Pre-Registered Report

The Impact of Immersive Technology on Nature Relatedness and Pro-Environmental Behavior

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Abstract: Those who feel connected to nature tend to be more likely to engage in pro-environmental behavior. How can this connection with nature be created? We examined whether viewing nature-related videos – specifically, the immersiveness of the technological devices used to display these videos – can enhance connection with nature and increase pro-environmental behavior. Participants watched videos of either natural or built environments through a head-mounted display (immersive technology) or a regular computer screen. We predicted that watching a nature video would enhance nature relatedness and pro-environmental behaviors, particularly when presented with immersive technology than with a traditional computer monitor. There was limited support for the hypotheses; watching the nature video significantly enhanced nature relatedness but not pro-environmental behaviors. The type of technology used did not influence the effect of the videos.

Keywords: immersive technology, presence, nature, environmental behavior

Over the last few decades, knowledge and concern about environmental problems have increased, and yet many people fail to translate their knowledge of these problems into responsible environmental actions (Bashir, Wilson, Lockwood, Chasteen, & Alisat, 2014; Pelletier, Dion, Tuson, & Green-Demers, 1999). Perhaps one of the main reasons why people in modern-day society are not sufficiently engaged in pro-environmental actions is their detachment from the natural world. The majority of the world population lives in urban settings and the number is expected to grow (Montgomery, 2007). Hence, many individuals worldwide may not have the opportunity to spend time in nature. Indeed, research shows that having direct contact with nature tends to increase the degree to which people feel related to, or connected with, nature (Mayer, Frantz, Bruehlman-Senecal and Dolliver, 2009; Nisbet & Zelenski, 2011; Schultz & Tabanico, 2007); and that nature relatedness captures many of the predictors of environmentally responsible behavior (Nisbet, Zelenski, & Murphy, 2009).

Technology has the potential to be a useful tool for bringing nature closer to individuals in urban settings. Some forms of technology – such as 3D videos and/or head-mounted displays – may provide a particularly immersive viewing experience and enhance the realism of virtual environments to resemble direct contact with nature. The role of immersive technology in influencing nature relatedness and environmental behavior is important to study. In the present research, we examine whether the immersiveness of the technology used to watch videos of natural (vs. built) environments can affect nature relatedness and pro-environmental behavior.

Nature Relatedness and Pro-Environmental Behavior

Over the past decade, psychologists have started exploring the concept of nature relatedness. A number of self-report questionnaires have been created to capture individual differences in the extent to which people associate themselves with the natural environment such as the Connectedness to Nature Scale (Mayer & Frantz, 2004), the Connectivity With Nature Scale (Dutcher, Finley, Luloff, & Johnson, 2007), the Nature Relatedness Scale (Nisbet et al., 2009), and the inclusion of nature in the self measure (Schultz, 2002). The degree to which people feel connected to nature tends to be a robust predictor of happiness (e.g., Zelenski and Nisbet, 2014; for a review see Capaldi, Dopko, & Zelenski, 2014) and engagement in environmental behavior (e.g., Dutcher et al., 2007; Nisbet et al., 2009). Mayer and Frantz (2004) explain the latter relationship by suggesting that if people feel that they are connected to nature, harming the environment would be akin to inflicting harm on the self.

Although nature relatedness has been generally conceptualized as an individual difference, it can shift in the moment. Several empirical studies attest to the malleability of self-nature associations. Spending time in nature (e.g., a short walk) was shown to increase connections with nature as well as positive affect (Mayer et al., 2009; Nisbet & Zelenski, 2011; Schultz & Tabanico, 2007). There is some evidence that exposure to virtual nature can also have some restorative effects such as decreased stress and reduced negative affect (e.g., De Kort, Meijnders, Sponselee, & IJsselsteijn, 2006; Kjellgren & Buhrkall, 2010; Valtchanov, Barton, & Ellard, 2010). In experiments comparing the effects of real and virtual nature, Mayer et al. (2009) found that spending time experiencing nature virtually (e.g., by watching a video of nature) can also increase connectedness to nature but to a smaller degree than experiencing real nature.

Given that many individuals – particularly those living in urban settings – may not always have the opportunity to be in direct contact with nature, *virtual* nature experienced through technology may be a promising avenue for boosting nature relatedness and pro-environmental behavior. Indeed, there is some evidence supporting the idea that watching nature videos may boost sustainable behavior. Zelenski, Dopko, and Capaldi (2015) found that watching a video of nature (vs. built or neutral control stimuli) can increase sustainable behavior in the context of a commons dilemmas game. Zelenski et al. (2015) also found that videos of nature increased nature relatedness, but this effect was only apparent in one of two studies. Because the effects of watching videos of nature on nature relatedness and environmentally responsible behavior have been generally small and inconclusive (Mayer et al., 2009; Zelenski et al., 2015), more empirical research is needed on experiencing nature in virtual environments and its potential role. We propose that using immersive technology can be one way of bridging the gap between experiencing actual and virtual nature. Immersive technology tends to enhance the realism of virtual experiences. Hence, watching a nature-related video via immersive technology may be powerful enough to produce a strong effect on nature relatedness and thereby change actual behavior.

