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Restore or Get Restored: The Effect of Control on Stress Reduction and Restoration in Virtual Nature Settings

Gerhard Reese *, Elias Kohler and Claudia Menzel

Department of Social, Environmental, and Economic Psychology, Institute of Psychology, University of Koblenz-Landau, 76829 Landau, Germany; kohl2900@uni-landau.de (E.K.); menzel@uni-landau.de (C.M.)

* Correspondence: reese@uni-landau.de

Abstract: Virtual nature experiences can improve physiological and psychological well-being. Although there is ample research on the positive effects of nature, both in virtual and physical settings, we know little about potential moderators of restoration effects in virtual reality settings. According to theories of needs and control beliefs, it is plausible to assume that control over one's actions affects how people respond to nature experiences. In this virtual reality (VR) experiment, 64 participants either actively navigated through a VR landscape or they were navigated by the experimenter. We measured their perceived stress, mood, and vitality before and after the VR experience as well as the subjective restoration outcome and the perceived restorativeness of the landscape afterwards. Results revealed that participants' positive affective states increased after the VR experience, regardless of control. There was a main effect such that participants reported lower stress after the VR experience; however, this was qualified by an interaction showing that this result was only the case in the no control condition. These results unexpectedly suggest that active VR experiences may be more stressful than passive ones, opening pathways for future research on how handling of and navigating in VR can attenuate the effects of virtual nature.

Keywords: virtual reality; restoration; stress; nature experience; control; mood; affect

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1. Introduction

Nature experiences are beneficial for individuals. Not only do natural environments provide food, shelter, and symbolic or cultural meaning [1], they also come with various positive physiological and psychological benefits for individuals [2–6] and societies as a whole [7–9]. It is therefore not surprising that people seek regular opportunities to spend time in nature and natural environments (e.g., during the coronavirus pandemic [10]). However, this is not always possible. Time constraints due to long working days or immobility may hamper opportunities for physical nature experiences so that alternative means for psychological and physiological restoration are needed (cf. [11]).

It is useful to know that many of the psychological effects of nature on well-being could be elicited by virtual nature, such as videos, images, or virtual reality (VR; [2,12–15]). This suggests that visual (and in some cases auditory) input is sufficient to evoke such effects on well-being. Possibly the most elaborated method of presenting digital nature input is through immersive VR experiences. Previous studies suggest that VR nature experiences are useful to reduce pain [16], to increase restorativeness, vitality, mood, and relaxation ([11,17–19], or to reduce blood pressure and heart rate [20,21]. During cancer treatment, they can help to distract people, reduce patients' frustration, and increase relaxation and peacefulness [22]. Recent evidence suggests that a VR nature experience can be highly similar to a physical nature experience as it results in comparable restoration outcomes [18,19].

These effects notwithstanding, there is, to our knowledge, only very little research addressing moderators of such effects of VR nature experiences on health and well-being.

To understand the conditions under which virtual nature experiences are successful, however, it is necessary to provide guidelines for VR interventions. It would also contribute to further developing restoration theories because most approaches contrast nature and urban settings to assess nature's effects. However, this contrast is not always useful [23] or needed to investigate what influences nature's beneficial effects.

One potential moderator candidate is the extent to which people have control over their own actions and experiences. Previous research in the health domain suggests that active control in contrast to no control in a VR setting may reduce pain and stress ([24]), whereas other research could not find such evidence [16]. The primary goal of the current study is to shed light on this potential moderator. Using an experimental setup, we built on theoretical assumptions of self-determination theory (SDT) [25], stress recovery theory (SRT) [26,27], and attention restoration theory (ART) [28]. Specifically, we tested the hypothesis that control over one's actions moderates the effects of a VR nature experience on mental health outcomes.

