Eliciting the feeling of Awe in Virtual Reality

Literature Review

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ABSTRACT

One particular emotion that has shown to have health, wellbeing, pro-social and transformative experiences is the feeling of awe. Awe is described as the experiencing of events that expand one's frame of reference due to an aspect of vastness that one then needs to accommodate by altering their mental schemas. This paper investigates the available studies and research on the use of Virtual Reality in regards to eliciting emotions, namely the feeling of awe. Research regarding the elicitation of emotions is relatively new, and to date there are no methodology to identify how to efficiently design Virtual Reality Environments to elicit certain emotions. Awe-inspiring Virtual Reality applications are very few in number and design features and aspects to include when designing these applications has been found inconclusive as awe is a complex emotion that can be elicited through various and vastly different means. Most of the research on VR applications designed to evoke awe incorporate popular and well-known awe-elicitors, such as the Overview Effect where a person views Earth from outer space and aspects such as nature, the supernatural, spirituality, artwork and others that incorporate a sense of vastness in one way or another. A few strategies to design an effective VR application to invoke awe has been described in one study but do not provide specific guidelines as to the colours, objects, sounds, interactions, etc., that need to be incorporated to achieve the best affect. Methods on the assessment of were evaluated and found that the use of goosebump identifying devices helped assess the effectiveness of eliciting awe. Self-reports such as questionnaires and interviews were also helpful in assessing the effectiveness of eliciting awe and the importance of immediate feedback once participants have ended their VR interactions was identified.

KEYWORDS

Virtual Reality, Virtual Environments, Emotions, Awe, Eliciting

1 Introduction and Motivation

Virtual reality (VR) is a technology that blends multimodal inputs to create the illusion of presence in digital settings (Dozio et al., 2022). It offers users the chance to engage with 3D content in a way that mimics real-world interactions (Dozio et al., 2022). VR is a relatively new technology being explored and recent research, with piqued interest in the elicitation of various emotions for various uses, have suggested VR to be one of the best tools to achieve this due to the increased immersive ability of Virtual Reality Environments (VRE) and the sense of "Presence" a user experiences when interacting with this technology (Colombo et al., 2021, Diemer et al., 2015, Ke and Yoon, 2020). This allows for the use of invoking emotions in people to take place in a safe and controlled environment (Colombo et al., 2021). The research in invoking emotions for various uses have very little methodology provided for the design of features in a Virtual Environment (VE) that will effectively elicit a certain emotional response (Ke and Yoon, 2020). Awe is an emotion that has recently been identified to have many positive effects on people and has, therefore, become a new area of interest in research which has investigated the replication of this emotion in controlled and safe environments to provide positive effects on people (Ke and Yoon, 2020). Our project aims to design effective awe-eliciting environments due to its relatively unexplored territories and lack of implementation in VR applications and the potential benefits it may provide. The objective is to create three distinct VEs that can be used to elicit awe in users which can potentially be used as a basis for future designs of awe-eliciting applications. This paper aims to uncover the roles of emotional invocation in VR and potential uses of invoking awe in VR applications. It also aims to assess the current methodology to design and evaluate effective VEs that evoke emotional responses and awe to uncover where gaps in this research field lie and the strengths and weaknesses of the different methods studies have used to evaluate its effectiveness.

2. Eliciting Emotions in Virtual Reality

The study of the use of emotions in Virtual Reality (VR) is relatively new, and research into the use and implementation of eliciting specific emotions in Virtual Environments (VE) is gaining popularity. However, there are not many studies that have been conducted so far into this new field of Virtual Reality. This section aims to uncover how emotions are effectively induced in VR, what roles they play and how to assess the effectiveness of inducing certain emotions.

2.1 Roles of Emotions in Virtual Reality

Eliciting emotional responses can play various roles and be used for various purposes in VR applications. Introducing the evocation of emotions can enhance the immersive experience of a virtual environment, allowing users to feel more engaged with their digital surroundings (Susindar et al., 2019). This benefits the entertainment applications of VR as it enhances the sense of "Presence" a user experiences, giving the illusion that the virtual environment is reality (Dozio et al., 2022, Quesnel and Riecke, 2018). This increased feeling of reality when using the virtual reality applications can also be used in different training applications where it is too dangerous to simulate in real-life. An example of this is the use of simulated VEs for firefighting training (Lipp et al., 2021). This allows firefighters to complete their tasks, without being in actual danger (Lipp et al., 2021). With the inclusion of evoking fear, sadness, guilt, frustration and other emotions in the VR simulation that a firefighter may feel on the scene, it allows the firefighter to persevere through the negative emotions that they may feel to get the job done (Lipp et al., 2021). The use of emotions in VR can also be used to safely study human behaviour and their decision-making when experiencing different emotions (Diemer et al., 2015, Susindar et al., 2019). VR also provides safe and controlled environments that, in conjunction with eliciting certain emotions, can be used for different types of medical treatments (Dozio et al., 2022). Inducing positive emotions such as relaxation and joy can have therapeutic uses to better a person's mental health and help people with depression (Dozio et al., 2022, Colombo et al., 2021). It can also be used to treat phobias and trauma in psycho- and exposure therapy by designing specific environments that induce fear and stress relating to the patient's phobia or past trauma (Dozio et al., 2022). Other uses of inducing emotions in VR include investigating the causes of mental disorders, better a person's empathy, social behaviour and skills as well as to evaluate behaviour of consumers with regards to marketing (Marin-Morales et al., 2020, Colombo et al., 2021, Diemer et al., 2015).

