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Physiological and Psychological Benefits of Viewing an Autumn Foliage Mountain Landscape Image among Young Women

Hyunju Jo †, Harumi Ikei † and Yoshifumi Miyazaki *

Center for Environment, Health and Field Sciences, Chiba University, Kashiwa 277-0882, Japan
* Correspondence: ymiyazaki@faculty.chiba-u.jp
† These authors contributed equally to this work.

Abstract: Empirically, viewing nature landscapes, including mountains, can promote relaxation. This study aimed to examine the physiological and psychological effects of visual stimulation using an autumn foliage mountain landscape image on autonomic nervous and brain activities. We included 27 female university students who viewed mountain and city (control) landscape images displayed on a large, high-resolution display for 90 seconds. As an indicator of autonomic nervous activity, heart rate variability (high frequency [HF], reflecting parasympathetic nervous activity, and low frequency/high frequency [LF/HF], reflecting sympathetic nervous activity) and heart rate were recorded. Simultaneously, as an indicator of brain activity, oxyhemoglobin concentrations in the prefrontal cortex were assessed using near-infrared time-resolved spectroscopy. Viewing the mountain landscape image significantly increased HF, indicating increased parasympathetic nervous activity. Furthermore, the visual stimulation using the mountain image induced comfortable, relaxed, and natural feelings, as well as improved mood states. In conclusion, viewing an autumn foliage mountain landscape image via large display induced physiological and psychological relaxation in women in their 20s.

Keywords: autumn mountain; heart rate variability; natural landscape image; nature therapy; near-infrared spectroscopy; physiological and psychological relaxation; stress reduction

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1. Introduction

From 6–7 million years ago, humans underwent evolution until they reached their current form [1]. The evolution took place in a natural environment more than 99.99% of the time. However, today, it is considered that we are under a stress state because we inhabit an urbanized and artificial environment [2,3].

In recent decades, the stress recovery and relaxation effects of nature have attracted attention worldwide [4,5]. The scientific data on the physiological effects of nature have been accumulated [2,6]. Previous studies performed field experiments in forests [7–10] and parks [11,12], and indoor experiments have focused on the sensory effects of various senses, such as visual [13,14], olfactory [15,16], tactile [17,18], and auditory [19,20].

Various nature-derived stimuli have been used to study the visual effects in indoor experiments [21]. The studies have reported the physiological relaxing effects on the brain and autonomic nervous system activity by viewing natural landscapes through display [22] and slide [23] and by viewing other actual natural stimuli, including flowers [24,25], foliage plants [26,27], and bonsai trees [28,29].

To validate the physiological and psychological relaxing effects of a natural landscape by indoor experiment, it is important to present a stimulus with a realistic sensation, such as being in a field. Recently, virtual reality [30] and large, high-resolution displays [22] have been utilized as stimulation methods to enhance realism. Song et al. [22] investigated the physiological and psychological effects of a green Metasequoia forest landscape image on a large, high-resolution display, which was the same as the one used in the current experiment.

The results showed that compared with the city image, the green forest image induced a physiological relaxing effect that significantly decreased oxyhemoglobin concentrations in the right prefrontal cortex. Furthermore, the forest image resulted in a psychological effect inducing slightly comfortable, slightly relaxed, and moderately natural feelings.

On the other hand, although autumn foliage has a special meaning for the Japanese people, scientific data have not yet been reported regarding the physiological relaxing effects of natural landscapes with autumn foliage. In Japan, there is a tradition called "momijigari", which is to visit scenic areas where leaves have turned red in the autumn [31], and several tourist destinations hold "momijigari" in autumn [32]. Liu et al. [33] have reported a correlation between the number of tourists and the time of autumn foliage, indicating that autumn foliage is a special natural landscape for Japanese people. Although no previous studies have reported on the effects of viewing autumn foliage landscapes, some studies have reported that viewing colored flowers, such as red [24] and pink roses [13], induced visual physiological relaxation. In addition, some field experiments focused on natural seasonality; Song et al. found that walking in an urban park in spring [12], fall [34], and winter [11] induced physiological relaxation.

Therefore, the present study aimed to verify the physiological and psychological effects of a realistic autumn mountain landscape image with autumn foliage on a large, high-resolution display compared with a city image. To evaluate physiological responses, we measured sympathetic and parasympathetic nervous activities in terms of heart rate variability (HRV) and heart rate and prefrontal cortex activity in terms of oxyhemoglobin (oxy-Hb) concentrations in the left and right prefrontal cortices using near-infrared time-resolved spectroscopy (TRS), which allows absolute value measurements. To evaluate psychological responses, we used the modified semantic differential (SD) method and the Profile of Mood States second edition (POMS 2).

2. Materials and Methods

Experimental procedures and physiological and psychological measurements were performed, as described by Song et al. [22]. The short version of the POMS 2 was used, as stated by Ikei et al. [18].

