ATMIRE

Awe in the metaverse: Designing and validating a novel online virtual-reality awe-inspiring training

Item Type	Article
Authors	Pizzolante, Marta;Borghesi, Francesca;Sarcinella, Eleonora;Bartolotta, Sabrina;Salvi, Carola;Cipresso, Pietro;Gaggioli, Andrea;Chirico, Alice
Citation	Pizzolante, Marta, Francesca Borghesi, Eleonora Sarcinella, Sabrina Bartolotta, Carola Salvi, Pietro Cipresso, Andrea Gaggioli, and Alice Chirico. "Awe in the Metaverse: Designing and Validating a Novel Online Virtual-Reality Awe-Inspiring Training." Computers in Human Behavior 148 (November):107876. 2023.
DOI	https://doi.org/10.1016/j.chb.2023.107876
Rights	Attribution 4.0 International
Download date	2025-08-07 06:24:50
Item License	http://creativecommons.org/licenses/by/4.0/
Link to Item	https://hdl.handle.net/20.500.14490/936

Computers in Human Behavior 148 (2023) 107876

Contents lists available at ScienceDirect

Computers in Human Behavior

journal homepage: www.elsevier.com/locate/comphumbeh

Awe in the metaverse: Designing and validating a novel online virtual-reality awe-inspiring training

Marta Pizzolante [a,*], Francesca Borghesi [b], Eleonora Sarcinella [c], Sabrina Bartolotta [c], Carola Salvi [d,e], Pietro Cipresso [b,f], Andrea Gaggioli [a,f,1], Alice Chirico [a,1]

[a] Research Center in Communication Psychology, Catholic University of Milan, Italy
[b] Department of Psychology, University of Turin, Italy
[c] Department of Psychology, Catholic University of Milan, Italy
[d] Department of Psychiatry and Behavioral Sciences, University of Texas at Austin, Austin, TX, United States
[e] John Cabot University of Rome, Italy
[f] Applied Technology for Neuro-Psychology Lab, I.R.C.C.S Istituto Auxologico Italiano, Milan, Italy

ARTICLE INFO

Handling Editor: Prof. Paul Kirschner

Keywords:
Creativity
Metaverse
Complex emotions
Virtual reality
Awe-inspiring training

ABSTRACT

An increasing number of studies have unveiled the nuanced nature of awe - a complex emotion stemming from stimuli so perceptually and conceptually vast to impact individuals' current mental frames. Its positive impact on human wellbeing and health have been reported even after a single short exposure to awe-inspiring stimuli. Recently, Virtual Reality (VR) has emerged as a suitable technique for eliciting brief moments of intense awe. Moreover, nowadays, the Metaverse has increased the opportunity to access even complex experiences, such as awe, for a prolonged period. However, the impact of a prolonged exposure to an awe-inspiring simulated experience still must be investigated. Here, in the first study, we designed and tested usability, user experience and preliminary effectiveness of the first VR awe-inspiring training vs. an equivalent neutral training in VR. We relied on an immersive virtual reality online social platform- *Altspace VR* - for designing the training. In the second study, we investigated whether a prolonged exposure to awe could hold the same effect on creative thinking as it was demonstrated for brief exposure to awe in VR. Specifically, we tested the impact of a long-lasting exposure to awe on creative thinking in the short and on the long run (after the training and in a one-week follow-up) and vs. an equivalent neutral condition (the same as the first study). Creativity thinking, was assessed through Alternative Uses Task (AUT). Additionally, measures related to the disposition to feel positive emotions, social desirability and level of curiosity were collected. The first study supported the feasibility of the training together with the usability of the platform as well as its effectiveness in eliciting awe (vs. neutral condition). Moreover, for the second study, there was a main effect of time on some of the dimensions of creative thinking. Participants scored higher in fluency, originality, and flexibility one week after the training compared to the pre-training phase. These results suggested preliminary design guidelines for creating awe experiences in the Metaverse, unveiling the role of time exposure and duration of their effects on individuals.

1. Introduction

Awe is a complex emotion mainly composed of two appraisal themes, that is, the *sense of vastness* -the perception of being in front of something either perceptually or conceptually vast, - and the *need for accommodation*, as the urgency to change current mental schema in response to those stimuli (Keltner & Haidt, 2003), which can exceed individuals' expectancies (Gocłowska et al., 2021).

A perceptual vastness can be elicited in various ways, and nature has emerged as a frequent source of this feeling (van Cappellen & Saroglou, 2012a). However, other effective physical elicitors of awe also include human artifacts, i.e., large cathedrals or skyscrapers, which feature great sizes (Keltner & Haidt, 2003). On the other hand, awe can be also elicited by conceptually vast stimuli, such as great scientific discoveries or historical characters as both being capable of disrupting previous conceptions and providing a totally new way of viewing reality (Chirico &

* Corresponding author.
E-mail address: marta.pizzolante@unicatt.it (M. Pizzolante).
[1] These authors equally contributed as last authors of this manuscript.

https://doi.org/10.1016/j.chb.2023.107876
Received 14 December 2022; Received in revised form 17 February 2023; Accepted 10 July 2023
Available online 20 July 2023
0747-5632/© 2023 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).

Yaden, 2018).

With this regard, awe has been increasingly conceived more than a basic emotion but as something closer to an experience (Bonner & Friedman, 2011; Chirico & Gaggioli, 2018; Pearsall, 2007). Already, Keltner and Haidt suggested different *flavors* of awe, depending on the type of elicitor. *Threat* represents a fear component when awe is accompanied by and combined with feelings of fear, experienced when faced with threatening and dangerous stimuli (e.g., a tornado). *Beauty* is related to stimuli that characterize the emotion of awe with a component of "aesthetic pleasantness" (Keltner & Haidt, 2003, p. 304) whereas a*bility* is felt when awe is accompanied by admiration when in the presence of someone with outstanding abilities or skills. Finally, *virtue* is faced with cases of remarkable moral virtue, namely elevation (Keltner & Haidt, 2003)while *supernatural causality* is connected to the presence of a supernatural entity, which can be perceived as positive or negative adding an uncanny characteristic to the experience of awe, qualifying awe respectively with elements of magnificence or terror. Also, at the experimental level, eliciting awe can induce also a wider range of discrete emotions, suggesting a multifaceted nature of this emotional experience (Nelson-Coffey, 2019).

Investigating the complexity of awe has resulted in a multiple labelling of this emotion depending on which awe's dimension and effect is mostly considered. As a *positive* emotion, awe has been shown to broaden thought-action repertoires, in terms of higher levels of perception and wider focus of attention while as an *aesthetic* emotion it has been considered like the notion of sublime, which usually arises from somewhat fascinating but threatening stimuli (Arcangeli, Sperduti, Jacquot, Piolino, & Dokic, 2020; Clewis, Yaden, & Chirico, 2022). This mixed valence has also been found in profound and rare moments of change in which a person is no longer the same as before, that is, in transformative experiences (Bonner & Friedman, 2011; Chirico et al., 2022; Pearsall, 2007). This has suggested a *transformative* nature of awe (Chirico & Yaden, 2018), also encompassing a *self-transcendent* dimension of change (Chirico et al., 2022; Yaden et al., 2016, 2017), which entail heightened sense of *connection* and of *self-diminishment*, known as the "small self" (Piff, Dietze, Feinberg, Stancato, & Keltner, 2015). These two features also emerged as key assets in the *prosocial* potential of this emotion (Perlin & Li, 2020) till embracing the entire humanity as a part of our self (Chen & Mongrain, 2021; Seo, Yang, & Laurent, 2022), or the surrounding nature (Ambrose, Wiezel, Pages, & Shiota, 2021; Wang, Zhang, Shi, Lu, & Song, 2019). Finally, awe has been also conceived as an *epistemic or knowledge* emotion able to ignite the desire to fill existing gaps of knowledge (Valdesolo, Shtulman, & Baron, 2017). With this regard, awe was also found associated with cognitive processes entailing a cognitive restructuration of individuals' current mental frames, - as a plausible counterpart of the need for accommodation dimension of this emotion - such as creative thinking, at the level of divergent (Chirico, Glaveanu, Cipresso, Riva, & Gaggioli, 2018) or convergent thinking and daily creativity (Zhang et al., 2021). This awe-creativity link subsisted also at the personality level and in different cultures. Zhang demonstrated that trait awe was associated with curiosity and creative personality, reporting that awe predicted more creative personality among adolescents in the U.S. and adults in the U.S.A., Iran, and Malaysia and, in terms of creative behavior, also predicted an increased likelihood of solving a creativity problem (Zhang et al., 2021). Given the inherently nuanced nature of this emotion, it is not surprising that researchers from different disciplines have increasingly pledged to unveil its potential, and to elucidate its underpinnings by reviewing secondary data as well as by manipulating it in the lab (Chirico & Gaggioli, 2018; Takano & Nomura, 2022). With this last regard, several techniques have been proposed and employed.

The most frequently used are video or images, in which participants were exposed to grand and vast panorama ranging from deep space images, Earth and stars (Silvia et al., 2015), to supercell (Gordon et al., 2017), or disruptive natural phenomena (e.g., tsunami and tornado) or notorious threatening animals (e.g., *Tyrannosaurus rex*) (Griskevicius, Shiota, & Neufeld, 2010; Saroglou, Buxant, & Tilquin, 2008; Shiota, Keltner, & Mossman, 2007; van Cappellen, Saroglou, Iweins, Piovesana, & Fredrickson, 2013; van Cappellen & Saroglou, 2012b)or asking participants to recall and write about awe experiences (Griskevicius et al., 2010). Rarely, these techniques have been also used for eliciting awe in consecutive days. Dobson (Dobson, 2015)conducted a two-step study in which a sample of 180 students was required to report a personal problem. Then, participants were either assigned to an awe-inspiring amusement-eliciting or a neutral video. After each exposure, participants were asked to solve the problem they had written about before. Interestingly, Dobson discovered those participants seeing the awe-inspiring video felt less distressed by their problem and wrote longer solutions. However, when participants were asked for a solution for task-related problems of a general nature, participants in the awe condition reported a higher level of problem-related distress. Therefore, experience of awe emerged as beneficial when dealing with a personal problem, but not when the problem involved a task to be accomplished. In Dobson's second study, 162 students were randomly assigned to the condition of awe, amusement or control. Participants watched a short video aimed at eliciting targeted emotions every day for five days. One week, two weeks, and four weeks after watching the video, participants' subjective well-being was measured using Emotions Experienced Questionnaire (EEQ) (King & Emmons, 1990). Participants in the awe-inspiring condition experienced high levels of awe and positive emotions (vs. amusing condition and the neutral one) and reported greater levels of subjective well-being, compared to participants in the other two conditions. That is, awe's effects on the short and long run emerged as different. A single exposure to awe resulted in higher perceived distress in solving a nonpersonal issue, while being repeatedly exposed to awe-inspiring stimuli was beneficial for individual subjective wellbeing.

These results were also in line with Anderson et al. exposed 124 veterans and youth repeatedly to awe through either 1-day or 4-day whitewater rafting trips (Anderson, Monroy, & Keltner, 2018). In this case, a natural experience of awe was used, thus enhancing the ecological validity of awe-induction. At the end of each day of rafting, participants completed a rafting diary in which they reported how much of each of six positive emotions they felt during the day, selected to capture a wide array of distinct positive states, including awe (Shiota et al., 2007). Results showed for the first time that the awe that people felt during both extraordinary and daily nature experiences predicts unique variance in improvements in well-being and stress-related symptoms above and beyond the effects of other positive emotions.