The Impact of Immersive Technology

Historically, technological advancements have enabled social science researchers to conduct research more effectively and efficiently. The development of immersive virtual environment technology presents immense opportunities for psychologists. Researchers are now able to create realistic virtual environments and to employ sophisticated devices that enable participants to be immersed in such environments and to experience them as though they were real (Blascovich et al., 2002; Fox, Arena, & Bailenson, 2009). A call for greater use of immersive technology to enhance the mundane realism of experiments and strengthen effects of experimental manipulations (Blascovich et al., 2002) remains relevant today.

Immersive technology (e.g., head-mounted displays, computer-generated kinesthetic and tactile feedback) tends to increase the users' subjective sense of presence – defined as "the subjective experience of being in one place or environment, even when one is physically situated in another" (Witmer & Singer, 1998, p. 225) – compared with less immersive forms of technology (e.g., traditional computer monitors; Baños et al., 2004; De Kort et al., 2006; Moreno & Mayer, 2002). Researchers have examined consequences of experiencing a sense of presence in virtual environments such as video games (Skalski, Tamborini, Shelton, Buncher, & Lindmark, 2011), learning environments (Moreno & Mayer, 2002), and advertising contexts (Li, Daugherty, & Biocca, 2002). However, most of this research examined potential affective (e.g., enjoyment) and cognitive (e.g., memory) consequences of experiencing presence, and yielded mixed results. One study (De Kort et al., 2006) showed that increasing immersiveness of technology by using larger monitors to display a nature video can influence physiological responses to that video, with more immersive technology leading to greater restorative effects of watching the video. Further research is needed to understand *behavioral* consequences of experiencing presence in virtual environments. Can experiencing an enhanced sense of presence when using immersive technology actually change human behavior outside of the virtual environment?

We examine the impact of immersive technology in the domain of environmental connectedness and pro-environmental behavior. To our knowledge, this is the first study to experimentally assess the effect of using immersive technology (head-mounted display vs. traditional desktop display) when viewing nature on environmental attitudes and behavior. If immersive technology enhances connectedness with nature and pro-environmental behaviors after viewing nature videos, such a finding would underscore the importance of the type of technology chosen when presenting stimuli. If immersive technology makes no difference to connectedness with nature and pro-environmental behavior, such a finding would underscore the validity of purely online or less immersive research procedures.

The Present Research

The purpose of the present research is two-fold: First, we would like to provide a replication of the effects of nature-related videos on nature relatedness (Mayer et al., 2009; Zelenski et al., 2015). Second, we would like to assess whether using immersive technologies would enhance such effects. Specifically, participants were randomly assigned to watch a video of nature or a built environment. We also varied the degree of the immersion in the virtual environment by having half the participants view the video on a traditional computer monitor and the other half use a head-mounted display. We expected participants to report greater connectedness with nature after watching a video of a natural (vs. built) environment (Hypothesis 1). Moreover, immersive technology was expected to enhance the effect of watching the nature video on nature relatedness (Hypothesis 2). Similarly, we expected participants to engage in more pro-environmental behaviors after watching a video of a natural (vs. built) environment (Hypothesis 3) and we expected immersive technology to enhance the effect of watching the nature video on environmental behavior (Hypothesis 4).

Method

Participants

In all, 230 undergraduate students from a Canadian university participated in this study in exchange for partial course credit. This sample size was determined based on the 2 × 2 between-subject design. Based on calculations in G*Power 3.1 (Faul, Erdfelder, Buchner, & Lang, 2009), a sample size of 199 participants should be large enough to detect a small-to-medium sized effect (an effect size of 0.20) with over 80% power for analyses like the ones outlined here (see Electronic Supplementary Material, ESM 1). We assumed a small-to-medium effect as a conservative benchmark, given that documented effect sizes of the effects of nature exposure vary widely and effect sizes for behavioral effects are usually smaller. For example, effect sizes of nature exposure that were below 0.20 were typically deemed to be small and insignificant (e.g., Zelenski et al., Study 2). Our power was calculated to detect the smallest effect size of interest. We recruited 230 participants to account for the possibility of attrition or drop-out. Three participants withdrew their data from the study. Thus, the final sample included 227 participants (67 male, 158 female, 1 other, 1 undisclosed, M_{age} = 21.20, SD = 6.42).[1]

