Quiet the Mind with a Dose of Nature:

Exploring the role of awe in nature in our wellbeing within virtual reality mediations

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Abstract

Today's constant digital information, societies' obsession with productivity, the deficiency of nature exposure, and the increased number of stressors in modern life prevent individuals from being in a state of physical and psychological rest, contributing to their stressful and anxious lifestyles. Considering the comparable positive outcomes of *awe* and *mindfulness* such as feeling connected and having more awareness of the present moment, this research aims to explore the potential effects of awe-eliciting landscapes on individuals in the context of a mindfulness practice in VR on the wellbeing of adults.

Participants responded to a survey before and after partaking in a two-minute meditation experiment in a 360-degree video of nature in Virtual Reality. There were three conditions, two high-awe landscapes (beach and mountain) and one low-awe forest condition. The survey measured state anxiety (pre-and post-experience), state mindfulness, awe, perceived body boundaries, and positive emotions.

Indeed, findings (marginally) show that high-awe nature landscapes caused a higher reduction of state anxiety than the low-awe landscape. Moreover, participants in all three conditions perceived a reduced salience of their body boundaries and experienced a diminished sense of self, resulting in a more fundamental connectedness to their environment. In general, this study shows that natural landscapes, even if simulated, and meditation offer individuals beneficial outcomes that can be incorporated in everyday life.

In today's hectic world, surrounded by an abundance of stressors, nature, and meditation (through VR) can offer individuals a way to unwind from everyday life and improve their wellbeing, especially those who are enabled and restricted.

Keywords: Awe, Meditation, Anxiety, Mental Health, Virtual Reality , Perceived Body Boundaries

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1. Introduction

Society has changed drastically throughout the years. Since the rise of technological innovations, information has emerged from all corners of an individual's life. Consequently, society challenges individuals to keep up and stay on course, leading them to unconsciously constantly be on their digital devices to check texts, emails, and social media platforms. Accordingly, the human brain has been more occupied than ever before, flooded by an abundance of real-time information. As a result, feeling overwhelmed by unmanaged demands may lead to pressure, uncertainties, mental fatigue, stress, and anxiety (Pfaffinger et al., 2021).

Furthermore, enormous populations worldwide live in urban environments, which according to several studies, is associated with an increase in mental health issues compared to natural settings due to the lack of green spaces and the large number of existing stressors (Hartig & Kahn, 2016; Okkels et al., 2018). Hence, the absence of nature in an individual's life is a potential disharmony. Unfortunately, human beings are losing touch with nature. The 2020 National Trust survey results show that approximately 80% of individuals have seldom/never watched wildlife, drawn, taken a photograph of nature, or smelled wildflowers (National Trust, 2020). Furthermore, considering global warming and the loss of biodiversity on planet Earth, one can indicate the disconnection, and the fragile relationship humans have with nature, which may partially explain the prevalence of mental health issues among individuals (Hartig & Kahn, 2016; Soga & Gaston, 2016).

Approximately 30% of the global population suffers from mental disorders (Steel et al., 2014). Moreover, the COVID-19 pandemic has increased the occurrence of anxiety and depression by 25% globally (World Health Organization, 2022). Hence, several factors in today's world prevent individuals from being in a state of physical and psychological rest and contribute to their stressful and anxious lifestyles. However, instead of actively responding to

stressful circumstances, individuals usually employ coping strategies to deal with stress (Berto, 2014).

A potential means to cope with stress is nature. Research shows that nature exposures offer various benefits to humans. Natural environments help individuals endure the effect of stressors, providing them with physiological, emotional, and attention restoration (Berto, 2014). For instance, the feeling of awe in nature triggers positive physiological, psychological, and social behaviors within individuals, including a diminished sense of self, an increased feeling of connectedness, a sense of having more available time, and an awareness of being in the presence of something greater than oneself – a self-transcendent experience (Yaden et al., 2017). Similarly, mindfulness is characterized by developing awareness without criticism or judgment, which corresponds to a selfless state, a strong sense of connection, and a focus on the present moment. Both experiences may encourage individuals to separate themselves from the monotonous everyday concerns and issues in life, distancing them from a stressful state. Thus, the concept of mindfulness and awe have several overlaps and may complement each other. As mindfulness meditations are becoming a popular antidote for everyday life, nature could be a means to exercise mindfulness practices.

Correspondingly, since technology has dominated the world, it is to be considered that it has the potential to be used as a solution to current issues. Thus, this paper aims to explore the link between different (awe-eliciting) natural landscapes and wellbeing in the context of mindfulness meditation, using 360 degrees videos in Virtual Reality (VR).

Due to the inherent characteristic of nature to evoke awe, a beach (blue space) and mountain environment (green space) attributing characteristics of awe such as a sense of vastness is chosen as opposed to each other to examine which of the two awe-inducing environments results in higher stress reduction, state mindfulness, perceived body boundaries, awe, and positive emotions. Additionally, a low-awe forest landscape was integrated as a

control condition. The originality of this study lies within the comparison between distinct types of awe-eliciting natural dimensions with the inclusion of mindfulness meditation. Thus, the main research question that will be examined in this study is:

RQ: To what extent can awe-eliciting nature in a VR meditation help reduce symptoms of stress and anxiety, as well as increase mindfulness and positive emotions within adults?

2. Theoretical Framework

2.1 Stress and Anxiety

Stress is inevitable in a modern lifestyle. The growing amount of information and stressors individuals face daily, accompanied by the obsession they have with productivity, results in an incredibly stressful and anxious lifestyle. It has been claimed that the activation of stress was developed through evolution as a coping strategy to deal with circumstances threatening wellbeing (Grinde & Patil, 2009). Stress is caused within an individual by either real or imagined external stressors. However, how individuals approach stressful situations and manage them to stay calm is essential to being healthy and having a pleasant life (Vibe et al., 2012). Such skills can be learned and practiced throughout one's lifetime.

Stress and anxiety are closely related, both being emotional responses to threatening and worrisome situations, with stress being a common trigger for anxiety (Grinde & Patil, 2009). Moreover, stress can activate various common health issues, including cardiovascular diseases, anxiety disorders, and depression (Grinde & Patil, 2009). However, anxiety is when an individual experiences a constant heightened vigilance that stays even in a stressor's absence. Moreover, anxiety is related to increased overall sensitivity (Grupe & Nitschke, 2013). According to Spielberger and Sydeman (1994), there are two types of anxiety: state anxiety and trait anxiety. State anxiety is triggered by a situation characterized as challenging or uncertain, while trait anxiety is more threatening and rooted within an individual, causing

a more enduring response (Spielberger & Sydeman, 1994). Moreover, individuals with a generalized anxiety disorder (GAD) report worrying uncontrollably and excessively about various things and evaluating their thoughts, emotions, and physiological sensations negatively (Wells & Carter, 1999).

As for coping means, some people seek out nature in being in stress. Unfortunately, due to the constant increase in urbanization, modern individuals experience the absence of nature in their surroundings, increasing their exposure to stressors, and eventually affecting their physical and psychological wellbeing (Okkels et al., 2018). Alternatively, there a rising interest in meditation practices to shut down from the busy everyday life and create a moment of peace and relaxation.

Recently, VR technologies have been adopted in various areas of society. An increasing amount of research show the success and effectiveness of VR in addressing mental health issues, such as phobias, depression, stress, and pain (Matamala-Gomez et al., 2021; Park et al., 2019; Liszio & Masuch, 2019; White et al., 2018). These outcomes show evidence of the potential effectiveness and benefits of VR innovations for contemporary issues.

2.2 Effects of nature on wellbeing

Several studies within the field of Environmental Psychology deal with the psychological benefits of natural stimuli. For instance, nature can potentially decrease stress and mental exhaustion (Bratman et al., 2015) and elicit positive moods and emotions like awe (Allen, 2018). Moreover, research on the psychological effects of nature is fundamentally rooted in the biophilia hypothesis. According to Wilson's biophilia hypothesis (1984), individuals' psychological health is linked with their relationship to nature. The term "Biophilia" – "bio" meaning "life" and "philia," "love" – describes the inherent inclination of individuals to affiliate with nature, implying the love for all that is alive (Wilson, 1984). In other words, humanity holds an emotional attachment to nature.

Moreover, based on the Environmental Psychology theories, Attention Restoration Theory (ART) (Kaplan & Kaplan, 1989) and Stress Reduction Theory (SRT) (Ulrich, 1981; Ulrich et al., 1991), natural landscapes enable restoration from stress, mental fatigue, and negative moods. ART posits that exposure to green landscapes restores the attention of humans to recover from mental fatigue. Trees, water, and sunsets are "softly fascinating," meaning they catch individuals' involuntary attention and only demand little cognitive effort to process, enabling directed attention for rest and recovery (Kaplan, 1995). Furthermore, SRT suggests that nature exposure stimulates stress recovery (Ulrich et al., 1991). Ulrich and his colleagues (1999) claim that the positive psycho-physiological responses humans have towards nature can be traced back to the evolution of humankind since humans have evolved and developed in natural environments. Thus, natural exposures protect individuals from stressors in their surroundings.