A further promising trade-off between standard awe-eliciting methods in the lab and the exposure to real awe-inspiring stimuli, can be new digital media (Cybulski, Keller, Nguyen, & Saundage, 2015; Lee, 2015) and more specifically, Virtual Reality (VR). In order to preserve awe's intensity even in a controlled space, several virtual simulations of prototypical instances of awe have been designed and tested (Chirico et al., 2017; Chirico, Ferrise, Cordella, & Gaggioli, 2018). Virtual reality (VR) has provided researchers with the possibility to resemble even paradoxical scenarios, such as the Overview Effect (i.e., the view of the Earth from outside its atmosphere (Yaden et al., 2016). In 2015, Gallagher et al. used a mixed reality test environment to induce this Effect and in which participants watched four simulations of the Earth or deep space as if they were astronauts on the International Space Station (Gallagher, Reinerman-Jones, Janz, Bockelman, & Trempler, 2015). Moreover, VR allows for racking participants' movements and psychophysiological parameters during the ongoing experience. At the same time, participants can access the simulation from a first and/or third-person perspective and they can potentially interact with object within the simulation. These are all key ingredients supporting another crucial variable associated to an enhanced emotional intensity in VR, which is the *sense of presence*, defined as the subjective feeling of being in another physical or imaginary place as it was reality itself (Riva, Waterworth, Waterworth, & Mantovani, 2011; Riva & Waterworth,

2014). For instance, Chirico et al. (2017) found that immersive and realistic VR scenarios effectively increased the intensity of awe experiences compared to normal non-immersive videos. Moreover, VR increased the sense of engagement, the sense of physical space – as key components of the sense of presence, as well as the perception of vastness (Riva, Baños, Botella, Mantovani, & Gaggioli, 2016; Stepanova, Quesnel, & Riecke, 2018).

If VR could be conceived as a new methodological frontier in the study of complex experiences, including awe, now, we are on the edge of a relatively new revolution concerning simulated experiences (Angelini et al., 2022). On the one hand, there is significant increase in accessibility, technical sophistication of VR devices, and in terms of connection among users. On the other hand, VR has evolved in its online social form, with the rise of the "Metaverse" (Cerasa, Gaggioli, Marino, Riva, & Pioggia, 2022). A crucial feature of this relatively novel form of VR is the possibility to act within these environments for a long time and as if they were in continuity with individuals' real life. Metaverse employs technology to create a hybrid experience that users can manipulate and explore as if they were physically present. To achieve this goal, the Metaverse is to promote different processes (Cerasa et al., 2022): a) the embodiment process, as the ability of simulative technologies to generate a sense of ownership of a digital/virtual body or a part of it; b) the Proteus effect: the tendency for people to be affected by their digital representation; and c) the seamless fusion of the digital and physical dimensions allowing a high level of personalization and customization. These key assets could be particularly valuable for the design of complex experiences and for the study of their effects on human wellbeing and health in the short, medium and long term, and both at the individual and at the social level. This last is quite underrepresented within the domain of awe, with few seminal exceptions in which collective elicitors of awe have been considered (e.g., Goldy, Jones, & Piff, 2022; Graziosi & Yaden, 2021).

In this article, in **Study 1**, we reported the first attempt to design and test the effectiveness of the first awe-inspiring training in the Metaverse, on the *AltspaceVR* platform, compared to a neutral training featuring information on the history of VR. In **Study 2**, the impact of a prolonged awe-inspiring VR training on creative thinking was tested, always in comparison to the same control condition as Study 1. In the following, the potential of the Metaverse for the elicitation of prolonged experiences of awe was outlined and discussed.

1.1. Study 1

1.1.1. Designing awe in the "Metaverse"

AltspaceVR – a novel virtual reality online social platform - was selected to design the awe-inspiring training and the neutral training in this study. *AltspaceVR* is the most prominent social VR platform, purchased by Microsoft in 2017, and it has become a major reality where people can meet and interact. *AltspaceVR* can be accessed both through a virtual reality headset and via other devices: PC, Tablet, smartphone, *smartTV (AltSpaceVR,* Microsoft inc., 2022). This versatility has made the platform increasingly accessible to users worldwide. The platform allows users to create events, create communities, and collaborate worldwide. An advantage of this platform is the ability to create and change the worlds that can be visited by users, increasing control over the environments. AltspaceVR platform was chosen among others since it allows the implementation of multiplayer experiences and multiple useful features to design an online training of this kind. It features two build-in media player screens, for uploading videos and pictures and scrolling through them like a slideshow. The second screen was used for sharing the awe-eliciting narrative. AltspaceVR also featured useful access control for administrators of the event, allowing them to mute or enhance the voice of any participant, remove potential troublemakers and keep track of everyone that joined any room of the event.

For the current study, 4 immersive VREs (Virtual Reality Environments) were created (two awe-inspiring and two neutral scenarios), following design guidelines provided in previous studies on VR awe-inspiring scenarios (Chirico et al., 2017; Chirico, Ferrise, et al., 2018; Gallagher et al., 2015; Kahn & Cargile, 2021; Kitson, Stepanova, Aguilar, Wainwright, & Riecke, 2020), and using predefined *AltspaceVR* templates. The first awe-inspiring environment represented a big natural space immersed in water, surrounded by immense trees and with a huge waterfall ("Tall Forest"). The second awe-inspiring scenario consisted of an outer space with planets, asteroids, and a reproduction of the Solar System ("Deep Space"). Some objects were created from scratch using the software Unity (version 2021.1.17) and were imported onto the platform, since objects present in *Altspace*'s creator's worlds was still limited to several pre-existing packages. The control and neutral scenarios represent a public plain garden and an empty room. To create a neutral scenario, aiming at inducing a non-specific emotional state, we followed guidelines by Baños (Baños et al., 2004, 2008; Diemer, Alpers, Peperkorn, & Shiban, 2015, Riva et al., 2007 and we deprived these virtual environments of several other cues used in the scenarios. Specifically, to contrast the effect of vastness conveyed by awe-inspiring scenarios and to ensure that these environments would not convey a need for accommodation, the public plain garden consists of a green floor, simulating a turf bordered by a fence, while the empty space consists of a closed three-dimensional space, simulating a waiting-room (for the entire procedure, please, see Procedure section, in **Study 1**).

The potential of each single virtual scenario for eliciting awe had been preliminarily tested in a pilot study involving a sample of ten high school teachers (Chirico, Shiota, & Gaggioli, 2021). Control condition consisted in a waiting list. Specifically, two immersive VREs, "Deep Space", "Tall Forest", in which participants could move freely while listening to the experimenters and two *ad-hoc* validated awe-inspiring narratives, were employed. Preliminary results of this pilot study showed an increase in the perceived sense of awe among participants in the experimental condition, in the post-training compared to the pre-training. Finally, *AltspaceVR* emerged as a simple tool to create engaging virtual scenarios connecting even distant people and conveying a stable and high sense of presence.

Here, we built upon encouraging results from this pilot study to fully develop a VR awe-inspiring training and its equivalent neutral condition. Moreover, in the current study also, a time dimension of effects was considered by including a pre-training assessment phase, a post-training one and a follow-up.

User experience and usability of the platform.

AltspaceVR is an online platform, and it can be accessed remotely. Participants in the training accessed the platform using their own devices – personal computers – and performed the training. Therefore, also usability and user experience (UX) of the platform was a further object of analysis in this study.

The goals of usability testing included establishing a baseline of user performance, validating user performance measures, and identifying potential design concerns to be addressed in order to improve the efficiency, productivity, and end-user satisfaction onboarding and executing in *AltspaceVR*. Hence, the second aim of the first study was to identify whether *AltspaceVR*'s visual design, interaction design, and technical communication was captivating, clear to new users, and to identify any barriers in the use of the platform.

User experience, from a long tradition, has been characterized by its considerable importance within the realization and optimization of products and systems. Despite the various studies and the rich validated methodologies, however, UX has remained a complex and difficult field to be defined in its entirety, due to the richness of methodologies and tools that can be used, coming from a huge variety of different disciplines. Working on user experience in fact means bringing together different but complementary contributions from disciplines such as design, engineering and even psychology. It is precisely psychology that has been able to make its way, adding itself to the investigation of the user experience by increasingly emphasizing on how the 'user' component is an essential element to be taken into consideration, especially

when designing experiences in which individuals are involved in complex experiences and in which emotions are the core center of those experiences themselves.

Within the more general topic of User Experience then, special attention has been paid to usability, namely, the evaluation of a technology or a product by means of efficiency, memorability, errors and satisfaction. If, during a final UX testing, these dimensions are all satisfied, then the designed experience can be considered successful (Law, Roto, Vermeeren, Kort, & Hassenzahl, 2008). If it is not the case, the goal of UX testing is to look for a strategy to improve the UX and to find the easiest way to implement the changes. It is precisely in this process that the usefulness of these UX analyses emerges, which makes it possible, by working on the elements deemed problematic, to avoid this scenario (Hassenzahl & Tractinsky, 2006). Moreover, design and testing VR scenario must consider issues such as perception, navigation, exploration, and engagement. They present far more significant challenges in terms of developing a coherent approach to design and comprehending the concept of usability in the context of VR, especially since conventional UX methods or guidelines are not fully applicable (Rebelo, Noriega, Duarte, & Soares, 2012; Wienrich, Döllinger, Kock, Schindler, & Traupe, 2018). As a result, even if the user is placed in a highly unreal world, VR experiences should strive to maximize intuitive operation, which is easiest to achieve when based on real scenarios (commonly known templates for dealing with the natural world). As previously stated, VR design is governed by its own set of rules, and there is still only a bare minimum of best practices in place. Therefore, usability testing plays a crucial role in creating a well-designed VR experience (Kaminska et al., 2022).

For this reason, one of the aims of the current study was to understand whether the platform used to assess the online training was able to ensure good usability in terms of ease of use and achievement of objectives with the least amount of effort, thus providing participants with an overall sense of satisfaction and positive user experience.

2. Methods and hypotheses

The general objective of this two-steps study is to test - by exploiting the potential of a virtual reality platform - the effectiveness of a validated training created *ad-hoc* to induce complex emotions such as awe. Consequently, we hypothesized that participants in the awe-inspiring training showed higher levels of awe after the training compared to the control condition (**H1**). Together with testing the effectiveness of the training in inducing awe, the second hypothesis of the first step of the study is therefore that the configuration of the *AltspaceVR* platform is structured in such a way as to ensure good usability in terms of ease of use and achievement of objectives with the least amount of effort, thus guaranteeing participants an overall sense of satisfaction and a positive user experience (**H2**).

2.1. Sample size calculation

55 participants took voluntarily part in the study. A priori power analysis was conducted using G*Power version 3.1.9.7 (Faul, Erdfelder, Lang, & Buchner, 2007)to determine the minimum sample size required to test the study hypothesis. Results indicated the required sample size to achieve 95% power for detecting a large effect, at a significance criterion of $\alpha = 0.05$, was $N = 55$ for independent samples *t*-test (Experimental condition vs. Control condition). Thus, the obtained sample size of $N = 55$ was adequate to test the study hypothesis.

2.2. Inclusion criteria

The inclusion criteria considered were the participants' age - between 18 and 60, language -as full knowledge of Italian is required. Moreover, participants with vestibular or neurological disorders were excluded. The experimental protocol was approved by the Ethical Committee of the Università Cattolica del Sacro Cuore prior to data collection. Each participant provided written informed consent for study participation. Written consent and all methods were carried out in accordance with the Helsinki Declaration.

3. Measures and Instruments

3.1. Awe

- *Dispositional awe*

The disposition to experience awe was assessed through one single item from the Italian validation of the Dispositional Positive Emotion Scale (DPES) scale (Chirico et al., 2021) aimed at investigating how each participant was inclined to experience awe.