Procedure and Materials

Participants were randomly assigned to one of four conditions in a 2 (video: nature vs. built) × 2 (display device: desktop screen vs. head-mounted display) between-subject design. The materials used in the study are presented in Electronic Supplementary Material, ESM 2. After providing consent and reporting demographics (age, gender) participants viewed a 4-min video. The nature video depicted various landscape scenes (e.g., forests, mountains, rivers, and wildlife) whereas the built environment video depicted various scenes from a city (e.g., vehicles, skyscrapers, bridges, and crowds). The videos were equal in duration and featured accompanying audio consistent with being in a natural (e.g., birds chirping) or built (e.g., vehicles honking their horns) environment. Pilot testing of sample videos with similar content indicated that the two settings were equally pleasant and fun to watch (Davydenko & Peetz, 2015). Participants in the low-immersion condition viewed the video on a regular desktop screen with speakers, whereas those in the high-immersion condition viewed the same video using a virtual reality head-mounted display with headphones. The participants in the low-immersion condition watched the video on a DELL E228WFPc LCD 22" monitor with 1,680 × 1,050 resolution. The participants in the high-immersion condition wore a Sony HMZ-T2 display, which features a 45° field of view of a virtual screen. The resolution of the display was 1,280 × 720 with an aspect ratio of 16:09. The rest of the procedure was the same in all conditions. Specifically, participants rated their attitudes toward nature, mood, and experience and evaluation of the video. Then, they completed behavioral measures, as outlined in the next section. Questionnaires were answered using the same medium (i.e., computer-based surveys) in all conditions to ensure that differences in responses cannot be attributed to the technology used to record ratings. The only difference between immersion conditions was the technology used for presenting the video stimuli.

First, participants reported their attitudes about nature in two measures. They reported the degree to which nature was important to their self-concept. This inclusion of nature in the self measure (Schultz, 2002) consists of pairs of circles that overlap to varying degrees with one another. In each pair, one circle is labeled *self* and the other is labeled *nature*. Participants were asked to select the pair of circles that best represents how connected they felt to

[1] The data, syntax, and additional analyses files are available for download through the Open Science Framework (OSF): https://osf.io/76796/?view_only=14b7ae2e02454663bead8a8e1e480654

nature. This measure was used in previous research (e.g., Schultz, 2001; Zelenski and Nisbet, 2014). It was adapted from the Inclusion of Other in Self Scale (Aron, Aron, & Smollan, 1992; Aron, Aron, Tudor, & Nelson, 1991), which has been widely used in psychological research and has been well validated. Participants also rated their connectedness to nature using a 14-item scale (Mayer & Frantz, 2004) on Likert scales from 1 = *strongly disagree* to 5 = *strongly agree*. This scale includes items such as "I often feel a kinship with animals and plants" and had good reliability in the present study (Cronbach's $\alpha = .83$).

Second, as a measure of mood, participants rated the extent to which they felt happy and sad (reverse-scored) right in that moment on Likert scales from 1 = *not at all* to 5 = *extremely*. These items correlated ($r = .43$, $p < .001$) and were averaged to indicate positive mood.

Third, we measured participants' experience while watching the video. Specifically we assessed participants' sense of *presence* while watching the videos; we used an adapted version of a presence scale developed by Witmer and Singer (1998). The adapted scale includes 13 items (e.g., "How completely were all of your senses engaged?"), rated on 7-point Likert scales. Some of the items from the original scale were not relevant to our procedure (e.g., items assessing haptic experiences) and were thus excluded. This measure was included for exploratory purposes only; analyses involving this measure are presented on the Open Science Framework (see Footnote 1).

In addition to their sense of presence in the presented video, participants also rated how fun the video was to watch and how pleasant it was on 5-point Likert scales. Finally, the experimenter assessed participants' engagement in three pro-environmental behaviors. First, the experimenter asked if participants wanted to receive a copy of the debriefing form in a hard-copy format or as an e-mail (paper-saving format = pro-environmental choice). Second, the experimenter asked participants if they wanted to sign up for a monthly nature and sustainability newsletter (yes = pro-environmental choice). Participants were told that this online newsletter contains information about practical tips on sustainable living. Past research indicated that acquiring knowledge about environmental issues and sustainable living is one form of pro-environmental behavior and it tends to correlate significantly with other forms of pro-environmental behaviors (Bashir et al., 2014; El Gamal, Wilson, Schuett, & Courneya, 2014). Third, the experimenter asked participants whether they wanted to receive the download link for the campus sustainability strategic plan (yes = pro-environmental choice). The experimenter recorded the number of pro-environmental choices that participants make (ranging between 0 and 3). Finally, participants were debriefed.

Results

Confirmatory Analyses

To test our main hypotheses, we conducted 2 (video: nature vs. built) $\times$ 2 (display device: desktop screen vs. head-mounted display) ANOVAs examining the effects of our experimental manipulations on nature connectedness and pro-environmental behaviors. The two measures assessing nature connectedness – the Connectedness to Nature Scale (Mayer & Frantz, 2004) and the Inclusion of Nature in the Self Scale (Schultz, 2002) – were only moderately correlated, $r = .56$, $p < .001$. Thus, the two measures were analyzed separately. The number of environmental choices made was positively correlated with the inclusion of nature in the self ($r = .26$, $p < .001$) and with connectedness to nature ($r = .29$, $p < .001$). Zero-order correlations between the variables are presented in Electronic Supplementary Material, ESM 3.

