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Understanding AWE: Can a Virtual Journey, Inspired by the Overview Effect, Lead to an Increased Sense of Interconnectedness?

Ekaterina R. Stepanova, Denise Quesnel and Bernhard E. Riecke*

iSpace Lab, School Of Interactive Arts and Technology, Simon Fraser University, Surrey, BC, Canada

Immersive technology, such as virtual reality, provides us with novel opportunities to create and explore affective experiences with a transformative potential mediated through awe. The profound emotion of awe, that is experienced in response to witnessing vastness and creates the need for accommodation that can lead to restructuring of one's worldview and an increased feeling of connectedness. An iconic example of the powers of awe is observed in astronauts who develop instant social consciousness and strong pro-environmental values in response to the overwhelming beauty of Earth observed from space. Here on Earth, awe can also be experienced in response to observing vast natural phenomenon or even sometimes in response to some forms of art, presenting vast beauty to its audience. Can virtual reality provide a new powerful tool for reliably inducing such experiences? What are some unique potentials of this emerging medium? This paper describes the evaluation of an immersive installation *"AWE"*—Awe-inspiring Wellness Environment. The results indicate that the experience of being in *"AWE"* can elicit some components of awe emotion and induce minor cognitive shifts in participant's worldview similar to the Overview Effect, while this experience also has its own attributes that might be unique to this specific medium. Comparing the results of this exploratory study to other virtual environments designed to elicit Overview Effect provides insights on the relationship between design features and participant's experience. The qualitative results highlight the importance of perceived safety, personal background and familiarity with the environment, and the induction of a small visceral fear reaction as a part of the emotional arc of the virtual journey—as some of the key contributers to the affective experience of the immersive installation. Even though the observed components of awe and a few indications of cognitive shift support the potential of Virtual Reality as a transformative medium, many more iterations of the design and research tools are required before we can achieve and fully explore a profound awe-inspiring transformative experience mediated through immersive technologies.

Keywords: virtual reality, overview effect, awe, transformative experiences, interconnectedness, cognitive shift, positive technology, experience design

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University of Southern California,
United States

****Correspondence:***
Ekaterina R. Stepanova
erstepan@sfu.ca

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1. INTRODUCTION

The overwhelmingly beautiful sight of our Earth triggers a profound emotional response in most astronauts, leading to a cognitive shift, making them realize the global interconnectedness of all life and feel responsibility for the future of our planet. This phenomenon was described by White (2014) and termed the *Overview Effect*. This experience has the attributes of self-transcendence and awe (Yaden et al., 2016) and is a remarkable example of a transformative experience. Besides the Overview Effect, there are other experiences that have similar effect of evolving an individual as a changed person and promoting the feeling of unity or interconnectedness. For instance, such experiences happen in the context of interaction with nature (Williams and Harvey, 2001; McDonald et al., 2009; Tsaur et al., 2013) or in religious or spiritual context (Keltner and Haidt, 2003; Levin and Steele, 2005), as well as mystical experiences, meditation, peak and flow experiences during high task performance and several other contexts (Yaden et al., 2017). The emotion of *awe* is often at the core of these experiences (Yaden et al., 2017; Chirico and Yaden, 2018). Even though the terms "transformative," "transcedent," and "awe-inspiring" experiences are not interchangeable, there is a large overlap between the phenomena they are describing. For the purpose of the project described in this paper, as we were aiming for the experience that is laying anywhere within the cluster of these phenomena, we will be discussing them together, without drawing a careful distinction between the terms.

Besides being an enjoyable experience (Shiota et al., 2011), such phenomena can have short and long-term positive outcomes: leading to increased well-being (Ihle et al., 2006; Suedfeld et al., 2012; Krause and Hayward, 2015), pro-social (Piff et al., 2015; Prade and Saroglou, 2016; Yang et al., 2016; Stellar et al., 2017, 2018), and pro-environmental (White, 2014; Garan, 2015) attitudes, and even improved physical health (Stellar et al., 2015). The feeling of interconnectedness can lead to the development of social consciousness, which in turn would lead to pro-social behavior (Schlitz et al., 2010). However, despite all the benefits of transformative and awe-inspiring experiences, they remain rare, inaccessible to some people (e.g., due to physical or economic reasons) and could be challenging to achieve at will. Developing tools that could allow us to create environments that could reliably invite such experiences to happen would greatly benefit the world on both individual and societal levels. If we can facilitate the invitation of transformative experiences even only half of the time, that already would make such experiences much more accessible, and the tool allowing us to do that, arguably, would be able to claim itself as a transformative medium.

Virtual Reality (VR) technology with its controllability and ability to afford sense of presence could provide us with a unique medium to design for and study awe-inspiring experiences (Chirico et al., 2016), making them more accessible to the public and researchers (Stepanova et al., 2018). The potential of immersive technology to create applications for positive change has been widely explored in different contexts, see reviews in Kitson et al. (2018a) and Riva et al. (2016). Researchers explored the potential of VR to induce awe in controlled lab conditions through using immersive videos (Chirico et al., 2017) and virtual environments (Chirico et al., 2018a), and were successfully able to elicit a self-reported awe response in some of their participants. Quesnel and Riecke (2018) and Gallagher et al. (2015) have also used virtual experiences of a spaceflight and evaluated its potential for inducing awe. Even though none of these studies observed a transformative experience of a similar scale to the Overview Effect in their participants, they still showed promising results indicating that VR, as a medium, could successfully deliver experiences that can trigger profound emotional responses such as awe.

However, there is still little research on awe, as well as the Overview Effect and other transformative experiences, that could inspire the design of a transformative experience in VR. Moreover, a larger body of knowledge needs to be build about the specific potential and affordances provided by VR for the design of profound experiences, as well as an understanding of what would someone's experience of going through such installation be like. As VR technology and affective design are both relatively new fields, it is important to not only bring in the understanding of how profound transformative experiences happen outside of VR as a guidance for the design of the immersive experiences and assessment of their effectiveness, but to also develop rich body of knowledge of how such immersive installations are experienced by different individuals. This study attempts to contribute to this developing body of knowledge by describing and analyzing personal experiences of individuals going through an immersive VR installation designed with a goal of awe elicitation and invitation of a transformative experience. This understanding will be essential for future assessment of VR technology as a more ecologically-valid approach to conducting controlled lab studies of complex phenomena and for informing design strategies, affordances and limitations for the development of profound positive immersive experiences with transformative potential. VR technology can not only allow us to "replicate" in a virtual world experiences that are poorly accessible in real world, such as a spaceflight, but this medium also presents its own unique opportunities for creating spaces and journeys that can invite a transformative experience. For instance, technology in itself, with the vastness of the data it can connect you to, can elicit awe (Bai et al., 2017). Thus, it is reasonable to explore the virtual transformative experiences as its own sub-cluster of transformative phenomena with its own unique attributes and processes, but similar desired benefits such as an increased feeling of interconnectedness, and the benefits for well-being and pro-social and pro-environmental attitudes that could follow from it.

In order to build this knowledge base about the transformative potential of VR and the phenomenology of individual's experience in a VR installation, we need to utilize our knowledge of profound transformative experiences to motivate the design of VR installations and then study the experience it induces as its own phenomenon. Using qualitative research methods allows us to develop an understanding of how personal experience is unfolding and what the important aspects of it are. Then, we can relate that understanding to the attributes of the design and the desired outcome. Comparing the experience elicited by different VR installations would provide deeper insights in how

different design elements, as well as the setting and participant's background might correlate with particular aspects of the elicited experience. Additionally, relating the personal experiences of participants to the design decisions will help developers of transformative VR experiences validate their design hypotheses and intuitions, as well as propose new direction for investigation.

To achieve that, for this exploratory study we designed an immersive VR installation *"AWE"*—Awe-inspiring Wellness Environment (description of the development including the design hypotheses can be found in Quesnel et al., 2018b)—that was inspired by the Overview Effect and other awe-inspiring experiences in nature. This installation is not an attempt of a virtual replication of an astronaut's experience, but rather an artistic creation aiming at eliciting an experience that will have some similar outcomes to the Overview Effect. The Overview Effect is described as a cognitive shift that includes an experience of *awe* and feeling of *connectedness* to the world, the people and nature (White, 2014; Yaden et al., 2016; Stepanova et al., 2018, 2019), so these were the qualities of the experience that we were hoping to observe in the immersants going through AWE. At the same time, giving the complexity of the experiences of awe, self-transcendence, connection and the Overview Effect, and the complexity of the conditions in which they may occur, at this stage we couldn't directly test for an effect of singular aspect of the design of the virtual experience on likelihood of the desired experience occurring. It doesn't seem to be possible to isolate a singular aspect of the experience that might be responsible for the desired experience in the immersants. Thus, in order to form testable hypotheses about the relationship of the design and user experience, we first need to develop a VR experience capable of eliciting the feelings of awe, connectedness and cognitive shifts, related to the Overview Effect; and then build a rich knowledge of the phenomenological experience of that VR experience, from which new hypotheses can be derived.