- *State awe*

Levels of awe were measured after the training through the Italian version of Awe-Experience Scale (AWS), a scale consisting of 29 total items designed to investigate the lived experience (Yaden et al., 2019). The questionnaire consists of 6 different sub-scales, altered time perception, self-diminishment, connectedness, perceived vastness, physical sensations, need for accommodation.

Moreover, a single item Likert self-report measure was used to assess *awe* on a 7-point Likert scale (from 1 = not at all; to 7 = extremely), along with other items measuring other seven distinct emotions (from 1 = not at all; to 7 = extremely): joy, and consensual definitions of emotions taken from literature (Algoe & Haidt, 2009; Frijda, 1988; Griskevicius et al., 2010; Haidt, 2000; Herring, Burleson, Roberts, & Devine, 2011; MORREALL, 1989; Tong, 2015) before and after the training, on a 7-point Likert scale (from 1 = not at all; to 7 = extremely).

3.2. Presence

- *Sense of presence*

Sense of presence was assessed before and after the training through ITC-Sense of Presence Inventory (ITC-SOPI) (Lessiter et al., 2001). ITC-SOPI aimed at investigating the users' perceived sense of presence in relation to the use of a medium. It consists of 42 total items divided into two blocks, the first consisting of 6 items while the second consists of 36 items. A 5-step Likert scale is provided for both blocks (1 = strongly disagree; 5 = strongly agree).

- *Social presence*

Social presence within the online platform was assessed before and after the training using Networked Minds Social Presence Inventory (NMSPI). NMSPI is an inventory consisting of 34 total items distributed among four dimensions - Co-presence, Social presence, Subjective symmetry, and Intersubjective symmetry - that aims to investigate the perceived 'social presence' dimension following a lived experience, specifically, the feeling of being together with someone else within the same mediated space (Biocca, Harms, & Burgoon, 2003). The degree of agreement with the proposed items is measured by means of a 5-step Likert scale.

3.3. User experience and usability

User Experience and usability of the platform were assessed through the System Usability Scale (SUS) (Brooke, 1996), a 10-item scale through which the concept of usability of a system is quickly investigated. The degree of agreement with each of the statements regarding the system used is measured using a 5-step Likert scale (1 = strongly disagree; 5 = strongly agree). Moreover, another questionnaire, User

Experience Questionnaire (UEQ-s) - short version was employed. This is a short version of the User Experience Questionnaire aimed at investigating the experience the user had and perceived with regard to a product. This version consists of 8 items, each of which has two extreme adjectives (obstructive-supportive, complicated-easy, inefficient-efficient, confusing-clear, boring-exciting, not interesting-interesting, conventional-inventive, usual-leading edge) and a 7-level graduated scale within which to position oneself in the evaluation of the product (Schrepp, Hinderks, & Thomaschewski, 2017).

3.4. Procedure

The training consisted of four phases (see Table 1).

First, participants were invited to download *AltspaceVR* the day before the training took place. On the day of the training, they were trained in the use of *AltspaceVR*. Basic controls (e.g., walking, turning on the microphone, listening to other participants, etc.) were showed, and explained, and participants had the change to try them under the supervision of a facilitator.

Then, the entire procedure was explained again to participants, and they were required to keep a browser window open with the link of the online questionnaires, they had been already provided with, besides the window in which *AltspaceVR* run. Once questionnaires had been completed, in the experimental group, a first theoretical introduction on emotions and their basic features (elicitors, appraisal themes, action tendencies, evolutionary function) was performed using the virtual presented, provided by the VR platform. Conversely, in this phase, participants in the control condition were shown a presentation on the history of virtual reality.

In the third phase, the experimental group accessed the world "Deep space", which also featured a validated awe-inspiring narrative lasting about 5 min. After this condition, participants were required to move to the other simulated scenario called "Tall Forest", in which, again, a validated 5-min awe-inspiring narrative started (see Fig. 1). Participants in the control condition entered two different virtual neutral scenarios (see Fig. 2). Furthermore, for the control condition, the narratives proposed were concerning the application of reality in medicine and psychotherapy while in the second room a narrative concerning the applications of virtual reality in design and entertainment was played. At the end of the awe-training, participants in the experimental condition were invited to take part in two different activities. In the first one, the conductor asks participants whether they wish to share a brief report of their experience and elaborate on the emotional side of it by using the emotional labels presented in the first phase of the training. The conductor wrote down on a whiteboard the key sentence and phrases and looked for connections and recurrent themes.

Finally, participants were required to look for potential connections between their actual experience in VR and past ones. They were free to share their thoughts or not openly. At the end of the whole procedure, participants in the experimental and control group were administered the post-training questionnaires. The entire training lasted 1 h with 3 different moments of break for participants, in order to avoid fatigue and cybersickness. The previous study conducted to test the feasibility of the training showed that participants' sense of presence remained constant across the different phases, and despite the breaks participants reported to have been felt immersed for the overall duration of the training in the experience and to have appreciated the whole design of the environments.

3.4.1. Data analysis

Analyses were performed using SPSS software for statistical analyses. The total sample consisted of 31 females and 23 males (mean age = 31.44 years; S. D = ± 13.01). All participants were eligible according to the selection criteria. Moreover, 26% of participants reported to have a high school diploma, 55.6% a bachelor's degree, 14.8% a master's degree and 3.7% a second-level master's degree, as their last degree. Finally, 36.6% of participants reported having previous experiences with VR.

4. Results

4.1. Awe

- *Dispositional awe*

As a preliminary check, we conducted an independent samples *t*-test comparing the two conditions (Experimental vs. Control condition) on participants' dispositional awe. Results showed no statistically significant difference between the two groups in terms of dispositional awe.

- *State awe*

In order to test the hypothesis that the training was able to induce the emotion of awe in the experimental group, an independent samples *t*-test

Table 1
Phases of the training for both groups, experimental and control, together with the measured used.

Phases	Experimental group	Control group	Measures
Welcoming (*Pre-training questionnaires, presentation*	- Familiarization of participants with the platform (moving around the environment, test microphones) - Administration of pre-training questionnaires through the link sent previously - PowerPoint presentation (topic: emotions).	- Familiarization of participants with the platform (moving around the environment, test microphones) - Administration of pre-training questionnaires through the link sent previously - PowerPoint presentation (topic: Virtual Reality).	DPES Awe-S ITC-SOPI Single Item Emotions BIDR-6
Experience in virtual worlds	Entrance into the two worlds: "Deep space" (Fig. 2) and "Mountains" (Fig. 3) and listening to the eliciting narratives awe.	Entrance into the two worlds: Room One (Fig. 4) and Room Two (Fig. 5) and listening to the narratives on the applications of virtual reality.	
Group discussion	Return to the "Experience Lab- Meeting Room" laboratory and group discussion on specific tasks (search for keywords that can represent the lived experience and reflections on how the sensations experienced could be useful in everyday life).	Return to the "Experience Lab- Meeting Room" laboratory and group discussion on specific tasks (search for keywords that can represent the lived experience and reflections on how virtual reality could be useful in everyday life).	
Conclusion + post-training questionnaires	Final thanks and request to exit the platform, retrieve the link in the e-mail and fill in the post-training questionnaires.	Final thanks and request to exit the platform, retrieve the link in the e-mail and fill out the post-training questionnaires.	Awe-S ITC-SOPI Single Item Emotions SUS UEQ-S NMSPI

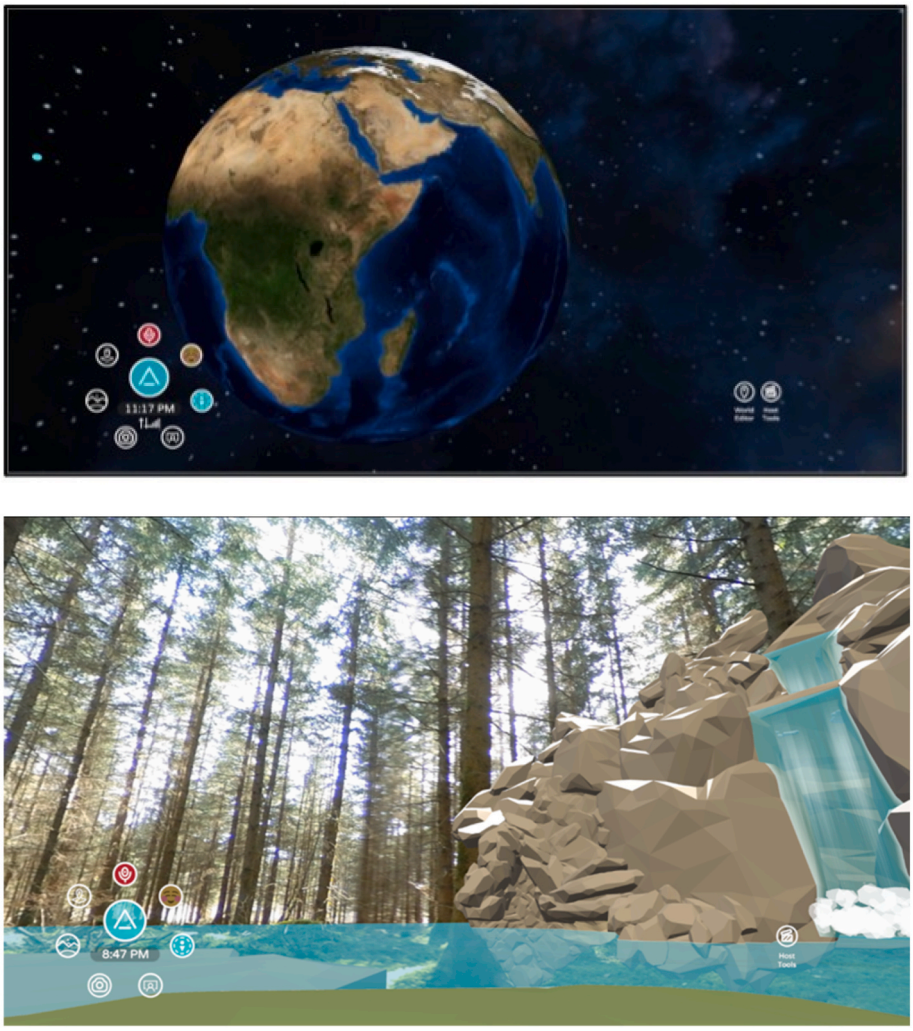


Fig. 1. Virtual scenarios representing "Deep Space" above, and "Tall Forest" below, used for the experimental training.

was conducted with awe ("Total awe" measured with the Awe-S) as a measure. A first analysis showed a statistically significant difference between the two groups in this scale [t (52) = 2.095, p = .041, d = 1.08] and specifically for the subdimensions vastness [t (52) = 2.05, p = .036, d = 1.68] and connectedness [t (52) = 2.12, p = .034, d = 1.64]. Specifically, the experimental group reported statistically higher scores of perceived awe than the control group after the training (see Table 2). Moreover, analysis conducted for the single item used to assess *awe* along with other items measuring other seven distinct emotions showed, about the post-training phase and only for the single item measuring awe, a statistically significant difference between the two groups [t (52) = 2.249, p = .029, d = 1.8]. Specifically, after the training, participants in the experimental group reported to have felt statistically higher levels of awe than the control group (see Table 3) (see Table 4).

4.2. Presence

- *Sense of presence*

We carried out an independent samples *t*-test comparing the two conditions (Experimental vs. Control condition) on each separate dimension of the individual presence (i.e., sense of physical space, engagement, ecological validity, negative effects), No statistically significant differences for all the four dimensions considered between the two groups were found.