2.2 Eliciting Emotions in Virtual Reality

There is not much research into how to particularly design a VE to induce specific emotions as there are countless variations that can achieve this but articles and journals do provide information on what aspects can influence the emotions elicited. How effective the VR application is at evoking a specific emotion can be determined by the strength of "presence" the user feels in the environment as the more involved the user feels, the stronger the emotional response will be (Susindar et al., 2019). There are also many models consisting of different dimensions that can be used to determine how emotions can be elicited by falling on certain positions of a spectrum. A very popular model is the valence, arousal and dominance spectrum where valence refers to the degree of which an emotion is positive or negative, arousal refers to the intensity of which the emotion is felt and dominance refers to how in-control the user feels when experiencing this emotion (Dozio et al., 2022, Susindar et al., 2019, Marin-Morales et al., 2020). Virtual Reality applications can then alter different features within the environment to experience varying degrees of these dimensions which then determine the emotion(s) elicited. Active and passive methods that determine the features of the VE can be used to influence these dimensions (Marin-Morales et al., 2020). Active methods involve the direction manipulation of the user which includes the manipulation of the user's behaviour and the social interaction the user experiences whereas passive methods involve external manipulation of the features, such as the sounds, pictures and smell used in the environment (Marin-Morales et al., 2020). The International Affective Picture System (IAPS) and Digitalised Sound System (IADS) is a popular tool used to access standardized depictions of features based on valence, dominance and arousal that can be included in the VE to elicit certain emotions (Marin-Morales et al., 2020). These features include the objects, sounds, people and events (Marin-Morales et al., 2020). Different strategies can also be implemented in VR to elicit specific emotions. Situational, attentional, cognitive and response modification strategies can be used to design a VE that will influence emotional response of a user (Colombo et al., 2021). These strategies describe how the VE can be designed through situations being selected or modified, certain features grabbing the user's attention, altering stimulus to change its meaning and influencing the emotion a user is feeling, respectively (Colombo et al., 2021). The afore-mentioned strategies, methods and dimensions are all implemented using semantic and sensory elements, dynamism and interaction in the virtual reality environment (Dozio et al., 2022). Semantic elements refer to the real-life recognisable objects that are present in the VE and the use of colour, shapes, sounds and smell that are abstract which can possibly evoke memories from the user or have a symbolic meaning (Dozio et al., 2022). Sensory elements make up the semantic elements as it includes the features that the user can see, smell, hear and touch which evoke emotional responses (Dozio et al., 2022). Dynamism refers to the actions of the user and the objects in the VE including characters, plants, animals and objects which allows the user to understand what is happening in the simulation (Dozio et al., 2022). Interactive elements describe the use of cues to guide the user to certain places or incorporate elements that act as obstacles or surprises the user encounters which influence the actions and reactions of the user (Dozio et al., 2022).

2.3 Assessing the Evocation of Emotions in VR

There are many methods that can be used to assess the emotional stimulation of participants in emotion elicitation VR studies, including various types of questionnaires, interviews, observations and biosensors such as heart rate monitors, electrodermal activity, goosebump cameras etc. This section aims to assess how previous studies on designing VR applications to evoke emotions have implemented the experiments and assessed the results.

2.3.1 Aim of Studies

The first study refers to the research done by Dozio et al. (2018) which aimed to discover how the combination of different design features of a Virtual Reality Environment (VRE) elicits a specific emotion (Dozio et al., 2022). They designed VEs for five different emotions namely fear, disgust, anger, sadness and happiness and provided two designs for each emotion to determine which aspects of the VE elicit a stronger sense of the desired emotion (Dozio et al., 2022).

The second study refers to the research done by Susindar et al. (2019) which aimed to determine if different media displays, namely a desktop computer and VR technology, elicit emotions differently (Susindar et al., 2019). They conducted this by having the participants watch a short clip from a film called “My Bodyguard” to elicit anger, it is not specified if this was used on both media displays or not, and participants either play a VR game called “Play with me” or watch a video recording of the game on a desktop computer to elicit fear (Susindar et al., 2019). The participants interacted with both types of media devices but only used each device for one emotion (i.e., if they interacted with the VR equipment for fear then they would interact with the desktop computer for anger and another participant would be the opposite (Susindar et al., 2019). After interacting with the media, they would then complete the Balloon Analog Risk Task (BART) where they would pump 90 balloons which each had a variable number of allowed pumps before it bursts and earn money for each pump if the balloon did not burst (Susindar et al., 2019).

The third study refers to the research done by Felnhofer et al. (2015) which aimed to discover if changing features in a park setting will effectively elicit different emotions (Felnhofer et al., 2015). A total of five park VEs were designed to evoke different emotions in the user, namely sadness, anger, joy, anxiety and boredom, and was designed based on prior research (Felnhofer et al., 2015). They tried to keep the park as similar as possible to see if the different features effectively evoked the intended emotion and achieved this by changing the weather, lighting, time of day, sounds and objects such as birds and umbrellas and also by the removal of some of the features such as characters (Felnhofer et al., 2015).