In this exploratory study we discuss the aspects of the experience that the participants of *"AWE"* have described and relate their accounts to the research on the Overview Effect and awe-inspiring experiences. This study has two distinct goals: (1) evaluate the potential of the current research prototype, *"AWE,"* for eliciting some of its desired effects that have been associated with the Overview Effect; (2) develop a better understanding of what are the important components of an individual's experience of going through an affective VR installation designed for awe elicitation, and how it can inform future system development and hypothesis formation. To develop a better understanding of the different components of the experience of a person going through an affective VR installation like *"AWE"* we performed in-depth qualitative interviews with participants about their experience. To evaluate the potential of our *"AWE"* experience to elicit awe and ideally lead to a cognitive shift and increased interconnectedness, besides comparing the thematic analyses of interviews to existing qualitative research on awe and Overview Effect, we also implemented two quantitative measures that could be used for assessing components of the Overview Effect: occurrences of awe measured through goosebumps extending work of Quesnel and Riecke (2017) and Benedek and Kaernbach (2011) and connectedness to nature measured through an Implicit Association Test (IAT) used in Schultz et al. (2004).

As this is an exploratory and largely qualitative study, we were not testing any formal scientific hypothesis. However, in the process of designing the *"AWE"* installation, several *design hypotheses* were made as a part of the creation process. Some of these design hypotheses are discussed in our paper describing the development of *"AWE"* (Quesnel et al., 2018b). Even though these hypotheses are not directly tested in this study, they might have formed some expectations that we had prior to collecting and analyzing the data, that were informed by these hypotheses. Additionally, in a separate publication, we have also proposed design guidelines for a virtual Overview Effect experience based on astronauts' recollections of it and available research—Stepanova et al. (2019). Those proposed guidelines have both informed the design of the *"AWE"* and might have formed our expectations for the current study. To minimize our bias in the analyses, we used phenomenological method that attempts to suspend the researchers' expectations through the process of epoché (a.k.a. "bracketing") (Smith and Osborn, 2004). After the analyses and reporting results, we turn back to our expectations formed prior to the study and discuss the relation of the results of this study to the guidelines discussed in Stepanova et al. (2019) in the section 4 of this paper.

This paper makes a contribution to several fields: to the field of the VR experience design (esp. VR4Good—Virtual Reality for positive change) by identifying the aspects of an affective experience of being in VR that can be supported with thoughtful design of VR installation; to the field of transformative experience design by describing possibility for inducing cognitive shifts in VR and how they might occur; to the field of psychology describing possible methodological approach for investigating awe, the feeling of connectedness and transformative experiences, that might be difficult to access, like the Overview Effect.

2. MATERIALS AND METHODS

2.1. Immersive Experience and Physical Set-Up

Participants were invited into the study room where there was a separate "tent" section for the virtual experience and the preparation area with a table and a laptop, where participants were signing the consent form and doing the IAT. The "tent" was set up with a 305 × 305 × 211 cm gazebo, that was diagonally separated with black curtains into the VR and the researcher (from where the equipment was operated) areas. Inside the "tent" there was an office chair covered with a blanket (to suggest the atmosphere of comfort) and some pillows on the floor (to match the virtual environment (VE)); the outside of the "tent" was decorated with fairy lights, that resemble starry night sky when viewed from inside, which corresponds to the first stage of the VE (**Figure 1**). We set up the virtual experience inside the physical tent for two main reasons. Firstly, to create an explicit entry into the experience space, that would separate it from the formal study procedures

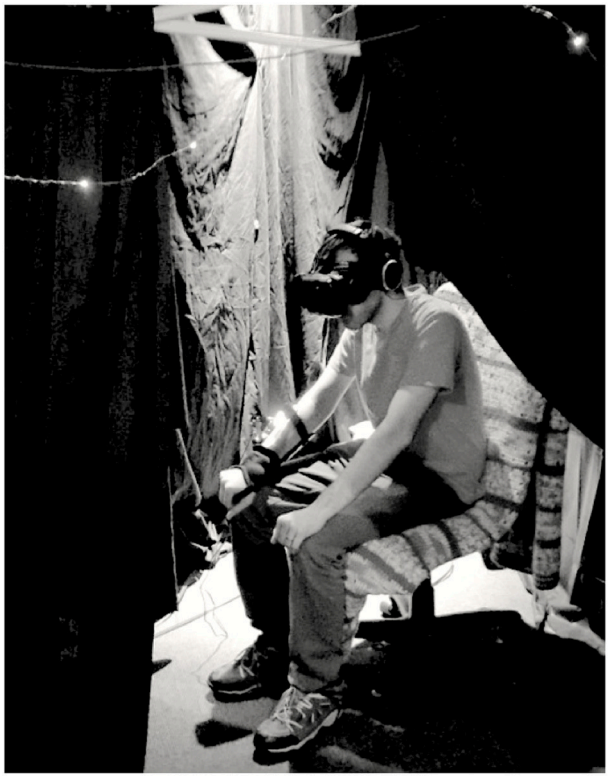

FIGURE 1 | A participant inside the tent (with the open entrance curtain) inside the *"AWE"* installation. The participant is seated on a swivel chair, wearing an HTC Vive (2016 model, 2,160 × 1,200 total resolution, 1,080 × 1,200 per eye, 90 Hz refresh rate at 110° diagonal field of view) and noise-canceling headphones on his head, and a goosebump camera on his right hand. Written informed consent for the publication of this image was obtained from the person depicted.

space. As such, the stepping into the tent was serving as a small ritual, that is proposed as a design guideline for transcendent VR experiences (Kitson et al., 2018b). Secondly, the tent was creating a semi-private environment where participants knew that they were not being directly observed and can be more immersed and expressive. We believed that these two conditions might be important for inviting the opportunity of a transformative experience.

The navigation interface used for locomotion was adapted from Swivel Chair (Nguyen-Vo, 2018), which uses the rotation and leaning of one's body for locomotion through a virtual space. Participants were sitting on an office chair and controlling their simulated self-motion by leaning in the direction they want to go, with the amount of leaning determining the translation velocity in the direction they were leaning. To rotate, participant turn around on the chair that can spin 360°. The interface was calibrated for the individual's height.

The immersive experience *"AWE"* (Quesnel et al., 2018b) consisted of three environments: forest, lake and space (see **Figure 2** and a video of the latest prototype http://ispace.iat.sfu.ca/project/awe/).

The three stages of VE allowed for different amounts of active locomotion:

1. In the forest stage, immersants could freely explore the environment along the horizontal plane;
2. in the lake, there is a limited range of movement in the horizontal plane, but the overall vertical direction is directed by descending within a virtual tube;
3. in space participants were taken on a pre-designed trajectory with a limited range of movement.

2.2. Participants

As the main contribution of this exploratory study relies on the phenomenological analyses of the interviews, we were aiming for the recommended sample size between 5 and 25 participants (Creswell, 1998). We used purposive sampling method commonly used in exploratory qualitative research in order to obtain rich descriptions from knowledgeable participants (Palys, 2008). A total of 15 participants were recruited through a purposive sampling method with the help of our partner organization—NGX Interactive, a local company that creates interactive exhibits for culture industry. Participants were recruited within the company's employees and clients and are representing the community of professionals working in the field of culture industry and technology. We specifically recruited participants who will be able to provide us with well-informed feedback on the system and its potential to be used in culture industry for facilitating shifts in worldviews, but they were naive in terms of the specific details of this study. Additionally, even though the experience with VR technology varied between participants, they had ample experience with interactive technologies, and therefore would be able to go beyond the initial "wow" response, that first time users of VR sometimes have. We will be referring to participants as P#. Two participants (P07,P15) were excluded from the analyses as they did not finish the experience due to cybersickness, resulting in a final sample of 13 (7 females). The ethics approval was granted by Simon Fraser University Office of Research Ethics (Study#: 2017s0269).

Throughout the iterative development of the AWE experience we conducted a multitude of smaller formative user tests with a range of participant populations to inform the design of the AWE experience. While they generally confirm the results of the current study, reporting them in any detail goes beyond the scope of the current study and would not substantially alter the findings.