- *Social presence*

We carried out independent samples *t*-test comparing the two conditions (Experimental vs. Control condition) on each separate dimension of social presence (i.e., Co-presence, Social presence, Subjective symmetry, and Intersubjective symmetry). No statistically significant

differences between the two conditions were found on any of the social presence dimensions.

4.3. Usability of the platform

Independent samples *t*-test comparing the two conditions (Experimental vs. Control condition) were carried out on System Usability Scale (SUS) and User Experience questionnaire (UEQ-s) scores. Analyses concerning SUS showed that there were no statistically significant differences between the scores of the experimental group and those of the control group. Both groups provided a positive assessment of the Usability variable. In fact, for the evaluation of the score of the SUS scale (Usability), the average value considered cut-off is 68; values below 68 are to be interpreted as synonyms of low usability while values above 68 are to be interpreted as synonyms of high - and therefore good - usability. In this case, both groups reported values above the average of 68.

Analyses carried out on User Experience Questionnaire (UEQ-s) showed that there were no statistically significant differences between the experimental group and the control group. Both groups provided a positive evaluation to the User Experience variable. In fact, the interpretation of the scores for the UEQ-s scale is based on the following cut-offs: the values between the scores −0.8 and 0.8 indicate a neutral evaluation and therefore neither positive nor negative -scores above 0.8 indicate a positive rating -values less than −0.8 indicate a negative rating. In this case, both groups, experimental and control groups, reported values above 0.8. This means that the platform has been judged – both by the experimental group and by the control group – as providing a good user experience. Moreover, positive results emerged for both subcategories of which the User Experience variable is composed ("pragmatic quality" and "hedonic quality"). For both, in fact, the overall score of the total sample indicated a positive judgment with respect to the platform and consequently with respect to the general user experience (see Fig. 3.).

5. Discussion

The aim of the study was to test the effectiveness of the awe-inspiring training vs. control one. A significant interaction effect between training (awe vs. Neutral) and time (pre vs. post exposure) was found for awe. The experimental group reported higher awe in the Awe-S and in the single item on awe, after the training and compared to the control group. Independent samples *t*-test evidenced that some dimensions of awe (vastness, connectedness and physical sensations) as measured by the Awe-S, were significantly higher in the experimental condition compared to the neutral condition. No trait variable emerged as a significant covariate, thus suggesting the training's effectiveness beyond individual differences.

Concerning the Usability and UX of the platform *AltSpaceVR* used to design the training, both control and experimental groups described usability of the platform as good and user experience as satisfactory. Therefore, the actual training setup can be considered as "*user-friendly*", i.e., easy, and intuitive to use. Finally, the fact that no statistically significant differences emerged between the two groups in terms of Usability and overall UX of the platform supported the suitability of the

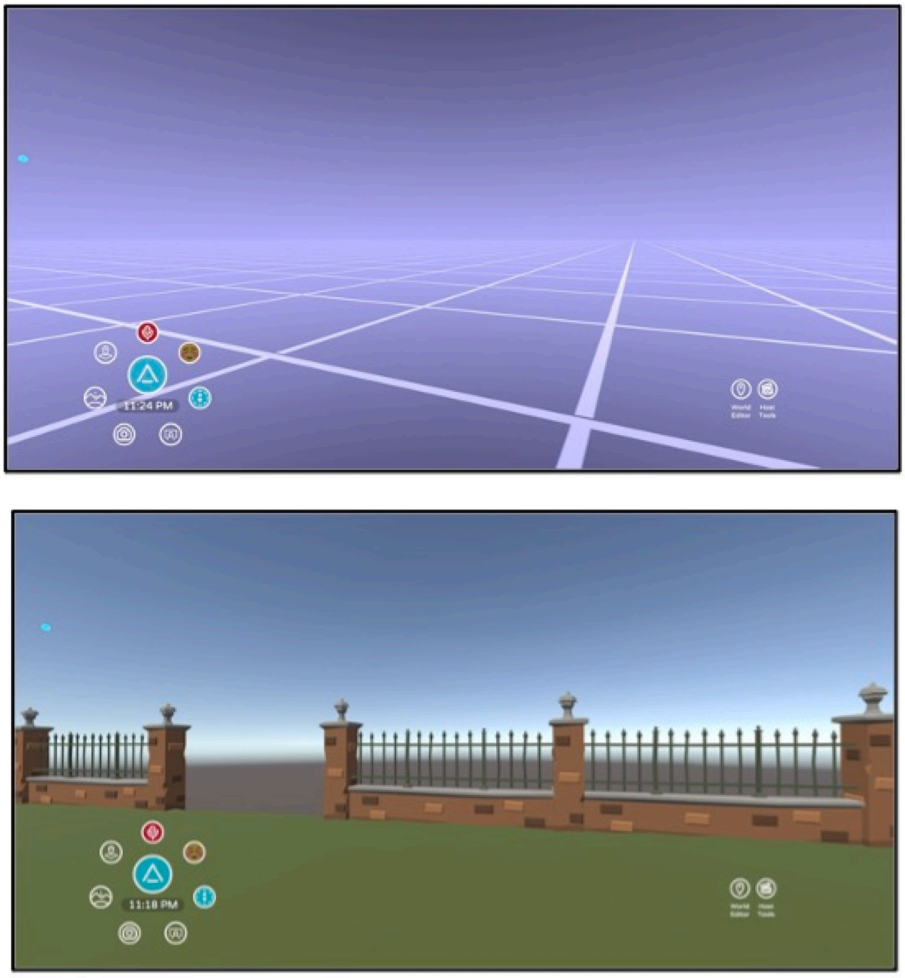
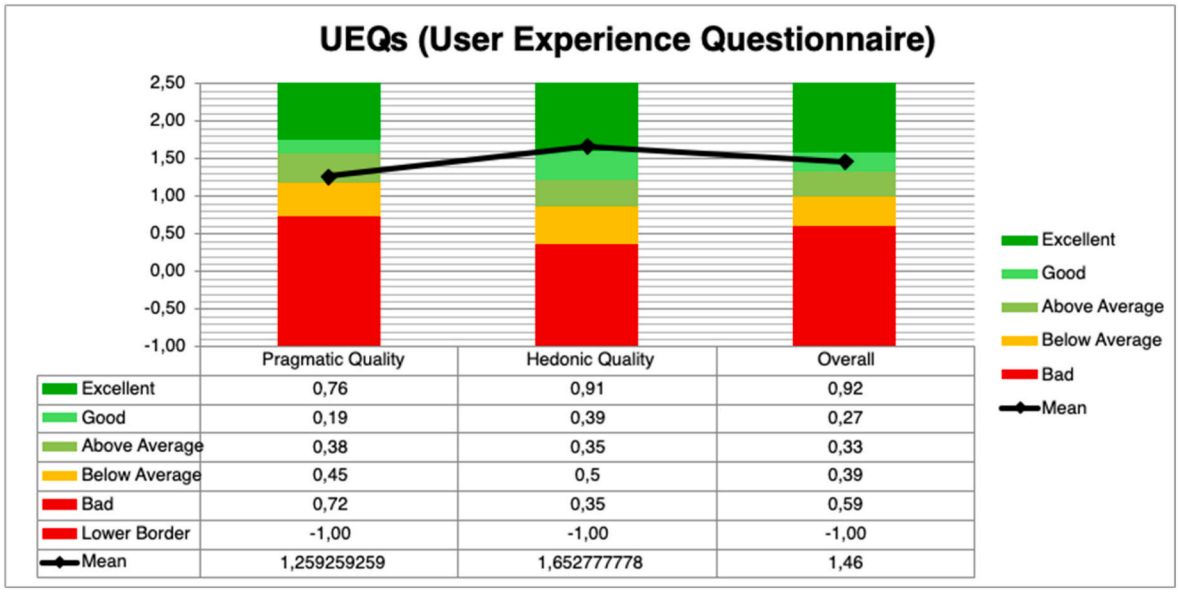


Fig. 2. Virtual scenarios representing two neutral spaces used for the control training.



	Pragmatic Quality	Hedonic Quality	Overall
Excellent	0,76	0,91	0,92
Good	0,19	0,39	0,27
Above Average	0,38	0,35	0,33
Below Average	0,45	0,5	0,39
Bad	0,72	0,35	0,59
Lower Border	-1,00	-1,00	-1,00
Mean	1,259259259	1,652777778	1,46

Fig. 3. Visualization of the User Experience Questionnaire (UEQ) benchmarks. The line represents the results computed by scores given by both experimental and control groups.

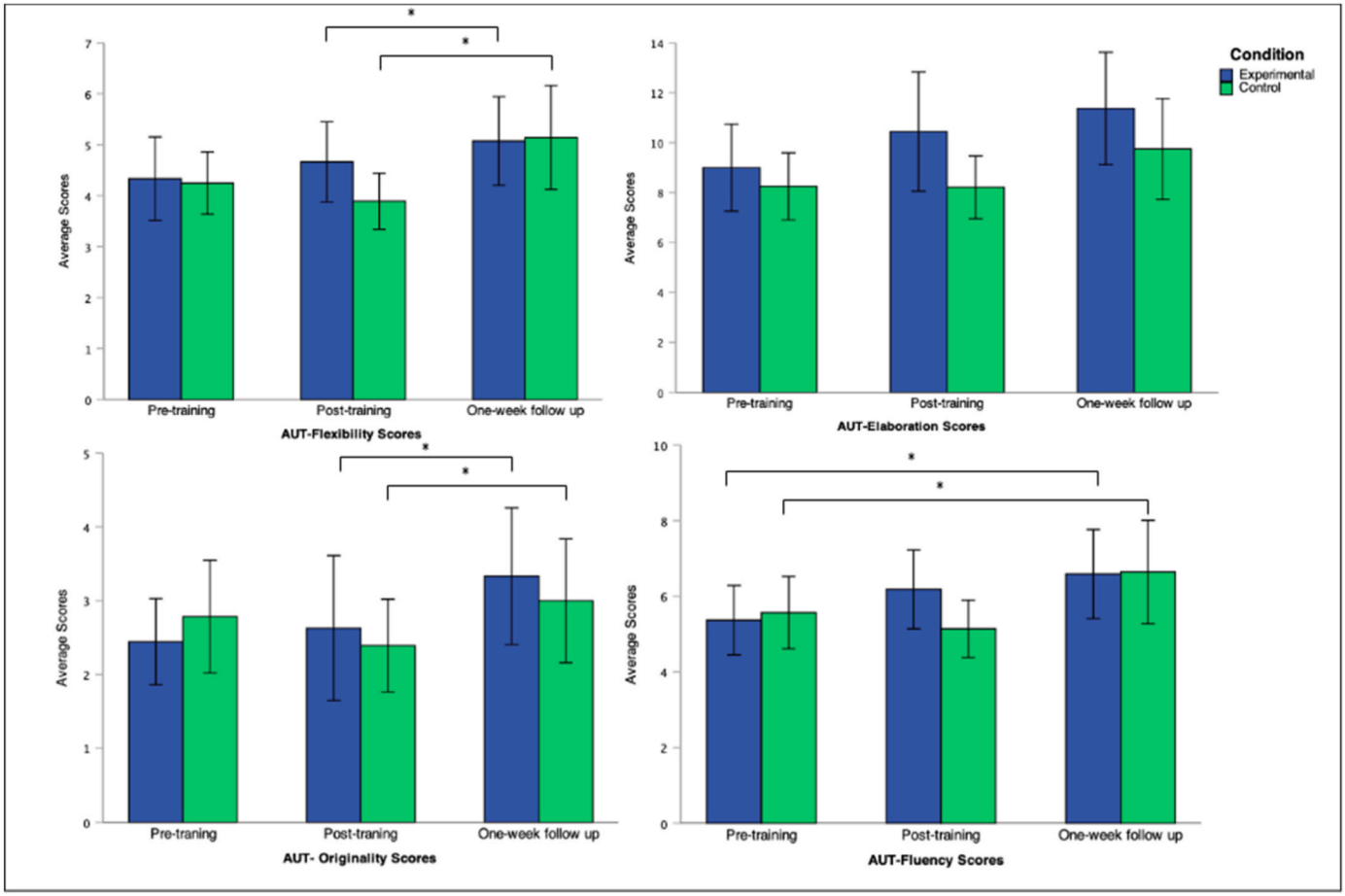


Fig. 4. AUT Flexibility, Elaboration, Originality and Fluency scores in the experimental and control condition before, after the training and in one-week follow up.

