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Contact with nature through virtual reality and video: An effective solution for improving self-esteem in adults

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It is widely acknowledged that exposure to natural environments offers emotional, cognitive, and behavioural benefits. However, some individuals may face difficulties in accessing these areas frequently and conveniently due to urbanisation, disability, or a lack of time. As a result, research has explored the advantages of nature substitutes, such as photographs, videos, or virtual reality (VR), and has demonstrated their ability to provide psychological benefits. Therefore, our study aims to examine the impact of these substitutes on enhancing individuals' self-esteem.

The study involved 236 participants, who were divided into six experimental groups based on the type of exposure (photographs, video, or virtual reality) and the environment (natural or urban). A control group was also exposed to geometric shapes. The participants completed the French version of the Rosenberg Self-Esteem Scale three times: upon arrival at the experimental room (baseline), after the rumination induction task (post-induction), and after exposure (post-exposure). The analysis focused on changes in self-esteem scores during the experimental study, considering the type of exposure and its content.

The results suggest that exposure to nature, in any form, enhances self-esteem more than exposure to urban environments or geometric shapes. Additionally, it was found that virtual reality or video exposure to nature produced greater benefits than natural photographs.

In the future, alternative tools may serve as valuable support for individuals who are unable to experience direct contact with nature. However, it is important to recognise that they should be considered as supplementary options rather than exclusive substitutes.

Keywords: restorative effect, nature, self-esteem, video, virtual reality.

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Introduction

The restorative effect of nature and theoretical foundations

Nature contact has been linked to a restorative impact on individuals' psychophysiological stress and cognitive abilities (Markevych et al., 2017). According to Stress Reduction Theory (SRT) (Ulrich, 1993; Ulrich et al., 1991) and Attention Restoration Theory (ART) (Kaplan & Kaplan, 1989; Kaplan, 1995), natural spaces facilitate the renewal of psychological resources depleted by daily activities (Hartig, 2004).

According to the psycho-evolutionary theory of SRT, humans have historically relied on nature to meet basic needs such as food, water, and shelter (Kellert, 2018). Consequently, individuals may have developed a biological connection with these environments, which are perceived as conducive to survival and fulfillment (Subiza-Pérez et al., 2018). If the environment is considered safe, contact with nature can lead to a reduction in psychophysiological stress and an improvement in emotional state. In urban environments, the promptness with which these benefits become apparent is advantageous because interactions with nature are often brief and infrequent (Hartig, 2004).

The ART is based on the work of William James (1892), who posits that individuals are constantly exposed to a continuous flow of information. However, only a small fraction of this information is necessary for individuals to function properly. Therefore, individuals must select and

favour certain information while eliminating irrelevant information. According to James (1892), directed attention is responsible for selecting a specific stimulus while inhibiting distractors. This directed attention is considered an essential element in information processing (Kaplan, 1995). However, the resources of this system are not unlimited, and an overload can lead to exhaustion (James, 1892). This is especially true in urban environments, which are information-rich and likely to induce mental fatigue (Herzog et al., 1997). In contrast, natural environments are considered restorative because they offer many sources of fascination that capture involuntary attention, allowing the directed attention system to rest (Herzog et al., 1997). Therefore, natural environments are a beneficial solution for enhancing cognitive function and well-being. This is due to their ability to provide four essential restorative characteristics: capturing involuntary attention with fascinating elements, being physically and conceptually distinct from everyday life (being away), providing a coherent and rich experience of being in a different world, and aligning with individual objectives and needs (Kaplan, 1995).

Self-esteem and the restorative effect of nature

Self-esteem refers to an individual's sense of self. It refers to a person's perception of themselves in terms of their values, qualities, and importance as a human being. Self-esteem therefore refers to a person's attitude towards themselves (Rosenberg, 1965). Self-esteem plays a crucial role in the daily lives of individuals, influencing their interactions with the environment and people they encounter (Zeigler-Hill, 2011). Furthermore, Zeigler-Hill (2011) highlights its significant contribution to the development and persistence of psychopathological disorders. According to the vulnerability model, individuals with low self-esteem lack the resources to effectively adapt and cope with the challenges of everyday life.

Self-esteem is therefore a key concept in both short and long-term mental health (Barton & Pretty, 2010). For this reason, it seems particularly interesting to work on tools that can improve people's self-esteem. In this sense, contact with nature could be an appropriate solution. Barton and Pretty (2010) explain that it is recommended that self-esteem be employed as a standard measure for evaluating the impact of exposures to nature-based interventions. None of the aforementioned theories explicitly addresses the direct impact of exposure to nature on self-esteem. Nevertheless, it seems reasonable to suggest that the emotional and cognitive benefits described in the ART and SRT can be applied to the concept of self-esteem.

