Virtual Reality to Evoke Awe

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ABSTRACT

Producing substantial amounts of awe in the lab has been challenging with limited two-dimensional (2D) images and videos. However, virtual reality (VR) has immensely impacted the study of this emotion, owing to two key advantages it possesses. Firstly, VR enhances the sense of presence through the use of headsets, handheld devices and headphones. It is more effective at leaving the user feeling involved or engaged in the scene compared to simple 2D medias which were used previously. The second asset of VR is its integrability of participant assessment. Researchers can measure bahviour and physiological responses to the display during the experience while still having the opportunity to record self-report responses post-experiment. This paper explores the success of VR as an awe-evoking tool in the lab, examining key factors behind this success and identifying the gap for similar studies in future.

INTRODUCTION

Awe is a complex and powerful emotion that comes about when people are confronted with something that is perceived as vast and overwhelming. It is a response to something that challenges one's mental structures. This response is described by Keltner & Haidt (2003) as both intensely pleasurable and slightly fearful. It is triggered by a range of stimuli, including natural wonders, breath-taking artwork or exceptional music.

Over the past twenty years there has been an increasing interest in the study of awe. Awe contains two central attributes: perceived vastness and a need for accommodation (Keltner & Haidt, 2003). Vastness entails the observation (perceptual vastness) or realization (conceptual vastness) of something large or complex. The need for accommodation feature has been associated with surprise (Keltner & Haidt, 2003). Awe experiences are widely regarded as having positive effects. This includes recognizing the interconnectedness of all living beings and developing a sense of responsibility towards the wider community (Shiota, Keltner & Mossman, 2007). Awe binds individuals through charitable behaviour (Stellar et al., 2017). Awe is also correlated with positive health and welfare. It can help decrease the risk of heart disease and strokes (Deverman, 2017). Individuals go to great lengths in the search for experiences which are awe-conductive. However, inducing awe within the lab has been a challenging task. Although experimental studies have successfully managed to produce the emotion, it has tended to be a slight magnitude of the response (Silvia et al., 2015).

In the most recent experiments to elicit awe and other emotions virtual reality has been employed as a tool to enhance the intensity of the response under lab settings. VR is a cutting-edge technology that utilizes computer-generated three-dimensional (3D) settings to generate a lifelike sensory encounter that can be operated by means of specialized equipment, including head-mounted displays and handheld controllers. The primary objective of VR is to establish an absorbing experience that enables users to believe that they are within a virtual environment, generating the impression of a complete virtual world. One of the advantages of using VR in research on awe is that it allows for the manipulation of the stimuli that elicit the emotion (Bohil, Alicea & Biocca, 2011). For example, researchers can create virtual settings that imitate natural wonders, like mountains or waterfalls, to analyse how variations in the setting

impact the experience of awe. This technique can shed light on the specific characteristics of the environment that contribute to the emotion, including the magnitude, intricacy, or unpredictability of the setting. Another advantage of VR is its potential to study the physiological reactions connected with awe. This information can assist in recognizing the neural and physiological mechanisms that underpin the experience of awe, thereby providing a more comprehensive understanding of the emotion.

VIRTUAL REALITY TO RESEARCH AWE

Ever since its introduction, virtual reality has been commonly used in the study of a range of emotions. One study showed fear and anger are more intensely induced via VR as opposed to a desktop computer view (Susindar et al., 2019). Another study by Felnhofer et al. (2015) used five different virtual parks and successfully induced a range of emotions, namely joy, boredom, anger and anxiety. Each park targeted one emotion by varying the music, weather and expressions on faces within the parks. It must be noted that the study failed to produce significant sadness responses to its specific simulation. Nevertheless, VR has been an effective tool for drawing out different types of emotions in controlled environments (Chirico et al., 2016).

The earliest attempt to evoke awe through virtual environments was made by Reinerman-Jones et al. (2013). Participants were shown two views – one where they slowly moved away from earth and the other where they travelled through space watching distant stars. Each view lasted 12 minutes. The earth scene was discovered to be more effective than the view of deep space.

A more recent successful study comprised of four virtual environments which each portrayed natural scenes under lab settings (Chirico, Ferrise, et al., 2018). Three simulations were designed as awe-inducing – a forest, a high snow mountain and an earth view from deep space, each with a vastness component. The fourth environment was a simple design of grass, trees and flowers and it was used as a control. The three awe-conductive VEs were found to induce higher levels of awe compared to the control. Results also showed no difference in the awe induced by the forest and earth simulations, but the mountain VE was more effective than both. The mountains and the earth view were most effective in conveying vastness, with the control being the worst.

There have been several other successful studies. Interestingly, VEs of places familiar to participants were discovered to be very effective when they were able to select their preferred scene from a complete VE of earth, and most chose a place well known to them (Quesnel & Riecke, 2018). This slightly contradicts the element of surprise which is known to be a core characteristic of awe (Keltner & Haidt, 2003). In another study by Chirico et al. (2017) , two videos were selected based off a preliminary study of awe-conductive scenarios. A scene with tall trees and one with hens on a patch of grass were selected as they were found to be the most and least effective awe-inducing visuals respectively (Chirico, Cipresso, et al., 2018). A 2D video and an immersive 360° video were designed for each of the selected scenes. Each video lasted 2 minutes. The awe-inspiring 2D and immersive videos considerably intensified the awe induced compared to the neutral videos. It was the combination of immersion and awe-inducing content which resulted in the most extreme awe experience. In fact, the study by Chirico, Ferrise, et al. (2018) revealed the 360° awe-inspiring videos were more effective than awe-inspiring VEs. This comparison was made after ensuring the distribution of data was consistent over the two studies, making it a valid result.