Table 2
Descriptive statistics of subdimensions measured by Awe Experience Scale post-training for both experimental and control condition.

Dimension of awe	Experimental condition		Control condition		T-test (Equal variances assumed)		
	Mean	SD	Mean	SD	T (df = 52)	p	*d* (Cohen)
Vastness	4.52	1.58	3.54	1.70	2.15	**.036**	1.68
Connectedness	4.03	1.80	3.08	1.40	2.12	**.038**	1.64
Self-diminishment	3.33	1.57	2.96	1.56	0.86	.38	1.56
Physical sensations	3.02	1.53	2.25	1.43	1.9	**.06**	1.49
Need for accomodation	2.70	1.24	2.51	1.17	0.56	.57	1.20

Note. N = 27. In bold, significant results.

Table 3
Descriptive statistics of eight discrete emotions measured through eight ad-hoc items post-training for both experimental and control condition.

Emotion	Experimental condition		Control condition		T-test (Equal variances assumed)		
	Mean	SD	Mean	SD	T (df = 52)	p	*d* (Cohen)
Anger	1.07	.26	1.33	1.00	−1.3	.19	.73
Disgust	1.11	.42	1.22	.50	−.87	.20	.46
Fear	1.26	.65	1.89	1.39	−1.12	.39	1.09
Pride	2.59	1.62	2.44	1.71	.32	.74	1.67
Amusement	4.59	1.69	4.11	1.62	1.06	.29	1.65
Sadness	1.89	1.34	1.44	.80	1.48	.14	1.10
Joy	4.11	1.69	3.90	1.79	0.85	.39	1.74
Awe	4.85	1.91	3.70	1.83	2.24	**.02**	1.86

Note. N=27. In bold, significant results.

neutral training as a comparable control condition for the target awe-inspiring training. The two trainings did not differ in terms of sense of presence and social presence, thus suggesting stability in this experience across the two conditions.

5.1. Study 2

5.1.1. Creativity and awe in the Metaverse

Appraisals of vastness and accommodation have been indeed demonstrated to cause people to explore the environment, gain new information, and develop new ways of thinking (Shiota, Campos, Keltner, & Hertenstein, 2004; Zhang et al., 2021). Curiosity, indeed, is triggered by information that makes the individual aware of gaps in existing knowledge structures. Awe-inspiring stimuli not only indicate a gap in current knowledge systems due to their need to be accommodated, but their vastness makes them highly noticeable due to their departure from one's typical frame of reference. To "fill the gap", people engaged in awe-related experiences frequently reported themes related to exploring the environment, altering existing worldviews, and generating novel perspectives (Campos, Shiota, Keltner, Gonzaga, & Goetz, 2013; Shiota et al., 2007). As a result, experiencing awe can foster an open mindset and motivate curiosity, that, in turn could encourage people to explore and approach experiences from novel perspectives, namely, to be more creative (Anderson, Dixson, Monroy, & Keltner, 2020). Furthermore, it has been shown that experiences that are affectively ambivalent and perceived as unusual would lead people to be more sensitive toward unusual and creative associations, more specifically, drawing from informational approach to emotions, when people feel emotionally ambivalent, the atypicality of this emotional experience could be interpreted as a reminder of being in an unusual environment wherein other unusual relationships might exist as well. Thus, this reminder would signal that people should adaptively process stimuli in this unusual environment in a more flexible way, being open to look for unusual associations and, consequently, being more sensitive to identify relationships between apparently unrelated concepts. In a recent study, Richardson et al. (Richardson, Tagomori, & Devlin, 2022) demonstrated how an unusual experience, such as that of being immersed in an underwater nightclub, has positive effect on the divergent thinking creativity performances.

As a diversifying experience, awe involves people in highly unusual, unexpected events which are actively experienced by individuals to embrace novel perspectives, values, and ideas through the breaking of routines (Gocłowska et al., 2021; Ritter et al., 2012). However, to our knowledge, only few studies attempted to rigorously test the direct link between awe and creative thinking. Güsewell & Ruch demonstrated that the willingness to be more prone to awe-related experiences than amusing ones is related to the intellectual disposition to creativity (Güsewell & Ruch, 2012), while Anderson (Anderson et al., 2020) showed that people most likely to experience awe were also those who report higher levels of dispositional curiosity and that awe at the dispositional level is indirectly associated with several academic outcomes of students (i.e., work ethic, behavioral engagement, academic self-efficacy). Zhang et al. (2021), conducted three different studies in which, confirming previous evidence, firstly confirmed that trait awe was associated with unconventionality and creative personality, above and beyond trait amusement and, in a second study, demonstrated that trait awe was related to convergent creativity, tested through the Duncker's Candle Problem (Duncker, 1945). In the last study, through daily diary methods and by surveying the same people daily, authors were able to demonstrate that people reported more creative behaviors on days when they also felt more awe than typical (Zhang et al., 2021).

Only a single study, the one by Chirico (Chirico, Glaveanu, et al., 2018) exposed participants to an awe-inducing 3D video to test whether even a single exposure to awe-eliciting content was able to increase participants' divergent thinking. The virtual content, aimed at eliciting awe, depicted a natural scenario. Compared to the control condition, in which participants were exposed to a neutral video, subjects belonging to the awe VR-eliciting experience performed better in the divergent thinking tasks, in terms of fluency, originality, flexibility and elaboration.

To conclude, the feeling of a complex emotion such as awe, is thought to be deeply linked to the possibility to experiment higher levels of creative thinking. First studies on awe, both in terms of state and dispositional awe, and creativity, suggested that the experience of awe and the consequent adoption of a more open mindset and a less conventional perspective may lead to greater creative potential which, in turn, may lead to better creative performance. However, firstly, studies attempting at setting a link between awe and creativity used a single

Table 4
Total awe score computed through the Awe Experience Scale (Total Awe), pre-training, post-training and one-week after the training for both experimental and control condition.

Time	*Experimental condition*						*Control condition*						*ANOVA (time*condition)*		
	Pre-training		Post-training		One-week follow up		Pre-training		Post-training		One-week follow up		F (1)	p	η2
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD			
Total awe	2.35	.81	3.17	1.03	3.01	1.20	2.54	.86	2.51	1.02	2.55	1.07	7.94	**.007**	1.64

Note. N = 27.

brief exposure to it without considering the effect of this emotion on the long run and, secondly, only one of these studies, that by Chirico (Chirico, Glaveanu, et al., 2018), attempted to test the effect of awe on creative thinking by means of a digital medium.

6. Methods and hypotheses

Our study intends to test the effects of prolonged exposure to awe, through a standardized training, on creative thinking, giving some insights into the nascent literature linked to Metaverse experiences. Therefore, we hypothesized that participants in the awe-inspiring training showed higher creative thinking, in terms of its subdimensions of fluidity, flexibility, originality and elaboration, after the training and compared with the control condition (**H3**).

6.1. Sample size calculation

54 participants voluntarily took part in the study. A priori power analysis was conducted using G*Power version 3.1.9.7 (Faul et al., 2007) to determine the minimum sample size required to test the study hypothesis. Results indicated the required sample size to achieve 95% power for detecting a medium effect, at a significance criterion of $\alpha = 0.05$, was $N = 54$ for a 2 [Condition (control vs. experimental):] x 3 [time (pre vs. post vs. Follow up) mixed ANOVA. Thus, the obtained sample size of $N = 54$ was adequate to test the study hypothesis.

6.2. Inclusion criteria

Inclusion criteria followed **Study 1** procedure. The experimental protocol was approved by the Ethical Committee of the Università Cattolica del Sacro Cuore prior to data collection. Each participant provided written informed consent for study participation. Written consent and all methods were carried out in accordance with the Helsinki Declaration.

6.3. Procedure

Procedure for Study 2 was the same as in Study 1. The second study consisted also of a follow-up phase that took place one week after the training.

7. Measures and Instruments

7.1. Awe

See "**Measures and Instruments**" in Study 1.

7.2. Sense of presence

Sense of presence was assessed through ITC-Sense of Presence Inventory (ITC-SOPI). For further details see "**Measures and Instruments**" in Study 1.

7.2.1. Excitement, curiosity and activation

Excitement, curiosity and activation were assessed by three ad-hoc single items in relation to the training experienced by the participants. The items were adapted from those originally used by Zhang and colleagues and measured on a 5-step Likert scale (Zhang et al., 2021) ("How much did you feel excited?" "*Durante lo svolgimento training, quanto ti sei sentito/a stimolato/a*?"; "How much did you feel curious?", "*Durante lo svolgimento del training, quanto ti sei sentito/a curioso/a?*"; "How much did you feel activated?" *"Durante lo svolgimento del training, quanto ti sei sentito/a inspirato/a?*")

7.2.2. Creative thinking

Creative thinking was measured through Alternative Uses Task (AUT) designed and developed by Guilford in 1967 (GUILFORD, 1967). AUT is one of the most used and effective existing way to test for divergent creativity. Unlike other way of testing divergent thinking, it focuses on how the participant develops a diverse set of responses and solutions to the same problem. Moreover, this test is suitable for the training, since, given the purpose of the second study, it is easy to be implemented in an online version and given the high duration of the training, it allows for repeated administration by keeping the same standardized procedure and it requires a lower amount time to be administered to participants compared to other ways of testing divergent thinking. In the Alternative Uses Task (AUT), the participant is asked to generate as many alternatives uses as possible for common objects. Objects chosen for this study were a brick, a can and a rope. Responses are analyzed by two different judges - an independent rater, who was not aware of the objective of this study nor of the experimental design, evaluated all responses - that categorized or "coded" them, based on the nature of the function given in the response; responses with similar functions received the same code. Originality and flexibility were computed based on the assigned codes, while fluency and elaboration were computed based on the raw responses (for further details about scoring, see Alhashim et al., 2020). Originality, flexibility, fluency and elaboration were the four subscales trough which scores were organized in our dataset.

7.2.3. Data analysis

Analyses were performed using SPSS software for statistical analyses. The sample consists of a total of 55 subjects (37 females), (mean age 23.93 years = SD = ± 2.193). All participants were eligible according to the selection criteria. Moreover, 30.9% of participants reported to have high school diploma, 56.4% a bachelor's degree, 10.9% a first-level master's degree 3.6%, 1.8% a 2nd level Master's degree. Finally, 44.2% of participants reported to have previous experiences with VR.

8. *Awe measures*

- *Dispositional awe*

As a preliminary check, we conducted an independent samples *t*-test (experimental vs. Control condition) on scores measuring the disposition to feel awe (DPES awe subscale). Results showed no statistically significant difference between the two groups.