2.3. Procedure

After signing the written informed consent form, participants were asked to enter the tent and sit down on the swivel chair. The researcher explained the set-up procedure and the navigation, handed the Head-Mounted Display (HMD, HTC Vive) and the noise-canceling headphones to the participant and assisted with putting the equipment on. Participants were instructed in case of a mild cybersickness to close their eyes for a moment, and, if the feeling persists or is strong, to notify the researcher and they would stop the experience. Next, the researcher asked

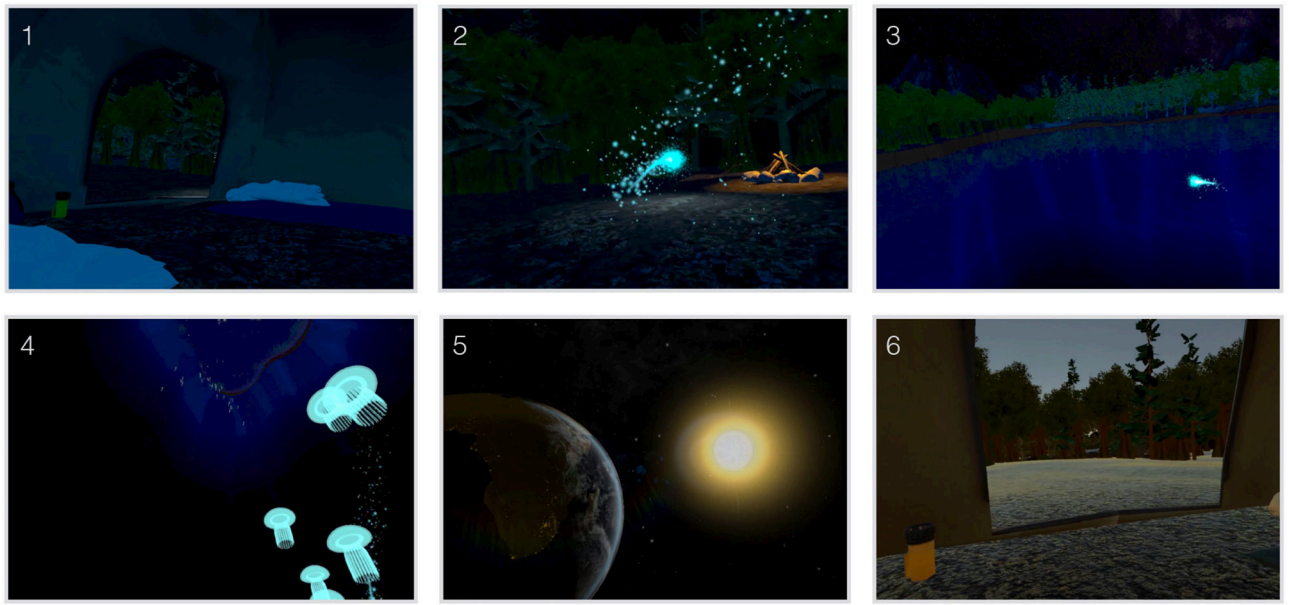

FIGURE 2 | A summary of the virtual journey through *"AWE."*. **(1)** The immersant finds themselves in a tent at a campsite. **(2)** The magical Sprite creature lures the immersant out of the tent to explore the night forest. **(3)** Following the Sprite, immersant takes a leap of faith into the lake, **(4)** where they descend down passing by deep water creatures. **(5)** The bottom of the lake opens into space where the Earth and Sun appear in a dramatic reveal. **(6)** After orbiting around the Earth, the immersant finds themselves back in the campsite.

the participant to roll up their sleeve and put the goosebump camera (explained in the following section) on their arm. Once confirmed that the participant feels comfortable, the second researcher starts the virtual experience, and the first researcher directs the participant through the initial calibration process for the navigation, while second researcher starts the recording of the goosebump camera. Then, the first researcher notifies the participant that everything is now in order and leaves the tent leaving the participant in privacy for the experience. After the virtual experience, the first researcher returns to the tent to assist the participant with taking off the equipment and sets up for the interview. After the interview, the participant is directed out of the tent to complete the Implicit Association Test (IAT) on a laptop (13-inch MacBook Pro). The participant's experience in the VE was recorded through screen capture and the interviews were recorded with a GoPro camera. The study took approximately 1 h.

2.4. Evaluation Methods

We have used a combination of qualitative and quantitative measures to help us address two goals: (1) understand the participant's phenomenological experience and (2) to assess the potential of the AWE experience to create conditions in which an awe-inspiring experience similar to the overview effect (or a degree of) may occur. As the overview effect is described as a cognitive shift that starts with an experience of awe and leads to the increased feeling of connection and responsibility for Earth (White, 2014; Yaden et al., 2016; Stepanova et al., 2018, 2019), we included measures of awe and connection with nature. We didn't include specific measures of the responsibility for Earth at this stage, as first we needed to establish that earlier stages of the desired transformative experience can be achieved.

We used interviews to collect qualitative data about the participants' phenomenological experience of going through the VR installation. Additionally, we included two quantitative measures to assess two components of the Overview Effect experience: an implicit association test to assess the interconnectedness, and a measure of piloerection (goose bumps) to assess the occurrences of awe. These two quantitative measures were included as a methodological exploration in preparation for future studies, that will use a randomized controlled experimental design, less in-depth qualitative measures and a larger sample size. Here, we hypothesized that we will observe a trend indicative of correlation between the measure of awe and the measure of connectedness (higher scores on the implicit association test will co-occur with higher number of instances of piloerection), as in the Overview Effect they are described to occur together.

2.4.1. Interviews

We collected the qualitative data through either cued-recall debrief (Bentley et al., 2005) or micro-phenomenological interviews (Petitmengin et al., 2009). Both of these methods are designed to help participants get re-immersed in the past experience and therefor to have more direct access to different aspects of the experience reducing recall errors that could be introduced with the use of retrospective measures (Henry et al., 1994). To further minimize the recall errors caused by the delay between the experience and the interview, each interview was administered immediately after the virtual experience. We

implemented both methods in order to assess how they fit into the context of research of affective VR experiences and evaluate what type of data they will be most effective at yielding. To keep the study under an hour to avoid participant's fatigue, we used only one type of interview with each participant: four participants (P02, P03, P04, P09) were interviewed with micro-phenomenological and nine with cued-recall debrief methods. Each interview was followed by a short set of general questions about the experience. The type of the interview administered depended on the timeslot (determined by the availability of the trained micro-phenomenological interviewer). When signing up for the study, participants were not informed about the relationship between the timeslots and interview methods. Each interview took about 20–30 min.

2.4.1.1. Cued-recall debrief

After the virtual experience, the researcher would help the participant to take off the equipment, while the second researcher would turn around the monitor and load the recording of participant's experience on the screen and set-up the video camera. During cued-recall debrief (Bentley et al., 2005) the participant watched the screen capture of the experience together with the researcher and talked through what was happening at any particular moment of the experience. The researcher may prompt the participant with questions to direct their attention to different aspects of their experience, for example: *"What were you doing here?," "Did you have any thoughts when you looked up?"* or *"What did it feel like when you went in?"*; or to direct their attention to a specific behavior observed in the recording: *"You seem to be looking around a little more here, was there something that caught your eye?"*

2.4.1.2. Micro-phenomenology

Unlike cued-recall, micro-phenomenological interview (Petitmengin et al., 2009) did not use visual prompts to assist the participant with re-immersion, and was administered by an interviewer trained in the method. The interview started with a short practice interview not related to the virtual experience (discussing a moment from the recent weekend) to give an opportunity for the participant to get familiarized with the method and what is expected from them. Then the interviewer asked the participant to identify one or a few moments in their experience that stood out to them and invited them to focus on each moment at a time. The interviewer than lead the participant through the process of the re-evocation of that moment directing their attention to different sensory and temporary dimensions of their experience.

2.4.2. Implicit Attitudes

We used the same Implicit Association Test (IAT) for assessing one's connection to Nature as in Schultz et al. (2004). This measure is used to measure interconnectedness—the component of the Overview Effect. This test asks participants to categorize words in one of the two categories by pressing "E" or "I" key on a computer with left and right index finger, respectively. In the test trials the categories are appearing together creating either a congruent or non-congruent pair (**Figure 3**). The results are based on response reaction time and accuracy for congruent and non-congruent category pairs. The categories were Self vs. Other and Nature vs. Build with 7 blocks of trials.

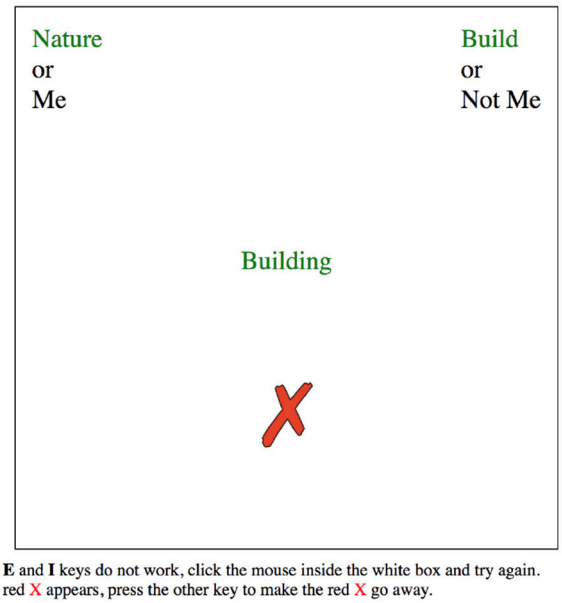

FIGURE 3 | The Implicit Association Test (IAT) screen with congruent categories pairing and inaccurate response.