2.3.2 Implementation of Study and Assessment of Emotions

Study 1 consisted of 48 participants, 17 of which were female and were between the ages of 19 and 40, with 26 being the average age (Dozio et al., 2022). Before the study took place, the participants completed tests which determined how empathetic they are, their level of emotional awareness and their current emotional state to be used to properly assess their results by determining how these aspects influence their experience with the VE and to use their current emotional state as a baseline (Dozio et al., 2022). The participants also were given a training session to allow them to become familiar with using the VR technology (Dozio et al., 2022). They then explored five different environments, each regarding a different emotion and after each environment had to answer a SAM questionnaire to describe the dominance, arousal and valence they had felt in that environment to determine the emotional effect they experienced (Dozio et al., 2022).

Study 2 consisted of 11 participants, 5 of which were female and fell in the age range of 19 to 29 (Susindar et al., 2019). The participants were guided through breathing and relaxation exercises before and between interacting with the different media displays to mitigate emotions they may have been feeling before interacting with the VR and desktop computer (Susindar et al., 2019). The participants’ emotional responses were recorded through a Positive and Negative Affect Schedule-Expanded (PANAS-X) scale questionnaire before the study began and after interacting with each environment and their heart rate and skin conductance response was monitored throughout the duration of the study (Susindar et al., 2019). After completing the PANAS-X questionnaire, the participants would complete the BART and the degree of anger or fear the participant felt would be determined by how long they it took them to decide to pump the balloon (Susindar et al., 2019). After interacting with the VR technology, the participants also completed a simulator sickness questionnaire to help determine if this affected their emotional responses to the VE (Susindar et al., 2019).

Study 3 consisted of 120 participants, 61 of which were females and had an average age of 25 years (Felnhofer et al., 2015). The participants’ emotional responses were recorded through self-assessment as well as through electrodermal activity (Felnhofer et al., 2015). The participants were also guided through a relaxation phase to obtain an EDA baseline from which their emotional stimulus could be compared (Felnhofer et al., 2015). The participants then interacted with one of the five VEs and answered a Differential Emotions Scale afterwards to describe the emotions they had felt (Felnhofer et al., 2015).

2.3.3 Critical analysis of Methods used

Study 1 had a decent number of participants but could have had more females partake to identify if different genders experienced the environments differently and compared their emotional responses. Including assessments of the participants’ empathy and emotional awareness levels was a good addition to properly assess the effectiveness of the VREs to elicit specific emotions which the other two studies did not include. The inclusion of a training session to give the participants understanding of how to interact with and use the VR equipment was also a good addition to ensure that the participants had no trouble when navigating the VE and allow for them to receive the full experience to ensure optimal emotion elicitation is achieved. A weakness of this study was that they only used a self-assessment questionnaire to determine the emotional stimulus of the VE which is not always accurate as the participants could be bias and answer what they think is expected or may not know how to convey the emotions that they felt. This study hoped that the break when taking the SAM assessments in between the different VREs would allow the emotions that they had been feeling to subside, however, this may not actually be entirely effective and could affect the elicitation of emotions evoked in the following VREs.

Study 2 had a very low number of participants and had the least number of participants compared to Study 1 and Study 3. A larger group of participants could provide a more accurate depiction of results. It did, however, have a more evenly distributed gender-base compared to study 1, which allowed them to compare if there were any difference in responses given by both genders. The use of breathing and relaxation methods before the start of the study and after the first interaction with one of the media forms was a good addition to subside any emotions they may have been feeling, which study 1 did not incorporate, possibly allowing for a more accurate representation of results. Study 2 was also more effective than study 1 and study 3 in assessing the emotional stimulation throughout the study as they incorporated heart rate and skin conductance response throughout the study and not solely relying on the PANAS-X questionnaire to gain information of the emotional response of the participant. The study could possibly have been more effective though if the participants did not have to complete the PANAS-X questionnaire before interacting with the BART to prevent the emotions that were evoked from subsiding and allowing for a more accurate representation to be achieved. This study did not, however, include the information obtained from the heart rate or SCR to provide further information and proof of their results.

Study 3 had the best number of participants out of all of the studies and also had an almost even number of males and females partaking. This study was better than study 1 in that it incorporated a biosensor (EDA), however it did not prove to be effective as it only supplied that there was an overall emotional response. As with study 2, study 3 was also better than study 1 in that it included a relaxation time before the study commenced to obtain a EDA baseline and diminish emotions the participants may have been feeling before interacting with the VE.

All three studies did not have a very good age range as the average was in the low 20's. Study 1 had the best age range; however, the mean was still very young. Younger people are more reliant to partake in these studies and are easier to recruit, but the results may not be accurate if being used to describe the emotional stimulation a VR application can have on people that are older.

3. Awe in Virtual Reality

Since the introduction of inducing emotions in Virtual Reality, very little research has been done on the elicitation of awe in VR applications. The many transformative qualities and various benefits awe has shown to induce has piqued the interest of research to uncover how to fully utilise this emotion. This section aims to uncover what awe is, where potential lies by invoking awe in VR applications and how to elicit and assess the feeling of awe if Virtual Environments.