VR ENHANCES PRESENCE

The most significant advantage of virtual reality is arguably its ability to provide users with a high sense of presence within the simulated environment. The technology uses visual tools, almost always a headset, and is able to deliver a mixed reality so lifelike. The addition of handheld devices ensures users can navigate through the environment. Hence, immersive VEs intensify the sense of presence much more than 2D videos (Chirico et al., 2017). However, Brivio et al. (2021) argues that a 360° immersive video may be

as effective at creating the sense of presence as a computer-simulated VE. Being cheaper and easier to develop, the 360° real panorama VE would make a more feasible solution to create presence. Nevertheless, VR simply extends on a 360° video through the use of handheld controllers which allow navigation and interaction with the environment. Thus, it'll never fall short of a 360° immersive video designed the same way.

Additionally, VR can make use of other sensorial channels to further amplify this feeling. Headphones were able to enrich the feeling of presence for the participants (Chirico, Ferrise, et al., 2018). In this study, results showed the mountain and forest scenes were each able to generate the highest sense of presence while the earth view from deep space surprisingly had the lowest. The headphones possibly had a large impact on this, given sound would be more impactful on earth than in space.

MEASURING AWE IN EXPERIMENTS

Virtual reality builds on previous traditional methods of assessing responses in experiments. Self-report questionnaires are still almost always used, especially the well-validated Likert scale questionnaire (Felnhofer et al., 2015; Chirico et al., 2017; Chirico, Ferrise, et al., 2018). However, VR extends on this by allowing real-time measurements of participants' responses during the experience. These are categorized into behavioural and physiological responses. At the behavioural level, researchers can make use of the motion-tracking devices to analyse head movements, facial movements and hand movements which could correlate to reported awe.

Furthermore, researchers can study the physiological products of awe. There is a correlation between goose bumps and greater gradings of awe. (Quesnel & Riecke, 2018). Measurements were taken by an instrument placed on the participant's arm which recorded goosebumps. Reinerman-Jones et al. (2013) made use of electrocardiogram (ECG) to record heart rate. In addition, Covidien's fNIR system was able to record oxygenation of haemoglobin in the frontal lobe. This is the area which manages crucial cognitive skills. The study by Chirico et al. (2017) used various wearable biosensors to measure peripheral nervous system (PNS) activation. Biosensors were equipped for skin conductance response (SCR) and for blood volume pulse (BVP). Additionally, two surface electromyography (sEMG) biosensors recorded muscular automatic micro-contractions. It was discovered that immersive videos inducing awe resulted in parasympathetic activation, whereas 2D videos did not. This finding suggests that the reported well-being associated with awe experiences could be connected to parasympathetic activation, but further investigation into this is required.

DISCUSSION

Virtual reality has developed an exceptional track record as a tool to evoke awe under lab settings. The VE scenes which were successful include a forest of tall trees, high snow-filled mountains, travelling through space as well as a view of earth from space, which was most commonly used. The mountain setting proved a contender for the view which elicited the highest amount of awe, but designs across experiments are difficult to compare. Thus, it is still not evident what particular scene is best. One clear feature of all the successful environments is that participants could interact with something perceived as overwhelming. This is what was expected as per a core component of awe, vastness (Keltner & Haidt, 2003). Interestingly, it was discovered across two experiments that 360° immersive videos had higher reported levels of awe than immersive VEs (Chirico, Ferrise, et al., 2018). This would probably be due to the distraction caused by VR along with the physiological measurement devices. Studies need to be aware of this when designing experiments to ensure accurate conclusions can be made.

Study	**Best setting**	**VR devices**	**Measuring techniques**
Reinerman-Jones et al. (2013)	Earth view from deep spcae	Screen	Self-report questionnaire, interviews, ECG system, fNIRs system

Quesnel & Riecke (2018)	Self-selected, familiar location from Google Earth VR	Headset, headphones, handheld controllers	Self-report questionnaires, goosebump detection device, interviews
Chirico, Ferrise, et al. (2018)	High snow-filled mountains	Headset, headphones, handheld controllers	Self-report questionnaire, biosensors, interviews

The greatest asset VR possesses over 2D media is its ability to enrich the feeling of being present in the view. Awe studies have targeted sight and hearing to do this through headsets, headphones and handheld devices. It has proved extremely effective, although there is still opportunity for enhancement. Researchers could target other senses such as touch and smell. Consequently, an even more lifelike simulation will be generated, and stronger results will follow.

VR also serves as a powerful tool for integration of assessment for researchers. Many body movements as well as less visible physiological responses can be assessed during the experience. Goosebumps were discovered to be correlated with higher ratings of awe (Quesnel & Riecke, 2018). These subtle responses enable researchers to better understand the emotion, however they must take care when assessing participants. Although VR comes with the opportunity to measure a wide range of responses, the devices used for this assessment are generally complex and unusual for the participants. Experiments should not impede users nor distract them during the experience, as this may heavily impact the results. During experiments researchers must be aware of the high possibility of users experiencing motion sickness. It is common with VR and should receive action should it be noticed.

CONCLUSIONS

The two central attributes of awe, vastness and surprise, have made it difficult to reproduce in experimental studies that have used 2D images or videos. Virtual reality has proved an effective tool to replace the previous methods used by researchers to evoke emotion, including awe, under lab settings. VR surpasses these methods owing to its ability to magnify individual's feeling of presence in the scene by targeting multiple senses. Consequently, assessment of these individuals is more accurate as their behaviour will mimic their real-life actions. Studies have only focused on activating a few senses. Future work should aim to target more senses to further enhance this feeling of engagement. VR also serves as an integrated measurement tool which enables peri-experimental assessment and allows studying the behavioural and physiological correlates of awe in finer detail. However, studies must always take care of issues ragearding user distraction, motion sickness and intrusive assessment.

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