FIGURE 4 | Custom made set-up of a wearable camera for recording a video of participant's skin for identifying goosebumps and shivers.

2.4.3. Piloerection: Goosebumps and Shivers

Piloerection observed in a form of goosebump or shivers can be used as a physiological marker of awe (Benedek and Kaernbach, 2011; Quesnel and Riecke, 2017). A "goosebump camera" (see **Figure 4**) was placed on participant's arm to record a video of their skin during the experience. The researcher helped participant to put on the camera and adjusted the focal distance from the camera to the skin for the best clarity of image. Video recording from the camera was manually synchronized with the screen recording of participant's experience for future alignment.

2.5. Analyses

2.5.1. Interview Thematic Analyses

The interviews were transcribed and analyzed in NVivo. Even though some of the data was collected with micro-phenomenological interviews, we didn't perform a micro-phenomenological analyses for this study, but analyzed all of the interviews through the same phenomenolgical method. First, two researchers independently went through the transcripts, identified meaning units and combined them into higher level themes. The two researchers then compared and discussed the themes, they have identified, to agree upon one set of themes. Then the researcher went back to NVivo and proceeded with coding. To minimize the researcher's bias in interpreting the data we used "bracketing" and a bottom-up coding approach similar to interpretive phenomenology analyses (Smith and Osborn, 2004) and looked for themes that naturally emerge from the data instead of coding for the specific themes of interest. We present the summary of the distribution of all themes, however, in the interest of space, we will only report in detail on the most prominent and relevant themes.

2.5.2. Implicit Association Test

We calculated IAT effect D scores of strength of association based on a standard algorithm for IAT (Wittenbrink and Schwarz, 2007). D scores have a possible range of -2 to +2. According to standard conventions we identified the strength of connection in accordance with the following break points: "slight" - ($0.15 \leq |D| < 0.35$), "moderate" - ($0.35 \leq |D| < 0.65$); and "strong" - ($0.65 \leq |D|$).

2.5.3. Goosebumps and Shivers

The video recordings from goosebumps camera were independently manually coded by two researchers to identify moments of goosebumps or shivers. Moments of goosebumps are visually evident from hairs erecting, with the appearance of raised bumps on the skin. Shivers have less prominent raised bumps, but they are evident from micro-movements of muscles under the skin that visually look like a wave lifting the hairs up slightly.

3. RESULTS AND DISCUSSION

The first two section of the results report on quantitative data, and the following discuss the interview data. First, we present the interview data based on the thematic analyses. After, we present the analyses of categories of emotions related to awe based on a hermeneutical analyses reported in Gallagher et al. (2015) and compare it to the results observed in Quesnel and Riecke (2018), that used Google Earth VR.

3.1. Implicit Association Test

Mean D score across all participants was 0.46 ($SD = 0.54$), which indicates a moderate strength of positive connection between Self and Nature. Nine participants had a moderate to strong positive connection ($M = 0.78$, $SD = 0.23$), two participants had slight or moderate negative connection ($M = -0.39$, $SD = 0.25$), and two participants had neutral scores ($M = -0.11$, $SD = 0.0015$).

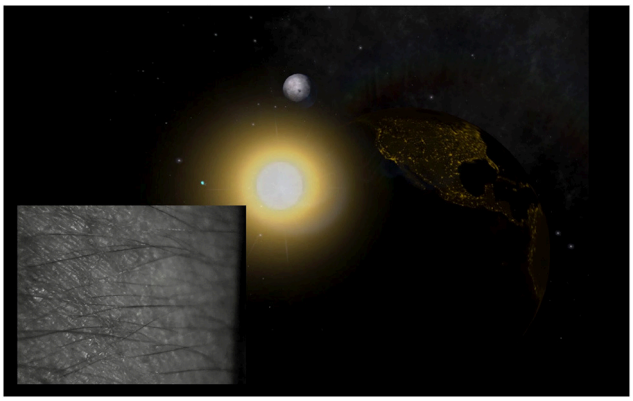

FIGURE 5 | The moment of shivers: aligned recording from the goosebump camera and screen recording from the HMD showing the Earth scene with the sun appearing from behind it.

To give context to our observed results, we compared our results to to D-scores obtained on the same IAT test by Schultz and Tabanico (2007), who observed an average 0.40 score between 60 undergraduate psychology students and 0.45 between 121 park visitors in California, we can speculate that possibly the effect of our virtual experience is similar to the effect of walking in the park in terms of one's implicit connection with nature. However, the sample sizes and the context in which the measures were conducted were widely different, and therefor a strong comparison is not possible.

3.2. Shivers

In this study we observed one moment of shivers in one participant, when the participant was observing the sun revealing behind the dark Earth. The **Figure 5** illustrates the moment when the shivers occurred.

3.2.1. Thematic Interview Analyses

Table 1 summarizes all the themes observed and coded in the data. We are setting the usability and design related comments aside, as they are outside of the scope of this paper and will be reported separately. We are reporting on the most prominent and relevant themes to this paper, specifically: emotions and feelings, body-centric sensations and embodiment, familiarity and novelty (role of the personal background) and cognitive mini-shifts. These themes are highlighted in the **Table 1** and their frequencies are summarized in **Figure 6**.

3.2.2. Emotions and Feelings

3.2.2.1. Curiosity and wonder

After "cool," "interesting," and "pretty," "*curiosity*" was the most frequent affect related word used by participants. Curiosity and wonder were positive emotions driving participants' exploration behavior: "*Another sense of delight: Oh it's a lake! Not knowing what's gonna happen. Do I just look at the lake? But when I break through the lake its quite a sense of wonder: oh, that's quite lovely!*" (P08). The properties of the environment, specifically some level of mysteriousness or the "unknown-ness" of it, were inspiring

TABLE 1 | Comprehensive summary of themes coded in the interview data, with the prominent themes reported in this chapter bolded.

Emotions and Feelings	**Affects**	**Positive**
		Negative
	Emotional states	**Fear/Discomfort**
		Safety/Trust/Comfort
		Immersion and Engagement
	Bodily sensations	**Internal bodily reactions**
		Reflexes
		Vection
		Weightlessness/Floating
Cognitive shifts and Processes	**Mini-shifts**	**Connectedness**
		Renewed conceptual knowledge
		Vastness and small-self
		Intent of behavioral change
	Processes	Anticipation
		Imagination
	States and Constructs	Experiential vs. Analytical
		Agency/Self-relevance
		Embodiment
		Presence ("being there")
Acts & Intents	Orienting	**Anchoring**
		"Where am I?"
		Seeking a goal
		Justifying/Making sense
	Inner tensions and debates	Exploring vs. Following
		"Taking it in" vs. Goal-oriented
	Thinking of/testing the system	Fear to miss something
		Pushing to the edge
		Trying to predict what is coming
External (to the system) factors	**Personal background**	**Familiarity vs. Novelty**
		Love or hate of the environment
		Comparing to other mediums
	Expectation	Participant bias
		Realistic representation
System/Experience design	Usability	Navigation Interface
		Quality of models
		Collisions
		Cybersickness
		Physical space and objects
	Narrative	Transitions
		Ending
		Sprite character
	Attributes of the environment	Lighting
		Sound
		Open vs. Claustrophobic
		Realistic vs. magical

the curiosity: "*I was just curious about the environment. The environment felt deep. It reminded me the Truman show, where you have the bubble that you can explore.*" (P06), but at same time inducing some level of fear: "*It's really a lot of curiosity and I guess nervousness.*" (P11).

The novelty and new perspectives were also contributing to curiosity: "*I am enjoying the curiosity. I guess I was more interested in looking at the Earth, from this vantage point. I enjoyed looking at the space in reference to the Earth*" (P05).