Taking virtual reality into consideration – in a recent study conducted by O'Meara and her colleagues (2020), being in a comforting nature virtual reality environment for some time potentially reduces the anxiety that arises prior to an exam for students who have a high level of trait anxiety. Similarly, a pilot study conducted by Annerstedt and her colleagues (2013) aiming to investigate the effect of VR nature (with vs without nature sound) on physiological stress recovery in healthy participants, findings indicated that there was an enhancement in stress recovery and parasympathetic activation in the group exposed to VR nature with sounds as opposed to those who were in VR nature without nature sounds, indicating that "nature-like-experience" with multiple sensory cues may be essential.

Hence, these findings suggests that immersive VR environments provoke a high sense of presence in a simulated reality, suggesting that nature, even if simulated, can cause benefits for individuals such as relaxation and emotional responses, especially when they include nature-like multiple sensory cues.

2.2.1 Green Space vs Blue Space

Nature may vary in different forms, types, and qualities. In Environmental Psychology, it is still uncertain which particular landscape, whether the presence of vegetation, bodies of water, or other features, contribute to positive reactions among individuals (Dramstad et al., 2006). Existing research mostly conceptualize nature as "green space," which is a term for areas of nature consisting of vegetated regions such as forest, parks, woodlands, and street trees (White et al., 2021). However, a growing number of research is investigating the effects of "blue spaces" on individuals. "Blue spaces" summarize bodies of water such as rivers, lakes, and beaches (Völker & Kistemann, 2011). In this study, both blue and green spaces will be examined.

Numerous studies suggest an increase in individuals' physical health and mental wellbeing when they have contact with "natural" green space environments such as woodlands, parks, and gardens (deVries et al., 2003; van den Berg et al., 2016b). In a study by Nutsford and his colleagues (2013), participants who had better access to woodlands are associated with decreased counts on anxiety/mood disorder treatment (Nutsford et al., 2013). Relatedly, Wells and Evan reveal in their study (2003) that nature serves as a buffer for the impact of stressful life events on children's psychological wellbeing in residential neighbourhoods in rural communities in New York. These findings suggest that green spaces offer individuals a space to cope with everyday stress and improve overall wellbeing.

According to Kaplan and Kaplan (1989), water is one of the most aesthetic landscape features. Moreover, it provides a sense of naturalness and spaciousness (Völker et al., 2011). Similarly, research with "blue spaces" reveal positive effects on wellbeing. Nutsford and his colleagues (2016) found that individuals who live in a neighbourhood where they have the chance to see blue spaces like the sea have lower levels of stress. The desirable features of

blue space, including its sound, colour, clarity, and motion, may increase its restorative characteristic (Völker et al., 2011).

Previously mentioned theories, namely attention restoration theory (ART) and stress recovery theory (SRT), potentially explain the multiple restorative mechanisms behind both environments. Furthermore, in general, an attractive landscape generates health and wellbeing for individuals (Abraham et al., 2010). However, most of the present studies focus on comparing natural environments to stressful built/urban environments (Wells and Evan, 2003; Nutsford et al., 2013; Okkels et al., 2018). Hence, this study compares two distinct features of natural environments, green and blue spaces in combination with attributes of awe eliciting landscapes (vastness), to explore and compare their potential to restore wellbeing.

2.3 Awe

The concept of awe is essential for this study because its effect on individuals will be closely investigated in a mindfulness mediation context.

Religious scholars and philosophers have studied the experience of awe for a long time. However, the science of awe was overlooked by psychologists until the early 2000s, when it gained a rising empirical interest (Allen, 2018). *Awe* is a complex emotion triggered by intense feelings of astonishment, wonder, and connectedness that occur during the encounter with something vast, causing a need for accommodation because it exceeds existing mental schemas (Haidt & Keltner, 2003). According to Keltner and Haidt, the feeling of awe is a "little studied emotion" that is "in the upper reaches of pleasure and on the boundary of fear" (2003; p. 297). Hence, awe often comprehends negative and positive emotions (Gordon et al., 2017).

Furthermore, awe is an essential part of nature's ability to decrease stress and increase well-being (Anderson et al., 2018) and potentially create a short-term life satisfaction boost (Rudd et al., 2012). As already touched upon, awe is characterized by two dimensions, namely

vastness and the need for accommodation. The former refers to the extent awe experiences are characterized by "qualities that were beyond measure" (Schurtz et al., 2012), and the latter refers to the need to adjust mental structures because they do not assimilate to a new experience (Keltner & Haidt, 2003). Essentially, vastness can be either perceptual or conceptual (Yaden et al., 2018)

The experience of awe causes various positive outcomes among individuals. Shiota and her colleagues (2006) found several psychological effects in their study in which participants needed to relive personal experiences of awe. The results show stronger feelings of being small and insignificant, having an awareness of the presence of something greater than oneself, and an increase in feelings of connectedness (Shiota et al., 2016). Further psychological effects include the sense of having more available time and an increase in positive moods (Allen, 2018).

Keltner and Haidt proposed several "flavors" that may elicit awe: threat-based awe, beauty-based awe, ability-based awe, virtue-based awe, and supernatural causality-based awe (2003). The focus of this study will be beauty-based awe since nature is specifically a common and most important awe elicitor due to its inherited vastness (Yaden et al., 2018) and the aesthetic beauty it portrays (Allen, 2018). As mentioned in the previous section, landscapes with awe-eliciting features, including vastness will be incorporated in the awe conditions that differ as green and blue spaces (beach vs mountain). Bodies of water may present a sense of emptiness and spaciousness (Völker et al., 2011) that relate to vastness; however, a mountain landscape may exhibit a sense of greatness and immensity that depict physical vastness. Therefore, alongside the difference in green and blue spaces, these two landscapes have distinct features that can allow an acceptable comparison.

With regards to VR, according to Chirico and her colleagues (2016), using VR is effective for eliciting awe since provides users with a controlled and safe, immersive environment that

can provoke a sense of "presence" in a simulated reality. This innovation may allow more boundless accessibility to the experience of awe and meditation to eventually ensue calmness in a stressful life.

2.4 Mindfulness

In this study a focus on awe in the context of a mindfulness practice will be placed, hence mindfulness will be briefly introduced.

Interest in mindfulness has risen tremendously throughout the past years, both in literature and among the public. In western societies, mindfulness training, including activities like meditation, yoga and breathing exercises has grown an increasing popularity as a means to manage stress, increase calmness and clarity, as well as to generate happiness, improve wellbeing and life satisfaction (Hofmann et al., 201). Historically, the concept of mindfulness originates from Buddhist and other reflective cultural and religious traditions, in which awareness and conscious attention is encouraged (Hofmann et al., 2010)

Various scholars attempt to define mindfulness in the field of psychology. The most frequently cited definition in mental health research is from Kabat-Zinn, stating that mindfulness means “paying attention in a particular way: on purpose, in the present moment, and non-judgmentally” (Kabat-Zinn 1990, p. 4). Similarly, according to Brown and Ryan, mindfulness is fundamentally a state of consciousness – ‘‘a receptive attention to and awareness of present events and experience’’ (Brown et al., 2003), decreasing the tendency of rumination over different experiences.

In modern psychotherapy, mindfulness-based therapy (MBT), including mindfulness-based cognitive therapy (MBCT; e.g., Segal et al., 2002) and mindfulness-based stress reduction (MBSR; e.g., Kabat-Zinn, 1982), has become an accepted and common form of therapeutic intervention. Hence, due to its success in the field of psychology, mindfulness has evolved from being merely a religious concept to a widespread psychotherapy intervention.

As already mentioned, the feeling of awe will be linked with the concept of mindfulness. Interestingly, like mindfulness, awe lies in the boarder of an emotional and altered state of consciousness, like a flow state, due its capacity to change the senses of self, time, space (Keltner & Haidt, 2003), also counting as a "self-transcendent experience (STE)" (Yaden et al., 2017). Comparably, the fact that mindfulness meditation has originated from a religious concept, just like awe, it can be elicited through a sense of spirituality. Both results in states that encourage people to separate oneself from the monotonous everyday concerns and issues in life, to change one's perspective and to focus on the bigger picture, like how one fits in the world. Thus, the concept of mindfulness and awe have several overlaps and may complement each other. Therefore, the relationship between the two will be investigated.