- *State awe*

In order to test the hypothesis that the training was able to induce the emotion of awe in the experimental group and that this same emotion could also be maintained one week later, a 2 [Condition (control vs. experimental):] x 3 [time (pre vs. post vs. follow up) ANOVA was conducted with awe ("Total awe" measured with the Awe-S) as a measure. A first analysis showed the existence of a main effect of the within time factor [$F(1) = 9.72$, $p < .001$, $\eta^2 = 0.029$] on awe. In contrast, there was no main effect of the conditions of belonging on awe levels. Furthermore, a significant interaction effect between the within factor and the between factor emerged [$F(1) = 1.56$, $p < .001$, $\eta^2 = 0.22$]. The post hoc pairwise comparisons – with Bonferroni's correction – between the three different time frames featured a significantly increased awe at the end of the awe-inspiring training and in the follow up, compared to the initial phase of the training. Moreover, we also conducted a 2 [Condition (control vs. experimental):] x 3 [time (pre vs. post vs. follow up) ANOVA with awe measured through the single item as a measure. Significant differences in terms of awe levels were found between the control and experimental condition only in the post-training phase [$F(1) = 8.72$, $p < .001$, $\eta^2 = 0.025$].

8.1.1. Sense of presence

Regarding the dimensions of individual presence measured through the ITC-SOPI, an independent samples *t*-test was conducted by comparing the two conditions in terms of each single dimension of the sense of presence (i.e., ecological validity, physical presence, engagement, negative effects). A significant difference between the two conditions was found regarding the dimension of ecological validity [t (d.f = 52) = 2.204, p = .032, d = 0.75]. Specifically, the experimental group reported higher scores on the ecological validity sub-scale than the control group ($M_1 = 2.54$, $SD_1 = 0.78$; $M_2 = 2.10$, $SD_2 = 0.71$).

8.1.1.1. Excitement, curiosity and inspiration

Regarding excitement, curiosity and inspiration, a 2 x 3 mixed ANOVA on scores obtained by the experimental and the control group before, after or in a one-week follow up from the training did not show any statistically significant differences.

8.1.1.2. Creative thinking

To test whether the training was able to promote creative thinking, a 2 [Condition (control vs. experimental):] x 3 [time (pre vs. post vs. Follow up) ANOVA was carried out regarding each separate dimension of divergent thinking (i.e., originality, elaboration, fluidity, flexibility). Specifically, it can be Flexibility [F (d.f = 1) = 4.847, p = .010, η2 = 0.036] and Originality [F (d.f = 1) = 3.218, p = .044, η2 = 0.020] at time 3 (one-week follow-up) [($M_{1flexibility} = 5.01$, $SD_1 = 2.44$; $M_{2flexibility} = 5.14$, $SD_2 = 2.63$), ($M_{1originality} = 3.40$, $SD_1 = 2.44$; $M_{2originality} = 2.78$, $SD_2 = 2.18$)] were significantly higher compared to the post-training phase [($M_{1flexibility} = 4.70$, $SD_1 = 1.66$; $M_{2flexibility} = 4.25$, $SD_2 = 1.57$), ($M_{1originality} = 2.56$, $SD_1 = 1.78$; $M_{2originality} = 1.89$, $SD_2 = 1.18$)] in both conditions (control and experimental), while Fluency [F (d.f = 1) = 3,144, p = .047, η2 = 0.029] emerged as significantly higher in the follow up ($M_{1fluency} = 6.59$, $SD_1 = 2.97$; $M_{2fluency} = 6.64$, $SD_2 = 3.53$) compared to the initial phases of both trainings ($M_{1fluency} = 6.19$, $SD_1 = 2.63$; $M_{2fluency} = 5.576 SD_2 = 2.45$). In other words, no significant differences between the two conditions were observed regarding each dimension of divergent thinking.

Finally, no significant interaction effect of time x condition for any of the divergent thinking dimension was found. See Fig. 4. For a synthesis of these results.

10. Discussion

This second training aimed at testing the impact of a novel awe-inspiring training in the Metaverse, which is based on prolonged exposure to several awe inductors by means of different awe-eliciting techniques, on creative thinking. Considering the main effects of the condition (experimental vs. control training) analyses revealed that none of the four dimensions tested for creative thinking – fluency, flexibility, originality, and elaboration – showed significantly different scores between the experimental and control group. However, a difference was observed when considering the main effect of time and, thus, the increasing of the scores of the four sub-dimensions within each group over the three times – before the training, right after the training and one week later. The main effect of time was found for the sub-dimension fluency, together with flexibility and originality, but not for elaboration. This can suggest an unfolding potential of both training over time, hinting at a new variable to be considered within the domain of awe: duration of number of awe experiences. Moreover, these results can be deemed as partially in line with previous studies. Zhang et al. (Zhang et al., 2021) found that people who reported high levels of trait awe demonstrated greater creativity on various components of the construct. They also reported that trait and state awe also predicted an increased likelihood of solving a creativity problem. Our results demonstrated that state awe predicted, even if not significantly, better performance in terms of creativity thinking, in fluency, originality and flexibility dimensions. What emerged clearly, however, was the increase of creativity scores right after and one week after the training compared to the performance in the same tasks before the training itself. This underlined the huge impact of the training, in terms of good usability of the platform and designing of the experience itself, on creativity skills of participants. Also, we aimed at improving results from previous studies attempting at setting a link between awe and creativity but that used only a single brief exposure to awe without considering the effect of this emotion on the long term (Chirico, Glaveanu, et al., 2018).

On one hand, the lack of a significant difference of creativity performance between experimental and control conditions, could be due to a novelty effect, represented using the platform. For both groups, indeed, at least 56% of participants reported to have never experienced VR and specifically a social VR-based platform. On the other hand, in this study, due to the duration of the training, a between-subjects design was adopted. Novelty could have played a role in the detection of significant differences between groups in terms of divergent thinking dimensions. However, also the role of previous expertise with VR and related devices was measured and imported as a covariate, and it did not emerge as a significant intervenient variable. Therefore, a measure of novelty not related to the objective novel nature of the stimulus might be considered.

Secondly, qualitative data, collected in the final debriefing phase, showed that all participants in both conditions reported that the training allow them the deep expression of positive emotions, such as “wonder, “astonishment” and “joy”, among all the phases of the training and particularly when asked to discuss and share, through the focus group, their own feelings. Participants in both conditions reported positive feelings during the training. At the same time, participants reported a sense of disquiet, fear at times, for being confronted with something never seen before, sometimes perceived as “infinite”, or in any case “incredibly vast”. A sense of altered spatial and temporal dimensions was also reported by some participants in both groups. Furthermore, several participants reported a sense of feeling “connected” to the experience they were having, which also led them to make deeper reflections on themselves. So, although the levels of awe experienced within the experimental group were significantly higher than those of the control group, the experience with the platform and the training itself was emotionally arousing in both groups.

Moreover, in line with previous studies in the literature (Gocłowska et al., 2021; Richardson et al., 2022; Ritter et al., 2012) this affective ambivalence experienced by participants, both in the experimental group and – even if to a lesser extent – in the control group, could partly explain the absence of significant differences in the two groups. Likewise, such affective ambivalence experienced following the training could partly shed light on the increases over time observed in both the experimental and control groups in the different sub-dimensions of creative thinking. As demonstrated by Fong, individuals who are feeling emotionally ambivalent show heightened sensitivity to associations. This enhanced sensitivity is due to emotional ambivalence being regarded as an unusual and unique emotional experience (Fong, 2006). That is, being immersed for a prolonged period in an environment that arouses ambivalent feelings may have prompted participants to generate a greater number of innovative and original associations and ideas in AUT task, detected only for and by the subdimension elaboration.

Moreover, as also posited in the Diversifying Experiences’ model of Gocłowska et al. (2021), this unusual class of experiences could hold moderate intensity, otherwise, it turns into something expensive at the cognitive and emotional level. In this case, maybe, the duration and commitment – in terms of cognitive resources – required of the participants for active participation in the training together with the performance in the creative tasks may have contributed to the different scores obtained by participants in creativity tasks at time 2, right after the training, and time 3, in a one-week follow-up. That is, one week after the training, participants executed again only creativity tasks without taking part into the awe-inspiring training and so, performing significantly

better in terms of creative thinking skills.

11. Conclusions and future directions

This two-steps study aims at testing for the first time whether an evidence-based training designed in VR conducted on the Metaverse, the social platform *AltSpaceVR,* was effective in eliciting awe in two different groups of participants. Specifically, the study followed an incremental logic in analyzing, together with the effectiveness of the training, the usability of the platform, for Study 1, and the link between awe and creativity, for Study 2. The second aim, addressed by the first study, was to analyze the user experience provided by the platform, as well as its usability while the third objective, exploited by the second study, was to test the levels of creativity of participants, in terms of creative thinking, immediately after the training and one week later. In order to meet these objectives, two different training were conducted.

This is the first time the impact of a prolonged exposure to an awe-inspiring VR environment was tested. With respect to the first hypothesis concerning the effectiveness of the training, quantitative results from the first study were able to confirm the effectiveness of the training, both for its structure and the type of platform chosen, for inducing a complex emotion such ad awe. Levels of awe were found to be significantly higher than that elicited by the control training and the effect could be seen also in a follow-up, one week after the end of the training. Moreover, for the first training, we hypothesized that the configuration of the *AltspaceVR* platform would ensure good usability in terms of ease of use and achievement of objectives with the least amount of effort, thus providing participants with an overall sense of satisfaction and a positive user experience. Participants reported a satisfying experience related to the use of the platform, which supported the potential of social VR as an effective tool for designing complex experiences. Participants' qualitative reports indeed indicated that the wide array of options for customizing avatars emerged as a positive factor capable of generating a sense of general satisfaction in users. Some participants noted that realizing their avatar version was a moment when they could either recreate themselves while remaining true to themselves or, on the other hand, choose to opt for a new identity. Regarding the use of the platform as a way to interact and meet other people online, sharing thoughts and feelings, all participants stated that they feel confident talking and interacting with other people and that the communication within the social space was fluid and, in some circumstances, even easier compared to that in real everyday life.

Therefore, VR social platforms such as *AltspaceVR* confirm themselves as an efficient, user-friendly and effective tools for designing such trainings aims at eliciting complex emotions and investigating their link to constructs such as creativity. Indeed, the second main aim of the current research was to test whether the experimental training, by eliciting awe, would also increase participants' creative thinking levels. In this case, the results obtained only partially confirm the research hypotheses since we find out a main effect of time on some of the dimensions of creative thinking, namely fluency, flexibility and originality. Future research, however, have to improve some aspects regarding the administration of the training. In our case, all participants logged onto the platform using a computer and enjoyed the multimedia content in non-immersive mode via the PC screen itself. Although an increase in awe levels was observed in the participants belonging to the experimental group, confirming the effectiveness of the training in inducing this complex emotion, it is nevertheless possible that a more immersive inductive technique (i.e., VR viewers) would have ensured an optimal activation level to be reached, which would have allowed a greater impact of the training on creative thinking measures to be observed.

Moreover, we may not find out a stronger difference between experimental and control groups in creativity performance due to the overall duration of the training that may have contributed to fatigue of the participants and, consequently, indirectly impacted on the performance obtained in the post-training phase. For this reason, it would certainly be useful to test whether reducing the overall duration of the training (i.e., only using the narratives and experiences in the two virtual worlds) could lead to different results. Moreover, the neutral training could be further emptied of arousing stimuli to decrease its emotional impact on participants. In summary, further studies could advance current findings in four main ways. First, they can replicate the same methodology but requiring participants to use more immersive devices such as Head Mounted Displays (HMDs). Then, as already mentioned, creative thinking can be investigated also in terms of convergent thinking, and not just divergent thinking. Therefore, a suitable future conclusion can be considering both divergent and convergent thinking measures in the different phases of the training, along with measures of insight placed in the most arousing moments of the training itself (Salvi, 2021; Salvi, Simoncini, Grafman, & Beeman, 2020). Moreover, the methodology itself can be sharpened by adding more pauses and more VR scenarios able to feature different instances of awe, such as the view of an Eclipse or Auroral Borealis.