1.1. Effects of Nature Experiences on Well-Being

Nature's effects on well-being have often been studied in comparison to similar urban experiences. The beneficial psychological effects of nature in such studies are most often discussed in the light of two major theories in the field, namely ART [28] and SRT [26,27]. ART claims that directed attention (a type of voluntary attention) depletes in urban environments and restores in nature [28]. This theory was tested frequently, and people performed better in working memory tasks, but not in other cognitive tasks, when they stayed in or viewed virtual nature (compared to urban environments; for meta-analyses see [29,30]). SRT claims that natural environments support recovery from stressors by raising positive affective states. Accordingly, many studies revealed accentuated positive affective responses and reduced stress in real and virtual natural environments compared to urban environments (e.g., [31–33]).

Although these findings are informative with regard to the power of nature, they do not reveal under which conditions nature experiences are more or less successful. There is, however, reason to assume that both situational and individual factors contribute to the effects of the environment on well-being [23]. There is some evidence suggesting that control over one's actions moderates such effects, which we review in the following.

1.2. Control and Well-Being

A sense of control over one's actions is important. Control, or autonomy, is one of the fundamental basic psychological needs, associated with various indicators of mental health and well-being [25]. According to SDT [34], the sense of autonomy is defined as a sense of volition and choice. It is "reflected in the experience of integrity, volition, and vitality that accompanies self-regulated action" ([25], p.28). In fact, previous research suggests that a lack of control over one's actions may be detrimental to health, as was suggested in the work by Langer and Rodin [35]. In their field studies in nursing homes, the authors showed that giving control to elderly residents increased their well-being: they were happier, more active, and more communicative (for an overview on related studies, see [36]). Other research reports, for example, identified relations between the loss of sense of control (e.g., through economic disruptions) and depression (cf. [37]). It is thus plausible to assume that control may affect the effectiveness of interventions on the human psyche. In the domain of mental health and restoration through nature, there is surprisingly little research on the effects of control or self- vs. other-guided effects. A study by Dahlquist and colleagues [24], for example, reported that children experienced less stress and indicated less pain when they could actively interact within a 360° video game (presented through a head-mounted display), compared to those who only watched footage of someone else playing this game. However, in a similar setup, Tanja-Dijkstra and colleagues [16] could not replicate this effect. In their study, participants either explored a computer-generated coastal scenery on their own or watched footage of this scenery without control over the walk. They found no difference between active and passive VR experiences on dental pain and pain memory, suggesting that the nature environment in itself reduced pain and pain recollection. They did not assess stress and other restoration outcomes, however. It is thus an open question whether the context of restoration is subject to individuals' control beliefs. Despite strong evidence for a beneficial effect of control for health and well-being, it is also reasonable to assume that people may find relief in dispensing control (e.g., in guided stress relaxation interventions) [38], which would counteract assumptions of SDT.

1.3. The Present Research

The goal of the present research was to test whether the well-being effects of a nature experience are subject to people's control over the experience. Whereas Tanja-Dijsktra and colleagues [16] used VR to test effects on pain and pain retrieval, we focused on well-being outcomes (i.e., affect, subjective stress, and restoration) in order to provide evidence for the need of psychological moderators within restoration theories. Tanja-Dijsktra and colleagues [16] asked participants in the no control condition to merely watch footage, whereas our study made having no control more salient. In our experiment, participants were explicitly told that someone else (i.e., the experimenter) would lead them through a coastal scene. Based on our theoretical reasoning above, we tested the following hypotheses.

Hypothesis 1. *People with active control over their nature experience report more positive and less negative affect than people with no control.*

Hypothesis 2. *People with active control report lower stress levels than people without control.*

Hypothesis 3. *People with active control (a) report higher restoration after the VR experience and (b) perceive the VR landscape as more restorative than participants without control.*

These differences between active and passive VR experience notwithstanding, we assumed that:

Hypothesis 4. *Across conditions, people would report more positive and less negative affect after the VR experience, as well as lower stress.*

Note that since the aim of the current study was to assess the role of control on beneficial effects evoked by virtual nature environments, we did not include a control environment. A vast amount of studies (including VR) have shown that natural environments, including coastal nature environments, evoke beneficial effects on well-being (e.g., [11,16,18]), and, therefore, we assumed that our coastal environment was appropriate to evoke such effects. In fact, the scenery with its beaches, pebbles, trees, and hills conformed to the criteria for exploration and relaxation exemplified by Ulrich [26]; see [39].