2.5 Perceived Body Boundaries

A common phenomenon related to mindfulness and awe is the perceived body boundaries, measuring the transformation from the state of being self-centred to a selfless state through the perceived salience of one's own body boundaries (Dambrun, 2016). This originates from Dambrun and Ricard's Self- Centeredness/Selflessness Happiness Model (2011), suggesting that a self-transcendence state initiated by meditation practices result in a diminished self, leading to more awareness of the present moment and one's environment. As already mentioned, awe inducing experiences caused by nature also have the potential to establish self- transcendence states (Yaden et al., 2017) which may cause a higher level of unity within individuals and their environment, generating a diminishing salience of body boundaries. Yaden et al. (2017) define this occurrence as "transient mental states of decreased self-salience and increased feelings of connectedness" (p. 143). Findings from mindfulness research suggest an embodied process at the root of a mindful state in which perceived boundaries between body and environment loosen up (Dambrun, 2016). Hence, for explorative purposes, whether awe reduces the salience of perceived body boundaries will be explored in this study.

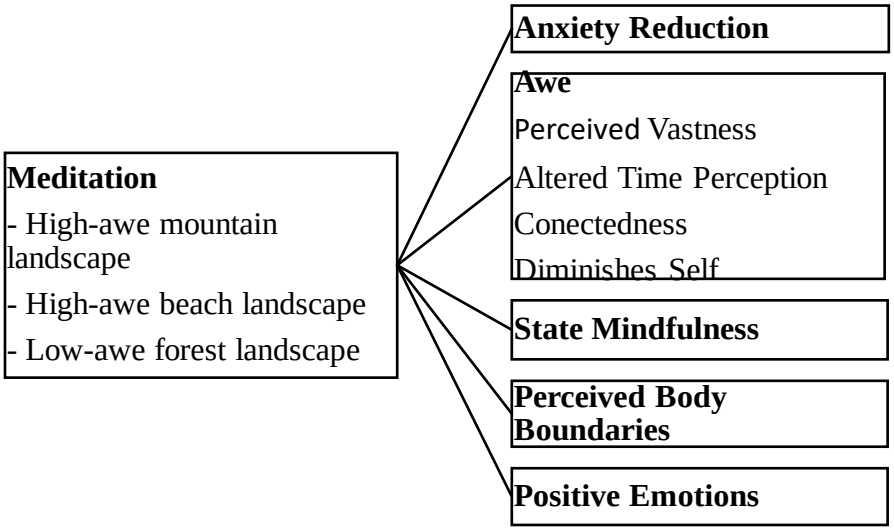
2.6 Positive Emotions

Positive emotions including joy, interest, contentment, and love are indicators of wellbeing and are the contrary of negative emotions such as anxiety, anger, and sadness. The broaden-and-build theory of positive emotions (Fredrickson, 2001) suggest that positive emotions broaden the capacities of cognition, attentional focus, and behavioural repertoire, eventually increasing emotional wellbeing. According to Fredrickson (2004), individuals should encourage positive emotions in themselves to be able to achieve psychological growth and increase physical and psychological wellbeing in the course of time. Furthermore, positive emotions have undoing effects on negative emotions (Fredrickson, 2004). Similarly, the findings of Lyubomirsky and Tucker (1998), in which they conducted surveys and quasi-experiments to examine coping strategies among individuals who perceive themselves to be happy, reveal that individuals who are characteristically happy and unhappy vary in the ways they respond to life occurrences and everyday situations, ultimately showing that dispositional positive emotions may be be associated in maintaining wellbeing over time. As positive emotions broaden attention and cognition, they also potentially have an essential role in facilitating adaptive self-regulation such as coping with stress and difficulties (Aspinwall, 1998).

In terms of nature, according to Ballew and Omoto (2018), ordinary experiences in nature can enhance positive emotions, especially feelings of awe, happiness, and joy among individuals. Moreover, Ballew and Omoto (2018) suggest that a state of absorption by features of nature are responsible for nature's emotional effects. Considering the lasting benefits of positive emotions and the fact that experiences in nature can elevate individuals' positive emotions, it is interesting to explore if nature in the context of a mindfulness meditation triggers different positive emotions besides awe.

Figure 1

Research Model



The following hypotheses will be tested in this study:

H1: The high-awe conditions will generate a higher reduction of state anxiety as opposed to the low-awe condition.

H1a: Anxiety reduction is more pronounced in the high-awe mountain landscape as opposed to the high-awe ocean landscape.

H2: The high-awe conditions will enhance higher state mindfulness as opposed to the low-awe condition.

H2a: State mindfulness is more pronounced in the high-awe mountain landscape as opposed to the high-awe ocean landscape.

H3: Meditation in an awe-eliciting VR nature environment reduces the salience of Perceived Body Boundaries because participants feel more connected to the environment.

H4: The high-awe conditions will enhance more positive emotions as opposed to low-awe condition.

H4b: Positive emotions are more pronounced in the high-awe mountain landscape as opposed to the high-awe ocean landscape.

H5: The feeling of awe correlates with the concept of mindfulness.

3. Methods

3.1 Design

To test the mentioned hypotheses and research question, a research design with suitable measurements needs to be established. In this study, a between-subject design with a pre-post test intervention is chosen to investigate stress and anxiety, state mindfulness, perceived body boundaries, awe and other positive emotions affected by the virtual reality experience.

There are three different conditions: Two groups obtain different awe-inducing virtual environments: (a) a beach view with the sound of the waves and (b) a mountainous view with the sound of the wind, both with the same instrumental music. The control group obtains a (c) non-vast virtual landscape of a forest with bird-chirping sounds, accompanied by the same instrumental music as the first two conditions. The mountain landscape is characterized as a green space and depicts a sense of vastness through the physical magnitude of the mountains. On the other hand, the awe-inducing beach landscape is considered a blue space which is incorporated with elements that illustrate vastness, spaciousness, and emptiness. Therefore, both mountain and beach scenes are high-awe conditions. The control forest condition is also a green space, however, the aspects that may evoke awe, such as vastness is very low. Hence, this allows to investigate which specific type of landscape elicit a more intense feeling of awe, and eventually its subsequent effects on wellbeing.

3.2 Participants

The experiment was conducted within 14 days with the total sample consisting of 91 participants that were gathered via convenience sampling. Moreover, the participants were made aware of the study via personal contacts, social media, as well as through the platform *Sona* from the University of Twente. Out of the respondents, 47 (51.6%) are female and 44 (48.4%) are male. The mean age of the participants is 22.93 years old, with a standard deviation of 5,63 years. The majority (54.9%) of the sample indicated to be German, followed by 31.9% of the sample being Dutch. The remaining group indicated to be either Chinese, Irish, Romanian, Italian, Taiwanese, Spanish, Austrian, Australian, and French.

Table 1

Respondent Characteristics

Gender	
Male	48.4%
Female	51.6%)
Age Mean (SD)	22.93 (5,63)

The number of participants were evenly distributed among the three experimental conditions. The beach (high-awe landscape) group consisted of 29.55% males (N=13) and 36,17% females (N=17), and the mountain (high-awe landscape) group consisted of 36.36% male (N=16) and 31.91% female (N=15). Lastly, the forest scene (low-awe landscape) comprised of 34.09 % male (N=15) and 31,92% female (N=15). 21.98% (N=20) of the participants already achieved a bachelor's degree and the rest 78.02% were students.

Table 2

Condition Distribution

Condition	n	%
Vast Landscape (Mountain with wind sound)	31	34%
Vast Landscape (Ocean with wave sound)	30	33%
Non-vast (Forest with bird chirping sound)	30	33%

3.3 Procedure

The study was approved by the Ethics Committee of the University of Twente (220688). The data collection method used in this study was a quantitative self-reported questionnaire concerning the participants feelings and perceptions prior and after the experiment. The experiments were conducted at the University of Twente or the researcher came to the site of the participants. At the beginning of the data collection, the researcher gave a brief explanation about the study and the structure of the experiment. Once all questions were answered and the participants have given their consent to partake in the survey, they were asked to fill out a pre-experiment questionnaire involving questions regarding their basic demographics and their current state anxiety. In the same questionnaire, a meditation text which they had to read attentively before partaking in the VR experience was to be found. Then, participants were given the VR glasses for a two-minute meditation, each video was randomly assigned to them. The researcher made sure that the glasses were properly and comfortably put on, and that one of the three videos was displayed correctly. During the meditation, the researcher left the room to facilitate privacy for the participants. After finishing the meditation, participants were asked to fill out the post-test questionnaire, indicating their level of state anxiety and state mindfulness in that given moment, as well as questions concerning the awe experience, their

perceived body boundaries, and the positive emotions they experienced during the meditation. At the end, the participants were given a more in-depth explanation of the purpose of the study, as well as the researchers contact details in case of rising questions or specific interest about the study's outcomes.