3.1 What is Awe

Awe is an emotion that is difficult to define as it is very complex to describe and determine what, exactly, elicits this emotion (Shiota et al., 2007). It has also been described to elicit both positive and negative feelings in a person, although it is more commonly a positive emotion that is evoked (Yaden et al., 2019). Negative feelings of awe tend to be evoked by great destruction, such as what is caused by natural disasters, that is unimaginable and difficult for a person to comprehend and can be described by intense feelings fear and dread (Shiota et al., 2007, Pearce et al., 2017). Positive feelings of awe have been associated with strong feelings of wonder, connectedness, surprise and astonishment (Chirico et al., 2018, Ke and Yoon, 2020). The most accepted description of awe is that it is characterized by vastness and need for accommodation of mental schemas (Shiota et al., 2007). Vastness does not specifically refer to large size but rather that it is something that is so difficult for a person to comprehend or grasp that it needs to be accommodated by expanding their frame of reference (Shiota et al., 2007). Awe has been described in numerous ways such as experiencing self-diminishing and self-transcendent feelings; however, some papers differentiate awe as being self-diminishing and that self-transcendent emotions are entirely different (Nelson-Coffey et al., 2019, Quesnel and Riecke, 2018). Self-transcendence is used to describe awe as a person's limits are overcome by the realization of this new vastness that they have encountered (Quesnel and Riecke, 2018). Whereas, self-diminishing is used to describe awe as a person realises how small and insignificant they are in comparison to this new and great discovery or experience and that they focus on the greatness they are witnessing rather than themself (Nelson-Coffey et al., 2019, Shiota et al., 2007).

3.2 The Potential of Evoking Awe in VR

There are numerous benefits that the feeling of awe can impart on a person. The feeling of awe is seen as transformative since it can alter one's worldview, perspective, and sense of self (Ke and Yoon, 2020). Awe has the potential to increase a person's wellness and satisfaction with their life as well as improving their social interactions (Quesnel and Riecke, 2018). Awe is also able to expand a person's perception of time and can even protect a person's immunity system (Chirico et al., 2018, Chirico et al., 2016). Awe also has the potential to influence beliefs as people felt more inclined to explore spirituality after experiencing a sense of awe (Chirico et al., 2016). Awe has also shown to alter the behaviour of people to be less aggressive and increase their willingness to learn as well as encouraging people to better look after our planet (Ke and Yoon, 2020). Experiencing awe invokes a drive for people to go out and see more of the world and decreases the shortcuts people use to understand and gain new knowledge and increases a person's humility (Nelson-Coffey et al., 2019). Many people are unable to encounter these awe-eliciting experiences because of financial struggles or physical mobility and ability limitations and, even without these struggles, most people do not experience them very often (Quesnel and Riecke, 2018). VR has the potential to make awe-eliciting experiences more accessible as it a portable device that is a lot cheaper than travel and does not require much ability or mobility to be used (Quesnel and Riecke, 2018). Research into the use of VR applications to elicit the feeling of awe is being done as VR has better features to ascertain enhanced emotional stimulus (Quesnel and Riecke, 2018). These advantages of VR technology include the sense of "Presence" that users feel when interacting with VREs due to its ability to stimulate multiple senses within a user, thus making the environment appear real or natural, the capacity for stimulus to be controlled and for this control to be maintained as well as the ability to change the environment so that is tailored for a specific user (Quesnel and Riecke, 2018, Chirico et al., 2018). VR technology also allows developers to create environments that can be realistic or completely fictionally, such as events that do not abide by the laws of physics or logic (Chirico et al., 2018). Thus, VR has the most potential over other media forms to elicit the feeling of awe that one could experience in real life. The potential use can allow for all the aforementioned benefits to be ascertained in people who make use of VR-induced awe and be used for learning, psychological and entertainment applications. No research has been done as to whether different types of awe elicitors affect the different benefits which it can pertain.