Attitudes Toward Nature

Consistent with Hypothesis 1, participants reported including nature into their self-concept more (Schultz, 2002) after watching a video of a natural (vs. built) environment, $M = 4.63$, $SD = 1.46$ vs. $M = 4.12$, $SD = 1.55$ respectively, $F(1, 223) = 6.70$, $p = .010$, $d = 0.34$, $\eta^2_p = 0.03$.[2] However, the main effect of the display device and the video $\times$ display device interaction effect were not significant, $F(1, 223) = 0.001$, $p = .977$, $d = 0$, $\eta^2_p = 0$ and $F(1, 223) = 0.004$, $p = .952$, $\eta^2_p = 0$, respectively (see Figure 1). Thus, the type of device did not influence inclusion of nature in the self.

Similarly, on the Connectedness to Nature Scale (Mayer & Frantz, 2004), participants reported greater connectedness with nature after watching a video of a natural (vs. built) environment, $M = 3.50$, $SD = 0.61$ vs. $M = 3.30$, $SD = 0.65$, $F(1, 223) = 5.63$, $p = .018$, $d = 0.32$, $\eta^2_p = 0.03$. Again, the main effect of the display device and the interaction were not significant, $F(1, 223) = 0.33$, $p = .564$, $d = 0.08$, $\eta^2_p = 0$ and $F(1, 223) = 0.15$, $p = .698$, $\eta^2_p = 0$, respectively (see Figure 2). In other words, when examining attitudes toward nature, the content of the video mattered (supporting Hypothesis 1), but the type of technology used to deliver it did not (not supporting Hypothesis 2).

Pro-Environmental Behaviors

The number of pro-environmental choices that participants made was not significantly different in the natural

[2] Cohen's *d* was calculated for main effects after running the ANOVA based on the means and standard deviations of the relevant groups. The omnibus effect size, partial eta-squared, was computed in SPSS.