Finally, on one hand, AltspaceVr platform proved as an efficient, user-friendly, emotion-inducing training. This result may suggest that also social VR platforms could become suitable instruments not just for eliciting complex emotional states, but also for testing the impact of these phenomena on specific skills, such as creative abilities. Specifically, it would be useful, as a further step, to test the transferability of skills learnt during these social VR emotional trainings in reality.

With this regard, our findings open the more general debate around the potentiality of employing awe-inspiring training in the Metaverse within different fields and domains. In healthcare, awe-eliciting scenarios can be implemented to stimulate self-transcendence positive emotions, which, in turn have been linked to well-being (Yaden, Haidt, Hood, Vago, & Newberg, 2017). Moreover, there is a growing interest in elucidating the potential therapeutic role of awe for depression by considering the potential connections between these two phenomena across multiple levels—namely, the psychological, hormonal, neurophysiological, and existential levels (Chirico et al., 2020; Chirico & Gaggioli, 2021). In education, awe-eliciting scenarios could be applied in online-based learning activities; indeed, there is growing interest in incorporating creativity, along with other elements such as collaboration and positive emotions, into the learning process to enhance students' critical and reflective thinking skills (Supena, Darmuki, & Hariyadi, 2021). Digital platforms like AltspaceVR, enable the creation of collaborative environments that can evoke complex and positive emotions, potentially enhancing educational processes. Implementing awe-inducing scenarios in specific moments of learning process (e.g., during abstract conceptualization or reflective thinking) could potentially broaden the cognitive resources of the learner, leading to better elaboration of contents material. To conclude, the training can be used for potentially unlimited purposes and giving the increasing number of evidence in favor of virtual nature of wellbeing promotion and nature connectedness and Pro environmental behavior promotion, these fields might be an urgent and promising object of analysis in this Metaverse experience.

Credit author statement

Marta Pizzolante: Conceptualization, Data curation, Formal analysis, Investigation, Writing - original draft, Project administration, Funding acquisition. **Francesca Borghesi**: Data curation, Formal analysis, Writing - review & editing. **Sabrina Bartolotta***:* Software, Visualization. **Eleonora Sarcinella**: Writing - review & editing, Visualization. **Carola Salvi:** Writing - review & editing, Visualization. **Pietro Cipresso:** Methodology, Writing - review & editing. **Andrea Gaggioli:** Conceptualization, Funding acquisition, Supervision. **Alice Chirico:** Conceptualization; Methodology, Project administration, Funding acquisition, Supervision, Writing - review & editing.

Funding

This work has been supported by the Ministry of University and Research (MUR), formerly Ministry of Education, University and Research (MIUR) within two projects funded by "Education and research for recovery – REACT-EU", included in the NOP Research and Innovation 2014–2020 and by Fondazione Cariplo, grant: "Promoting Education of Scientific and Technological Societal Issues Through Sublime (PROMETHEUS)" n°: 2019–3536.

Publication ethics

The experimental protocol was approved by the Ethical Committee of the Università Cattolica del Sacro Cuore prior to data collection (Date: 20/05/2022, N. 53–122). Each participant provided written informed consent for study participation. Written consent and all methods were carried out in accordance with the Helsinki Declaration.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Acknowledgments

The authors wish to thank all participants as well as Dr. Valentina Gramaglia and Alessio D'Angelo for their valuable contributions to this study.

References

Algoe, S. B., & Haidt, J. (2009). Witnessing excellence in action: The 'other-praising' emotions of elevation, gratitude, and admiration. *The Journal of Positive Psychology, 4*(2), 105–127. https://doi.org/10.1080/17439760802650519

Alhashim, A. G., Marshall, M., Hartog, T., Jonczyk, R., Dickson, D., van Hell, J., et al. (2020). WIP: Assessing creativity of alternative uses task responses: A detailed procedure. In *ASEE Annual Conference and Exposition*. Conference Proceedings, 2020-June.

Ambrose, L. E., Wiezel, A., Pages, E. B., & Shiota, M. N. (2021). Images of nature, nature-self representation, and environmental attitudes. *Sustainability, 13*(14). https://doi.org/10.3390/su13148025.

Anderson, C. L., Dixson, D. D., Monroy, M., & Keltner, D. (2020). Are awe-prone people more curious? The relationship between dispositional awe, curiosity, and academic outcomes. *Journal of Personality, 88*(4), 762–779. https://doi.org/10.1111/jopy.12524

Anderson, C. L., Monroy, M., & Keltner, D. (2018). Awe in nature heals: Evidence from military veterans, at-risk youth, and college students. *Emotion, 18*(8), 1195–1202. https://doi.org/10.1037/emo0000442

Angelini, L., Mecella, M., Liang, H.-N., Caon, M., Mugellini, E., Abou Khaled, O., et al. (2022). Towards an emotionally augmented metaverse: A framework for recording and analysing physiological data and user behaviour. 13th augmented human international conference, 1–5. https://doi.org/10.1145/3532530.3532546.

Arcangeli, M., Sperduti, M., Jacquot, A., Piolino, P., & Dokic, J. (2020). Awe and the experience of the sublime: A complex relationship. *Frontiers in Psychology, 11*. https://doi.org/10.3389/fpsyg.2020.01340

Baños, R. M., Botella, C., Alcañiz, M., Liaño, V., Guerrero, B., & Rey, B. (2004). Immersion and emotion: Their impact on the sense of presence. *CyberPsychology and Behavior, 7*(6), 734–741. https://doi.org/10.1089/cpb.2004.7.734

Baños, R. M., Botella, C., Rubió, I., Quero, S., García-Palacios, A., & Alcañiz, M. (2008). Presence and emotions in virtual environments: The influence of stereoscopy. *CyberPsychology and Behavior, 11*(1), 1–8. https://doi.org/10.1089/cpb.2007.9936

Biocca, F., Harms, C., & Burgoon, J. K. (2003). Toward a more robust theory and measure of social presence: Review and suggested criteria. *Presence: Teleoperators and Virtual Environments, 12*(5), 456–480. https://doi.org/10.1162/105474603322761270

Bonner, E. T., & Friedman, H. L. (2011). A conceptual clarification of the experience of awe: An interpretative phenomenological analysis. *The Humanistic Psychologist, 39*, 222–235. https://doi.org/10.1080/08873267.2011.593372

Brooke, J. (1996). SUS-A quick and dirty usability scale. *Usability Evaluation in Industry, 189.194*, 4–7.

Campos, B., Shiota, M. N., Keltner, D., Gonzaga, G. C., & Goetz, J. L. (2013). What is shared, what is different? Core relational themes and expressive displays of eight positive emotions. *Cognition & Emotion, 27*(1), 37–52. https://doi.org/10.1080/02699931.2012.683852

van Cappellen, P., & Saroglou, V. (2012a). Awe activates religious and spiritual feelings and behavioral intentions. *Psychology of Religion and Spirituality, 4*, 223–236. https://doi.org/10.1037/a0025986

van Cappellen, P., & Saroglou, V. (2012b). Awe activates religious and spiritual feelings and behavioral intentions. *Psychology of Religion and Spirituality, 4*(3), 223–236. https://doi.org/10.1037/a0025986

van Cappellen, P., Saroglou, V., Iweins, C., Piovesana, M., & Fredrickson, B. L. (2013). Self-transcendent positive emotions increase spirituality through basic world assumptions. *Cognition & Emotion, 27*(8), 1378–1394. https://doi.org/10.1080/02699931.2013.787395

Cerasa, A., Gaggioli, A., Marino, F., Riva, G., & Pioggia, G. (2022). The promise of the metaverse in mental health: The new era of MEDverse. *Heliyon, 8*(11), Article e11762. https://doi.org/10.1016/j.heliyon.2022.e11762

Chen, S. K., & Mongrain, M. (2021). Awe and the interconnected self. *The Journal of Positive Psychology, 16*(6), 770–778. https://doi.org/10.1080/17439760.2020.1818808

Chirico, A., Cipresso, P., Yaden, D. B., Biassoni, F., Riva, G., & Gaggioli, A. (2017). *Effectiveness of Immersive Videos in Inducing Awe: An Experimental Study. Scientific Reports, 7(1), 1218*. https://doi.org/10.1038/s41598-017-01242-0

Chirico, A., Ferrise, F., Cordella, L., & Gaggioli, A. (2018). Designing awe in virtual reality: An experimental study. *Frontiers in Psychology, 8*. https://doi.org/10.3389/fpsyg.2017.02351

Chirico, A., & Gaggioli, A. (2018). Awe: "More than a feeling". *The Humanistic Psychologist, 46*(3), 274–280. https://doi.org/10.1037/hum0000098

Chirico, A., & Gaggioli, A. (2021). The potential role of awe for depression: Reassembling the puzzle. *Frontiers in Psychology, 12*. https://doi.org/10.3389/fpsyg.2021.617715

Chirico, A., Glaveanu, V. P., Cipresso, P., Riva, G., & Gaggioli, A. (2018). Awe enhances creative thinking: An experimental study. *Creativity Research Journal, 30*(2), 123–131. https://doi.org/10.1080/10400419.2018.1446491

Chirico, A., Maggioni, E., Dossi, G., Schiena, G., Barale, A., Rozzoni, C., et al. (2020). Drafting the psychological sublime brain: A pilot EEG study. *Annual Review of CyberTherapy and Telemedicine, 18*, 243–246.

Chirico, A., Pizzolante, M., Kitson, A., Gianotti, E., Riecke, B. E., & Gaggioli, A. (2022). *Defining Transformative Experiences: A Conceptual Analysis. Frontiers in Psychology, 13*. https://doi.org/10.3389/fpsyg.2022.790300

Chirico, A., Shiota, M. N., & Gaggioli, A. (2021). Positive emotion dispositions and emotion regulation in the Italian population. *PLoS One, 16*(3), Article e0245545. https://doi.org/10.1371/journal.pone.0245545

Chirico, A., & Yaden, D. B. (2018). *Awe: A self-transcendent and sometimes transformative emotion. In The function of emotions: When and why emotions help us. (pp. 221–233). Springer International Publishing/Springer Nature*. https://doi.org/10.1007/978-3-319-77619-4_11

Clewis, R. R., Yaden, D. B., & Chirico, A. (2022). Intersections between awe and the sublime: A preliminary empirical study. *Empirical Studies of the Arts, 40*(2), 143–173. https://doi.org/10.1177/0276237421994694

Cybulski, J. L., Keller, S., Nguyen, L., & Saundage, D. (2015). Creative problem solving in digital space using visual analytics. *Computers in Human Behavior, 42*, 20–35. https://doi.org/10.1016/j.chb.2013.10.061

Diemer, J., Alpers, G. W., Peperkorn, H. M., & Shiban, Y. (2015). The impact of perception and presence on emotional reactions: A review of research in virtual reality. *Frontiers in Psychology, 6*. https://doi.org/10.3389/fpsyg.2015.00026

Dobson, J. A. (2015). *Examining the Psychological Consequences of Experiencing Awe*.

Duncker, K. (1945). *On problem-solving. Psychological Monographs, 58(5), i–113*. https://doi.org/10.1037/h0093599

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39*(2), 175–191. https://doi.org/10.3758/BF03193146

Fong, C. T. (2006). The effects of emotional ambivalence on creativity. *Academy of Management Journal, 49*(5), 1016–1030. https://doi.org/10.5465/amj.2006.22798182

Frijda, N. H. (1988). The laws of emotion. *American Psychologist, 43*(5), 349–358. https://doi.org/10.1037/0003-066X.43.5.349

Gallagher, S., Reinerman-Jones, L., Janz, B., Bockelman, P., & Trempler, J. (2015). A neurophenomenology of awe and wonder. Palgrave macmillan UK. https://doi.org/10.1057/9781137496058.