2. Material and Methods

2.1. Instruments

VR Environment

The VR experiment was conducted in the department's VR lab. This lab consists of a high-performance PC with a Zotac GeForce GTX 1080 graphics card (8 GB RAM) and an Intel i7-7700K main processor with 4 GHz and 16 GB RAM, running with Windows 10. The VR unit used was an OculusRift head-mounted-display with its two-hand controlling device and sensors. When mounted, participants could move within the room with a 2 m radius. The environment was selected from the commercial software Nature Trek VR by Greener Games [40], which provides a range of natural immersive environments. For this study, we selected a coastal nature environment (see Figure 1), as did previous studies (e.g., [16]).

Figure 1. Screenshot of virtual coastal environment Blue Ocean. © NatureTrek VR/Greener Games. Displayed with permission.

2.2. Measures

The following measures were used to test our hypotheses. Affect and stress were measured before and after the intervention. Restoration outcome and perceived restorativeness were only measured after the intervention.

To measure affect, we used the German version of the positive and negative affect schedule (PANAS) [41]; original version [42]. The scale consisted of 20 items, with ten items measuring positive affect and ten items measuring negative affect. Asking participants how strongly they experienced the respective affect, a 5-point-Likert-type scale measured responses from 1 (not at all) to 5 (totally). Both mean-scales were reliable before and after the nature experience ($\alpha_{t1\_positive} = 0.81$, $\alpha_{t2\_positive} = 0.90$, $\alpha_{t1\_negative} = 0.82$, $\alpha_{t2\_negative} = 0.78$).

We measured stress using the standard stress scale (SSS) [43] both before and after the VR experience. This scale measures perceptions and experiences of everyday hassles and concerns about the future. A 5-point-Likert-type scale from 1 (I fully disagree) to 5 (I fully agree) was used and the mean-scale was sufficiently reliable before ($\alpha = 0.72$) and after ($\alpha = 0.73$) the intervention.

We used the restoration outcome scale (ROS) to measure restoration as the subjectively experienced reduction of stress [44]. A 5-point-Likert-type scale from 1 (I fully disagree) to 5 (I fully agree) was used and the mean-scale was reliable ($\alpha = 0.87$).

Perceived restorativeness of the coastal environment, based on assumptions of ART (Kaplan & Kaplan, 1989), was measured with the PRS-11 scale [45]. It is assessed with 11 items on a 5-point-Likert-type scale from 1 (I fully disagree) to 5 (I fully agree) and the mean-scale was reliable ($\alpha = 0.81$).

Additionally, we measured motion sickness by asking participants whether they felt unease, nausea, or dizziness (yes vs. no). At the end of the questionnaire, demographic data were collected (for an overview, see Table 1).

Table 1. Demographic data of the total sample and within each of the experimental conditions.

		Experimental Condition	
Demographic Data	**Full Sample**	**Active Control**	**No Control**
Sample size	$n = 64$	$n = 32$	$n = 32$
Male	$n = 17$	$n = 8$	$n = 9$
Female	$n = 47$	$n = 24$	$n = 23$
Age	$M = 23$, $SD = 3.87$	$M = 23.31$, $SD = 4.7$	$M = 22.7$, $SD = 2.85$
Education			
College degree	$n = 56$	$n = 29$	$n = 27$
University degree	$n = 8$	$n = 3$	$n = 5$
Study major			
Psychology	$n = 36$	$n = 19$	$n = 17$
Education	$n = 14$	$n = 5$	$n = 9$
Human environment studies	$n = 7$	$n = 3$	$n = 4$
Other	$n = 5$	$n = 3$	$n = 2$
NA	$n = 2$	$n = 2$	$n = 0$
Motion sickness	Yes = 14 No = 50	Yes = 7 No = 25	Yes = 7 No = 25