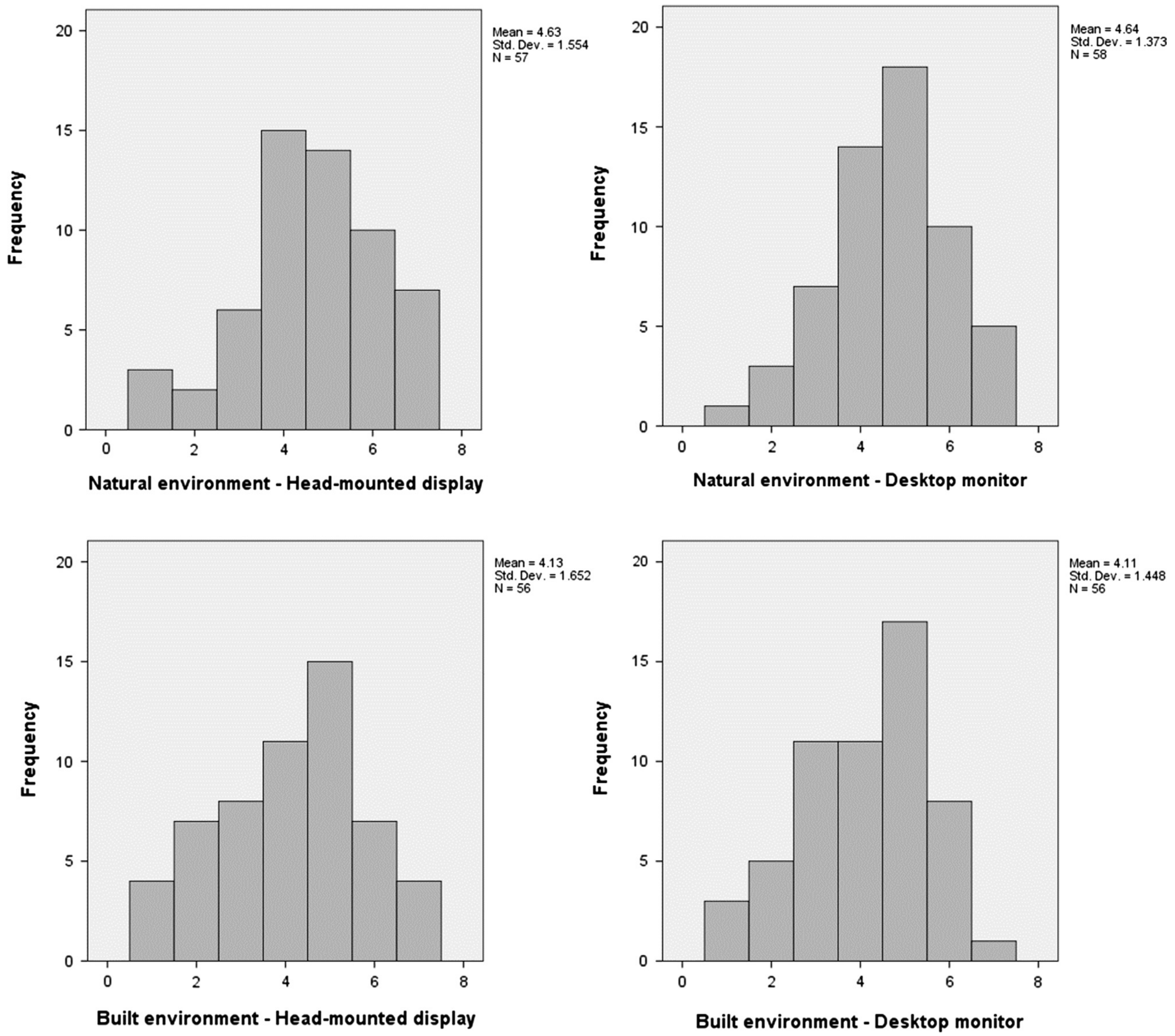

Figure 1. Frequency distribution of inclusion of nature in the self in each experimental condition.

environment condition (M = 2.20, SD = 0.86) than in the built environment condition (M = 2.00, SD = 0.87), $F(1, 222) = 2.97$, $p = .086$, $d = 0.23$, $\eta^2_p = 0.01$. The main effect of display device and the video × display device interaction were also not significant, $F(1, 222) = 0.47$, $p = .495$, $d = 0.09$, $\eta^2_p = 0$ and $F(1, 222) = 0.32$, $p = .574$, $\eta^2_p = 0$, respectively (see Figure 3). In other words, neither the content of the video nor the type of technology used to deliver it had a significant influence on environmental behavior (not supporting Hypotheses 3 and 4).[3]

Exploratory Analyses

Next we examined additional variables that were not part of the main hypotheses but that represent aspects in which the videos or display devices might have differed.

[3] There were two unforeseen limitations in the measure of environmental behavior. First, a Shapiro-Wilk test indicated that the data deviated significantly from a normal distribution, $p < .001$. Second, the relationships between the three environmental behaviors were not as strong as one would expect, suggesting a low reliability of the three-item environmental behavior measure: There was a significant positive relationship between choosing to receive the monthly newsletter and the sustainability plan ($\phi = .47$, $p < .001$). However, choosing to receive the debriefing form by e-mail (vs. on paper) was not significantly related to the choice of receiving the monthly newsletter ($\phi = -.12$, $p = .065$) or downloading the sustainability plan ($\phi = -.02$, $p = .743$). To address these limitations, further analyses were conducted (logistic regression analyses) and are presented on the OSF: https://osf.io/76796/?view_only=14b7ae2e02454663bead8a8e1e480654