It has been demonstrated that fluctuations in self-esteem are closely associated with emotional states (Brown & Marshall, 2001), anxiety (Manna et al., 2016; Sowislo & Orth, 2013) and rumination (Watkins, 2008). For example, positive emotions, such as joy or pride, have been demonstrated to enhance self-esteem. Conversely, negative emotions, such as sadness, shame, or guilt, have the potential to diminish self-esteem by engendering a negative perception of oneself and one's capabilities. Anxiety can also have a detrimental impact on self-esteem by instilling doubts about one's abilities and capacity to effectively navigate challenging circumstances. Furthermore, these disagreeable emotions and anxiety can be sustained, or even intensified, by the presence of ruminations, thus contributing to a decline in self-esteem. Consequently, it has been demonstrated that self-esteem fluctuates over time in accordance with intrinsic factors (emotions, ruminations, or anxiety) and environmental context (Cazenave & Michel, 2008).

It is noteworthy that the self-esteem of the participants in this study should fluctuate over the course of the experiment and the tasks requested. It can be reasonably assumed that the induction of rumination will affect self-esteem. This is because participants will have to think for approximately ten minutes about an unresolved problem, which will generate unpleasant emotions (such as sadness, guilt, or shame), unpleasant feelings (such as powerlessness, injustice, or regret) or anxiety. This will contribute to a decrease in participants' self-esteem. Conversely, exposure to a natural environment has the potential to restore people's self-esteem for three reasons. Firstly, the SRT has demonstrated that contact with natural elements can have indirect benefits on self-esteem by reducing psychophysiological stress and improving people's emotional state. Secondly, the ART demonstrates that contact with nature is associated with a restoration of cognitive resources. This restorative process occurs in four successive stages, contingent upon the quality and duration of exposure (Herzog et al., 1997; Kaplan & Kaplan, 1989). Initially, the subject eliminates the multitude of thoughts and cognitive disturbances accumulated from previous tasks. This will be followed by a period of rest of directed attention, which is vital for the subject's ability to function properly at a later stage. The subject will then be able to address any unresolved concerns. Ultimately, if the exposure is sustained, individuals may engage in reflection regarding their values, aspirations, and long-term objectives. Thus, in the context of an unresolved problem, exposure to nature could improve self-esteem by encouraging reflection and problem-solving abilities. Furthermore, researches has demonstrated that walking in a natural setting can diminish ruminations (Bratman et al., 2015a; 2015b). These observations are particularly noteworthy in light of the causal role of rumination in variations in self-esteem and in the emergence or maintenance of various disorders (Harvey et al., 2004).

In this context, a meta-analysis of 10 British studies showed that exercise in nature had a positive effect on mood and self-esteem. In general, exposure to nature through exercise improves mood and self-esteem regardless of location, duration, intensity, gender, age, or health status (Bar-ton & Pretty, 2010). For example, Pretty et al. (2007) showed that green exercise (walking, cycling, horse riding, fishing, etc.) increased people's self-esteem. Two years later, Barton et al. (2009) also showed that walking in natural heritage areas in England improved participants' self-esteem. In this study, contact with nature seemed to be particularly powerful, as the subjects had high self-esteem to begin with.

Restorative effect of nature and substitutes (photographs; video; VR)

Nevertheless, a considerable proportion of the population is unable to engage with the natural environment due to temporal, spatial and locational limitations, or a lack of mobility. In order to address this situation, studies have examined the benefits of nature through the use of substitutes, including photography, video and VR. For example, Brown et al. (2013) demonstrated that exposure to images of nature enhanced recovery from stressful experiences. More recently, Zabini et al. (2020) found that watching forest videos for five minutes reduced short-term anxiety. Finally, Chan et al. (2021) also showed that five minutes' exposure to nature in VR improved participants'

emotional state by reducing negative affect and perceived stress, while promoting a sense of relaxation. In the context of self-esteem, Pretty et al. (2005) showed that walking on a treadmill while viewing images of nature also improved self-esteem. With this exposure to nature, the increase in self-esteem was greater than walking alone or in the presence of urban images. The benefits of nature can thus be experienced through a variety of immersive formats, including photography, video, and VR. Although these substitutes do not appear to be as effective as direct exposure (Browning et al., 2020), they offer a practical alternative for those who cannot directly access natural spaces, particularly urban dwellers (Cox et al., 2018). Furthermore, these substitutes can be highly beneficial in a variety of settings, including the workplace, during health crises, hospitalisations, and incarcerations (Browning et al., 2020; Spano et al., 2023).