3.3 Eliciting Awe in Virtual Reality

With the low number of studies having being done on Virtual Reality awe-eliciting applications, methodology as to what aspect and features to design or include in a VRE to achieve the evocation of awe is uncertain. It is also difficult to design a VE that elicits awe as a lot of data that is collected in this research respect relies heavily on participants providing accurate answers and when biosensor devices are used, they could provide an annoyance for the participant, hindering the potential awe-inducing effectiveness that the VR application may actually have (Quesnel and Riecke, 2018). Most of the VR applications that have been created to elicit awe have primarily been designed to duplicate popular, real life environments that studies have shown to incur great responses of awe in people, such as viewing the world from outer space and witnessing the vast expanse of nature that can be viewed from great heights (Quesnel and Riecke, 2018, Chirico et al., 2018). It is difficult to pinpoint what exactly evokes awe in different environments but research on awe has uncovered a few aspects and environments that have shown to evoke this feeling in many people. The main elicitor of awe that research has identified is nature (Pearce et al., 2017). This possibly could be because nature is found everywhere and is more accessible and easily encountered, making it a very common awe-eliciting source than other aspects. Nature's vast features that incorporate many different fauna and flora provide what may seem to be an endless supply of awe-eliciting opportunities. Picturesque settings, outer space, mountains, aquatic life, biological phenomena, enormous geological settings, natural aesthetics, waterfalls, dinosaur skeletons and wildlife, especially rare or extinct animals, are all aspects of nature and are primary elicitors of awe (Dozio et al., 2022, Pearce et al., 2017, Shiota et al., 2007, Nelson-Coffey et al., 2019, Quesnel and Riecke, 2018, Chirico et al., 2018, Ke and Yoon, 2020). Nature can also provide moments of reflection or perspective that also induce the feeling of awe in people (Pearce et al., 2017). Other aspects and objects that can invoke awe include the supernatural, firework displays, discovering spiritual enlightenment, encountering magnificent artwork that encompass paintings, music and structures and even complex theories that people challenge to grasp (Pearce et al., 2017, Nelson-Coffey et al., 2019, Quesnel and Riecke, 2018, Chirico et al., 2018, Ke and Yoon, 2020). The wide variety of available prospects and ways to combine these different features to elicit awe appears unlimited, which makes it difficult to define exactly how to design VREs to elicit awe when there is so much potential. Ke and Joon (2020) provided research into different strategies that can be used to design affective awe-evoking VR applications (Ke and Yoon, 2020). These six strategies are defined by momentary beauty, classic designs that seem to transcend time, encountering a being or object that resembles existence of a higher power, a very complex design which can be either concrete or abstract, such as theories, abrupt transitions and erratic behaviour and the sense of interacting with hundreds of people all working towards a common objective (Ke and Yoon, 2020). All of these strategies play on the two key features of which awe is characterised, by different means of vastness and the need to accommodate these new experiences or findings (Ke and Yoon, 2020). The sense of "Presence" that VR is able to provide to users also assist in a stronger elicitation of awe as well as the extent to which VR applications play on a user's senses (Chirico et al., 2018, Pearce et al., 2017).

3.4 Assessing the Evocation of Awe in VR

Although not many studies have been conducted to assess the effectiveness of eliciting awe in VR applications, there are various indicators and tools that have been suggested to be able to help identify the feeling of awe in people. Research has shown that physical reactions people experience when feeling awe can be recognised by wide eyes, a parted mouth, physical and mental freezing as well as goosebumps (Yaden et al., 2019). Some research studies have reported that goosebumps occur more frequently in females than males which could imply that females are more susceptible to awe than males however, others studies showed no difference (Quesnel and Riecke, 2018). This could, however ascertain to the fact that boys are less likely to report on this occurrence than females (Quesnel and Riecke, 2018). Studies have also shown that EEG brainwaves and parasympathetic activation occurs when people experience awe (Quesnel and Riecke, 2018). This can be identified by the use of biosensors such as cameras for facial recognition, a heart rate monitor, a goose bump recorder device and a surface electromyography instrument (Quesnel and Riecke, 2018). Awe can also be identified by self-report using interviews and various questionnaires where participants can supply answers as to what emotions they were experiencing (Quesnel and Riecke, 2018). However, interviews may not be as effective as awe is a difficult emotion to convey in words, whereas questionnaires can provide words that are usually related to awe to get a better idea of what a person was feeling (Quesnel and Riecke, 2018). Self-report methods can be biased though, as participants can answer what they think is expected and answers can be open to interpretation (Quesnel and Riecke, 2018). This section aims to assess how previous studies have implemented and analysed the induction of awe in VR applications.

3.3.1 Aim of Studies

Study 1 refers to the research report done by Quesnel and Riecke (2018) which aimed to identify the effect of different aspects, namely beauty, vastness, individualisation and personlisation affects the elicitation of awe in users (Quesnel and Riecke, 2018). They made use of Google Earth to provide to design the VR application where each participant explored 4 different environments, each of which focused on a different awe-elicitor, namely a colour tour using a colourful location, a tour of Vancouver, Canada which provided familiarity as this is the location base of the study, Mount Everest which made use of vastness and personlisation was achieved in the final environment which the participant could choose (Quesnel and Riecke, 2018).

Study 2 refers to the research done by Chirico et al. (2018) which aimed to study how different types of perceived vastness can elicit awe by designing three VEs all regarding nature as well as a control environment (Chirico et al., 2018). One environment incorporated very tall trees and a waterfall falling from above the trees, another included high, snowy mountains where the participants walked along the top of the mountain and could see the vast expanse of the landscape and the last was a view of the earth from deep in space (Chirico et al., 2018). Sounds that occurred in the natural environments were also incorporated into the VR application to add to the effectiveness of inducing awe (Chirico et al., 2018).

Study 3 refers to the research done by Stepanova et al. (2019) which aimed to assess the effectiveness of a VR application called Awe-inspiring Wellness Environment (AWE) in eliciting awe and other effects that the Overview Effect has been identified to have on people (Stepanova et al., 2019). The application was designed so that the user first appeared in a campsite inside tent at night where a sprite then appears and guides them out of the tent and into the campsite where there is a fire in the center (Stepanova et al., 2019). The sprite then leads the user into a forest which they explore and end up at a lake which the sprite goes into, resulting in the user following it and jumping in as well (Stepanova et al., 2019). The user then descends in the column of water, viewing all the marine life in the lake and the bottom of the lake leads the user into space and where the sun and the earth are visible (Stepanova et al., 2019). After the user has orbited the earth once the user returns to the campsite which is the end of the VR experience (Stepanova et al., 2019).