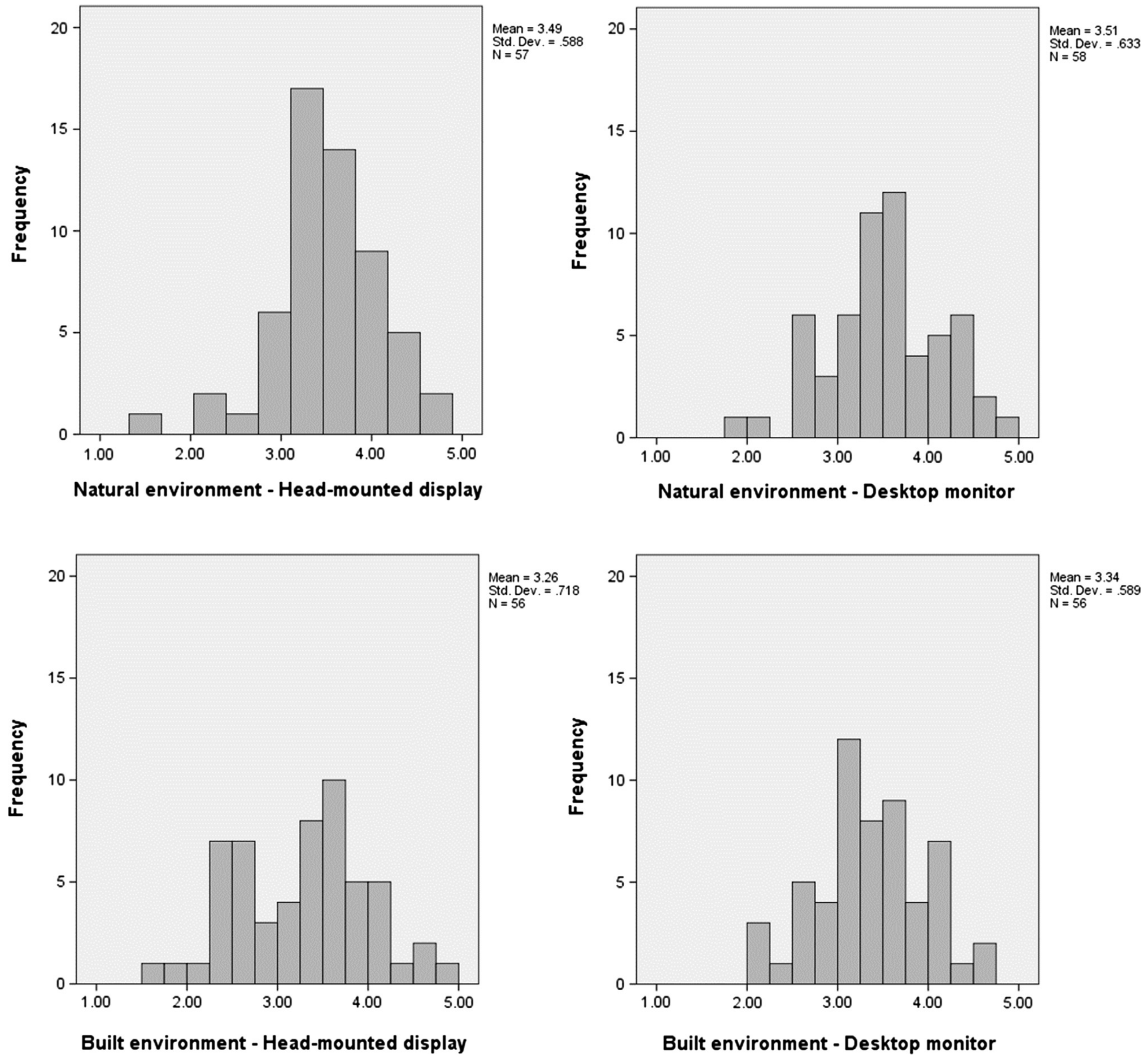

Figure 2. Frequency distribution of nature relatedness in each experimental condition.

Mood

A 2 (video: nature vs. built) × 2 (display device: desktop screen vs. head-mounted display) MANOVA with the two mood items as dependent variables indicated that participants' mood was not affected by the type of video they watched, $F(2, 215) = 0.07$, $p = .929$, $\eta^2_p = 0$, the type of display device, $F(2, 215) = 1.72$, $p = .181$, $\eta^2_p = 0.02$, or their interaction, $F(2, 215) = 1.82$, $p = .164$, $\eta^2_p = 0.02$. This null effect of video content on mood was surprising given the well-established association in the literature between nature and happiness (Capaldi et al., 2014).

Video Properties

We conducted 2 (video: nature vs. built) × 2 (display device: desktop screen vs. head-mounted display) ANOVAs examining effects of the experimental manipulations on ratings of how fun and how pleasant the videos were to watch. Type of video, $F(1, 222) = 0$, $p = .972$, $d = 0$, $\eta^2_p = 0$, type of device, $F(1, 222) = 2.09$, $p = .150$, $d = 0.19$, $\eta^2_p = 0.01$, or their interaction term, $F(1, 222) = 0.03$, $p = .855$, $\eta^2_p = 0$, did not affect how fun the video was to watch. Likewise, the type of device, $F(1, 222) = 1.53$, $p = .217$, $d = 0.15$, $\eta^2_p = 0.01$, and the