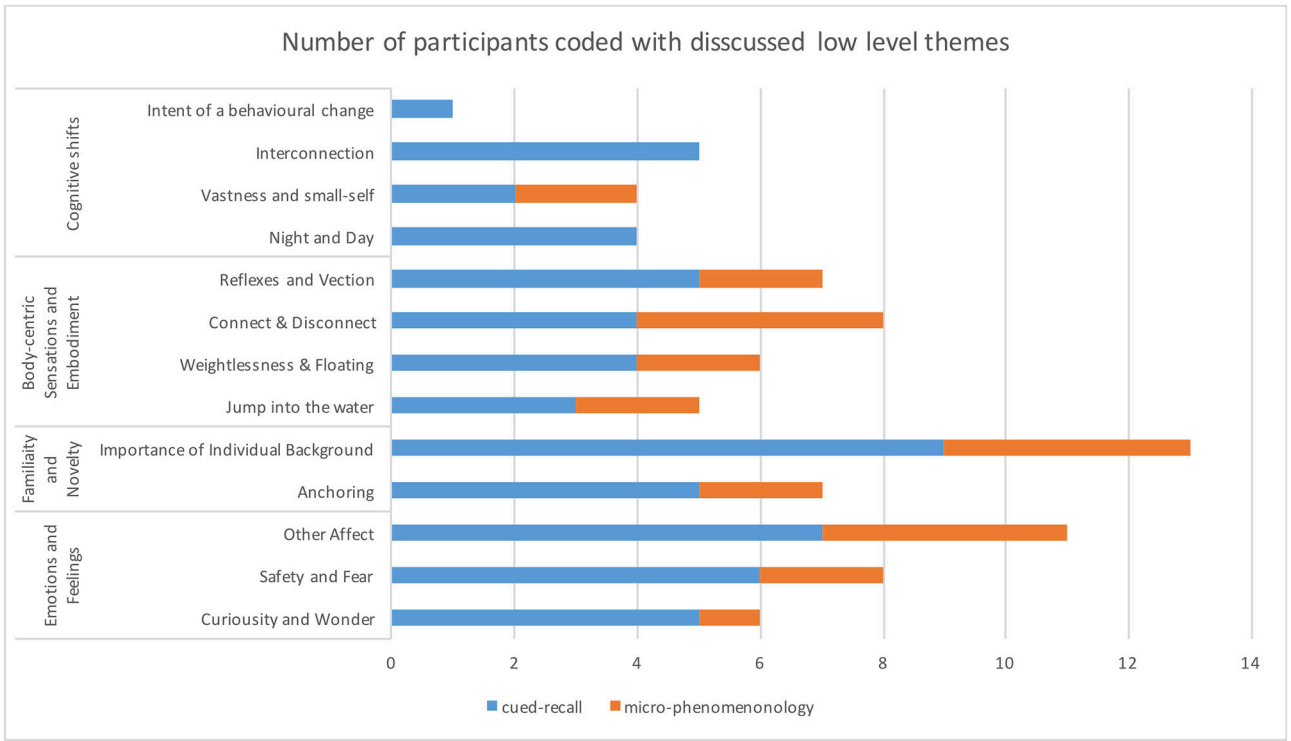

FIGURE 6 | The number of participants (total = 13), that had statements coded with themes reported in this paper.

3.2.2.2. Safety and fear

Most of participants (N = 8) were distinguishing two states in relation to the environment: comfortable and safe vs. uncomfortable and scary.

3.2.2.2.1. Safety. The majority (N = 11) considered the first environment, the forest, and especially the tent to be safe and comforting: "*the whole set up of the tent, and what I saw here... as a tent was really, like, I felt safe. I felt the tent provided a safe starting spot for me to start to going into the outside world.*" (P01). When aiming to achieve a transformative experience in VR, we believed that it was important to have a safe starting point, to help participants trust the system to take them on a potentially emotional journey and help them be more open to this experience. If the medium is not allowing participants to feel comfortable within it, they will likely be more resistant and closed-off from the experience. The physical and the virtual tent appeared to successfully serve that function for most participants. It was also important to conclude the experience with a safe environment. Here participant describes the last transition and coming back into the tent: "*this again is much more familiar, I do this every day kind of thing. It was comforting. Probably in a weird way one of the most comforting parts*" (P05). And since participants already developed some connection and familiarity with that environment, it was even more likely to elicit a sense of comfort: "*Cozy. I felt like I was home, even though it's a temporary home. Daylight, so it's more comforting*" (P06).

3.2.2.2.2. Fear. Fear, was probably one of the strongest and most interesting emotional reactions observed. Participants reported being a little "scared," "nervous," "uncomfortable," or "anxious," which was usually associated with the jump into or descend in the water, or, in a few cases, with walking through the dark forest. Both, the act of jumping of a height and the descend into the deep water was uncomfortable for some participants: *"Then I looked down and I see everything is dark, so for me it was .. I don't know how to explain.. it was just uncomfortable a little bit.. somewhere you are in the water and everything is dark and you are going down"* (P09). This was also the transition into the lake where the locomotion was more restricted than in the forest, that increased the level of fear:*"I know that if I jump into the lake I can get out as fast as I can, and it's up to me, but I felt like jumping in with the weights attached to your ankle—I am not in control of this situation and it doesn't make me feel comfortable. I am being lead. I don't want to be lead*" (P06). This also relates to the role of the sense of agency in the environment, the loss of which was often undermining participant's enjoyment.

There were many strong bodily reactions to the jump and descend into the lake in the VE, that was surprising and in some way profound for the participants: *"I felt a shock. It felt like I was choked. That surprised me. It was not just like "Oh that was kind of weird," I did feel like someone poked me or something. I felt an actual zap to myself, a tension, that I wasn't expecting."* (P05)

The strategies participants used to cope with this fear were: (1) dissociate from the experience and bring yourself to the analytical level: "*Mentally overwrote back that this is just the experience.*" (P06), (2) find a comforting point of reference: "*There is fish, which is a comforting reference point in this black void. Trying to follow the light.*" (P05), and (3) just wait for it to pass: "*I noticed myself clutching my hands. I am not comfortable, I am just going to wait it out until it goes away*" (P06).

3.2.2.3. Other affects

A distribution of positive and negative valence affects were observed. Negative affects were coming through two main sources: (1) usability issues were causing frustration and inability to explore something of interest was causing disappointment and (2) some parts of the environment were causing nervousness, anxiety or fear, discussed in the sections below. Positive affects could be categorized into the following groups: excitement, inner peace and appreciation of beauty.

3.2.2.3.1. Excitement. Participants were describing their experience as "fun," "exciting," "wow." These affects were often related to the visual and audio attributes of the environment: "*The sun was really exciting, because it is bright. There is music attached to it obviously, other than just my vision, it was also creating that kind of excitement. Bright and exciting*" (P04); or to an interest and anticipation: "*When I first looked around I was kind of hoping I would get to go in there, an when I saw that you can, there was a bit of excitement that I can go and explore the forest around. During that time I was actually looking around a lot. It was kind of immersive, it was fun"* (P03).

Another aspect of the experience that seemed to elicit excitement was the vertical dimension, which is opening a novel perspective. Often, when looking up: "*I kept looking up and thinking how far down am I. It was pretty neat, it was cool*" (P13) or down: "*So I didn't look down that much, but when I did, it was kind of fun and kind of scarier than looking elsewhere*" (P04) participants would describe themselves being more engaged and excited. While the lack of vertical dimension of gaze direction they considered to be the evidence of low engagement: "*I wasn't inclined to look up and down, I was looking more left and right, more like if you are in museum or something and you're kinda looking around*" (P03).

3.2.2.3.2. Inner peace. Participants reported feeling relaxed and peaceful. The soundtrack appeared to significantly contribute to it: "*It was very peaceful and soundtrack was nice and reminded me of nature and being in the forest*" (P08), which was also helping with coping with anxiety from jumping into the lake: "*The sound was calming, just seeing fish and seeing the opening above me made me feel a little more relaxed*" (P09).

3.2.2.3.3. Appreciation of beauty. Participants described the beauty of the elements of the experience and how it made them feel delighted or appreciative. Both, the mystical and novel environments like the nebula: "*There is something about it that I can't define. Because I know these are asteroids and that's probably a planet of some sort but then the fog is like 'Awww.'*" (P01) and familiar natural beauty of the forest: "*I like lakes, particularly because I can see the mountains and the sky behind it, so I wanted to look closer <…> I liked it, I can just sit there and look*" (P06), as well as the beauty of the image of our planet: "*It's just visually really striking. And again, familiar because you've seen images like that. And, the contrast between the dark and the light is really nice.*" (P12)—were all eliciting moments of appreciation and delight in participants.

3.2.3. Familiarity and Novelty

3.2.3.1. Relation to emotions

The feeling of safety or fear as well as curiosity and wonder seem to often be related to the feelings of familiarity and novelty. The first environment of a campsite in a forest was familiar to most participants, and associated with positive emotions, which let them feel comfortable going into the environment. "*It's a very familiar place. It's a tent, and there's a bonfire. There might be other people there. I chose to come here. I chose to be here and setup a tent and sleep in a tent*" (P01). Moreover, throughout the virtual experience, participants will form new connections with elements of the environment and use them to bring themselves back to the state of comfort in the parts that felt scary to them: "*…for my one comfort: 'here is the light, follow the light, here are some fish, I am being sort of acclimatized here'—that time helped*" (P05)

While usually familiar environments were providing a sense of comfort, for other participants, they appeared less engaging. Contrary, novel environments were stimulating curiosity, wonder and excitement. Here a participant is at the end of the lake scene: *"It felt like 'oh cool!'—Its not something you would normally be able to see, where is in the previous environment—I have gone camping before, so I get it. But here I am thinking this is cool, its really creative, really beautiful to see the stars through the water"*(P08). For some participants it was easier to accept and get immersed in more novel environments, they wouldn't have had a concept for, while having a compelling familiar environment seemed more challenging:

> *It is neat to explore a perspective on the world that you would have none of <…> Where is when anything that is too familiar, because I am so in-tune with how I walk and how that feels, so you have that disconnect <…> Where in space—I have no context for that. So okay, this is how I would float in space, fair enough, I have no other way of knowing it.* (P02)

3.2.3.2. Anchoring

The act of cognitive anchoring to a familiar place was quite prominent, and it was not only used as a coping mechanism against anxiety and discomfort provoking environments, but also to orient oneself: *"I saw the sun and recognized it, and quickly after that I saw the Earth, so there was a relation there—I knew where I was for the first time in the experience. Not that I haven't been in a tent before, that was quite familiar. But there I for sure knew where I was."* (P04) and to connect with the environment in a more meaningful way: "*This is kinda of an interesting angle of North America and South America. I have a colleague, who is*

working in Columbia right now, so I am trying . . . I am putting real people I know" (P05).