3.4 Materials

The 360 degrees videos were downloaded from the platform YouTube and edited via Adobe Premiere Pro, a video editing application, because it allows to edit VR videos that are compatible with VR glasses. Furthermore, Oculus Quest 2 VR glasses were barrowed from the BMS Lab at the University of Twente and the experiments were held in lab facilities on the campus of the University of Twente or at the homes of participants. The three different Virtual Reality conditions can be seen in Figure 2, 3, and 4 below.

Figure 2

Screenshot of the (beach) Awe condition

Figure 3

Screenshot of the (mountain) Awe condition

Figure 4

Screenshot of the control condition

3.5 Measurement

The survey was created by means of the software *Qualtrics* via the University of Twente. The complete questionnaire can be found in the Appendix (Figure 11). The variables applied for this study were validated scales retrieved from previous studies.

3.5.1. State Anxiety

In this study, state anxiety was measured with the use of the shortened version of the Y-1 form of the *State Trait Anxiety Inventory (STAI),* which was introduced by by Marteau and Bekker (1992) to propose a shorter and concise scale that has an acceptable reliability and totals comparable outcomes to the full-form of the STAI. It is a 6-item self-report measure of anxiety using a 4-point Likert-type scale, with questions concerning the momentary feelings of the participants in that specific moment, including statements like *I feel calm", "I am worried", "I feel upset", or "I am content"*. These questions were asked at the beginning of the pre-test and at the beginning of the post-test, right after experiencing the virtual reality environment. During the analysis, these set of items were labeled as 'Pre State Anxiety' (Cronbach's Alpha of .817) and 'Post State Anxiety' (Cronbach's Alpha of .726), with a third variable called 'State Anxiety Difference' which was the difference between the two. The state anxiety difference scale was reliable with a Cronbach's Alpha of .708.

3.5.2. Awe

To measure the connection between awe and mindfulness, the feeling of awe was measured using the Awe Experience Scale (AWE-S) by Yaden and his colleagues (2018) to evaluate whether participants perhaps experienced awe during the meditation. Moreover, the AWE-S includes a total of 30 items with five items per factor. However, only three out of six factors were used in this study, specifically, vastness, altered time perception, and connectedness,

because one factor is substituted with a more visual scale (Figure 5), and the chosen factors relate most to mindfulness. The three factors and the standardized alphas are as follows: perceived vastness α = .661; altered time perception α = .871; connectedness α = .897, two of which have solid internal reliability, while the factor vastness is minimally acceptable. This awe scale consists of items such as "What I watched provided me with a deep sense of vastness," "I sensed things momentarily slow down," and "I had the sense of being connected to everything."

As already mentioned, a more visual means of measuring awe was used (see Figure 5), which was adapted from Bai and her colleague's method of measuring the small self (2017). It is a set of illustrations of different-sized people in which participants are then asked which version they associate themselves the most with at the current moment (Bai et al., 2017).

Figure 5

The Small Self (Bai et al., 2017)

3.5.3. State Mindfulness

Followed by the state anxiety questions, participants' state mindfulness after the meditation experience was measured. The item state mindfulness was measured using the State Mindfulness Scale (SMS) by Tanay and Bernstein (2013). This specific assessment was developed to measure the self-regulation of one's attention and awareness of the participants in relation to their immediate experience of a mindfulness session. Additionally, the SMS is based on contemporary psychological science models and traditional Buddhist definitions of mindfulness (Tanay and Bernstein, 2013). The SMS consists of two subscales: The mindfulness of Mind subscale (Cronbach's α = .844) and the Mindfulness of Body subscale.

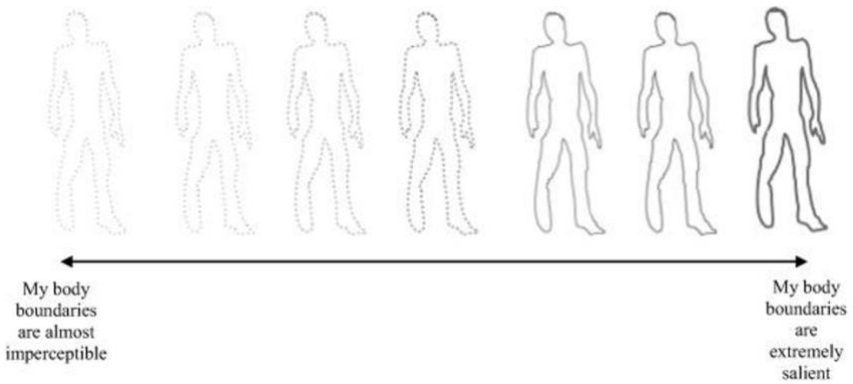
However, only the Mindfulness of Mind subscale was obtained for this research. Hence, it was a 15-item self-report measure of state mindfulness using a 5-point Likert-type scale. The statements for this part included “I noticed pleasant and unpleasant thoughts,” “I noticed emotions come and go,” and “I felt aware of what was happening inside of me.” This scale was chosen to evaluate whether participants developed mindfulness after experiencing the virtual reality environment.

3.5.4. Perceived Body Boundaries

Participants also indicated their body salience based on the *Perceived Body Boundary Scale (PBBS)* by Dambrun (2016), which is visualized in Figure 6. This scale portrays seven human body silhouettes, depicting almost imperceptible body boundaries (far left) to extremely salient (far right). This 7-point Likert type scale (1 = weak boundary, 7 = strong boundary) is to assess the boundary between the self and the world. Participants were asked to identify and choose which of the seven silhouettes reflected how they felt at the current moment. A high score on PBBS indicates the perception of a strong boundary between the participant and the world. In comparison, a lower PBBS score means the participant experiences imperceptible body boundaries, indicating a slight to no distinction between the self and the world (Dambrun, 2016).

Figure 6

Perceived Body Boundary Scale by Dambrun (2016)



3.5.5. Positive Emotions

The item positive emotions was measured using the Modified Differential Emotions Scale (mDES) by Fredrickson and his colleagues (2003) which was validated by Galanakis and his colleagues in 2016. It is a 19-item self-report measure of positive emotions using a 5-point Likert-type scale, having two subscales (positive and negative emotions). However, since the focus of this study is to identify positive emotions, only the positive emotions subscale was used (Cronbach's $\alpha = .84$). This scale consists of nine items concerning the momentary feelings of the participants in that specific moment with statements like "I felt awe, wonder, amazement", "I felt content, serene, peaceful" and "I felt inspired, uplifted, elevated".

3.6. Quality of Instruments

Reliability analyses of utilized constructs were conducted to confirm sufficient quality of the results. The results of the analyses show that all constructs have sufficient reliability and validity, with Perceived Vastness being minimally acceptable. The item scores can be found below in Table 3.

Table 3

Reliability Analysis

Construct	Number of items	Cronbach's Alpha
State Anxiety Difference	6	.708
Awe		
Perceived Vastness	4	.661
Altered Time Perception	5	.871
Connectedness	5	.897
State Mindfulness	15	.844
Positive Emotions	10	.840

4. Results

4.1 State Anxiety Difference

An ANOVA (Table 5) with State Anxiety Difference as dependent variable demonstrates marginally significant effects of the VR meditation conditions (F (2,88) = 2.45, p = .092). The results suggest that the high-awe beach landscape generated the greatest decrease in anxiety within participants (M = .59, SD = .67), followed by the high-awe mountain landscape (M = .46, SD = .42), and lastly the low-awe forest condition (M = .31, SD = .37).

4.2 Awe

4.2.1 Perceived Vastness

An ANOVA (Table 7) revealed that the effect of the VR meditation conditions for perceived vastness is significant, F(2,88)=10.45, p = <.001, implying that there is a significant difference between the means of the three conditions. The results suggest that the high-awe mountain landscape generated the greatest perceived vastness within participants (M = 4.73, SD = 1.2), followed by the high-awe beach landscape (M = 3.64, SD = 1.15), and lastly the low-awe forest landscape (M = 3.59, SD = .92).

4.2.2 Altered Time Perception

An ANOVA (Table 9) determined that the effect of the VR meditation conditions was not significant for altered time perception, F(2,88) = 1.762, p = .178, which implies that there is no significant difference between the means of the three conditions. The results suggest that participants in the high-awe beach (M = 5.51, SD = 1.08) and mountain landscape (M = 5.23, SD = 1.13) slightly experienced a higher altered time perception that those in the low-awe forest condition (M = 4.87, SD = 1.65).