This study

The objective of this study is to identify the most effective substitute for boosting self-esteem, independently of green exercise. This study was conducted with the objective of addressing several gaps in the existing literature, particularly the notable absence of research examining the impact of nature on self-esteem, which is a crucial aspect of psychological well-being. Furthermore, the existing studies that have explored the effects of nature on self-esteem have primarily focused on in vivo exposures combined with physical activity (Barton & Pretty, 2010). The objective is to conduct research based on the utilization of substitutes in order to develop instruments based on exposure to nature, which are capable of assisting individuals with motor difficulties or those who are unable to access natural environments directly.

Specifically, the study aims to compare the benefits of exposure to nature through photographs, video and VR with experimental conditions that gradually approximate reality. Participants will therefore be exposed to the environments through one of these formats, each of which calls on a variable number of sensory modalities and has different immersive characteristics. It's important to recognize that these formats involve an increasing number of sensory modalities. While photographs are limited to visual perception, video and VR involve both the visual and auditory senses. Real perception, however, results from the integration of multiple sensory modalities, where vision is not the only important aspect; hearing, smell and touch also play an important role (Van Hedger et al., 2019). Jahncke et al. (2015) found that incorporating natural sounds into a visual nature experience enhanced its restorative effect. Research also suggests that immersion and engagement are more pronounced in VR than in video or photography. The format of this technology creates a sense of reality from an egocentric perspective and allows for interaction with the environment (Slater & Wilbur, 1997). Unlike viewing on a computer screen, it can be difficult to identify spatial and temporal discontinuities in the exposure. Overall, it is clear that these features enhance the sense of presence in the environment, making VR the format that most closely resembles a real exposure (Li et al., 2023; Spano et al., 2023).

Hypothesis

The theoretical framework presented above suggests that the emotional, cognitive, and behavioral benefits observed when interacting with nature could be generalized to self-esteem. In consideration of the aforementioned evidence, two hypotheses have been formulated:

H1. Exposure to a natural environment will improve people's self-esteem, regardless of the presentation format, compared to the control group.

H2. The natural experience will be more beneficial in VR than video, which in turn would be more advantageous than simple photography.

Method

This research has been authorised by the Research Ethics Committee of the University of Lille.

Participants

A total of 236 participants took part in the study, comprising 128 women, 104 men, and four individuals of a different gender. The average age was approximately 24 years and 9 months, with a standard deviation of around 4 years and 8 months. The participants were randomly assigned to one of six experimental groups based on exposure format (photographs; video; VR) and environment type (natural; urban). A control group was also included, which exposed participants to geometric shapes. Table 1 presents a summary of participant information.

Participation in the study was voluntary and anonymous. Participants had to be of legal age and not suffer from depression.

Table 1. *Description of study participants as a function of group (format * type of environment, control group).*

			Photographs	Video	VR	Control group (geometric shapes)
Natural environment	**Gender**	**Woman (%)** **Man (%)** **Other (%)**	19 (55.88 %) 15 (44.12 %) 0 (0.00 %)	18 (52.94 %) 14 (41.18 %) 2 (5.88 %)	18 (54.55 %) 15 (45.45 %) 0 (0.00 %)	19 (54.28 %) 15 (42.86 %) 1 (2.86 %)
	Age	**Mean (SD)**	23.41 (4.74)	25.12 (4.49)	24.82 (2.97)	24.80 (4.32)
	Connexion with nature	**Score (SD)**	39.06 (8.66)	39.24 (9.99)	40.09 (8.68)	36.54 (11.72)

			Photographs	Video	VR	Control group (geometric shapes)
Urban environment	**Gender**	**Woman (%)** **Man (%)** **Other (%)**	18 (52.94 %) 15 (44.12 %) 1 (2.94 %)	18 (54.55 %) 15 (45.45 %) 0 (0.00 %)	18 (54.55 %) 15 (45.45 %) 0 (0.00 %)	
	Age	**Mean (SD)**	24.27 (4.31)	25.30 (6.16)	25.42 (4.98)	
	Connexion with nature	**Score (SD)**	38.24 (8.13)	37.91 (9.77)	37.24 (9.27)	

Material

The 'Inquisit Player 6' software was used on a 14-inch laptop to collect participants' responses.