2.3. Participants

Sixty-four participants were recruited via messenger services and social network sites as well as on-campus at the research facility. As can be seen in Table 1, participants were 23 years old on average, the majority were female, and all participants were well-educated. Importantly, there was no relevant demographic difference between the two experimental conditions to which participants were assigned randomly. There were also no differences between both conditions with regard to expressed motion sickness. Participants were randomly assigned to one of the two conditions: participants in the active control condition could actively navigate through the VR environment, whereas participants in the no control condition were navigated through the VR environment by the experimenter.

2.4. Procedure

At the beginning of the experiment, participants met the experimenter in the VR lab on campus and were seated in front of a computer screen. After being briefed about the VR study and signing an informed consent form, participants received additional oral information that they could stop and exit the VR environment at any time. Next, participants filled in the first part of the questionnaire (time 1), including the measures of positive and negative affect and stress. Subsequently, we introduced participants to the VR setting. Participants in the active control condition received instructions about how to use the controller and how to navigate through the scenery. The experimenter set up the VR display together with the participants to ensure comfort and sharpness of the application. After a 30-s familiarization, participants freely navigated through the scenery for about five minutes. Participants in the no control condition received the VR headset without the controlling device and were told that the experimenter would lead them through the scenery. The path was the same for all no control participants, but they could move their heads freely to look around. As in the active control condition, participants were first familiarized with the setup for 30 s. Then, the experimenter led them through the scenery.

After completion of the VR experience, participants filled in the second set of questionnaires (time 2): the second measure of positive and negative affect and stress, as well as measures on restoration outcome and perceived restorativeness of the scenery. They were then thanked, debriefed, and granted course credit if applicable. Additionally, we gave participants in the no control condition the opportunity to experience an active control trial after the study, to suppress potential disappointment. All subjects gave their informed consent for inclusion before they participated in the study. This study was conducted in accordance with the local as well as with the national codes of ethics.

3. Results

Means and standard deviations of all study variables are displayed in Table 2. Of the 64 participants, 14 reported motion sickness (seven each in the active control and in the no control condition; see Table 1). The results reported in the following were computed with the complete sample. The pattern of results without those participants indicating motion sickness were similar and can be studied in the Supplementary Materials (A). The data are publicly available at https://osf.io/h4q29/?view_only=fa81ffb4484c460e94216edf2f34106b (accessed on 9 February 2021).

Table 2. Descriptive statistics of the outcome variables. (n = 64).

Measure	Experimental Condition: Active Control		No Control	
	M	*SD*	*M*	*SD*
Positive affect t1	3.11	0.45	3.24	0.64
Positive affect t2	3.44	0.67	3.65	0.74
Negative affect t1	1.31	0.36	1.37	0.42
Negative affect t2	1.17	0.30	1.21	0.27
Stress t1	2.55	0.54	2.68	0.41
Stress t2	2.49	0.59	2.49	0.38
Restoration outcome	3.74	0.76	3.72	0.95
Perceived restorativeness	4.59	0.80	4.44	0.80

3.1. Positive and Negative Affect

We submitted the positive and negative PANAS scores into 2 (control: yes vs. no) × 2 (time: before vs. after) ANOVAs with repeated measures on the second factor. Results revealed that positive affect was significantly higher after the VR experience, $F(1, 62) = 29.45$, $p < 0.001$, $\eta_p^2 = 0.32$, and negative affect was lower, $F(1, 62) = 20.83$, $p < 0.001$, $\eta_p^2 = 0.25$ (Table 1; Figure 2a,b). There was neither a main effect of control, $F(1, 62) = 1.37$, $p = 0.24$, $\eta_p^2 = 0.005$, nor an interaction for positive emotions, $F < 1$. There was also neither a main effect nor an interaction for negative emotions, both Fs < 1. A MANOVA with difference scores between t1 and t2 indicated the same conclusion and can be inspected in Supplementary Materials (B).