2.1. Participants

A total of 27 female Japanese university students were recruited (mean ± standard deviation: age, 23.2 ± 2.4 years; weight, 48.0 ± 4.4 kg; height, 155.7 ± 4.4 cm; right and left eyesight, 0.9 ± 0.3 and 0.9 ± 0.3, respectively [based on the decimal vision acuity system used in Japan]). The exclusion criteria were participants with respiratory illness, poor physical condition, and <0.3 eyesight (including the corrected value) in the right and left eyes. Furthermore, we excluded females who were menstruating during the experiment period, because it is known that women during the menstrual period experience debilitating menstrual symptoms [35], such as mental fatigue [36]. The applicability of these criteria was self-reported.

The study was approved by the Ethics Committee of the Center for Environment, Health, and Field Sciences at Chiba University, Japan (project ID no. 42), and the research information was registered in the University Hospital Medical Information Network of Japan (ID no. UMIN000039320). We used a randomized block design to assign participants to one of two intervention groups in a different order of viewing images (Figure 1).

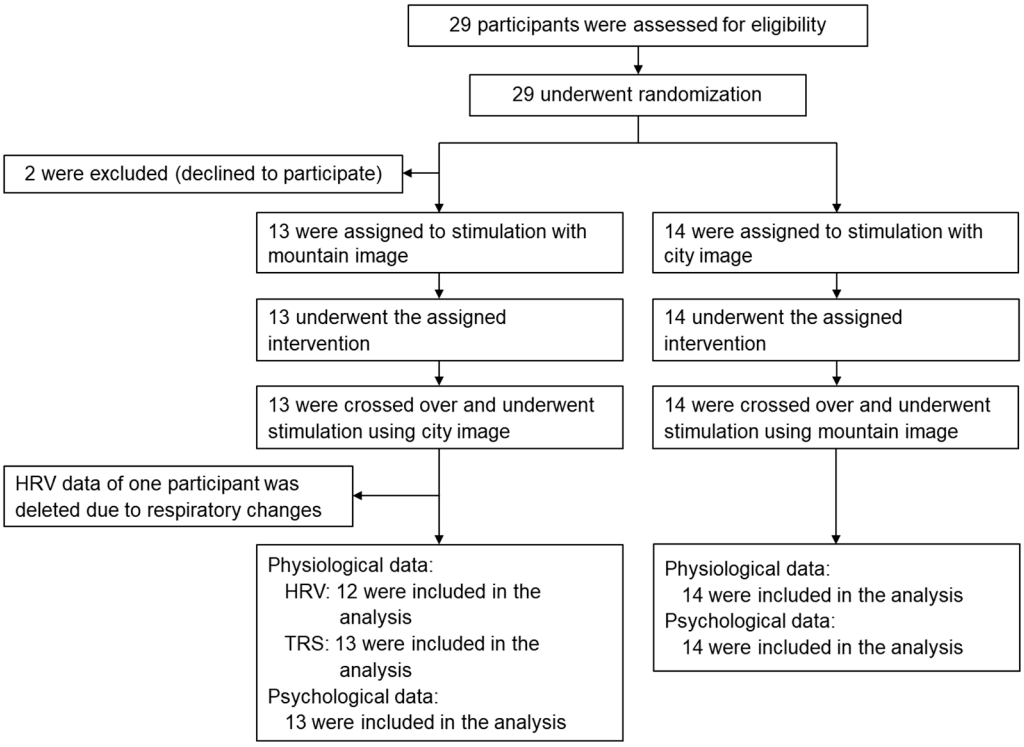


Figure 1. Flowchart of the experiment based on the CONSORT statement. Participant screening, enrollment, follow-up, and analysis flow. HRV (heart rate variability), TRS (near-infrared time-resolved spectroscopy).

2.2. Visual Exposure

Figure 2 shows the image used during visual exposure. The mountain image (Figure 2A) used herein was that of the Mount Bandai landscape in Fukushima Prefecture during the autumn foliage season. Mount Bandai is one of the most famous mountains in Japan, especially for autumn foliage. The city image (Figure 2B, control) was that of the skyscraper landscape of Shinjuku, a typical building district in the capital city of Tokyo. Each image was displayed on a high-resolution large plasma display (1872 [W] × 1053 [H] mm; 3840 × 2160 pixel resolution; 85 V type, TH-85AX900 by Panasonic, Osaka, Japan). Based on the preliminary test, the distance between the participants and the display that would fully facilitate visual stimulation but not cause discomfort was set to 1.1 m.



Figure 2. Images used in visual exposure. (**A**) Mountain image: Mount Bandai autumn landscape, Fukushima. (**B**) City image: Skyscraper landscape in Shinjuku, Tokyo.

2.3. Study Protocol

Figure 3 depicts the measurement protocol. The participants were fitted with the physiological measurement sensors and were instructed to rest in an artificial climate chamber (temperature, 24 °C; relative humidity, 50%) while viewing a gray image (rest

period: 60 s). Next, they were exposed to either the mountain or city image (stimulation period: 90 s). After the physiological measurement, the questionnaires for the subjective test were answered (120 s). This study used a within-participant design, and the mountain or city image was presented in a counterbalanced order.