The experimental groups were exposed to either a natural environment (a wooded path between a forest and a stream) or an urban environment (a busy street with an abundance of urban buildings, people, bicycles, cars, signs, and traffic lights) in one of the three mentioned formats. Figure 1 provides a revealing photograph of each environment. The exposure time was set at five minutes, regardless of the format. To create the 'photographs' and 'video' conditions, the researcher walked in both environments with a GOPRO HERO10 BLACK camera attached to the right shoulder. An INSTA360 ONE X2 camera was mounted on a tripod at a height of approximately 140 cm for the VR condition.

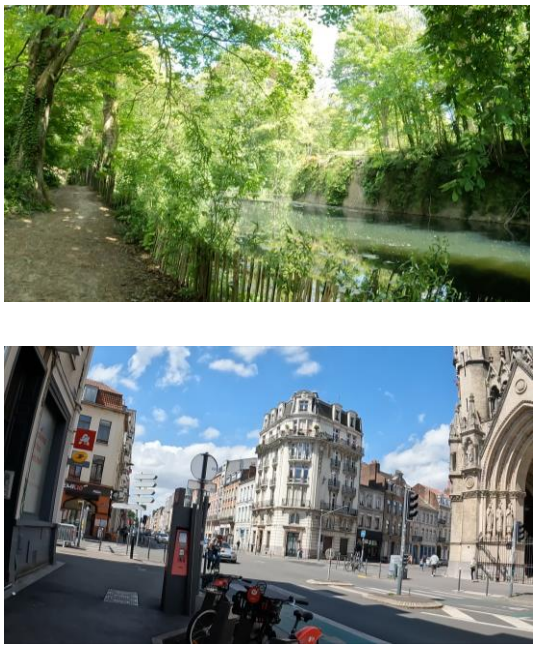

Figure 1. Descriptive photograph of the natural (first) or urban (second) environment.

The videos presented a 5-minute walk in either a natural or urban environment. The 'photograph' condition comprised a series of images extracted from the aforementioned video. Screenshots were captured at 12-second intervals from the video to create a slideshow. The participants were exposed to 25 photographs, each lasting 12 seconds, that retraced the walk. They were displayed in a 29 x 16.5 cm format and centered on the screen.

For VR, participants were exposed to the environments through an Oculus Quest 2 headset. The exposure consisted of ten 30-second videos stitched together to simulate a walk. Due to medical reasons, the videos were recorded from a fixed point and participants were seated during the exposure (Davis et al., 2014; Li et al., 2023).

In the control group, participants spent five minutes observing geometric shapes taken from research conducted by Berto (2005). The shapes were selected by four psychologists for their ease of visualization and were neither perceived as restorative nor as requiring attentional resources. The 25 geometric patterns were presented individually for a period of 12 seconds each. They were displayed in front of the participants in a 22.5 x 17 cm format, centered on the screen.

The Repetitive Negative Thinking (RNT) induction task

This task asked the participant to think about a specific problem in order to make it active. Specifically, participants were asked to focus for about ten minutes on a current unresolved problem. This problem had to cause distress, evoke unpleasant emotions, and have recurred frequently in the week prior to the test. In light of the difficulty of this exercise, participants are provided with a list of examples to assist them in identifying a current issue they may be facing. To illustrate, one example might be "a difficulty concerning an important objective that you have been unable to achieve". Once the problem had been identified, participants were asked to think about and mentally describe it for two minutes, and then to answer a series of six questions designed to assess the problem. Following this questionnaire, participants were given five instructions, each lasting one minute. These instructions focused on mentally describing the concerns raised by the problem, how it interfered with the achievement of personal goals, and how it related to other problems in the participant's life.

Measures

Measurement of self-esteem using the French version (Vallieres & Vallerand, 1990) of the Rosenberg Self-Esteem Scale (Rosenberg, 1965). This questionnaire measures the extent to which a person generally considers him/herself to be a good person with values and qualities. In other words, this questionnaire assesses the subject's attitude towards himself or herself. It consists of 10 items and respondents answer on a four-point Likert scale. Participants were instructed to respond in the present moment. The