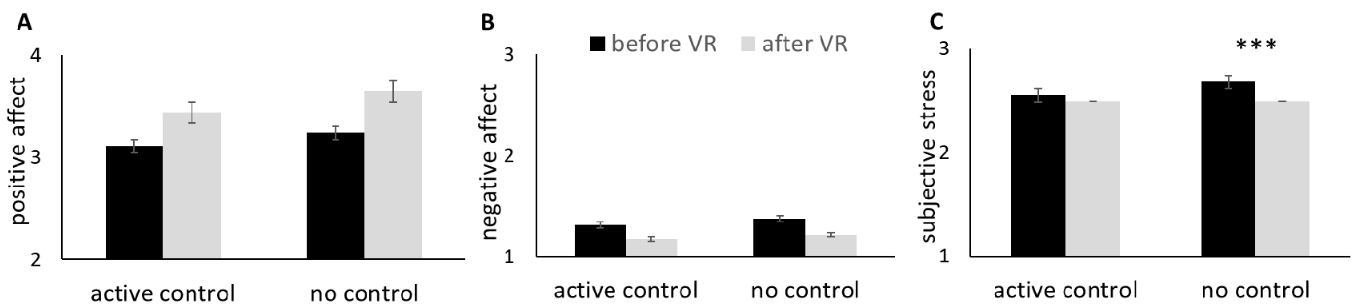

Figure 2. (**a**–**c**) Positive affect, negative affect, and subjective stress before and after the VR manipulation (active control vs. no control). Error bars represent standard error. *** $p < 0.001$.

3.2. Subjective Stress

We submitted the SSS score into a 2 (control: yes vs. no) × 2 (time: before vs. after) ANOVA with repeated measures on the second factor. Results revealed that subjective stress was significantly lower after the VR experience, $F(1, 62) = 19.96$, $p < 0.001$, $\eta_p^2 = 0.24$. There was no main effect of the control, $F < 1$, but the effect of measurement time was qualified by a significant interaction, $F(1, 62) = 6.63$, $p = 0.012$, $\eta_p^2 = 0.10$, suggesting that only among participants in the no control condition was stress reduced significantly from t1 to t2 ($M_{diffs} = 0.19$, $SE = 0.038$, $p < 0.001$; Figure 2C). In the active control condition, there was no significant change (M_{diff} = 0.05, *SE* = 0.038, *p* = 0.19). A MANOVA with difference scores between t1 and t2 indicated the same conclusion and can be inspected in Supplementary Materials (B).

3.3. Restoration and Perceived Restorativeness

To test the difference between an active and no control VR intervention with regard to restoration and perceived restorativeness, we submitted the ROS scale and the perceived restorativeness scale each to a *t*-test for independent variables. There were no significant differences—neither for the ROS, $t < 1$, nor for perceived restorativeness, $t < 1$; but mean values were generally relatively high (i.e., significantly above the scale midpoint 3: $M_{\text{ROS}} = 3.73$, $t[63] = 6.87$, $p < 0.001$; $M_{\text{perceived\_restorativeness}} = 4.52$, $t[63] = 15.22$, $p < 0.001$) and similar compared to a previous study (i.e., [11], who reported a mean of $M = 5.22$ (SD = 0.97) for an ROS on a 7-point Likert scale). Given the non-significant differences between both conditions, we refrained from alpha-error correction.

4. Discussion

The current study suggests that, regardless of whether they have control over their experience or not, people feel more positive and less negative after a virtual coastal walk and report relatively high levels of restoration (see also [11], for similar findings with a VR forest walk; [18]), corroborating hypothesis 4. Thus, a short VR nature experience seems to increase well-being. Besides conceptually replicating previous research, we showed that there was an interaction with regard to perceived stress, suggesting that in the no control condition, people felt they experienced less daily stress. This finding in particular is noteworthy, as we argued that control over one's actions, satisfying one of the basic psychological needs, should result in stronger well-being. However, we observed evidence for the opposite. As such, hypotheses 1, 2, and 3 could not be verified, and, in the following, we provide suggestions for why this may have been the case.