3.2.3.3. Importance of individual variables and background

We were surprised to observe polarly different responses from our participants within such a fairly simple experience, with a fairly consisted journey. Each of the stages and transitions in the experience has produced opposing responses from love to hate and from relaxation and peacefulness to excitement or fear. This distribution of reactions has stressed the significance of participant's individual background.

The lake environment was the most striking example of opposing experiences participants were having and its relation to their background. One participant describes her delight in that stage: "*I just love the water, and so going into the water was quite delightful. Happiness, familiarity, for me not too calm, but connectedness to nature in that way*" (P08). While another participant had a very different reaction to the same environment: "*A little worried. I don't like deep water. A little anxious. Okay, we got to go over to the lake, I hope we stay above it*" (P06). Transition into the lake as well, which was reported to be one of the most memorable moments by most participants, elicited opposing reaction depending on personal background: an uncomfortable anticipation and anxiety by one participant: *"coming down the little ledge to go in the water.. that was kind of .. I was a little bit hesitant before, because I don't normally like jumping into the water from height. Or jumping from height in general. That feeling scares me a little bit"* (P09), while another participant had a positive anticipation and excitement coming up to that transitions: *"I realized that okay, I am going down to the water, so perfect. This is great. <. . . > I was a little stoked, cause thats the direction where I wanted to go <. . . > I was a little bit timed here: Am I supposed to jump in here? <. . . > then I went for it"* (P11), this participant later mentioned being a cliff-jumper.

Another important influence on the experience was coming from the video-games experience, that participants had, that was both helping them with navigation: "*I have a little bit of a gaming background so I am sort of very comfortable with this first-person movement through virtual space*" (P13), and setting up an expectation to have a goal: " *it reminded me of old video games where there is like a mission or something, I wouldn't necessarily do that mission and I would end up going off somewhere else*" (P10).

3.2.4. Body-Centric Sensations and Embodiment

3.2.4.1. Jump into the water

As discussed in the section on safety and fear, the transition into the water environment, that was inviting participants to jump into the lake, was inducing strong reactions in participants' bodies. They were describing clutching their hands, tensing up their muscles and holding their breath: "*all your muscles constrict, or contract, so it's almost like you are trying to hold yourself tight, so when you get that cold, you can release it once you hit the water*" (P02). This tension was often followed by a release and relaxation, when "hitting the water": "*the body just kind of tense up, and you just kind of . . . just kind of muscles release . . . As soon as I got in the water*" (P09).

3.2.4.2. Weightlessness

Interestingly, that feeling of release might have facilitated the feeling of floating or weightlessness. Here a participant describes the moment when that release happened:

> *That's weird, because, on the ground, up to that transition, I am super conscious of how I am sitting on a chair, and that kind of leaning forward is feeling a little awkward. . . But in that second I didn't feel the. . . And that's what I kind of loved too, is how, I had no idea you could reproduce that, give that sense that you are weightless, suddenly I wasn't conscious of my body pressing into the Earth.* (P02)

For a different participant a similar moment of release leading to the sense of weightlessness happened in the transition into the space: *"When I was in the water I felt like I was not in control and I was weighted down, like if I had weights around my ankles, where is when I was transitioning into the night sky it felt like the opposite: the weights are off the ankles, you are weightless"* (P06). This participant was afraid of the water environment, and even though that transition into space produced less internal bodily responses for most participants than the transition into water, the psychological release of letting go of the fear still lead this participant to experience the illusion of weightlessness.

It was interesting to observe that 6 participants have mentioned floating or the feeling of weightlessness. It might not have been a strong bodily feeling for everyone, but it is encouraging to see that even with a simple hands-free leaning-based interface through a design of the storyline and the visuals, we were able to elicit some level of the feeling of weightlessness without submersing participants in a flotation tank [which would be a more literal induction of the feeling of weightlessness, for instance, planned by SpaceVR for 2018 Burning Man festival (Bonasio, 2018)].

3.2.4.3. Connect and disconnect between mind and body

Imaginative immersion in combination with sensory immersion (Ermi and Mäyrä, 2005) when achieved successfully creates a condition in which participants experience a disconnect between their mind and body. Participants discuss these moments of disconnect, and having their perceptions overridden by their imagination as the optimal moments of their experience: *"It was a bit more of the imagination and just like the feeling of being in warm water and submerging and yet not worrying about the panic of not being able to breath, and just something about that, that I quite liked. And maybe it's because I didn't feel this* [points at different parts of his body], *right?"* (P02). While the moments, in which the conflict between the physical body position and the virtual position became apparent, lead to frustration and disappointment: *"You start unpacking, okay, so you have this goggles, the audio here, and my arms and legs just feel static and crossed, how does that connect? Because that feels weird, when you come back to your body and then realize that it is a stagnate lump going through this* [points at where HMD would have been]*"* (P02). It would be interesting to investigate how this connect/disconnect transitions are being triggered. In case of this participant, he had this desired disconnect during the

lake stage that was initiated by a visceral jump into the lake and then "*something broke the spell*" (P02) when transition into the space happened. For him, the transition into the space came as a surprise and did not make sense. For a different participant, the conflict was the result of not having an avatar representation in the VE: "*I felt a bit disconnected from my body, because when I look down I don't see my body, and usually its there, obviously*" (P04).

3.2.4.4. Reflexes and vection

Vection (an illusion of self-motion) and reflexes are often perceived as an indicator of how immersive and "believable" the experience was by participants.

For example, a participant describes descending down in the lake: *"I see the sparkles, <…> I realized that they are kind of like surrounding me, that's when I really got the sense of the descent down. The closest I can compare it to is when you are going down a roller coaster, but it wasn't that intense, it was more calm kind of feeling"* (P03) and then going into space: "*As soon as the movement started, it kind of again felt a bit more immersive, the floating feeling came back again*" (P03). The lack of self-motion illusion for some participants in space combined with restricted locomotion might have also contributed to some of them feeling as if they are watching a movie instead of participating.

Sometimes, participants would also report having a reflex in reaction to an event in the VE: for example, when the sun appeared, a participant was surprised and reported: "*I am pretty sure I jumped.*" (P05) while another participant mentioned: "*I found the sun pretty bright, almost wanted to put my hand up. But yeah, this is neat.*" (P10). While putting the hand up to protect one's eyes wouldn't have worked with an HMD, a different participant adopted her reflexes from diving to the VR equipment: "*because I'm a diver I felt like I'm descending, there was one point were I adjusted my face but it's a bit like adjusting your regulator.*" (P14). This type of behavior could potentially indicate how "real" the experience was for the participants at that moment.

This "realness" and "being there" of the experience, that is indicated by multidimensional responses, including your internal body feelings and actions, are likely an important precursor to the possibility of transformative experience that could lead to cognitive shifts. For instance "presence," which is often described as the feeling of "realness" or "being there" in a virtual experience was shown to correlate with a stronger effect of the virtual experience on the following real-world behavior (Fox et al., 2009; Rosenberg et al., 2013).

3.2.5. Cognitive Mini-Shifts

As the ultimate goal of this project is to evaluate if VR experiences can be designed to elicit positive cognitive shifts similar to the Overview Effect and other awe-inspiring transformative experiences, we were excited (and a little surprised) to see some indication of some minor cognitive shifts voluntarily described in the interviews. Participants themselves were also intrigued by the shift in perspective resulted from their experience, even when the shift was in the perception of seemingly simple concepts:

> *I kinda compared that sort of spatial environment that I was in with all of the representations of space that we get used to, which is a very 2D item, the solar system prospective. And that difference, that being in it, and that way how it altered my sense of that relational space of one celestial body to another, that was really cool actually how it changed something in my mind slightly.* (P13)

3.2.5.1. Day and night

Four participants found the concept of day and night happening at the same time on different sides of the globe, that was observable in the experience when traveling around the Earth, very interesting. Even though they are intellectually familiar with this idea, seeing it from the first person perspective was a somewhat "eye-opening" experience. Participant reflects on her mental process of coming to that realization:

> *To realize that it is so easy to look at something through one lens, but when, if you are exposed to it in a different way, then something that was so familiar to you ... can give you such a different perspective. Something as simple as that sun is not shinning on the other side of the half of the world, means its night time, and it's so simple. And I studied, moons, and tides and sunrises and sunsets, but never thought about it quite so simply: that sun is shining on one side but not the other side.* (P08)

3.2.5.2. Vastness

Vastness can be better described as part of the perceptual experience that could lead to a cognitive shift (rather than a shift in itself), but as it is considered to be the precursor for the experience of awe (Keltner and Haidt, 2003) and cognitive shift of perspective (Gaggioli, 2016), they are closely related. A participant, who works at an aquarium described:

> *I remember thinking that the Pacific ocean is so big and for a while I thought that I am not seeing things correctly. Which is funny, because I <…> know that its huge. But it was so vast! And to see it in that perspective was what was very unique for me. <…> It was impressive and gave me another perspective on something that I see and think about everyday.* (P04)

This admiration of vastness is also often related to the realization of how small each individual human is on the scale of the whole world. Here a participant describes his thoughts when orbiting around Earth: *"I was really hoping to see maybe that sparkle of the civilization, some kind of movement, some kind of glimmer, to denote my … what's the word … like the size of people, how small compare to where I am"* (P03).