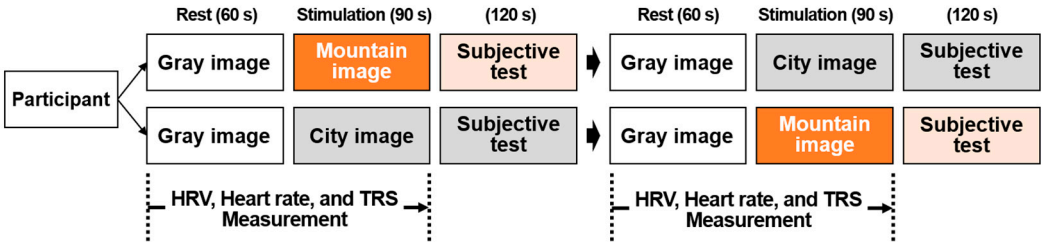


Figure 3. Measurement protocol for visual stimulation with mountain and city landscape images. The orders of mountain and city images were counterbalanced. The study employed a within-participant design.

2.4. Physiological Measurements

Figure 4 shows the method of assessment of physiological indicators. To evaluate autonomic nervous activity, we used HRV and heart rate with a portable electrocardiograph (Activtracer AC-301A; GMS, Tokyo, Japan) [37,38]. HRV was analyzed for the periods between consecutive R waves (R-R intervals, RRI). High frequency (HF; 0.15–0.40 Hz) and low frequency (LF; 0.04–0.15 Hz) power level components were calculated using the maximum entropy method (Mem-Calc/Win; GMS, Tokyo, Japan) [39,40]. The HF power indicated parasympathetic nervous activity, and the LF/HF power ratio indicated sympathetic nervous activity [37,41]. To evaluate brain activity, we used TRS (TRS-20 system; Hamamatsu Photonics K.K., Shizuoka, Japan) [42,43]. We measured oxy-Hb concentrations in the prefrontal cortex. Changes in oxy-Hb concentrations are known to be consistent with the changes in blood flow in the brain, and it is thought that a decrease in oxy-Hb concentration is associated with physiological calming [44]. It has been reported that oxy-Hb concentrations in the prefrontal cortex are reduced by pleasant emotions and increased by unpleasant emotions [45]. The value of physiological responses during visual stimulation (90 s) was calculated as the differences from the mean value for 30 s before exposure.

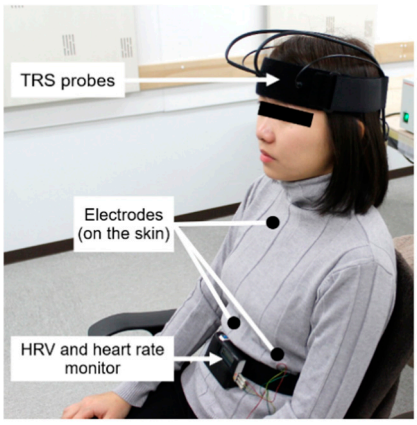


Figure 4. Assessment of physiological indicators.

2.5. Psychological Measurements

The psychological effects of visual stimuli were assessed using the modified SD method [46] and POMS 2 [47,48]. The modified SD method consisted of three paired adjectives (comfortable−uncomfortable, relaxed−awakening, and natural−artificial) to assess impressions of the stimuli. POMS 2 of seven subscales (A–H, anger–hostility; C–B, confusion–bewilderment; D–D, depression–dejection; F–I, fatigue–inertia; T–A, tension–

anxiety; V–A, vigor–activity; and F, friendliness) and total mood disturbance (TMD) were used to assess changes in mood states to the stimuli. To reduce participant burden, a shortened Japanese version of the POMS 2 with 35 questions was used.

2.6. Data Analysis

The Statistical Package for the Social Sciences software (version 21.0, IBM, Armonk, NY, USA) was used for statistical analysis. $p < 0.05$ was considered statistically significant.

Paired *t*-tests were used to compare the physiological responses (HRV, heart rate, TRS, and respiratory rate) between mountain and city images based on the overall mean value during 90-s visual exposures. The Wilcoxon signed-rank test was applied to compare the psychological effects (the modified SD method and POMS 2) of the mountain and city images.

3. Results

3.1. Physiological Effects

3.1.1. HRV and Heart Rate

We excluded one participant who showed a large change in respiratory rate while viewing the images because variations in these values could influence HRV data. No significant differences were noted in the respiratory rate between participants who viewed a mountain image and those who viewed a city image. Therefore, a statistical analysis of the HRV data was performed.

Figure 5 shows the results of the HF component, indicating parasympathetic nervous activity by exposure to mountain and city images. Figure 5A depicts the changes in 30-s mean HF component over 90-s exposure. During exposure to the mountain image, the HF component increased to 243.46 ± 113.52 ms^2 between 31 and 60 s and 198.95 ± 104.45 ms^2 between 61 and 90 s; however, during exposure to the city image, the HF component almost stayed at the baseline. Figure 5B displays the changes in the HF component during exposure to the mountain and city images for 90 s. In comparing the overall means in the 90-s exposure period, the HF component value of the participants who viewed the mountain image was significantly higher than that of the participants who viewed the city image (Figure 5B, mountain: 171.91 ± 78.98 ms^2; city: 31.18 ± 77.35 ms^2; $p = 0.037$).