questionnaire's scores range from 10 to 40. For example, participants were requested to respond to the following items: "I believe that I possess a number of commendable personal attributes" or "I maintain a positive self-image". This scale has been frequently used in research to evaluate the influence of nature on self-esteem (Barton et al., 2009; Barton & Pretty, 2010; Pretty et al., 2007; Pretty et al., 2005). This French version of the tool is a brief and easy-to-administer version that has been shown to have similar psychometric qualities to the original version developed by Rosenberg (1965). In fact, Vallieres and Vallerand (1990) demonstrated that this questionnaire is based on very interesting psychometric qualities: good internal consistency (Cronbach's alpha of .70); a very acceptable unidimensional structure; a good construct validity reflecting a negative correlation with depressive symptoms and a positive correlation with life satisfaction; a good fidelity tested with a test/re-test procedure. Additionally, the questionnaire translation followed the recommended methodological process for transcultural validation of psychological questionnaires (Vallerand, 1989). As part of the study, the internal consistency of the questionnaire was evaluated at all three measurement times. The respective Cronbach's alpha coefficients were .89 (pre-induction), .92 (post-induction) and .91 (post-exposure).

Measurement of connectedness to nature via the French adaptation (Navarro et al., 2017) of the 'connectedness to nature scale' (CNS) questionnaire (Mayer & Frantz, 2004). The purpose of this control measure is to assess any variations in subjects' assessments of and links with the natural world. This questionnaire consists of 11 questions on the individual's usual relationship with natural environments and other living beings. Participants were requested to indicate their level of agreement with each statement by using a 5-point Likert scale. For example, participants were requested to respond to the following items: "I am aware of and grateful for the intellectual capacity of other living beings" or "I am fully cognizant of the impact my actions have on the natural world". During the process of validation in the French language, Navarro et al. (2017) demonstrated that this questionnaire is a reliable and valid measure of connection to nature, showing good internal consistency (Cronbach's alpha of .80), a good convergent and discriminant validity, as well as good test-retest reliability. In this study, the Cronbach alpha coefficient was found to be 0.89.

Study Design and Procedure

Participants were alone in an experimental room with no windows, seated in front of a table containing a 14-inch computer. On arrival, participants were asked to complete a sociodemographic questionnaire. They then completed a baseline questionnaire on self-esteem. Participants then completed the RNT induction task for ten minutes. After this phase, they were again asked to respond to a measure of self-esteem (the post-induction measures). Participants were then exposed to specific content, depending on their exposure group and the type of environment. For example, one group watched a video depicting a walk in the city for five minutes (group: video * urban), while another group watched photographs of a walk in nature for the same amount of time (group: photographs * nature). Finally, participants were again asked to complete a measure of self-esteem (post-exposure measures). Finally, participants were also asked to respond to the control measure regarding their connection to nature. The study's maximum duration may be extended to one hour, depending on participant response time.

Data analyses

JASP software (version 0.16.3) is used for the analysis. Initial ANOVAs are conducted to ensure group equivalence in terms of age, sex, connection to nature, and baseline of self-esteem. Then, the analysis will focus on three variables: exposure medium (photographs, video, or VR), content (natural environment, urban environment, or geometric shapes), and time (pre-induction, post-induction, or post-exposure). Subsequent ANOVAs are conducted to investigate the impact of content on self-esteem, followed by an assessment of the influence of the exposure medium. Considering the number of groups and variables, it is preferable to conduct ANOVA analyses to evaluate main and interaction effects. Post-hoc contrast analyses were conducted to evaluate the evolution of self-esteem, with consideration given to the characteristics of the exposure and the timing of measurement during the experiment. The selection of this methodology was driven by the necessity to accommodate the considerable number of contrast analyses that were conducted. The aim of these analyses is to examine the changes in self-esteem associated with the medium and content of exposure.

Results

Description of the study population

The study participants were randomly assigned to either the control group or one of the six experimental groups based on exposure context and environment type. The seven groups were found to be equivalent in terms of age ($F(6,229) = .76$, $p = .60$), connection to nature ($F(6,229) = .56$, $p = .76$) and for baseline measure of self-esteem ($F(6,229) = .38$, $p = .89$). Additionally, the problems chosen during the PRN induction task had a similar impact within each group of subjects ($F(6,229) = .64$, $p = .70$).

Table 2. *Mixed ANOVA which considered 'group' (six experimental groups and one control group) and 'moment' (pre-induction, post-induction, and post-exposure) for self-esteem*

	Sum of Square	Df	Mean Square	F	P
Time	414.50	2	207.23	36.79	< .001***
Time * Group	198.60	12	16.55	2.94	< .001***
Residual	2579.60	458	5.63		

Note. * p < .05, ** p < .01, *** p < .001.