3.2.5.3. Interconnection

Overview Effect and other transcendent and awe-inspiring experiences have all in common the cognitive shift leading to a realization of interconnectedness of life. In our data there were a number of instances that could indicate this realization of wholeness of the world: "*transition from the bottom of the water into the space scape and that sort of the initial moment when you look at it holistically and you see … everything is involved in it*" (P11). But the most striking was the observation of the participant when traveling around the Earth:

> *There has been so many natural disasters lately with the hurricanes, fires and all of that.. When you see at a global level, the connection between things that are otherwise separate because of the political things... When you see as a whole—its just like, well, its just one planet. When you go around and see that Brazil is so close to Florida, you know politically things are so far away...* (P06)

This realization of interconnectedness can then lead to behavioral changes, where in case of the Overview Effect, astronauts feel the need for everyone to unite together to protect our planet and its inhabitants (White, 2014).

3.2.5.4. Intent of a behavioral change

In our data there were two comments from one participant that could suggest an intent for a change in behavior, that could be triggered by the feeling of interconnectedness. Firstly, on a personal level, she was inspired to learn more about other people and countries she may not know enough about: "*I don't know much about south America, so it was interesting to look at it when I can see all other distracting places I know more about. I thought I should learn more about it*" (P06). This could be related to the aspect of perspective shift related to brining cultures together by developing an understanding of other cultures [similar to what astronauts describe (Gallagher et al., 2015)]. Secondly, on a more global level, she had the urge to communicate this view of interconnectedness to more people:

> *Just need for people to figure out the environmental sciences, because its effecting everybody, but these are the artificial lines that seemed to be so unhelpful. I was thinking from the educators perspective. What a disservice it is to see a map as flat: things look so much further apart than they actually are. And that need—if we are going to problem solve bigger things, how this flat political map is just not going to get us there.* (P06)

3.3. Gallagher's Hermeneutic Analyses of Awe

Gallagher et al. (2015) undertook syntactical followed by hermeneutic analysis of astronauts' awe experiences based on 51 texts by 45 astronauts. From the analysis, Gallagher et al., generated 34 consensus categories of awe. They allow researchers to determine whether in experimental studies, participants have experience of awe and Overview Effect. Here (**Figure 7**), we count the frequency of statements made by our participants that fit into the awe consensus categories. The categories that were not observed in our data and not included in the graph are: sublime, poetic expression, peace (conceptual thought about), inspired, home (feeling of being at home), fulfillment, floating in void (not related to weightlessness), elation, disorientation.

We can compare the results of this study to the study by Quesnel and Riecke (2018), that had 16 participants traveling through Google Earth VR, whose interviews were coded with the same categories of awe based on Gallagher et al. (2015). **Figure 8** shows the comparison of the frequencies of participants coded with the awe categories between these two studies. The *"AWE"* experience was able to elicit more responses of totality, spatial perspective shifts, sensation of floating and inquisitiveness, while the Google Earth experience was better at eliciting feelings of sublime and elation. We can speculate that the sensation of floating and inquisitiveness were elicited as a result of the narrative arc of the *"AWE"* experience, that wasn't a part of the Google Earth experience used in Quesnel and Riecke (2018). Totality and the spatial perspective shifts observed in our data are likely related to the *"AWE"* experience presenting the Earth from a more distant perspective than Google Earth VR allows. While the lack of sublime and elation responses in our study could be explained by the difference of the quality of the Earth models that we had in *"AWE"* and in the Google Earth VR.

Gallagher et al. (2015) did not report on the number of participants coded with a certain theme, but rather the total frequencies of codes (within 19 interviews). However, since the lengths and types of interview procedures were different between the current and Gallagher et al. (2015) studies, we can not make a precise comparison based on these counts. Still, in their data the most frequent categories were perspective shift (moral,internal), contentment, interest/inquisitiveness, scale effect, and significant sensory experiences, which only partially intersects with our data, as these categories, even though present, were not as prominent in our data. The study design was fairly different between our studies: Gallagher et al. (2015) study used a spaceflight simulation, designed to be realistic, that was presented through the screens of cockpit/window as opposed to an HMD. As their study was a more literal simulation of a spaceflight than *"AWE,"* it is possible that their participants were more inclined to think about what they know about astronauts' experiences, so it is possible that some of these thoughts were introduced externally based on associations rather than emerged from the properties of the experience.

4. DISCUSSION AND LIMITATIONS

4.1. Relating to the Overview Effect

Stepanova et al. (2019) analyzed existing records and research on the Overview Effect and derived design guidelines and evaluation methods for virtual experiences aiming to elicit the Overview Effect or an extent of it. Comparing the themes that emerged from our data and the guidelines outlined in Stepanova et al. (2019), we identify an intersection in the themes outlined in **Table 2**.

From the evaluation guidelines we were pleased to observe some mini-shifts reported by participants, that would indicate each one of the 2b-2e themes. Even though we only observed a few instances of each, it was still very encouraging, considering that cognitive shifts are not easy to achieve, and it was still an early prototype of *"AWE."* From the design guidelines, the most strong and interesting intersection was in the privacy, initial fear, weightlessness and personal connection components.

4.1.1. Privacy and Social Space

Even though participants were not using the term "private," from their discussion of felt safety and comfort we can speculate that *"AWE"* was able to achieve the goal set out by the "privacy" design guideline—creating a safe space for participants to feel comfortable to have a transformative

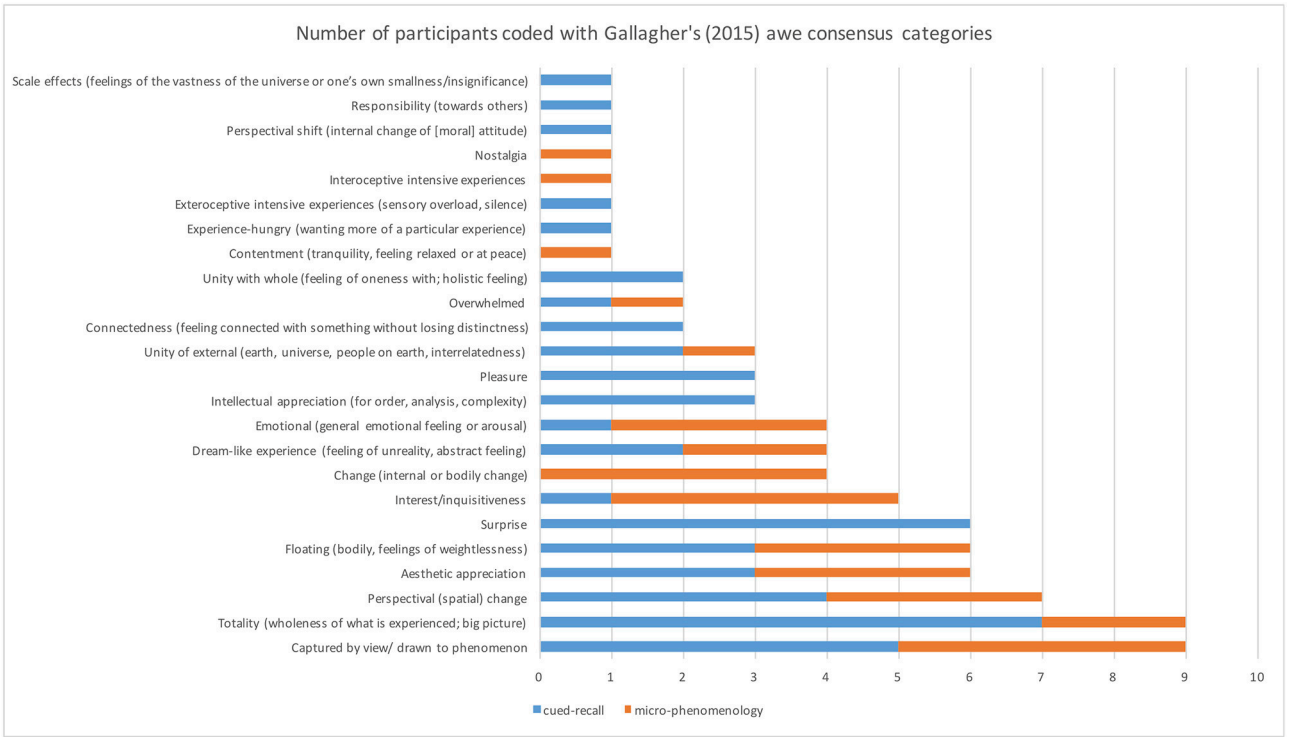

FIGURE 7 | The number of participants, that had statements coded with hermeneutics analyses of categories of awe (Gallagher et al., 2015).

experience. The social space guideline was aiming to assist with the process of accommodation that is a necessary component of a transformative experience following a witnessing of an awe-inspiring vista. Even though only one participant explicitly discussed it, but he reflected on how going through the process of the interview was valuable to help him unpack his experience and understand it on a deeper level than if he was just asked a few questions. Hence, we believe that the interviews, especially the microphenomenological method, were able to provide the social space and the conversation that could facilitate the process of accommodation.