Study 4 refers to the research done by Quesnel and Riecke (2017) which aimed to discover if awe can be effectively evoked in VR applications and if the orientation of the participant, which was tested by having the participants either lie flat on their stomach or standing up, changed the effectiveness of invoking awe in participants (Quesnel and Riecke, 2017). The application used Google Earth VR where the users could experience flying through the sky and were able to decide what locations to go to (Quesnel and Riecke, 2017).

3.3.2 Implementation of Study and Assessment of Emotions

Sixteen participants took part in the first study, six of which were females and the average age of participants was 21 (Quesnel and Riecke, 2018). These participants were recruited from a university and received course credit but no monetary imbursement for partaking in the research study (Quesnel and Riecke, 2018). Before the participant began the study, they were given a tour of the VRE to understand to use and navigate it so that facilitators were not needed during the process and provided interruptions (Quesnel and Riecke, 2018). The study made use of a Goose Bump Recorder instrument to recognise the occurrence of goosebumps in the participants as well as an interview and multiple questionnaires to assess and identify the participants' experience when using the VR application, their demographics, immersive tendencies and personality traits (Quesnel and Riecke, 2018). After the completion of all the VEs, the participants then completed all the questionnaires, with the experience one being completed first, and once those were complete an interview took place (Quesnel and Riecke, 2018).

36 participants took part in the second study, 18 of which were female with an average age of 24 (Chirico et al., 2018). The study gathered data by means of self-reports which consisted of an interview and several questionnaires which included a Likert measure questionnaire, Italian PANAS questionnaire, ITC-Sense of Presence Inventory questionnaire and an ad hoc questionnaire to asses awe, general affect, the sense of presence they felt and their perception of vastness and need for accommodation respectively (Chirico et al., 2018). Before the study commenced, the participants completed the questionnaires to assess their current levels of awe and general affect to be used as a baseline (Chirico et al., 2018). Instructions on how to navigate the environments were given to the participants before they interacted with each of the VEs (Chirico et al., 2018). Each participant explored the four environments and after completing the navigation of each environment, they answered all of the aforementioned questionnaires (Chirico et al., 2018). An interview resulted in the conclusion of the study (Chirico et al., 2018).

15 participants took part in the third research study, however two were excluded from the results as they experienced cybersickness which resulted in 13 participants being used in the analysis of the research study, 7 of which were female (Stepanova et al., 2019). The data for this study was collected via interviews which was done via a cued-recalled debrief and micro-phenomenology as well as an Implicit Association Test (IAT) and cameras that were set-up to identify goosebumps (Stepanova et al., 2019). The study started with a short introduction and warning about the possibility of inducing cybersickness and how to combat it, after which the user interacted with the VRE with cameras to identify goosebumps attached to the participant's arm (Stepanova et al., 2019). Once the Virtual Reality experience ended, the interview was conducted where a researcher displayed a video of the participant's interaction with the VE which the participant watched and spoke about different moments and aspects that they experienced (Stepanova et al., 2019). The research would also ask questions if needed to focus the participant's attention to certain events or features to get feedback on important aspects (Stepanova et al., 2019). After the cued-recall debrief, the micro-phenomenology interview took place where a trained individual prompted users to point out moments that were stuck out to them (Stepanova et al., 2019). The interviewer then encouraged the participant to think about one of those moments and led them to recall the scenario, concentrating their focus on various sensory and momentary aspects and eliciting responses as to what they experienced in those moments (Stepanova et al., 2019). After the interview, the participants completed the IAT on a computer which completed the research study (Stepanova et al., 2019).

16 participants took part in the fourth study, six of which were females and 27 was the average of the participants (Quesnel and Riecke, 2017). Some of the participants were recruited from a

university who received course credit for their participation (Quesnel and Riecke, 2017). Data was collected through the use of questionnaires on their experience, goosebumps recording device and phenomenological findings (Quesnel and Riecke, 2017). The participants were introduced to and practiced using the VR technology before the study began to avoid disturbances with the VR experience (Quesnel and Riecke, 2017). The participants interacted with the same Google Earth VR application twice, once while standing and the second while lying on their stomach (Quesnel and Riecke, 2017). Videos of what the participant was seeing were shown on a screen and observations were made on their actions such as their use of the ability to do a 360 degree turn to look around and their ease of use with the controllers (Quesnel and Riecke, 2017). After each interaction with the VE in different positions, the participants answered a questionnaire about their experience and the optical recording instruments to identify goosebumps was used throughout the study (Quesnel and Riecke, 2017).