Study of the dependent variable: self-esteem

The mixed ANOVA, which considered 'group' (six experimental groups and one control group) and 'time' (pre-induction, post-induction, and post-exposure), revealed a main effect of time ($F(2,458) = 36.79$, $p < .001$) and an interaction effect between the two variables studied ($F(12,458) = 2.94$, $p < .001$) (Table 2.). Nevertheless, this ANOVA did not reveal a main effect of the group ($F(6,229) = .51$, $p = .80$). Table 3 presents the self-esteem questionnaire scores for each of the seven groups at each measurement time point.

Table 3. *Self-esteem score (standard deviations) over time (pre-induction, post-induction, post-exposure) by the group (six experimental groups and one control group).*

Group	pre-induction	post-induction	post-exposure
	Mean (SD)	Mean (SD)	Mean (SD)
Natural environment * VR	30.91 (1.02)	28.46 (1.17)	31.55 (1.09)
Natural environment * Video	29.50 (1.01)	28.00 (1.15)	30.82 (1.07)
Natural environment * Photographs	31.79 (1.01)	29.47 (1.15)	31.32 (1.07)
Urban environment * VR	30.67 (1.02)	27.91 (1.17)	29.33 (1.09)
Urban environment * Video	28.88 (1.02)	28.15 (1.17)	28.94 (1.09)
Urban environment * Photographs	30.41 (1.01)	30.65 (1.15)	31.47 (1.07)
Geometric shapes	31.31 (.99)	29.80 (1.14)	30.66 (1.06)

When comparing pre-induction and post-induction scores using post-hoc contrasts, significant differences were found with lower self-esteem scores after the task ($p \leq .04$ for all compari-sons), except for the Urban * Photographs group. For this group, there was a non-significant increase in self-esteem after the induction task ($t(229) = .36$, $p = .72$). However, the 7 groups remained equivalent after the induction task ($F(6,229) = .84$, $p = .54$). These observations are presented in Figure 2.

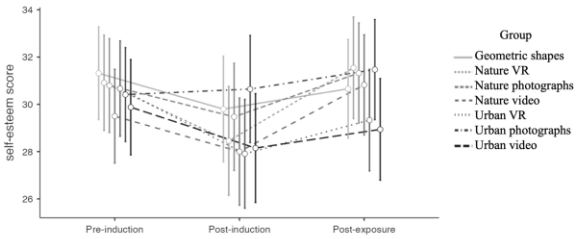

Figure 2. Self-esteem score as a function of group (format * type of environment, control group) and moment (pre-induction; post-induction; post-exposure).

Then, when comparing post-induction and post-exposure scores using post-hoc contrasts, significant differences were found, with higher self-esteem scores after the exposure for the three groups exposed to nature and for the Urban * VR group ($p \leq .01$ for all comparisons). A tendency towards enhanced self-esteem was discerned in the control group ($t(229) = 1.73$, $p = .09$), whereas the observed increases were not statistically significant for the group exposed to the city in the form of video or photographs ($p \geq .10$ for both groups). Despite the absence of a statistically significant difference in self-esteem scores at the third measurement time point following exposure ($F(6,229) = .93$, $p = .48$), self-esteem increased more consistently for the Nature * VR groups compared with the control group and the three urban groups ($p \leq .02$ for all comparisons). Nature * VR content also tended to be more effective than nature photographs ($t(229) = 1.73$, $p = .09$). The increase in Nature * Video was also significantly greater than the control group, Urban * video and Urban * Photographs ($p \leq .01$ for all comparisons). Nature * Video content also tended to be more effective than Urban * VR ($t(229) = 1.95$, $p = .05$). The Nature * VR and Nature * Video conditions did not differ for the increases ($t(229) = .37$, $p = .71$). In terms of natural exposure in photography, improvements were not different between the control and urban groups ($p \geq .14$ for all comparisons). To answer hypothesis H2, the findings of this study indicate that exposure to natural content in virtual reality and video formats is more effective than photographs in improving self-esteem. Thus, these results only partially confirm our hypothesis regarding the optimal format for exposure. The results indicated that nature photographs were less beneficial than the other two formats, which was to be expected given that photography is the least immersive format. Nevertheless, despite the more immersive characteristics of VR, it did not outperform video. In this sense, it is interesting to note that only the individuals exposed to nature on video had higher self-esteem scores after exposure than when they arrived at the experimental room ($t(229) = 2.34$, $p = .02$).