Drawing from SDT [25], one could argue that control over one's own (nature experience) actions increases well-being. Although we, as well as others [16], did not find evidence for this assumption, it becomes clear that a feeling of control may not be key to restoration. On the contrary, many people may find it particularly relaxing to dispense control so that there was no difference in terms of restoration between those who acted and those who did not. For example, research on guided relaxation (i.e., a physical or psychological relaxation process guided by a trained practitioner) suggests that people feel particularly calm and restored after a guided relaxation intervention in which they were led through a relaxation process (e.g., [38]). With regard to SDT, restoration research may indeed be an interesting context in which the theory's predictions may not hold. At least with regard to having control over one's actions, we provide evidence that, sometimes, we may actively seek situations in which we dispense of control. Although our participants had no control over the particular experience in the VR environment, they had control in attending the experiment, including the option to end the experiment at any time. They likely had trust in the experiment(er) as they signed an informed consent. This control of oneself entering into an assessable situation in which one has no control over one particular aspect may be more relevant in restoration contexts and may be investigated further in respective (and ethical) study designs.

Motion sickness, as can be seen in the Supplementary Materials, does not seem relevant here. However, investigating the influence of motion sickness on VR nature experiences should be studied systematically in the future to rule out potential negative influences [46].

There are some limitations that may affect the generalizability of our study. The first is that we chose one particular natural setting—a coastal scenery. Although this is not uncommon in research addressing well-being effects of nature, a comparison of different natural scenes may be useful to further address which nature works best in virtual settings. A second issue that future research could improve is to test the perseverance of the well-being effects. Korpela and colleagues [44] stated that the length of stay as well as repeated visits to one's favorite places may further increase positive restorative outcomes. In VR settings, it is, to our knowledge, yet unexplored whether duration (e.g., five minutes vs. thirty minutes) or frequency (e.g., one versus multiple virtual nature walks) affect well-being outcomes. Third, we did not measure previous experience in VR settings. It is likely that previous experience affects restoration outcomes because people who are already used to VR environments (and joypad controls) may concentrate more on the immersive qualities of the experience, rather than on navigating through the environment [47]. Finally, we did not measure participants' sense of control during the intervention. Possibly, many people enjoyed the situation of just watching VR, whereas others might have felt powerless. A measure of situative control, based on Deci and Ryan's assumptions in SDT [25], could be helpful to assess these feelings in future studies.

5. Conclusions

A short VR experience increased positive and reduced negative affect among our participants, regardless of whether they actively navigated through the VR or were navigated by another person. The latter condition, however, led to lower subjective stress than the former. We believe that the current study provides an early stage of practical applicability. In situations that prevent people from going outdoors, establishing a VR environment may enrich breaks or simply improve quality of life. This could be useful for people working in city centers or office blocks, and it could be vital for those who cannot access nature because of health constraints. Those affected most by immobility, being unable to navigate themselves through nature, may benefit most, as suggested by our finding that having no control reduces stress. Having a colleague or service worker navigating a person through a nature VR environment may reduce perceived daily stress and thereby likely benefit other health outcomes, such as reduced negativity or even heart rate. Additionally, with regard to the coronavirus pandemic and strict regulations of mobility, it may be useful to seek alternative means of psychological relief to better cope with the consequences of societal lockdown.

Supplementary Materials: Supplementa materials are available online at https://www.mdpi.com/2071-1050/13/4/1995/s1, and include alternative statistical analysis as described above.

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Informed Consent Statement: All subjects gave their informed consent for inclusion before they participated in the study.

Data Availability Statement: The data of the experiment are available on the Open Science Framework (OSF): https://osf.io/h4q29/?view_only=fa81ffb4484c460e94216edf2f34106b (accessed on 9 February 2021).

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

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