3.3.3 Critical Analysis of Methods used

All of the studies managed to elicit awe but struggled to determine the exact features that achieved this. A good addition to the research paper produced by study 1 was the inclusion of participants' comments regarding their experiences with the VRE which none of the other studies provided. In both study 1 and study 4, participants were recruited from universities and received course credit which could have influenced the participants to partake in the research study when they may not have if this benefit was not included. Study 1 and 4 both showed results that females experienced more goosebumps than males did, however, since both of these studies had a disproportionate number of females and males with females being less and their small number of participants, it is uncertain whether these findings hold any value. Studies 2 and 3 incorporated a proportionate distribution of the genders, allowing more accurate findings to be ascertained with regards to how VR elicited awe may be affected by gender. Studies consisting of a larger participant base and equal number of females and males could lead to more reliable results. Study 1 had no breaks in between the four different environments which could have resulted in the participants forgetting the emotions they felt and thoughts from previous environments, especially because each environment lasted five minutes. The questionnaires not involving the study, demographics and immersive tendencies, could've taken place before or after the study so that the interview at end could be more effective as the emotions and memories felt could have been more easily recalled. Studies 1 and 4 also included experience with prior interactions with VR technology which ensures that the user experience is more effective and has no disruptions whereas studies 2 and 3 did not include this, but rather verbal instructions, possibly hindering the effectiveness of the study if the user experienced any difficulty with the VR technology. Study 2 had the highest number of participants which was significantly higher when compared to the other three studies which can lead to more reliable results. Study 2 was the only study to not include any biosensors, leaving it vulnerable to the potential bias of participants' feedback which is used for analysis and providing results, thus can provide inaccurate feedback. Emotions evoked in participants from the previous environments could've affected the participants' experience in following environments even though there were breaks in between when participants were filling out questionnaires. This break, however, does not guarantee that emotions elicited in previous environments are subsided. Studies 1, 3 and 4 all made use of a form of goosebump identifier to assist in the recognition of goosebumps in the user while interacting with the VREs. Study 3 also recorded the entire interaction the participant had with the VRE and moments that goosebumps occurred could be matched with what the participant was viewing or experiencing. This can allow for certain aspects to be identified as good elicitors of awe. The recorded experience to help the user remember what they experienced and used trained interviewers to focus and re-evoke the what the user experienced. Did not analyse their emotional state before they entered the VR or try negate what they were feeling beforehand. Very good methods for retrieving data were used in Study 3, as they used a goose bumps recorder, an IAT and a cued-recall debrief and a micro-phenomenology interview. The latter two methods were a great addition as it eliminates some of the need for recall as re-watching and re-focusing on certain parts of the interaction can help the participant to remember what they were feeling and thinking. This is an advantage over the other studies as they all require the user to remember the experience without the use of an aid to assist in this regard. The recorded experience combined with the goosebump recorder instrument also allows the researcher to identify what the participant was looking at when they experienced goosebumps which can help in the future research and design by identifying what features, exactly, were awe-eliciting. No age information provided. Study 4 made good use of different data collecting methods, with using a goosebump sensor, questionnaires and phenomenological observations to assess the emotional response and overall experience of interacting with the VRE. The users only reacted with one VE twice in different oriental positions, and the length of the interaction, which was 10 minutes, could have affected what they remembered and what they were thinking and feeling. There is also no identification if the researcher made use of a recorded video of the experience for the self-report or not as there was a screen during displaying the participants interaction in real-time that was used the phenomenological observations. All of the studies, except study 3 which provided no data on the average age of participants, had a very young participant base, with the average of them ranging between 20 and 30. This makes interpreting the results in relation to older people difficult, as they may experience awe differently than young adults. None of the studies identified the emotional states of the participants before interacting with the virtual environments to incorporate this into the results nor did they include any relaxation methods before and between interacting with the VR application to elicit a neutral emotional state to allow for the subsequent VRE to be effective. Thus, the studies did not take into account how the participants' emotions that could have been evoked form previous VEs could affect the emotional responses they had when experiencing a new environment. Facial recognition devices and heart rate monitors were not investigated in these studies which have been suggested as effective methods to measure the elicitation of awe.

4. Conclusions

This paper has provided the roles of current uses of evoking emotions in VR applications which range from safe training applications to psychological treatments such as the overcoming of phobias. It has also uncovered the many benefits that awe has on a person such as increased wellbeing, decreased aggressive behaviour, the desire to discover spiritual enlightenment and gain new knowledge, encouraging people to be more pro-social, change a person's perspective and to increase empathy which the use of VR applications can potentially be used to provide these benefits to people by making it more accessible. Some design strategies were uncovered for emotional and awe elicitation but methodology on how to design the VEs to follow these strategies is still unknown with no guidelines given to ensure that the intended emotion is evoked. Although inclusion and altering of sounds, colours, textures, objects, interaction and features have shown to evoke awe and different emotions, the identification of what to include or change to achieve this has not been sufficiently defined. The invocation of awe was also suggested by using various environments and aspects such as large geological landscapes, supernatural beings and occurrences, magnificent forms of artwork and the presence of a superior power. Studies used different methods to assess the elicitation of emotions and awe and the use of biosensors were seen to enhance the results of the research compared to studies that only made use of self-report. Techniques used that should be practiced in conducting assessments of awe and emotion elicitation include a prior interaction with the VR technology to ensure participants are comfortable and know how to interact with it for smoother interactions and decreased likelihood of disturbances which could affect the effectiveness of the VR application. Relaxation sessions before and between exploring different VREs could also be beneficial to negate the effect emotions that they were feeling could have on their experience. Recording the interaction with the VR application to be used in interview processes may also assist the participants' recollection of the experience and can assist in pointing out features that evoked a specific response in them. Using questionnaires and not solely relying on interviews may also help in the identification of awe as awe is hard to describe and participants may struggle to convey the emotion that they were feeling. Studies on awe-eliciting VR applications have also yet to use other biosensors such as heart rate monitors and facial recognition tools to assess the intensity of awe experienced which has been pointed out to useful as wide eyes, dropped jaw and physical and psychological freezing have been identified to be indicators of feeling awe. This paper has provided ideas as to how we can design an awe-eliciting VR application and methods that we can make use of when assessing the effectiveness of our design VREs. It also identifies potential uses for our project which can be utilized by many people to experience the transformative effect of awe. Our project could also potentially cover the current gaps in this research field by providing more prominent guidelines on how to design a VR application to invoke the feeling of awe and how using facial recognition and heart rate monitors, if used in our project, affects the results of the awe felt by participants.

