D., Tassinary, L.G.: Anger and stress: the role of landscape posters in an office setting. *Environ. Behav.* **40**(3), 355–381 (2007). <https://doi.org/10.1177/0013916506298797>
- Lewis, A.: Meet From Literally Anywhere: Zoom Virtual Background. *Zoom Blog* (2016). <https://blog.zoom.us/wordpress/2016/09/23/zoom-virtual-background/>
- Liu, J.J.W., Ein, N., Peck, K., Huang, V., Pruessner, J.C., Vickers, K.: Sex differences in salivary cortisol reactivity to the trier social stress test (TSST): a meta-analysis. *Psychoneuroendocrinology* **82**, 26–37 (2017). <https://doi.org/10.1016/j.psyneuen.2017.04.007>
- Marteau, T.M., Bekker, H.: The development of a six-item short-form of the state scale of the spielberger state-trait anxiety inventory (STAI). *Br. J. Clin. Psychol.* **31**(3), 301–306 (1992). <https://doi.org/10.1111/j.2044-8260.1992.tb00997.x>
- Matud, M.P.: Gender differences in stress and coping styles. *Personality Individ. Differ.* **37**(7), 1401–1415 (2004). <https://doi.org/10.1016/j.paid.2004.01.010>
- Meidenbauer, K.L., et al.: The affective benefits of nature exposure: What’s nature got to do with it? *J. Environ. Psychol.* **72**, 101498 (2020). <https://doi.org/10.1016/j.jenvp.2020.101498>
- Menardo, E., Brondino, M., Hall, R., Pasini, M.: Restorativeness in natural and urban environments: a meta-analysis. *Psychol. Rep.* **124**(2), 417–437 (2019). <https://doi.org/10.1177/0033294119884063>
- Mygind, L., et al.: Effects of public green space on acute psychophysiological stress response: a systematic review and meta-analysis of the experimental and quasi-experimental evidence. *Environ. Behav.* **53**(2), 184–226 (2019). <https://doi.org/10.1177/0013916519873376>
- Nesher Shoshan, H., Wehrt, W.: Understanding “zoom fatigue”: a mixed-method approach. *Appl. Psychol.* **71**(3), 827–852 (2022). <https://doi.org/10.1111/apps.12360>

- Park, B.J., Tsunetsugu, Y., Kasetani, T., Kagawa, T., Miyazaki, Y.: The physiological effects of Shinrin-yoku (taking in the forest atmosphere or forest bathing): evidence from field experiments in 24 forests across Japan. *Environ. Health Prev. Med.* **15**, 18–26 (2010). <https://doi.org/10.1007/s12199-009-0086-9>
- Parsons, R., Tassinary, L.G., Ulrich, R.S., Hebl, M.R., Grossman-Alexander, M.: The view from the road: implications for stress recovery and immunization. *J. Environ. Psychol.* **18**(2), 113–140 (1998). <https://doi.org/10.1006/jenvp.1998.0086>
- Peper, E., Wilson, V., Martin, M., Rosegard, E., Harvey, R.: Avoid Zoom fatigue, be present and learn. *NeuroRegulation* **8**(1), 47–56 (2021). <https://doi.org/10.15540/nr.8.1.47>
- Pfund, G.N., Hill, P.L., Harriger, J.: Video chatting and appearance satisfaction during COVID-19: appearance comparisons and self-objectification as moderators. *Int. J. Eat. Disord.* **53**(12), 2038–2043 (2020). <https://doi.org/10.1002/eat.23393>
- Shaffer, F., Ginsberg, J.P.: An overview of heart rate variability metrics and norms. *Front. Public Health* **5**, 258 (2017). <https://doi.org/10.3389/fpubh.2017.00258>
- Spielberger, C.D.: Manual for the state-trait anxiety inventory STAI (form Y) (“self-evaluation questionnaire”) (1983). <https://ubir.buffalo.edu/xmlui/handle/10477/1873>
- Twedt, E., Rainey, R.M., Proffitt, D.R.: Beyond nature: The roles of visual appeal and individual differences in perceived restorative potential. *J. Environ. Psychol.* **65**, 101322 (2019). <https://doi.org/10.1016/j.jenvp.2019.101322>
- Ulrich, R.S.: Aesthetic and affective response to natural environment. In: Altman, I., Wohlwill, J.F. (eds.) *Behavior and the Natural Environment*, pp. 85–125. Springer US, Boston, MA (1983). https://doi.org/10.1007/978-1-4613-3539-9_4
- Ulrich, R.S., Simons, R.F., Losito, B.D., Fiorito, E., Miles, M.A., Zelson, M.: Stress recovery during exposure to natural and urban environments. *J. Environ. Psychol.* **11**(3), 201–230 (1991). [https://doi.org/10.1016/S0272-4944\(05\)80184-7](https://doi.org/10.1016/S0272-4944(05)80184-7)
- van den Berg, A.E., Koole, S.L., van der Wulp, N.Y.: Environmental preference and restoration: (How) are they related? *J. Environ. Psychol.* **23**(2), 135–146 (2003). [https://doi.org/10.1016/S0272-4944\(02\)00111-1](https://doi.org/10.1016/S0272-4944(02)00111-1)
- Wegge, J.: Communication via videoconference: emotional and cognitive consequences of affective personality dispositions, seeing one’s own picture, and disturbing events. *Hum. Comput. Interact.* **21**(3), 273–318 (2006). https://doi.org/10.1207/s15327051hci2103_1
- White, M., Smith, A., Humphries, K., Pahl, S., Snelling, D., Depledge, M.: Blue space: the importance of water for preference, affect, and restorativeness ratings of natural and built scenes. *J. Environ. Psychol.* **30**, 482–493 (2010). <https://doi.org/10.1016/j.jenvp.2010.04.004>
- Wiederhold, B.K.: Connecting through technology during the coronavirus disease 2019 pandemic: avoiding “zoom fatigue.” *Cyberpsychol. Behav. Soc. Netw.* **23**(7), 437–438 (2020). <https://doi.org/10.1089/cyber.2020.29188.bkw>