4.2.3 Connectedness

An ANOVA (Table 11) with connectedness as dependent variable demonstrated no significant effect of the VR meditation conditions, $F(2, 88) = 2.01$, $p = .140$, implying that there is no significant difference between the means of the three conditions. Participants in the high-awe beach landscape ($M = 4.75$, $SD = 1.31$) felt the highest connectedness, followed by the high-awe mountain landscape ($M = 4.18$, $SD = 1.14$), and then the low-awe forest landscape ($M = 4.16$, $SD = 1.41$).

4.2.4 Diminished Self (visual awe subscale)

An ANOVA (Table 13) with diminished self as dependent variable demonstrated a significant effect of the VR meditation conditions, $F(2, 88) = 7.05$, $p = .001$, implying that there is a significant difference between the means of the three conditions. Participants in the high-awe beach landscape ($M = 4.67$, $SD = 1.35$) felt largest compared to the other two conditions, followed by the low-awe forest landscape ($M = 4.07$, $SD = 1.41$). Lastly, participants in the high-awe mountain landscape felt smallest ($M = 3,19$ $SD = 1.82$).

4.3 State Mindfulness

An ANOVA (Table 15) with mindfulness as dependent variable demonstrates that there are no significant effects of the VR meditation conditions, $F(2,88) = 1.86$; $p = .162$, indicating that there is no significant difference between the means of the three conditions. The results demonstrate only a minimal difference in means between the conditions. Participants in the high-awe beach landscape ($M = 3.79$, $SD = .53$) had the highest state mindfulness, followed by those in the high-awe mountain landscape ($M = 3.65$, $SD = .52$) and the least in the low-awe forest landscape ($M = 3.50$, $SD = .69$).

4.4 Perceived Body Boundaries

An ANOVA (Table 17) shows that there is a significant difference in perceived body boundaries between participants in different conditions, F (2,88) = 3.45; p = .036. Participants in the low-awe forest condition have higher scores ($M = 4.17$, SD = 1.53) than those who have been in the high-awe mountain landscape ($M = 3.94$, SD = 1.09) and the high-awe beach landscape ($M = 3.30$, SD = 1.32), signifying that participants in the high-awe landscapes felt a slight to no distinction between the self and the world compared to those in the low-awe forest landscape.

4.5 Positive Emotions

An ANOVA (Table 19) shows that there is no significant difference in positive emotions between participants in the three different conditions, F (2.88) = 2.11; p = .127. The participants in each condition experienced very slight differences in positive emotion, with participants in the high-awe beach landscape ($M = 3.69$, SD = .72) experiencing the most positive emotions followed by those in the high-awe mountain landscape ($M = 3.68$, SD = .64), and lastly the low-awe forest landscape ($M = 3.38$, SD = .63).

4.6 Mindfulness and Awe Corelation

4.6.1 Mindfulness and Perceived Vastness

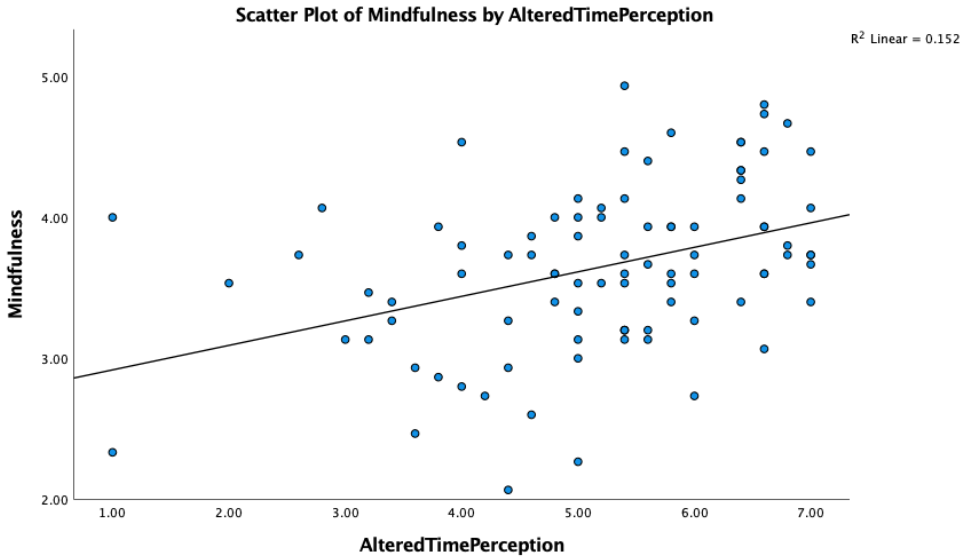
There was no significant correlation between perceived vastness and mindfulness, r = .044, p < .682, found which indicates a no association between the two variables (Table 21).

4.6.2 Mindfulness and Altered Time Perception

A significant moderate degree of positive correlation between altered time perception and mindfulness, $r = 389$, $p < .001$, was found which indicates a moderate association between the two variables (Table 21).

Figure 7

Correlation of Altered Time Perception (Awe subscale) and Mindfulness



4.6.3 Mindfulness and Connectedness

A significant moderate degree of correlation between awe and mindfulness, $r = 536$, $p < .001$, was found which indicates a moderate association between the two variables (Table 21).

Figure 8

Correlation of Connectedness (Awe subscale) and Mindfulness

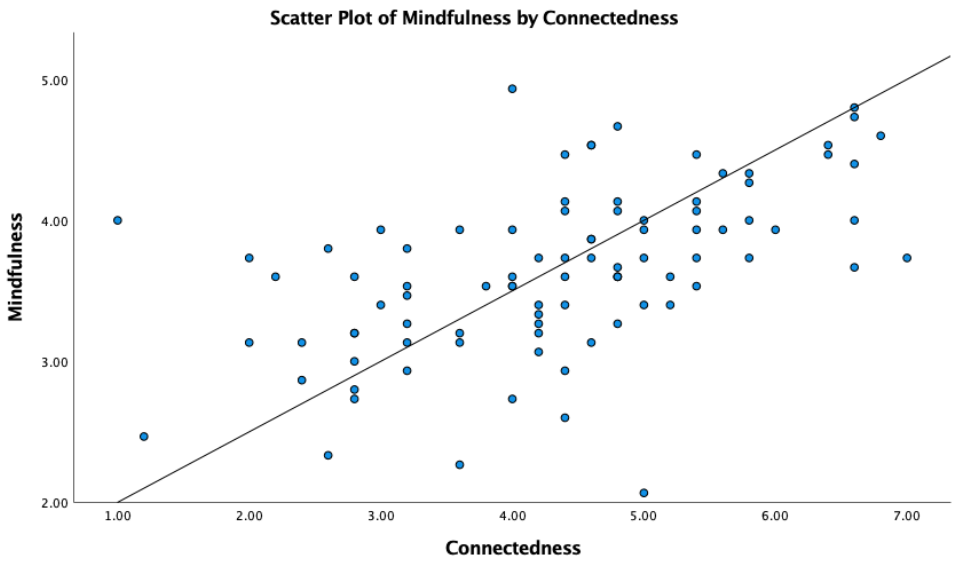


Table 4

Hypotheses

Hypotheses	Outcome
H1: The high-awe conditions will generate a higher reduction of state anxiety as opposed to the low-awe condition.	Supported
H1a: Anxiety reduction is more pronounced in the high-awe mountain landscape as opposed to the high-awe ocean landscape.	Rejected
H2: The high-awe conditions will enhance higher state mindfulness as opposed to the low-awe condition.	Rejected
H2a: State mindfulness is more pronounced in the high-awe mountain landscape as opposed to the high-awe ocean landscape.	Rejected
H3: Meditation in an awe-eliciting VR nature environment reduces the salience of Perceived Body Boundaries because participants feel more connected to the environment.	Supported
H4: The high-awe conditions will enhance more positive emotions as opposed to low-awe condition.	Rejected

H4b: Positive emotions are more pronounced in the high-awe mountain landscape as opposed to the high-awe ocean landscape.	Rejected
H5: The feeling of awe correlates with the concept of mindfulness.	Supported

5. Discussion

This research aimed to investigate the potential effects of awe in the context of a mindfulness practice in VR on the wellbeing of adults. Participants responded in a survey before and after partaking in a two-minute meditation experiment in one of three 360-degree videos of nature in Virtual Reality, either in one of the two high-awe landscapes (beach or mountain) or in the low-awe forest landscape. The survey measured state anxiety (pre-and post-experience), state mindfulness, awe, perceived body boundaries, and positive emotions. In the upcoming section, the findings from the data analysis will be examined and interpreted, followed by the practical implications, limitations of the research, and recommendations for future research.

5.1 Discussion of the Results

The study's main aim was to explore to what extent awe-eliciting landscapes in a mindfulness meditation context in VR help increase mindfulness and positive emotions and reduce symptoms of stress and anxiety within adults.