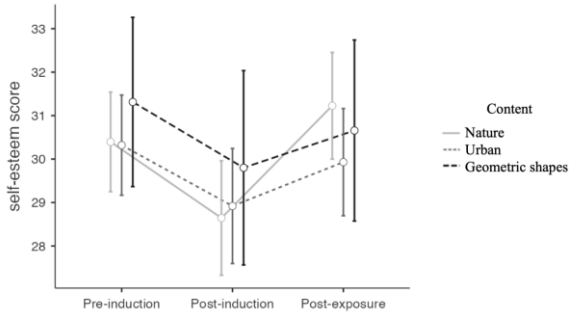

Figure 3. Self-esteem score as a function of content type (natural environment; urban environment; geometric shapes) and moment (post-induction; post-exposure).

Based on Figure 3 and taking into account only the type of content (nature, urban, and geometric shapes), there was a significant increase in self-esteem after exposure for all conditions (Table 4.). There was no difference in self-esteem after exposure to the different types of content

($F(2,233) = 1.08$, $p = .34$). However, it is worth noting that self-esteem increased more significantly with exposure to nature compared to exposure to urbanisation ($t(233) = 3.80$, $p < .001$) or geometric shapes ($t(233) = 3.00$, $p < .01$). No difference was found between the urban content and the control group ($t(233) = .27$, $p = .79$). This study contributes to the existing body of literature by demonstrating that all three types of stimuli have a positive impact on self-esteem. Nevertheless, the advantages of natural stimuli appear to outstrip those of urban and geometric stimuli (H1).

Table 4. *Self-esteem score (standard deviations) over time (post-induction, post-exposure) and by type of content (nature, urban, and geometric shapes).*

Content of exposure	post-induction	post-exposure	Test	P
	Mean (SD)	Mean (SD)		
Natural environment	28.64 (.67)	31.23 (.62)	t(100) = -7.66	p < .001***
Urban environment	28.92 (.67)	29.93 (.63)	t(99) = - 4.07	p < .001***
Geometric shapes	29.80 (1.14)	30.66 (1.06)	W(35) = 86.00	p = .02*

Notes. * p < .05, ** p < .01, *** p < .001. For the control group exposed to geometric shapes, a Wilcoxon W test was employed as the prerequisites for utilising Student's T were not met (Shapiro-Wilk normality test, p < .10), in addition to the small number of participants (n=35).

Discussion

Numerous studies have identified various substitutes, such as photography, video or VR, that generate a restorative effect of nature. Although they cannot accurately replicate the benefits of live nature (Browning et al., 2020), these alternatives can be particularly useful during health crises, hospitalisations or even during incarceration (Browning et al., 2020; Spano et al., 2023). Thanks to these substitutes, individuals can experience the benefits of nature in a controlled manner, regardless of location or time. These replacements are highly promising tools for the future, especially considering the ongoing growth of urbanisation (United Nations Publications, 2019). The aim of this study was to identify the most beneficial substitute for improving self-esteem. To achieve this, the restorative effect of nature through photographs was compared with that of video and VR. In accordance with Anderson et al. (2017), we included a control group that was exposed to geometrical shapes from the research of Berto (2005).

Effect of exposure content (Nature, Urban, Geometric Shapes)

All three stimuli were found to significantly improve the self-esteem of the participants, with no significant difference observed between them after exposure. However, it was noted that the increase in self-esteem was greater with natural stimuli compared to urban or geometric stimuli. This study contributes to the existing literature by suggesting that all three types of stimuli have a positive impact on self-esteem. However, the benefits of nature seem to outweigh those of the other two types of content. This is consistent with the findings of Pretty et al. (2005), which showed that walking on a treadmill while viewing natural images improved self-esteem. The increase in self-esteem was more consistent with natural exposure than with walking alone or in the presence of urban images.

Effect of exposure format (Photographs, Video, VR)

All groups showed an increase in self-esteem. However, it is worth noting that self-esteem increased more consistently in the Nature VR and Video groups than in the control group and the three urban groups. Additionally, the increase in the Nature * VR also tended to be more effective than with the nature photographs and only the individuals who viewed nature videos exhibited higher self-esteem scores after exposure than at the time of their arrival at the experimental room. However, there was no significant difference in benefits between the Nature * VR and Nature * Video conditions. Apart from simulating green exercise by viewing natural images while walking on a treadmill (Pretty et al., 2005), no study has investigated the use of substitutes to improve self-esteem. This study highlights that VR and video formats appear to be the most effective for enhancing self-esteem.