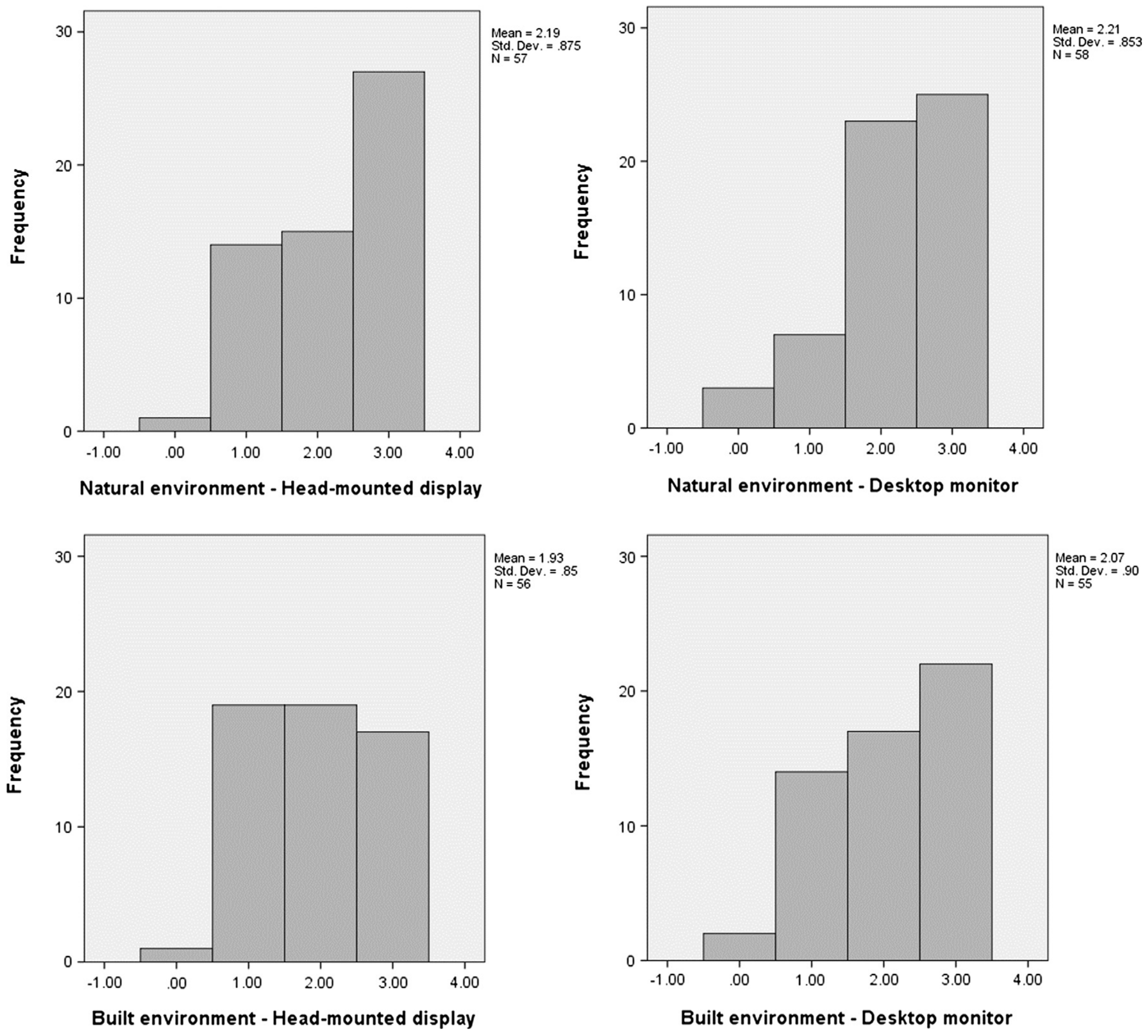

Figure 3. Frequency distribution of number of environmental behaviors chosen in each experimental condition.

video × display device interaction, $F(1, 222) = 0.04$, $p = .851$, $\eta^2_p = 0$, did not affect how pleasant the video was to watch. However, there was a significant main effect of the type of video, $F(1, 223) = 23.69$, $p < .001$, $d = 0.65$, $\eta^2_p = 0.10$, indicating that the nature video ($M = 4.70$, $SD = 0.59$) was more pleasant than the video depicting an urban environment ($M = 4.21$, $SD = 0.89$). This difference in video ratings was unexpected, given that the sample videos were rated as similarly fun and similarly pleasant in a pilot study with a sample drawn from the same population (Davydenko & Peetz, 2015).

Discussion

In this study, we examined the effects of watching videos of natural (vs. built) environments on nature attitudes and environmental behavior. By varying the type of technology used to present these videos (immersive head-mounted display vs. traditional desktop monitor), we sought to examine whether immersive technology can enhance effects of viewing nature videos on nature relatedness and on environmental behavior. The results of the study provided limited support for the hypotheses. Exposure to virtual nature increased the degree to which participants felt connected to nature compared with exposure to built environments. However, exposure to videos of nature (vs. built environments) did not meaningfully alter the propensity to make environmentally responsible choices. The type of technology used (and specifically, how immersive it is designed to be) did not influence the effect of watching these videos on either nature connectedness or environmental behaviors.

This research contributes to the body of work on nature relatedness and environmental behavior. Whereas the effects of exposure to real offline natural environments has been well established (e.g., Mayer et al., 2009; Nisbet & Zelenski, 2011; Schultz & Tabanico, 2007), the effects of exposure to virtual nature have been much less studied (Mayer et al., 2009; Zelenski et al., 2015) with mixed results. The present research provides further support that virtual nature may offer a promising avenue for bringing the benefits of nature closer to people living in urban environments who may have little opportunity to get frequent direct contact with nature.

The study is also the first to test whether exposure to virtual nature can increase actual pro-environmental behavior outside the virtual environment, as past research to date has only looked at effects on performance in a computer game (Zelenski et al., 2015). Watching the video depicting the natural environment did not meaningfully change the number of environmental choices that participants made, despite its effect on attitudes toward nature. This suggests a possible attitude–behavior gap whereby increased connectedness with nature following exposure to virtual nature may not always translate into more pro-environmental behaviors. It is also possible that effects of virtual nature on actual pro-environmental behavior may be smaller than previously assumed, and that a larger sample – than the sample in the present research – would be needed to detect such a small effect. A challenge for future research would be to identify conditions in which virtual nature can impact behavior (e.g., duration of exposure, type and familiarity of natural environment, etc.).

This study also contributes to research on immersive technology. We explored the effects of using immersive forms of technology such as head-mounted displays with headphones as opposed to more simple desktop screens with speakers. Contrary to expectations, the use of head-mounted display devices did not meaningfully alter the psychological effects of the videos on nature connectedness or pro-environmental behavior.