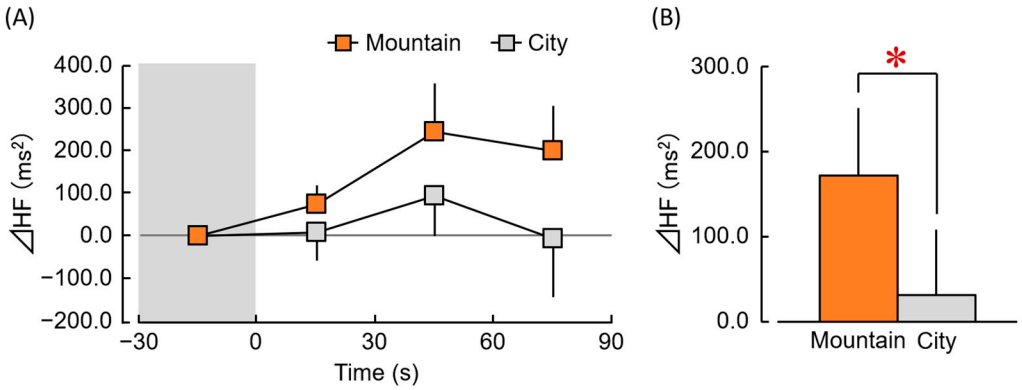


Figure 5. Changes in the high frequency (HF) of heart rate variability (HRV) for exposure to the mountain and city images. (**A**) Changes in the 30-s mean HF component over 90 s of exposure (difference from the mean value for 30 s before exposure). (**B**) Changes in HF during exposure to the mountain and city images for 90 s. ($n = 26$, mean ± standard error). * $p < 0.05$ (mountain vs. city), paired *t*-test.

However, no significant differences were observed in the ΔLF/HF value, indicating the sympathetic nervous activity (mountain: −0.23 ± 0.39; city: 0.31 ± 0.28; $p = 0.340$) and Δheart rate (mountain: −0.64 ± 0.50 beats/min; city: −0.05 ± 0.34 beats/min; $p = 0.234$) between the participants who viewed the mountain image and those who viewed the city image.

3.1.2. TRS

No significant differences were noted in Δoxyhemoglobin concentrations on the left (mountain: −0.37 ± 0.17 μM; city: −0.41 ± 0.25 μM; $p = 0.910$) and right (mountain: −0.45 ± 0.18 μM; city: −0.25 ± 0.14 μM; $p = 0.324$) prefrontal cortices between the participants who viewed the mountain image and those who viewed the city image.

3.2. Psychological Effects

Figure 6 shows the psychological responses of the participants, as measured using the modified SD method, after viewing the mountain and city images. In the comfortable−uncomfortable subscale, visual stimulation using the mountain image promoted slight to moderate comfort, and visual stimulation using the city image induced almost indifferent feelings. Thus, visual stimulation using the mountain image provided a more comfortable feeling than visual stimulation using the city image (Figure 6A, $p < 0.001$). In the relaxed−awakening subscale, visual stimulation using the mountain image induced slight to moderate relaxation, and visual stimulation using the city promoted slight awakening. Therefore, visual stimulation using the mountain image induced a more relaxed feeling than visual stimulation using the city image (Figure 6B, $p < 0.001$). Additionally, in the natural−artificial subscale, visual stimulation using the mountain image promoted moderate to very natural feelings, and visual stimulation using the city image induced almost moderate artificial feelings. Thus, the mountain image promoted a more natural feeling than the city image (Figure 6C, $p < 0.001$).

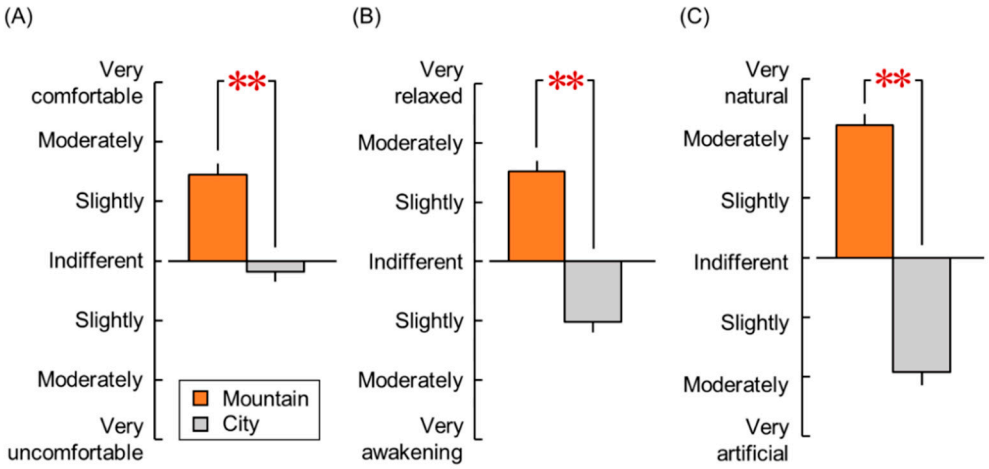


Figure 6. Psychological effects evaluated using the modified SD method based on three opposing adjective pairs after viewing the mountain and city images. (**A**) Comfortable versus uncomfortable. (**B**) Relaxed versus awakening. (**C**) Natural versus artificial ($n = 27$, mean ± standard error). ** $p < 0.01$ (mountain vs. city). Wilcoxon signed-rank test.