In this study, awe was measured through different awe subscales representing characteristics of an awe experience, namely perceived vastness, altered time perception, connectedness, and diminished self (visual awe subscale). Significant results show that in the high-awe mountain landscape, individuals perceived a greater sense of vastness and felt the smallest (visual awe subscale) compared to the high-awe beach and the low-awe forest landscape, proving that individuals experienced awe the most in the high-awe mountain environment. In this specific landscape, the massive and vast mountain view may have

potentially made the participants in the mountain condition feel physically small since vastness can be perceptual (Yaden et al., 2018). Interestingly, participants in the high-awe beach environment felt largest in relation to the other conditions, regardless of the sense of spaciousness bodies of water may portray (Völker et al., 2011).

There were no significant effects on either altered time perception or connectedness. However, although insignificant and with only a slight difference on the means, it is nevertheless interesting to view connectedness (beach: $M = 4.75$, $SD = 1.31$, mountain: $M = 4.18$, $SD = 1.14$), forest: $M = 4.16$, $SD = 1.41$), and altered time perception (beach: $M = 5.51$, $SD = 1.08$, mountain: $M = 5.23$, $SD = 1.13$), forest: $M = 4.87$, $SD = 1.65$) as they show that they were slightly highest in the high-awe beach, followed by the high-awe mountain, and lastly the low-awe forest landscape. Hence, approving the categorization of mountain and beach conditions as high-awe conditions and the forest as a low-awe condition.

Moreover, results show a significant effect on perceived body boundaries between participants in different conditions. In line with the hypothesis that meditation in an awe-eliciting VR nature environment reduces the salience of perceived body boundaries, findings show that participants score a lower PBBS score in the high-awe landscapes than in the low-awe environment, with the high-awe beach landscape scoring lower than the high-awe mountain landscape. Hence, participants in the high-awe landscapes felt little to no distinction between themselves and their environment, decreasing self-salience and increasing feelings of connectedness. This finding aligns with Dambrun and Ricard's Self-Centeredness/Selflessness Happiness Model (2011), suggesting that mediation practices trigger a diminished self and more awareness of the present moment and one's environment. Similarly, these results can be supported by the effects of awe, including an increase in feelings of connectedness and being less self-centered (Shiota et al., 2011). Therefore, hypothesis H3 can be supported.

However, taking close attention to the means of both visual scales, diminished self (*M = 4.67*, *SD* = 1.35, mountain: *M = 3*,19 *SD* = 1.82), forest: *M = 4.07*, *SD* = 1.41), and perceived body boundaries (beach: *M = 3.30*, *SD* = 1.32, *M = 3.94*, *SD* = 1.09, forest: *M = 4.17*, *SD* = 1.53), all participants, no matter which condition they find themselves in, felt a sense of connection to the environment and experienced a diminished sense of self, as figures five to seven on Dambrun's Perceived Body Boundaries Scale (2016) are very salient and only start getting imperceptible to their environment from the fourth figure downwards; comparably in the Diminished Self Scale (Bai et al.,) figures five to seven illustrate big individuals compared to the sun and become smaller from the fourth figure downwards. Looking at the bigger picture, all conditions triggered the feelings of awe and were aware of the present experience. These results support the findings of Chirico and her colleagues (2016) that using VR effectively elicits awe and that a sense of "presence" can be provoked in virtual reality. However, one can argue whether 360-degree videos can be called Virtual Reality because the 360-degree videos used in this study were made from real-life natural environments, which may have instigated these results more because of its nature-like multiple sensory cues (Annerstedt et al., 2013).

In line with the hypothesis, findings (marginally) show significant effects of the awe-eliciting VR meditation conditions on State Anxiety Difference. Overall, all three conditions reduced state anxiety among individuals who joined the experiment. However, the two high-awe landscapes, beach and mountain, reduced state anxiety within participants more than the low-awe forest landscape. Therefore, hypothesis H1 can be (marginally) supported as the two high-awe conditions display a more substantial enhancement of anxiety reduction than the control group, which highlights awe to be an essential part of nature's ability to decrease stress and increase well-being (Anderson et al., 2018). Therefore, the findings of this research

marginally answer the research question that awe-eliciting VR meditation reduce symptoms of stress and anxiety in adults.

However, contrary to the hypothesis, in contrast with the mountain scene, the beach scenery generated the most significant decrease in anxiety among participants, which led to H1a being rejected. This outcome may be due to the present desirable attributes of blue space in this condition, such as the sound of the waves, the color, and the ocean's clarity, and the waves' motion may have increased its restorative characteristic (Völker et al., 2011).

Additionally, the results do not indicate a significant effect of the VR meditation conditions on mindfulness. The insignificant outcome may be predictable because meditation is not a single, one-time practice but rather a training that should be learned and practiced over time (MBSR; e.g., Kabat-Zinn, 1982). Hence, H2 and H2a are rejected.

Furthermore, the data do not indicate a significant effect of the VR meditation conditions on positive emotions. Participants in all conditions experienced similar positive emotions during and after the VR meditation.Therefore, H4 and H4b are rejected.

Lastly, the study aimed to explore the relationship between the concept of mindfulness and awe since both have similar effects on individuals based on literature. Findings demonstrate a moderate positive correlation between the awe subscales connectedness and altered time perception with mindfulness, thus implying a direct relationship between the variables. Participants who score high on mindfulness ultimately felt stronger feelings of awe and vice versa. Therefore, H5 is supported.

5.2 Practical Implications

The study's results offer scientific support for a clear, moderate positive correlation between mindfulness and awe and the possible effectiveness of VR meditation on stress reduction. Today, individuals are confronted by increasing stressors in their daily lives, which are

accepted and seen as usual in society, eventually overwhelming most of the global population. *Mental health issues* are a serious matter that should inherently be acknowledged and accepted. As mental health issues are rising today, urgent solutions are required. The study shows that Virtual Reality effectively provides users a controlled and safe environment in which immersion is possible and a sense of "presence" delivered. This study adds to the evidence that the VR innovation allows more boundless accessibility for individuals to experience awe and meditation to cope with stress and potentially treat stress and mental health issues such as anxiety.

Accordingly, institutions, companies, or even the private consumer can make use of meditation in a natural VR environment as an instrument to improve wellbeing. This implication is substantial, especially for those who are enabled or restricted, since one has the opportunity to relax and unwind from the stressful modern lifestyle without needing to travel to a specific destination. On the other hand, taking VR out of the picture, these findings suggest that meditation, nature, or other aspects that may trigger awe should be encouraged in everyday life to improve overall wellbeing.

5.3 Limitations

Like every study, this research has several limitations that need to be considered. The main limitation is the absence of a pre-test to evaluate different environments that may or may not elicit awe beforehand, which would have resulted in a much clearer distinction between the high-awe and low-awe environments.

In addition, the length of the meditation session was slightly short, which likely did not give the full effect of a mindfulness meditation training, since these practices should be done repetitively over a more extended period to see their long-term effects, which was not the case in this one-time short meditation experiment. Hence, considering the success, duration and

structure of various mindfulness-based therapy (MBT), such as mindfulness-based cognitive therapy (MBCT; e.g., Segal et al., 2002) and mindfulness-based stress reduction (MBSR; e.g., Kabat-Zinn, 1982), mindfulness trainings should be practiced over time. Correspondingly, an experimental procedure that runs through a long period of time would have been more suitable for this study.

Moreover, the structure of the experiment, in which participants just had to read a guided meditation text before the meditation session, may not have been the best option. Participants were eager to use the VR glasses and experience immersion, potentially distracting them from the meditation practice and breathing exercises. A guided mindfulness meditation would have assisted the participants during the meditation, particularly those who had no prior meditation experience, potentially creating more substantial effects.

Furthermore, the findings of the present study show no significant effect of the VR meditation conditions on positive emotions. Possibly because the scale consisted of several distinct positive emotions that may have not been applicable to the experience. Hence, having subscales of different positive emotions instead of a general one might have resulted in significant effects.

Moreover, the study would have been more comprehensive if both negative and positive emotions were measured since the purpose of mindfulness is to let feelings, thoughts and emotions come and go without judgement. For instance, some participants may have associated negative emotions with a particular environment which have been completely ignored in this study.

5.4 Recommendation for Future Research

The limitations section gives future researchers an overview of what they need to consider if they plan to conduct similar research. First, pre-tests are always relevant to evaluate the

conditions that fit best with the research aim and identify issues that could have been prevented easily, such as a more substantial difference of the distinctive conditions. Thus, having awe conditions and the control condition tested before the final data collection offers a better comparison of different natural landscapes.