The study also contributes to emerging research on immersive technology and environmental behavior (Ahn, Bailenson, & Park, 2014; Bailey et al., 2014). This research tested the role of viewing an avatar performing nonsustainable behaviors – such as consuming coal to heat water or cutting down a tree – using a virtual reality head-mounted display on directly relevant behaviors (heating up water and using paper, respectively). In contrast to the findings of the present research, this past work demonstrated contexts where using virtual reality technology can have an impact on environmental behaviors. The discrepancy in findings may be attributed to a number of differences between the studies. First, the content of the videos in this past research depicted specific actions that harmed the environment such as cutting a tree, thus triggering embodied experiences of these actions. The content of the videos used in the present research depicted a natural environment, for which the underlying psychological mechanism – embodiment – is less applicable. Second, the behavior assessed in the previous research was closely tied to the content of the video (cutting a tree vs. using paper). Perhaps this direct link is necessary for virtual experiences to translate into meaningful real-world behavior. Third, the head-mounted displays used in these past studies enabled participants to interact with the virtual environment and to experience vibrations corresponding to actions happening in that environment. These additional features of the display device may have further enhanced immersion in the virtual experience, thus strengthening its effects. Of course, it is difficult to conclude which of these factors causally played a role in the differences in research findings. This line of work is still at its nascent stages, and more research is needed to establish the replicability of these past findings with larger sample sizes. Future research should also systematically vary the factors outlined here in an experimental setting to see if they moderate effects of immersive technology on environmental behavior.

The present research assessed actual choices that participants made when having options that vary in the degree to which they are pro-environmental (saving paper vs. using a hard copy; acquiring more knowledge about nature and sustainability vs. rejecting the resources offered). These behaviors were not directly linked to the content of the videos. Exploring an even wider array of environmental behaviors might uncover additional interactions in which virtual environments may have a greater bearing on behavior where the link with the natural world is more salient (e.g., resource conservation).

Nowadays, there is great variability in the types of technological devices designed to provide immersive viewing experiences, and the level of immersion resulting from these devices can vary considerably along a continuum. For instance, larger screens are designed to promote greater immersion relative to smaller computer monitors (De Kort et al., 2006). Head-mounted displays are among the devices designed to immerse viewers, but they can also vary considerably in terms of the features they offer (e.g., resolution, two-dimensional vs. three-dimensional viewing, ability to interact with the virtual environment). One possibility is that participants' experiences with the videos may have been impacted by their expectations of the head-mounted display used. Indeed, a few participants in the head-mounted display condition commented on having had greater expectations of the device relative to their actual experience. For example, they had the expectation that they would be able to manipulate the environment or see things in a true three-dimensional space when using the head-mounted display; in reality, the video was not three-dimensional and the device did not enable them to control aspects of the virtual environment. The gap between participants' expectations and their experience may have resulted in unanticipated consequences such as dissatisfaction with the environment that they have encountered, thus, counteracting any potential benefits of the device. Future research may consider assessing participants' expectations prior to the viewing experience. More broadly, the question of expectations of virtual reality devices warrants further investigation: If modern day users have greater expectations of a given technological device than what the device actually offers, how does that impact the user's experience and subsequent downstream psychological effects? It is also possible that using more advanced displays in which the viewer can control some aspects of the virtual environment would be more effective.

The findings also highlight the important distinction between the designer's intentions and the user's experience. Some technological devices are designed to provide an immersive viewing experience but the way in which different users experience the same device may vary considerably. It is possible that some people may experience virtual exposure to natural environments as fake and artificial regardless of the medium used to present it. Future research can examine potential moderators of the psychological effects of exposure to virtual environments, as people may vary in terms of their attitudes toward new technology and their responsiveness to it. For instance, some people may perceive technology to be a root cause in sustainability problems and in people's lack of connection with nature. Virtual nature is unlikely to be effective in this case.

Participants in the present research were all undergraduate students. It is possible that this sample was very familiar with technology, including head-mounted displays. Future research should examine whether benefits of virtual nature could be experienced to the same degree among individuals who may be less familiar with technology (e.g., older adults) and across a variety of research samples in order to assess the generalizability of these findings.

Conclusion

The development of immersive technology offers a world of opportunity for psychologists: both as a tool and as an area of investigation. Using immersive technology as a tool in research can increase realism in an experimental setting while maintaining experimental control; hence, such technologies can play a significant role in facilitating replication initiatives (Blascovich et al., 2002). The present study presented a preliminary step in this area of research showing that virtual environments changed attitudes such as nature relatedness. Furthermore, this study suggests that technologies intended to be more immersive may not provide an advantage over less advanced technology and did not, at least in this case, confer any additional impact to the effect of the virtual environment. Future technologies may, however, bridge the gap between exposures to actual versus virtual environments more completely.

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Electronic Supplementary Materials

The electronic supplementary material is available with the online version of the article at http://dx.doi.org/10.1027/1864-1105/a000213

ESM 1. Text (PDF).
Protocol of power analysis.
ESM 2. Figure, Text (PDF).
Study materials.
ESM 3. Table (PDF).
Zero-order correlations between nature attitudes, behavior, mood, and video properties.

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