Figure 7 shows the results of the seven subscales and the TMD scores based on the POMS 2 questionnaires after visual stimulation using the mountain and city images. The participants who viewed the mountain image had significantly lower negative subscale scores than those who viewed the city image (A–H, anger–hostility [$p < 0.01$]; C–B, confusion–bewilderment [$p < 0.001$]; F–I, fatigue–inertia [$p < 0.001$]; T–A, tension–anxiety [$p < 0.001$]), except for the subscale of D–D, depression–dejection ($p > 0.05$). However, they had significantly higher positive subscale scores (V–A, vigor–activity [$p < 0.001$]; F, friendliness [$p < 0.01$]). Further, participants who viewed the mountain image had significantly lower TMD scores than those who viewed the city image ($p < 0.001$).

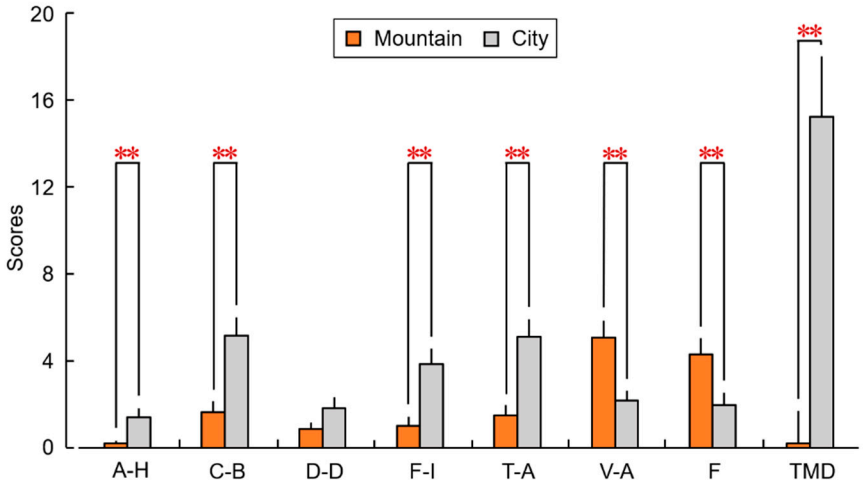


Figure 7. Psychological effects evaluated by POMS 2 after viewing the mountain and city images. (n = 27, mean ± standard error, ** $p < 0.01$ [mountain vs. city], Wilcoxon signed-rank test). A–H, anger–hostility; C–B, confusion–bewilderment; D–D, depression–dejection; F–I, fatigue–inertia; T–A, tension–anxiety; V–A, vigor–activity; F, friendliness; TMD, total mood disturbance.

4. Discussion

The present study demonstrated that visual stimulation using an autumn foliage mountain landscape image via a large display can induce physiological and psychological relaxation effects among women in their 20s.

Results of physiological effects showed that the autonomic nervous activity, viewing an image of a mountain, significantly increased the parasympathetic nervous activity of the HF component compared with viewing a city image. The modified SD method and POMS 2 showed that the psychological effects of viewing the mountain image induced comfortable, relaxed, and natural feelings, as well as improved mood states.

Ikei et al. have demonstrated the following: (1) visual stimulation of fresh roses in a vase increased the parasympathetic nervous activity in office workers [13] and (2) visual stimulation of Dracaena foliage plants also increased the parasympathetic nervous activity in high school students [27]. Studies using a bonsai tree as a visual stimulus demonstrated that older adult patients undergoing rehabilitation [28] and patients with spinal cord injury [29] who were under highly stressed conditions increased their parasympathetic nervous activity by observing the bonsai tree for 1 min. Gladwell et al. [23] have reported that viewing slides of natural scenery, such as trees and grass fields, significantly increased parasympathetic nervous activity. Similar to the results of the previous studies, the results of the present study confirmed that exposure to an autumn mountain landscape image via a large, high-resolution display increased parasympathetic activity. These results suggest that visual exposure to indoor plants, such as flowers, ornamental foliage, and bonsai tree, or to the natural landscape via slides or displays results in physiological relaxation and stress reduction. On the other hand, previous studies on visual effects showed that visual stimuli induced changes in both the autonomic nervous system (sympathetic or/and parasympathetic nervous activity) and prefrontal cortex [29,49]. However, in the current study, only parasympathetic activity increased as a result of the visual stimulation of the mountain image. The reason for this is unknown, and further investigations are needed to acquire more data.

The psychological assessment finding in the current study showed that exposure to the mountain image elicited greater comfortable, relaxed, and natural feelings, as well as improved mood states, than exposure to the city image. This is a psychological effect that is also consistent with staring at a rose for 3 min [13,24] and a bonsai tree with a reduced forest landscape for 1 min [29]. This indicates that indirect viewing of nature landscape images through displays and brief visual exposure to indoor plants, such as flowers and bonsai trees, can lead to psychological relaxation.

Since 2019, due to the COVID-19 pandemic, people are spending more time in their homes owing to telework, school closures, and their own choices to self-isolate. Moreover, several are experiencing stress owing to significant changes in lifestyle patterns [50,51]. The current study showed that an indirect observation of a large display of nature landscape images for a short time induces physiological and psychological relaxation. Indirect exposure to nature landscape images projected on a display could alleviate stress caused by these new social situations.