REFERENCES

[1] Chirico, A., Ferrise, F., Cordella, L. and Gaggioli, A., 2018. Designing awe in virtual reality: An experimental study. *Frontiers in psychology*, *8*, p.2351.

[2] Chirico, A., Yaden, D.B., Riva, G. and Gaggioli, A., 2016. The potential of virtual reality for the investigation of awe. *Frontiers in psychology*, *7*, p.1766.

[3] Colombo, D., Díaz-García, A., Fernandez-Álvarez, J. and Botella, C., 2021. Virtual reality for the enhancement of emotion regulation. *Clinical Psychology & Psychotherapy*, *28*(3), pp.519-537.

[4] Diemer, J., Alpers, G.W., Peperkorn, H.M., Shiban, Y. and Mühlberger, A., 2015. The impact of perception and presence on emotional reactions: a review of research in virtual reality. *Frontiers in psychology*, *6*, p.26.

[5] Dozio, N., Marcolin, F., Scurati, G.W., Ulrich, L., Nonis, F., Vezzetti, E., Marsocci, G., La Rosa, A. and Ferrise, F., 2022. A design methodology for affective Virtual Reality. *International Journal of Human-Computer Studies*, *162*, p.102791.

[6] Felnhofer, A., Kothgassner, O.D., Schmidt, M., Heinzle, A.K., Beutl, L., Hlavacs, H. and Kryspin-Exner, I., 2015. Is virtual reality emotionally arousing? Investigating five emotion inducing virtual park scenarios. *International journal of human-computer studies*, *82*, pp.48-56.

[7] Ke, J. and Yoon, J., 2020. Design for Breathtaking Experiences: An Exploration of Design Strategies to Evoke Awe in Human–Product Interactions. *Multimodal Technologies and Interaction*, *4*(4), p.82.

[8] Lipp, N., Dużmańska-Misiarczyk, N., Strojny, A. and Strojny, P., 2021. Evoking emotions in virtual reality: schema activation via a freeze-frame stimulus. *Virtual Reality*, *25*(2), pp.279-292.

[9] Marín-Morales, J., Llinares, C., Guixeres, J. and Alcañiz, M., 2020. Emotion recognition in immersive virtual reality: From statistics to affective computing. *Sensors*, *20*(18), p.5163.

[10] Nelson-Coffey, S.K., Ruberton, P.M., Chancellor, J., Cornick, J.E., Blascovich, J. and Lyubomirsky, S., 2019. The proximal experience of awe. *PloS one*, *14*(5), p.e0216780.

[11] Pearce, J., Strickland-Munro, J. and Moore, S.A., 2017. What fosters awe-inspiring experiences in nature-based tourism destinations?. *Journal of sustainable tourism*, *25*(3), pp.362-378.

[12] Quesnel, D. and Riecke, B.E., 2017, March. Awestruck: natural interaction with virtual reality on eliciting awe. In *2017 IEEE Symposium on 3D User Interfaces (3DUI)* (pp. 205-206). IEEE.

[13] Quesnel, D. and Riecke, B.E., 2018. Are you awed yet? How virtual reality gives us awe and goose bumps. *Frontiers in psychology*, *9*, p.2158.

[14] Shiota, M.N., Keltner, D. and Mossman, A., 2007. The nature of awe: Elicitors, appraisals, and effects on self-concept. *Cognition and emotion*, *21*(5), pp.944-963.

[15] Stepanova, E.R., Quesnel, D. and Riecke, B.E., 2019. Understanding AWE: Can a virtual journey, inspired by the overview effect, lead to an increased sense of interconnectedness?. *Frontiers in Digital Humanities*, *6*, p.9.

[16] Susindar, S., Sadeghi, M., Huntington, L., Singer, A. and Ferris, T.K., 2019, November. The feeling is real: Emotion elicitation in virtual reality. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 63, No. 1, pp. 252-256). Sage CA: Los Angeles, CA: SAGE Publications.

[17] Yaden, D.B., Kaufman, S.B., Hyde, E., Chirico, A., Gaggioli, A., Zhang, J.W. and Keltner, D., 2019. The development of the Awe Experience Scale (AWE-S): A multifactorial measure for a complex emotion. *The journal of positive psychology*, *14*(4), pp.474-488.