Taking mindfulness meditation into account, future research should consider conducting a study that occurs over a more extended period, so one can better evaluate the benefits of the meditation practice as it is a concept that should be practiced frequently. Additionally, a lengthier (in terms of time) guided meditation is more likely to offer participants, particularly those who did not have prior experience in meditation, the advantages of mindfulness meditation because they have a longer time to get used to the (new) situation. Moreover, in a guided meditation, participants are accompanied by a voice telling them what they must do, for instance, a breathing practice. Additionally, it may be ideal to evaluate both positive and negative emotions in mindfulness mediation. Thus, all these might help to enhance and maximize the effects and results to improve mental health interventions.

Furthermore, combining a self-report like the present study with physiological measures is interesting. This way, more examinations can be made, such as monitoring heart rate variability, breath frequency, and blood pressure, and measuring different stress hormones to have a complete picture of the effects of the feeling of awe and mindfulness among individuals.

Finally, the findings show a clear, moderate positive correlation between different characteristics of the feeling of awe and mindfulness, making it interesting to explore the combination of both concepts more in future research.

6. Conclusion

This research was designed to explore the role of awe in nature on our wellbeing in a mindfulness practice in VR. The results provide evidence of the effectiveness of VR meditation in eliciting awe and its corresponding effects (the small self and connectedness). Moreover, the study provides further proof of the ability of VR to provoke a sense of "presence." Though, one can debate if the 360-degree videos of real nature used in this study should be considered virtual reality since VR is normally known to be a computer-generated, interactive replication of an environment.

Moreover, significant marginal results show that meditation in high-awe landscapes in VR reduces stress, providing evidence of nature's therapeutic potential. In general, this study shows that any natural landscape, even if simulated, and meditation practices are likely to reduce stress among individuals. If future researchers consider the recommendations of this research, a more substantial outcome could be met.

We are approaching an increasingly urbanized and digitalized world, causing us to become more and more disconnected from nature. Hence, finding ways to promote mental health through novel innovations is an appropriate solution. While direct contact with real nature is favoured and recommended, VR can be an alternative for enabled and restricted individuals. Furthermore, a much more enhanced understanding of meditation will increase the acceptance and use of such training as a treatment for stress and other serious mental health issues, which eventually facilitates significant research regarding meditation. The corelation of awe and mindfulness could be a starting point for future research.

However, considering our extreme disconnection with nature and its consequences like mental health issues, global warming, and the loss of biodiversity, researchers and policymakers should also place attention and effort to reducing the loss of experience and

reconnecting individuals more with nature. This way, we are not just keeping ourselves healthy but also saving the environment.

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Appendix

Table 5

Tests of Between-Subjects Effects

Dependent Variable: StateAnxietyDifference

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1.253[a]	2	.626	2.452	.092
Intercept	18.614	1	18.614	72.851	<.001
Condition1	1.253	2	.626	2.452	.092
Error	22.485	88	.256		
Total	42.361	91			
Corrected Total	23.738	90			

[a]. R Squared = .053 (Adjusted R Squared = .031)

Table 6

Descriptive Statistics

StateAnxietyDifference

Condition1	Mean	N	Std. Deviation
Beach	.5944	30	.67194
Mountains	.4570	31	.42157
Forest	.3056	30	.37417
Total	.4524	91	.51357

Table 7

Tests of Between-Subjects Effects

Tests of Between-Subjects Effects

Dependent Variable: PerceivedVastness

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	25.182[a]	2	12.591	10.459	<.001
Intercept	1445.756	1	1445.756	1200.928	<.001
Condition	25.182	2	12.591	10.459	<.001
Error	105.940	88	1.204		
Total	1583.125	91			
Corrected Total	131.122	90			

[a]. R Squared = .192 (Adjusted R Squared = .174)

Table 8

Descriptive Statistics

Report

PerceivedVastness

The video I saw was:	Mean	N	Std. Deviation
Beach	3.6417	30	1.15349
Mountain	4.7258	31	1.19610
Forest	3.5917	30	.91793
Total	3.9945	91	1.20703

Table 9

Tests of Between-Subjects Effects

Tests of Between-Subjects Effects

Dependent Variable: AlteredTimePerception

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	6.053[a]	2	3.027	1.762	.178
Intercept	2463.920	1	2463.920	1434.548	<.001
Condition	6.053	2	3.027	1.762	.178
Error	151.145	88	1.718		
Total	2622.000	91			
Corrected Total	157.198	90			

[a]. R Squared = .039 (Adjusted R Squared = .017)

Table 10

Descriptive Statistics

Report

AlteredTimePerception

The video I saw was:	Mean	N	Std. Deviation
Beach	5.5067	30	1.07861
Mountain	5.2323	31	1.13266
Forest	4.8733	30	1.64965
Total	5.2044	91	1.32161

Table 11

Tests of Between-Subjects Effects

Dependent Variable: Connectedness

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	6.683[a]	2	3.341	2.008	.140
Intercept	1731.394	1	1731.394	1040.338	<.001
Condition	6.683	2	3.341	2.008	.140
Error	146.455	88	1.664		
Total	1883.360	91			
Corrected Total	153.138	90			

[a.] R Squared = .044 (Adjusted R Squared = .022)

Table 12

Descriptive Statistics

Report

Connectedness

The video I saw was:	Mean	N	Std. Deviation
Beach	4.7467	30	1.31194
Mountain	4.1806	31	1.13766
Forest	4.1600	30	1.41070
Total	4.3604	91	1.30443

Table 13

Tests of Between-Subjects Effects

Diminished Self: How small or big do you feel in the moment?

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	33.529[a]	2	16.765	7.046	.001
Intercept	1437.967	1	1437.967	604.384	<.001
Condition	33.529	2	16.765	7.046	.001
Error	209.372	88	2.379		
Total	1675.000	91			
Corrected Total	242.901	90			

[a.] R Squared = .138 (Adjusted R Squared = .118)

Table 14

Descriptive Statistics

How small or big do you feel in the moment?

Condition	Mean	N	Std. Deviation
Beach	4.67	30	1.348
Mountain	3.19	31	1.815
Forest	4.07	30	1.413
Total	3.97	91	1.643

Table 15

Tests of Between-Subjects Effects

Dependent Variable: Mindfulness

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1.271[a]	2	.636	1.860	.162
Intercept	1211.431	1	1211.431	3544.297	<.001
Condition	1.271	2	.636	1.860	.162
Error	30.078	88	.342		
Total	1243.089	91			
Corrected Total	31.350	90			

[a]. R Squared = .041 (Adjusted R Squared = .019)

Table 16

Descriptive Statistics

Report

Mindfulness

The video I saw was:	Mean	N	Std. Deviation
Beach	3.7933	30	.53257
Mountain	3.6516	31	.52287
Forest	3.5022	30	.68609
Total	3.6491	91	.59019

Table 17

Tests of Between-Subjects Effects

Dependent Variable: m

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	12.102[a]	2	6.051	3.450	.036
Intercept	1314.222	1	1314.222	749.341	<.001
Condition	12.102	2	6.051	3.450	.036
Error	154.338	88	1.754		
Total	1482.000	91			
Corrected Total	166.440	90			

[a]. R Squared = .073 (Adjusted R Squared = .052)

Table 18

Descriptive Statistics

m

Condition	Mean	N	Std. Deviation
Beach	3.30	30	1.317
Mountain	3.94	31	1.093
Forest	4.17	30	1.533
Total	3.80	91	1.360

Table 19

Tests of Between-Subjects Effects

Dependent Variable: Positive_Emotions

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1.854[a]	2	.927	2.110	.127
Intercept	1167.602	1	1167.602	2657.000	<.001
Condition	1.854	2	.927	2.110	.127
Error	38.671	88	.439		
Total	1209.110	91			
Corrected Total	40.525	90			

[a] R Squared = .046 (Adjusted R Squared = .024)

Table 20

Descriptive Statistics

Report

Positive_Emotions

The video I saw was:	Mean	N	Std. Deviation
A	3.6867	30	.71763
B	3.6806	31	.64157
C	3.3800	30	.62665
Total	3.5835	91	.67103

Table 21

Correlation Mindfulness and Awe (subscales)

Correlations

		Connectedness	AlteredTimePerception	PerceivedVastness	Mindfulness
Connectedness	Pearson Correlation	1	.586**	.264*	.536**
	Sig. (2-tailed)		<.001	.011	<.001
	N	91	91	91	91
AlteredTimePerception	Pearson Correlation	.586**	1	.263*	.389**
	Sig. (2-tailed)	<.001		.012	<.001
	N	91	91	91	91
PerceivedVastness	Pearson Correlation	.264*	.263*	1	.044
	Sig. (2-tailed)	.011	.012		.682
	N	91	91	91	91
Mindfulness	Pearson Correlation	.536**	.389**	.044	1
	Sig. (2-tailed)	<.001	<.001	.682	
	N	91	91	91	91

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Figrure 1

Pre- and Post-test

Dear participant,

Thank you for participating in this survey!