However, the current study had several limitations. (1) Future studies are needed to validate the physiological and psychological effects of visual stimulation using a home personal computer or a general TV screen, which are commonly used. (2) This study focused on the effects of landscape images consisting of mountains and buildings, which are typical examples of nature and city landscapes, respectively. In the future, research on different landscape types, such as a magnificent waterfall, is expected to elicit different responses that expand the range of physiological and psychological responses recorded for these categories of visual stimuli. (3) Factors such as the color, line, shape, and texture of the stimuli affect visual perception. In the future, it is necessary to consider such factors as evaluation scales in the modified SD method. (4) This study was limited to a short exposure time of 90 s and to the effects of visual stimuli. Further studies on the effects of long-term exposure to visual stimuli as well as the effects of stimulating auditory, tactile, olfactory, and other senses will further deepen the knowledge in this field. (5) The study participants were limited to women in their 20s. Future studies with a larger number of participants of different ages and gender need to be conducted for the generalizability of the results.

5. Conclusions

The current study demonstrated the physiological and psychological effects of viewing an autumn foliage mountain landscape image via a large, high-resolution display. The autonomic nervous activity and the prefrontal cortex activity were simultaneously measured. Results revealed that visual stimulation with the mountain image significantly increased parasympathetic nervous activity and promoted comfortable, relaxed, and natural feelings, as well as improved mood states. In conclusion, visual stimulation using an autumn foliage mountain landscape image via a large display induced physiological and psychological relaxation among women in their 20s.

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Institutional Review Board Statement: Informed consent was obtained from all subjects involved in the study. The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Ethics Committee of the Center for Environment, Health, and Field Sciences at Chiba University, Japan (project ID no. 42, approval date 20 January 2020).

Data Availability Statement: The data that support the finding of this study are available from the corresponding author upon reasonable request.

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Conflicts of Interest: The authors declare no conflict of interest.