Gocłowska, M. A., Elliot, A. J., van Elk, M., Bulska, D., Thorstenson, C. A., & Baas, M. (2021). Awe arises in reaction to exceeded rather than disconfirmed expectancies. *Emotion, No Pagination Specified-No Pagination Specified*. https://doi.org/10.1037/emo0001013

Goldy, S. P., Jones, N. M., & Piff, P. K. (2022). The social effects of an awesome solar Eclipse. *Psychological Science, 33*(9), 1452–1462. https://doi.org/10.1177/09567976221085501

Gordon, A. M., Stellar, J. E., Anderson, C. L., McNeil, G. D., Loew, D., & Keltner, D. (2017). The dark side of the sublime: Distinguishing a threat-based variant of awe. *Journal of Personality and Social Psychology, 113*(2), 310–328. https://doi.org/10.1037/pspp0000120

Graziosi, M., & Yaden, D. (2021). Interpersonal awe: Exploring the social domain of awe elicitors. *The Journal of Positive Psychology, 16*(2), 263–271. https://doi.org/10.1080/17439760.2019.1689422

Griskevicius, V., Shiota, M. N., & Neufeld, S. L. (2010). Influence of different positive emotions on persuasion processing: A functional evolutionary approach. *Emotion, 10*(2), 190–206. https://doi.org/10.1037/a0018421

Guilford, J. P. (1967). Creativity: Yesterday, today and tomorrow. *Journal of Creative Behavior, 1*(1), 3–14. https://doi.org/10.1002/j.2162-6057.1967.tb00002.x
Güsewell, A., & Ruch, W. (2012). Are only emotional strengths emotional? Character strengths and disposition to positive emotions. *Applied Psychology: Health and Well-Being, 4*(2), 218–239. https://doi.org/10.1111/j.1758-0854.2012.01070.x
Haidt, J. (2000). *The Positive emotion of elevation. Prevention & Treatment, 3(1)*. https://doi.org/10.1037/1522-3736.3.1.33c
Hassenzahl, M., & Tractinsky, N. (2006). User experience - a research agenda. *Behaviour & Information Technology, 25*(2), 91–97. https://doi.org/10.1080/01449290500330331
Herring, D. R., Burleson, M. H., Roberts, N. A., & Devine, M. J. (2011). Coherent with laughter: Subjective experience, behavior, and physiological responses during amusement and joy. *International Journal of Psychophysiology, 79*(2), 211–218. https://doi.org/10.1016/j.ijpsycho.2010.10.007
Kahn, A. S., & Cargile, A. C. (2021). Immersive and interactive awe: Evoking awe via presence in virtual reality and online videos to prompt prosocial behavior. *Human Communication Research, 47*(4), 387–417. https://doi.org/10.1093/hcr/hqab007
Keltner, D., & Haidt, J. (2003). Approaching awe, a moral, spiritual, and aesthetic emotion. *Cognition & Emotion, 17*(2), 297–314. https://doi.org/10.1080/02699930302297
King, L. A., & Emmons, R. A. (1990). Conflict over emotional expression: Psychological and physical correlates. *Journal of Personality and Social Psychology, 58*(5), 864–877. https://doi.org/10.1037/0022-3514.58.5.864
Kitson, A., Stepanova, E. R., Aguilar, I. A., Wainwright, N., & Riecke, B. E. (2020). Designing mind(set) and setting for profound emotional experiences in virtual reality. Proceedings of the 2020 ACM designing interactive systems conference, 655–668. https://doi.org/10.1145/3357236.3395560.
Law, E., Roto, V., Vermeeren, A. P. O. S., Kort, J., & Hassenzahl, M. (2008). Towards a shared definition of user experience. *CHI '08 Extended Abstracts on Human Factors in Computing Systems*, 2395–2398. https://doi.org/10.1145/1358628.1358693
Lee, K. C. (2015). Digital creativity: New frontier for research and practice. *Computers in Human Behavior, 42*, 1–4. https://doi.org/10.1016/j.chb.2014.06.001
Morreall, J. (1989). Enjoying incongruity. *Humor - International Journal of Humor Research, 2*(1), 1–18. https://doi.org/10.1515/humr.1989.2.1.1
Nelson-Coffey, S. (2019). The proximal experience of awe. *PLoS One, 14*(5), 1–19. https://doi.org/10.1371/journal.pone.0216780. Katherine AND Ruberton, P. M. A. N. D. C. J. A. N. D. C. J. E. A. N. D. B. J. A. N. D. L. S.
Pearsall, P. (2007). *Awe : The delights and dangers of our eleventh emotion. Deerfield*. Beach, FL: Health Communications.
Perlin, J. D., & Li, L. (2020). Why does awe have prosocial effects? New perspectives on awe and the small self. *Perspectives on Psychological Science, 15*(2), 291–308. https://doi.org/10.1177/1745691619886006
Piff, P. K., Dietze, P., Feinberg, M., Stancato, D. M., & Keltner, D. (2015). Awe, the small self, and prosocial behavior. *Journal of Personality and Social Psychology, 108*(6), 883–899. https://doi.org/10.1037/pspi0000018
Rebelo, F., Noriega, P., Duarte, E., & Soares, M. (2012). Using virtual reality to assess user experience. *Human Factors: The Journal of the Human Factors and Ergonomics Society, 54*(6), 964–982. https://doi.org/10.1177/0018720812465006
Richardson, D. C., Tagomori, H., & Devlin, J. T. (2022). Can extreme experiences enhance creativity? The case of the underwater nightclub. *Frontiers in Psychology, 13*. https://doi.org/10.3389/fpsyg.2022.785278
Ritter, S. M., Damian, R. I., Simonton, D. K., van Baaren, R. B., Strick, M., Derks, J., et al. (2012). Diversifying experiences enhance cognitive flexibility. *Journal of Experimental Social Psychology, 48*(4), 961–964. https://doi.org/10.1016/j.jesp.2012.02.009
Riva, G., Baños, R. M., Botella, C., Mantovani, F., & Gaggioli, A. (2016). Transforming experience: The potential of augmented reality and virtual reality for enhancing personal and clinical change. *Frontiers in Psychiatry, 7*. https://doi.org/10.3389/fpsyt.2016.00164
Riva, G., Mantovani, F., Capideville, C. S., Preziosa, A., Morganti, F., Villani, D., et al. (2007). Affective interactions using virtual reality: The link between presence and emotions. *CyberPsychology and Behavior, 10*(1), 45–56. https://doi.org/10.1089/cpb.2006.9993
Riva, G., & Waterworth, J. A. (2014). *Being present in a virtual world*. Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199826162.013.015
Riva, G., Waterworth, J. A., Waterworth, E. L., & Mantovani, F. (2011). From intention to action: The role of presence. *New Ideas in Psychology, 29*(1), 24–37. https://doi.org/10.1016/j.newideapsych.2009.11.002
Salvi, C. (2021). *Markers of insight*. Routledge International Handbook of Creative Cognition.
Salvi, C., Simoncini, C., Grafman, J., & Beeman, M. (2020). Oculometric signature of switch into awareness? Pupil size predicts sudden insight whereas microsaccades predict problem-solving via analysis. *NeuroImage, 217*(116933). https://doi.org/10.1016/j.neuroimage.2020.116933
Saroglou, V., Buxant, C., & Tilquin, J. (2008). Positive emotions as leading to religion and spirituality. *The Journal of Positive Psychology, 3*(3), 165–173. https://doi.org/10.1080/17439760801998737
Schrepp, M., Hinderks, A., & Thomaschewski, J. (2017). *Design and Evaluation of a Short Version of the User Experience Questionnaire (UEQ-S). International Journal of Interactive Multimedia and Artificial Intelligence, 4(6), 103*. https://doi.org/10.9781/ijimai.2017.09.001
Seo, M., Yang, S., & Laurent, S. M. (2022). No one is an island: Awe encourages global citizenship identification. *Emotion, No Pagination Specified-No Pagination Specified*. https://doi.org/10.1037/emo0001160
Shiota, M. N., Campos, B., Keltner, D., & Hertenstein, M. J. (2004). *Positive emotion and the regulation of interpersonal relationships. In the regulation of emotion. (pp. 127–155). Lawrence Erlbaum Associates Publishers*.
Shiota, M. N., Keltner, D., & Mossman, A. (2007). The nature of awe: Elicitors, appraisals, and effects on self-concept. *Cognition & Emotion, 21*(5), 944–963. https://doi.org/10.1080/02699930600923668
Stepanova, E. R., Quesnel, D., & Riecke, B. (2018). Transformative experiences become more accessible through virtual reality. *2018 IEEE Workshop on Augmented and Virtual Realities for Good (VAR4Good)*, 1–3. https://doi.org/10.1109/VAR4GOOD.2018.8576881
Supena, I., Darmuki, A., & Hariyadi, A. (2021). The influence of 4C (constructive, critical, creativity, collaborative) learning model on students' learning outcomes. *International Journal of Instruction, 14*(3), 873–892. https://doi.org/10.29333/iji.2021.14351a
Takano, R., & Nomura, M. (2022). Neural representations of awe: Distinguishing common and distinct neural mechanisms. *Emotion, 22*, 669–677. https://doi.org/10.1037/emo0000771
Tong, E. M. W. (2015). Differentiation of 13 positive emotions by appraisals. *Cognition & Emotion, 29*(3), 484–503. https://doi.org/10.1080/02699931.2014.922056
Valdesolo, P., Shtulman, A., & Baron, A. S. (2017). Science is awe-some: The emotional antecedents of science learning. *Emotion Review, 9*(3), 215–221. https://doi.org/10.1177/1754073916673212
Wang, L., Zhang, G., Shi, P., Lu, X., & Song, F. (2019). Influence of awe on green consumption: The mediating effect of psychological ownership. *Frontiers in Psychology, 10*. https://doi.org/10.3389/fpsyg.2019.02484
Wienrich, C., Döllinger, N., Kock, S., Schindler, K., & Traupe, O. (2018). Assessing user experience in virtual reality – a comparison of different measurements (pp. 573–589. https://doi.org/10.1007/978-3-319-91797-9_41.
Yaden, D. B., Haidt, J., Hood, R. W., Jr., Vago, D. R., & Newberg, A. B. (2017). The varieties of self-transcendent experience. *Review of General Psychology, 21*(2), 143–160. https://doi.org/10.1037/gpr0000102
Yaden, D. B., Iwry, J., Slack, K. J., Eichstaedt, J. C., Zhao, Y., Vaillant, G. E., et al. (2016). The overview effect: Awe and self-transcendent experience in space flight. *Psychology of Consciousness: Theory, Research, and Practice, 3*(1), 1–11. https://doi.org/10.1037/cns0000086
Yaden, D. B., Kaufman, S. B., Hyde, E., Chirico, A., Gaggioli, A., Zhang, J. W., et al. (2019). The development of the awe experience scale (AWE-S): A multifactorial measure for a complex emotion. *The Journal of Positive Psychology, 14*(4), 474–488. https://doi.org/10.1080/17439760.2018.1484940
Zhang, J. W., Howell, R. T., Razavi, P., Shaban-Azad, H., Chai, W. J., Ramis, T., et al. (2021). Awe is associated with creative personality, convergent creativity, and everyday creativity. *Psychology of Aesthetics, Creativity, and the Arts, No Pagination Specified-No Pagination Specified*. https://doi.org/10.1037/aca0000442