This survey is for my bachelor thesis in Communication Science at the University of Twente. The purpose of this study is to explore the relationship between different nature exposures in virtual reality and wellbeing, specifically mindfulness and positive emotions.

This survey has two parts: a pre and post VR experience.

Firstly, I kindly ask you to fill out the first part of the survey.
Then, you will be asked to read a mindfulness text, followed by the VR experience, where you will be asked to wear VR glasses.
Subsequently, you will fill out the final part of the survey.

Doing the experiment and filling in the questionnaire will take about 12-15 minutes of your time.

All your data will be kept strictly confidential and anonymous.

→

I hereby declare that I have been given information in a clear manner about the nature and method of the research that I am about to partake in. All my questions have been answered sufficiently. Hence, I consent voluntarily to participate in this study, and I am aware that I reserve the right to withdraw this consent without the need to provide any reason.

Yes, I consent.

→

What is your age in years?

What is your gender?

- Male
- Female
- Non-binary / third gender
- Prefer not to say

What is your nationality?

What is the highest level of education you have completed (so far)?

- High school or similar
- Bachelor degree
- Master degree
- PhD
- Not applicable/ prefer not to answer

→

How do you feel in this **specific moment**?

	Not at all	Mildy	Moderately	Very much so
I feel calm.	○	○	○	○
I am tense.	○	○	○	○
I feel upset.	○	○	○	○
I feel relaxed.	○	○	○	○
I feel content.	○	○	○	○
I feel worried.	○	○	○	○

Kindly read the meditation text carefully.

You are about to be in a virtual reality environment.

Take a moment to make yourself comfortable where you are. Maybe straighten your back or relax your neck. Once you've reached a place of stillness, begin to deepen your breath. In through the nose and out through the mouth.

Once you have the VR glasses on, you may look around.

Remember to take slow, deep inhales and complete exhales from time to time.
As you begin awareness of your breath, start to notice what thoughts are going through your mind.
What are you thinking about?
What emotions are you feeling?
Do not get caught up in your thoughts and emotions, but just begin to notice them as they travel across your mind.
Let them go as they pass, and watch them come and go.

Continue to breathe deeply.

Begin paying attention to even the smallest details that you can notice. Any sight that stands out. Try to notice how the place is making you feel.

Are you happy? Excited? Content? Or even sad?

Focus on the feelings and gently wrap your arms around them, like an embrace.
Remember, Take slow, deep breaths through your nose and out your mouth.

Allow the feeling to morph into you, so that you can take this happy state wherever you go.

Keep in mind:
"I am present. I am here. I am breath."

You completed the first part of the survey. You can now notify the researcher to get started with the Virtual Reality meditation.

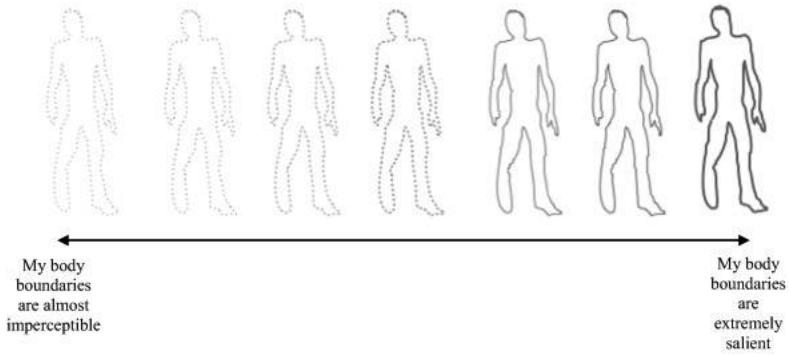
How do you feel in this **specific moment**?

	Not at all	Mildly	Moderately	Very much so
I feel calm.	○	○	○	○
I am tense.	○	○	○	○
I feel upset.	○	○	○	○
I feel relaxed.	○	○	○	○
I feel content.	○	○	○	○
I feel worried.	○	○	○	○

Below is a list of statements concerning mindfulness. Please use the rating scale to indicate how well each statement describes your experiences **in the past 3 minutes**. There are no wrong or right answers. Do not take too long to think about your answers, just take the first thing that comes up in your mind.

	Not at all	Rarely	Some of the time	Often	Most of the time
I noticed pleasant and unpleasant emotions.	○	○	○	○	○
I noticed pleasant and unpleasant thoughts.	○	○	○	○	○
I noticed emotions come and go.	○	○	○	○	○
I was aware of different emotions that arose in me.	○	○	○	○	○
I felt aware of what was happening inside of me.	○	○	○	○	○
I was aware of what was going on in my mind.	○	○	○	○	○
I felt closely connected to the present moment.	○	○	○	○	○
I had moments when I felt alert and aware.	○	○	○	○	○
I actively explored my experience in the moment.	○	○	○	○	○
I felt that I was experiencing the present moment fully.	○	○	○	○	○
I tried to pay attention to pleasant and unpleasant sensations.	○	○	○	○	○
It was interesting to see the patterns of my thinking.	○	○	○	○	○
I noticed many small details of my experience.	○	○	○	○	○
I noticed thoughts come and go.	○	○	○	○	○
I found some of my experiences interesting.	○	○	○	○	○

When we feel mindful, we may have the feeling that our bodies are not so strictly separated from the environment in which we find ourselves in, we feel more connected. Please have a look at the body silhouettes presented below. Indicate (after reflecting on your experience) which one best matches your experience of body boundaries **right now**. If the boundaries of your body are extremely salient you should select the image on the extreme right. If the boundaries of your body are almost imperceptible you should select the image on the extreme left.



1 (far left)

2

3

4

5

6

7 (far right)

Please indicate which one of the following drawings best describes yourself in this **specific moment**.

1 (far left)

2

3

4

5

6

7 (far right)

Please indicate if you agree with these statements.
At this specific moment:

	Completely disagree	Moderately disagree	Slightly disagree	Neutral	Slightly agree	Moderately agree	Complete agree
What I watched provided me with a deep sense of vastness	○	○	○	○	○	○	○
I felt small in front of what I watched	○	○	○	○	○	○	○
I felt meaningless in front of what I saw	○	○	○	○	○	○	○
I felt my sense of self diminish in front of what I saw.	○	○	○	○	○	○	○

Please indicate if you agree with these statements.

At this specific moment:

	Completely disagree	Moderately disagree	Slightly disagree	Neutral	Slightly agree	Moderately agree	Completely agree
I sensed things momentarily slow down.	○	○	○	○	○	○	○
I noticed time slowing.	○	○	○	○	○	○	○
I felt my sense of time change.	○	○	○	○	○	○	○
I experienced the passage of time differently.	○	○	○	○	○	○	○
I had the sense that a moment lasted longer than usual.	○	○	○	○	○	○	○

Please indicate if you agree with these statements.

At this specific moment:

	Completely disagree	Moderately disagree	Slightly disagree	Neutral	Slightly agree	Moderately agree	Completely agree
I had the sense of being connected to everything.	○	○	○	○	○	○	○
I felt a sense of communion with all living things.	○	○	○	○	○	○	○
I experienced a sense of oneness with all things.	○	○	○	○	○	○	○
I felt closely connected to humanity.	○	○	○	○	○	○	○
I had a sense of complete connectedness.	○	○	○	○	○	○	○

Please think back to **how you felt after experiencing the natural environment in Virtual Reality,** and rate how often you experienced the following emotions.
There are no wrong or right answers. Do not take too long to think about your answers, just take the first thing that comes up in your mind.

	Not at all	Hardly	Some of the time	Often	Most of the time
I felt amused, fun-loving, silly.	○	○	○	○	○
I felt awe, wonder, amazement.	○	○	○	○	○
I felt content, serene, peaceful.	○	○	○	○	○
I felt glad, happy, joyful.	○	○	○	○	○
I felt grateful, appreciative, thankful.	○	○	○	○	○
I felt hopeful, optimistic, encouraged.	○	○	○	○	○
I felt inspired, uplifted, elevated.	○	○	○	○	○
I felt interested, alert, curious.	○	○	○	○	○
I felt love, closeness, trust.	○	○	○	○	○
I felt proud, confident, self-assured.	○	○	○	○	○

You are basically finished!

Which of these destinations do you prefer?

- The Beach
- Mountainous areas
- Wilderness areas

Have you tried meditation prior to this experience?

- yes
- no

The video I saw was:

A

B

C

- A
- B
- C

You are basically finished!

Which of these destinations do you prefer?

- The Beach
- Mountainous areas
- Wilderness areas

Have you tried meditation prior to this experience?

- yes
- no

You have finished the survey!

Thank you for your participation! :)

If you request further information about the research, now or in the future, contact the researcher (Jeanine Röhr) via roehrjeanine@gmail.com