References

1. Brunet, M.; Guy, F.; Pilbeam, D.; Mackaye, H.T.; Likius, A.; Ahounta, D.; Beauvilain, A.; Blondel, C.; Bocherens, H.; Boisserie, J.R. A new hominid from the Upper Miocene of Chad, Central Africa. *Nature* **2002**, *418*, 141–151. [CrossRef]
2. Song, C.; Ikei, H.; Miyazaki, Y. Physiological effects of nature therapy: A review of the research in Japan. *Int. J. Environ. Res. Public Health* **2016**, *13*, 781. [CrossRef] [PubMed]
3. Miyazaki, Y.; Park, B.J.; Lee, J. Nature therapy. In *Designing Our Future: Local Perspectives on Bioproduction, Ecosystems and Humanity*; Osaki, M., Braimoh, A., Nakagami, K., Eds.; United Nations University Press: New York, NY, USA, 2011; pp. 407–412.
4. Corazon, S.S.; Sidenius, U.; Poulsen, D.V.; Gramkow, M.C.; Stigsdotter, U.K. Psycho-physiological stress recovery in outdoor nature-based interventions: A systematic review of the past eight years of research. *Int. J. Environ. Res. Public Health* **2019**, *16*, 1711. [CrossRef] [PubMed]
5. Kotera, Y.; Richardson, M.; Sheffield, D. Effects of Shinrin-Yoku (forest bathing) and nature therapy on mental health: A systematic review and meta-analysis. *Int. J. Ment. Health Addict.* **2022**, *20*, 337–361. [CrossRef]
6. Miyazaki, Y. *Shinrin-Yoku: The Japanese Way of Forest Bathing for Health and Relaxation*; Aster: London, UK, 2018; p. 192.
7. Kobayashi, H.; Song, C.; Ikei, H.; Park, B.J.; Lee, J.; Kagawa, T.; Miyazaki, Y. Forest walking affects autonomic nervous activity: A population-based study. *Front. Public Health* **2018**, *6*, 278. [CrossRef] [PubMed]
8. 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.* **2011**, *15*, 18. [CrossRef]
9. Song, C.; Ikei, H.; Kagawa, T.; Miyazaki, Y. Physiological and psychological effects of viewing forests on young women. *Forests* **2019**, *10*, 635. [CrossRef]
10. Song, C.; Ikei, H.; Kagawa, T.; Miyazaki, Y. Effects of walking in a forest on young women. *Int. J. Environ. Res. Public Health* **2019**, *16*, 229. [CrossRef]
11. Song, C.; Joung, D.; Ikei, H.; Igarashi, M.; Aga, M.; Park, B.J.; Miwa, M.; Takagaki, M.; Miyazaki, Y. Physiological and psychological effects of walking on young males in urban parks in winter. *J. Physiol. Anthropol.* **2013**, *32*, 1–5. [CrossRef]
12. Song, C.; Ikei, H.; Igarashi, M.; Miwa, M.; Takagaki, M.; Miyazaki, Y. Physiological and psychological responses of young males during spring-time walks in urban parks. *J. Physiol. Anthropol.* **2014**, *33*, 8. [CrossRef]
13. Ikei, H.; Komatsu, M.; Song, C.; Himoro, E.; Miyazaki, Y. The physiological and psychological relaxing effects of viewing rose flowers in office workers. *J. Physiol. Anthropol.* **2014**, *33*, 6. [CrossRef] [PubMed]
14. Nakamura, M.; Ikei, H.; Miyazaki, Y. Physiological effects of visual stimulation with full-scale wall images composed of vertically and horizontally arranged wooden elements. *J. Wood Sci.* **2019**, *65*, 55. [CrossRef]
15. Igarashi, M.; Song, C.; Ikei, H.; Ohira, T.; Miyazaki, Y. Effect of olfactory stimulation by fresh rose flowers on autonomic nervous activity. *J. Altern. Complement. Med.* **2014**, *20*, 727–731. [CrossRef] [PubMed]
16. Ikei, H.; Song, C.; Miyazaki, Y. Physiological effect of olfactory stimulation by Hinoki cypress (*Chamaecyparis obtusa*) leaf oil. *J. Physiol. Anthropol.* **2015**, *34*, 44. [CrossRef] [PubMed]
17. Ikei, H.; Song, C.; Miyazaki, Y. Physiological effects of touching sugi (*Cryptomeria japonica*) with the palm of the hand. *J. Wood Sci.* **2019**, *65*, 48. [CrossRef]
18. Ikei, H.; Miyazaki, Y. Positive physiological effects of touching sugi (*Cryptomeria japonica*) with the sole of the feet. *J. Wood Sci.* **2020**, *66*, 29. [CrossRef]
19. Jo, H.; Song, C.; Ikei, H.; Enomoto, S.; Kobayashi, H.; Miyazaki, Y. Physiological and psychological effects of forest and urban sounds using high-resolution sound sources. *Int. J. Environ. Res. Public Health* **2019**, *16*, 2649. [CrossRef]
20. Ochiai, H.; Song, C.; Jo, H.; Oishi, M.; Imai, M.; Miyazaki, Y. Relaxing effect induced by forest sound in patients with gambling disorder. *Sustainability* **2020**, *12*, 5969. [CrossRef]
21. Jo, H.; Song, C.; Miyazaki, Y. Physiological benefits of viewing nature: A systematic review of indoor experiments. *Int. J. Environ. Res. Public Health* **2019**, *16*, 4739. [CrossRef]
22. Song, C.; Ikei, H.; Miyazaki, Y. Physiological effects of visual stimulation with forest imagery. *Int. J. Environ. Res. Public Health* **2018**, *15*, 213. [CrossRef]
23. Gladwell, V.F.; Brown, D.K.; Barton, J.L.; Tarvainen, M.P.; Kuoppa, P.; Pretty, J.; Suddaby, J.M.; Sandercock, G.R.H. The effects of views of nature on autonomic control. *Eur. J. Appl. Physiol.* **2012**, *112*, 3379–3386. [CrossRef] [PubMed]
24. Song, C.; Igarashi, M.; Ikei, H.; Miyazaki, Y. Physiological effects of viewing fresh red roses. *Complement. Ther. Med.* **2017**, *35*, 78–84. [CrossRef] [PubMed]
25. Igarashi, M.; Aga, M.; Ikei, H.; Namekawa, T.; Miyazaki, Y. Physiological and psychological effects on high school students of viewing real and artificial pansies. *Int. J. Environ. Res. Public Health* **2015**, *12*, 2521–2531. [CrossRef]
26. Park, S.A.; Song, C.; Choi, J.Y.; Son, K.C.; Miyazaki, Y. Foliage plants cause physiological and psychological relaxation as evidenced by measurements of prefrontal cortex activity and profile of mood states. *HortScience* **2016**, *51*, 1308–1312. [CrossRef]
27. Ikei, H.; Song, C.; Igarashi, M.; Namekawa, T.; Miyazaki, Y. Physiological and psychological relaxing effects of visual stimulation with foliage plants in high school students. *Adv. Hortic. Sci.* **2014**, *28*, 111–116. [CrossRef]
28. Song, C.; Ikei, H.; Nara, M.; Takayama, D.; Miyazaki, Y. Physiological effects of viewing bonsai in elderly patients undergoing rehabilitation. *Int. J. Environ. Res. Public Health* **2018**, *15*, 2635. [CrossRef] [PubMed]