Clinical implications

In the interest of recall, individuals' self-esteem is of great importance in their daily lives, influencing their interactions with their environment and the people they meet (Zeigler-Hill, 2011). Furthermore, Zeigler-Hill (2011) highlights the significance of self-esteem in the onset and maintenance of psychopathological disorders. The vulnerability model postulates that individuals with low self-esteem lack the requisite resources to adapt and cope effectively with daily challenges. Consequently, self-esteem is a pivotal factor in both short-term and long-term mental health (Barton & Pretty, 2010).

It is therefore of particular importance to develop tools to improve self-esteem. Our study shows that contact with nature can be an effective solution in this respect. Indeed, a mere five minutes of exposure to nature in VR or video can demonstrably improve people's self-esteem. As part of their care, patients could be encouraged to engage with nature. Naturally, direct contact with nature is the optimal scenario. However, if this is not feasible, virtual reality or video exposure may be a viable alternative. These tools could therefore be beneficial in the care of patients whose self-esteem may be affected, particularly in the context of depressive disorders (Orth et al., 2012), anxiety disorders (Rosenberg, 1965; Servant, 2012), maladaptive behaviour with occasional heavy drinking (Bartsch et al., 2017), or eating disorders (Lo Coco et al., 2021). In a more general sense, exposure to nature could be employed as a therapeutic intervention for individuals with a proclivity towards brooding, as this has a direct impact on self-esteem, as evidenced in this study.

Limitations and perspectives of this study

Firstly, Li et al. (2023) suggested that the benefits of exposure depended on the immersive qualities of the material used. Consequently, it was assumed that the effectiveness of natural exposure would increase in proportion to the sense of presence perceived by individuals during the exposure. Nevertheless, the advantages of VR not seem to outstrip those of video. This may be due to the passive nature of VR exposure (Yeo et al., 2020). Thus, allowing individuals to interact freely with their environment and explore the place could potentially reinforce interactions with the environment.

Secondly, the objective was to identify the most efficacious substitute for enhancing self-esteem. In this context, it would have been appropriate to introduce a real exposure condition in order to identify the substitute that most closely resembles this experience in terms of benefits for self-esteem. Unfortunately, methodological and ethical constraints precluded its implementation in this study. Nevertheless, it would have been intriguing to contemplate its construction. In order to address this gap, it could be interesting to create experimental conditions that are even closer to reality. Other sensory modalities, such as smell, can be integrated (Lee et al., 2016). Schebella et al. (2019) demonstrated that the addition of sounds and smells enhances the restorative effect compared to visual stimulation alone. Therefore, combining new sensory modalities to increase the immersive capacity of these tools (De Kort et al., 2006) could be an interesting approach to improve their restorative capacity (Yeo et al., 2020).

Additionally, it would have been beneficial to include a question regarding the frequency of VR utilisation as suggested by Li et al. (2023). This would have allowed for better control of potential biases related to the participants' familiarity with VR. Chirico and Gaggioli (2019) found that participants with prior VR experience were more likely to perceive VR scenarios as realistic and authentic.

Finally, the benefits of natural exposure in these three formats were demonstrated. The frequency of exposure was not taken into account in this experiment as the subjects were only exposed to the environment once. However, there is a potential attenuation effect on the benefits as the frequency of exposure increases (Bringslimark et al., 2007). A comparable long-term study with several exposures would be useful in determining the most effective substitution format over time.

Conclusion

For several decades, studies have consistently highlighted the emotional, cognitive, and behav-ioural benefits associated with nature. However, there has been a growing decline in the amount of time people spend in natural surroundings, and this trend is expected to continue. Therefore, it is crucial to develop tools that can provide the benefits of nature to those who do not have direct access. The main objective was to identify the most effective substitute for improving self-esteem. Contrary to the initial hypothesis, exposure to urban life did not have a negative impact on self-esteem. The analyses revealed that any form of contact with nature, regardless of the substitute, had a positive effect. The findings suggest that natural experiences with virtual reality (VR) and video may be more beneficial than in the presence of photographs. In other words, exposure to these two formats led to a greater increase in self-esteem than exposure to natural photographs. Furthermore, research has demonstrated that exposure to urban environments does not have a significant negative impact on an individual's self-esteem.

In the future, these tools based on natural exposure could serve as valuable temporary aids for individuals with low self-esteem who have no direct access to nature. It is important to acknowledge that these substitutes should be viewed as supplementary and not as exclusive re-placements for actual exposure to nature.

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