29. Ochiai, H.; Song, C.; Ikei, H.; Imai, M.; Miyazaki, Y. Effects of visual stimulation with bonsai trees on adult male patients with spinal cord injury. *Int. J. Environ. Res. Public Health* **2017**, *14*, 1017. [CrossRef]
30. Syed Abdullah, S.S.; Awang Rambli, D.R.; Sulaiman, S.; Alyan, E.; Merienne, F.; Diyana, N. The impact of virtual nature therapy on stress responses: A systematic qualitative review. *Forests* **2021**, *12*, 1776. [CrossRef]
31. Available online: https://en.wikipedia.org/wiki/Leaf_peeping (accessed on 28 July 2022).
32. Available online: https://www.japan.travel/en/things-to-do/nature/autumn-leaves/ (accessed on 28 July 2022).
33. Liu, J.; Cheng, H.; Jiang, D.; Huang, L. Impact of climate-related changes to the timing of autumn foliage colouration on tourism in Japan. *Tour. Manag.* **2019**, *70*, 262–272. [CrossRef]
34. Song, C.; Ikei, H.; Igarashi, M.; Takagaki, M.; Miyazaki, Y. Physiological and psychological effects of a walk in urban parks in fall. *Int. J. Environ. Res. Public Health* **2015**, *12*, 14216–14228. [CrossRef]
35. Schoep, M.E.; Nieboer, T.E.; van der Zanden, M.; Braat, D.D.M.; Nap, A.W. The impact of menstrual symptoms on everyday life: A survey among 42,879 women. *Am. J. Obstet. Gynecol.* **2019**, *220*, 569. [CrossRef] [PubMed]
36. Li, S.H.; Lloyd, A.R.; Graham, B.M. Physical and mental fatigue across the menstrual cycle in women with and without generalised anxiety disorder. *Horm. Behav.* **2020**, *118*, 104667. [CrossRef] [PubMed]
37. Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology. Heart rate variability: Standards of measurement, physiological interpretation and clinical use. *Circulation* **1996**, *93*, 1043–1065. [CrossRef]
38. Kobayashi, H.; Ishibashi, K.; Noguchi, H. Heart rate variability; an index for monitoring and analyzing human autonomic activities. *Appl. Hum. Sci.* **1999**, *18*, 53–59. [CrossRef] [PubMed]
39. Kanaya, N.; Hirata, N.; Kurosawa, S.; Nakayama, M.; Namiki, A. Differential effects of propofol and sevoflurane on heart rate variability. *Anesthesiology* **2003**, *98*, 34–40. [CrossRef] [PubMed]
40. Sawada, Y.; Ohtomo, N.; Tanaka, Y.; Tanaka, G.; Yamakoshi, K.; Terachi, S.; Shimamoto, K.; Nakagawa, M.; Satoh, S.; Kuroda, S.; et al. New technique for time series analysis combining the maximum entropy method and non-linear least squares method: Its value in heart rate variability analysis. *Med. Biol. Eng. Comput.* **1997**, *35*, 318–322. [CrossRef] [PubMed]
41. Pagani, M.; Lombardi, F.; Guzzetti, S.; Rimoldi, O.; Furlan, R.A.; Pizzinelli, P.; Sandrone, G.; Malfatto, G.; Dell'Orto, S.; Piccaluga, E. Power spectral analysis of heart rate and arterial pressure variabilities as a marker of sympatho-vagal interaction in man and conscious dog. *Circ. Res.* **1986**, *59*, 178–193. [CrossRef]
42. Ohmae, E.; Ouchi, Y.; Oda, M.; Suzuki, T.; Nobesawa, S.; Kanno, T.; Yoshikawa, E.; Futatsubashi, M.; Ueda, Y.; Okada, H. Cerebral hemodynamics evaluation by near-infrared time-resolved spectroscopy: Correlation with simultaneous positron emission tomography measurements. *NeuroImage* **2006**, *29*, 697–705. [CrossRef]
43. Ohmae, E.; Oda, M.; Suzuki, T.; Yamashita, Y.; Kakihana, Y.; Matsunaga, A.; Kanmura, Y.; Tamura, M. Clinical evaluation of time-resolved spectroscopy by measuring cerebral hemodynamics during cardiopulmonary bypass surgery. *J. Biomed. Opt.* **2007**, *12*, 062112. [CrossRef]
44. Hoshi, Y.; Kobayashi, N.; Tamura, M. Interpretation of near infrared spectroscopy signals: A study with a newly developed perfused rat brain model. *J. Appl. Physiol.* **2001**, *90*, 1657–1662. [CrossRef]
45. Hoshi, Y.; Huang, J.; Kohri, S.; Iguchi, Y.; Naya, M.; Okamoto, T.; Ono, S. Recognition of human emotions from cerebral blood flow changes in the frontal region: A study with event-related near-infrared spectroscopy. *J. Neuroimaging* **2011**, *21*, 94–101. [CrossRef] [PubMed]
46. Osgood, C.E.; Suci, G.J.; Tannenbaum, P. *The Measurement of Meaning*; University of Illinois Press: Urbana, IL, USA, 1957.
47. Heuchert, J.P.; McNair, D.M. *POMS 2: Profile of Mood States*, 2nd ed.; Multi-Health Systems Inc.: New York, NY, USA, 2012.
48. Yokoyama, K.; Watanabe, K. *Japanese Translation of POMS 2: Profile of Mood States*, 2nd ed.; Kaneko Shobo: Tokyo, Japan, 2015. (In Japanese)
49. Igarashi, M.; Yamamoto, T.; Lee, J.; Song, C.; Ikei, H.; Miyazaki, Y. Effects of stimulation by three-dimensional natural images on prefrontal cortex and autonomic nerve activity: A comparison with stimulation using two-dimensional images. *Cogn. Process.* **2014**, *15*, 551–556. [CrossRef] [PubMed]
50. Pfefferbaum, B.; North, C.S. Mental health and the Covid-19 pandemic. *N. Engl. J. Med.* **2020**, *383*, 510–512. [CrossRef] [PubMed]
51. Kar, N.; Kar, B.; Kar, S. Stress and coping during COVID-19 pandemic: Result of an online survey. *Psychiatry Res.* **2021**, *295*, 113598. [CrossRef] [PubMed]