4.1.2. Initial Fear

The precursors for the Overview Effect are hard to separate from components of a spaceflight, but the initial moment of fear naturally experienced when being shot in a rocket into space, is, quite possibly, an important stage in the progression of the experience (White, 2014). However, few people have personal experiences associated with rockets, and as such, jumping into water is a more visceral experience for most and therefore, when part of VR, has a potential to induce stronger response, which we indeed observed. However, we were surprised by the strength, length and frequency of fear experiences, as we were only intending for the jump into the lake to be a moment inducing hesitation and requiring participants to take the leap of faith. The personal background of participants shaped their experience of descending through water to be more fearful than we anticipated during the design process.

4.1.3. Weightlessness

The connection of feeling of weightlessness and Overview Effect is also unknown as the records of them are inseparable: it might be essential or not relevant (White, 2014). As the sense of weightlessness on Earth is logistically challenging to achieve in combination with VR, we were not aiming to replicate it as a part of the experience. It was insightful to observe that several participants did have a feeling of floating or weightlessness, and informed us how the narrative of the experience can facilitate the induction of this sensation.

4.1.4. Personal Connection

In at least some astronaut's descriptions the feeling of connectedness starts small from the personal connection to a familiar location, and then extends from there to the rest of the world. It was interesting to see in our data how prominent the concept of familiarity was—10/13 participants were discussing it (with no targeted prompts from interviewers). Two participants also described how, when orbiting around the Earth, they were picking out familiar locations to establish connection to them, much like the astronauts describe. The virtual travel to a familiar place in Google Earth was also powerful at eliciting awe in the study by Quesnel and Riecke (2018).

The other three design guidelines (embodied experience and self-relevancy, vastness, suspending disbelief through aesthetics) were not as evident in our data. Even though there are some indications of self-relevancy, for a lot of participants it was significantly reduced as a result of restricted locomotion in

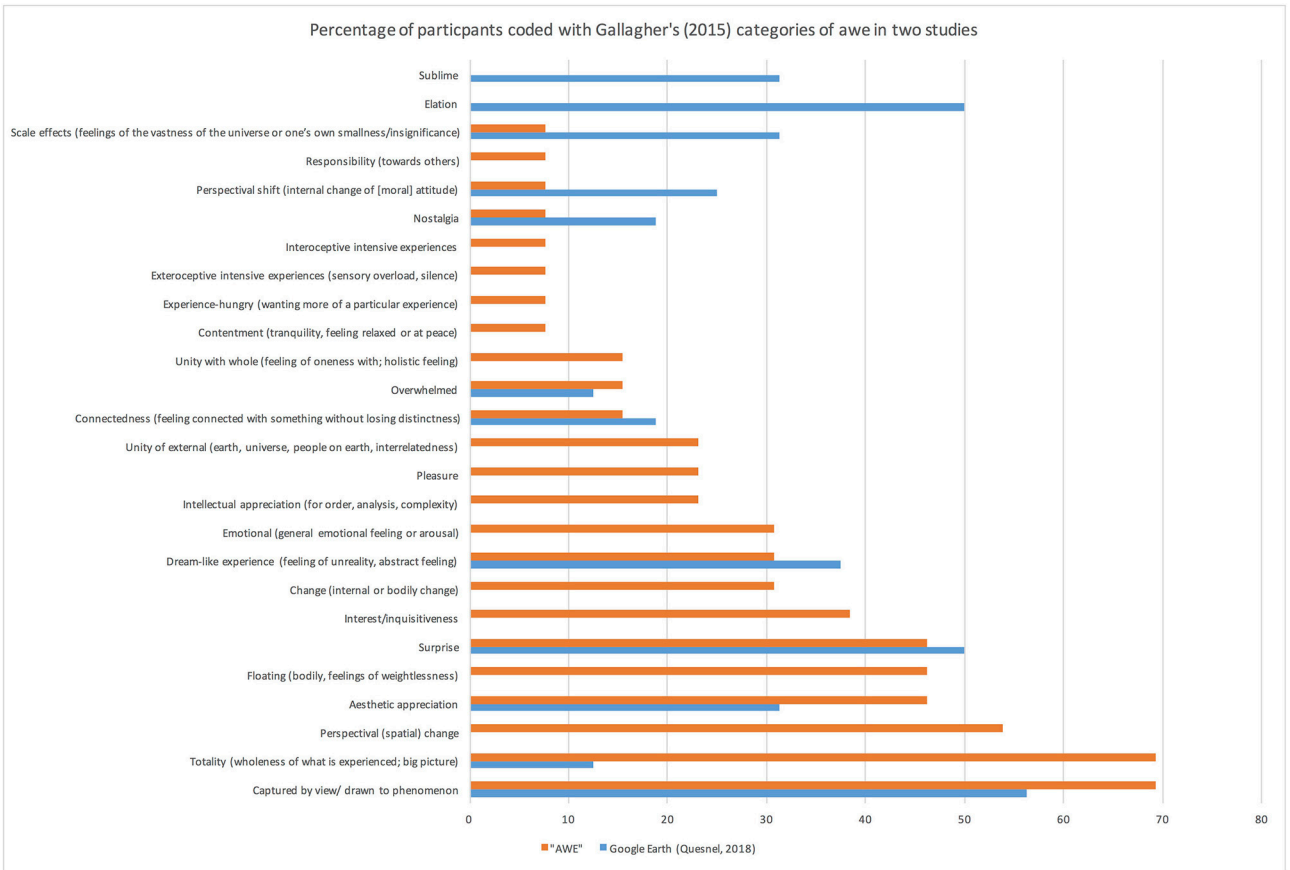

FIGURE 8 | The percentage of participants, that had statements coded with hermeneutics analyses of categories of awe (Gallagher et al., 2015) in current study and Quesnel and Riecke (2018).

the last parts of the experience. While perceived vastness was mentioned three times, this is a fairly low frequency for an experience aiming to elicit awe (Keltner and Haidt, 2003). Suspending disbelief through aesthetics was only partially successful, as a lot of participants were still expecting an accurate representation of the real world inside the VE and were thrown off by any observable conflicts. Despite the clearly magical creature, sprite, and the lake portal into space, some participant's sense of immersion was broken by seeing jellyfish in fresh water, some trees appearing too tropical for the local biosphere or the tent seeming too large for one person. Evidently having magical elements in the narrative wasn't enough for suspending participant's disbelief, especially when they were very familiar with a specific environment (e.g., the jellyfish comment was made by participant working at the aquarium). It might be important to set up the right expectations from before the VR experience starts by adding a narrative to why participants enter the tent for going into the VR experience to prepare them for the virtual story.

Overall, even though the *"AWE"* experience did not follow all of the guidelines outlined in Stepanova et al. (2019), it was able to achieve some indications of each one of the core components of the overview effect: awe, increased connectedness, increased responsibility for the environment. The latter being indicated only once by a participant discussing the need for everyone to unite together to develop a better understanding of the weather systems as it is effecting everyone. While *awe* is a complex emotion, it is hard to make definite claims as to how much awe did our participants experience: their interviews indicate a number of components of awe identified by Gallagher et al. (2015) specifically in the context of the Overview Effect. However, the physiological measure of piloerection (Benedek and Kaernbach, 2011) revealed only one instance of awe in this study, which is either the fault of the recording instrument or, more likely, the result of the lack of intensity of awe that, even though experienced to some degree, didn't trigger the physiological reaction.

Connectedness is also a difficult cognitive construct to objectively measure, that we attempted with IAT. IAT scores indicated a fairly strong connection between Self and Nature, however these results are challenging to interpret, as we don't have a baseline for our Vancouver population. We made the comparison with the data collected with the same test (with identical items) in California, which could be an approximately comparable population as they are both from the West Coast of North America, although there still might be differences. Besides lack of baseline, we also cannot know how much of the

TABLE 2 | Selected design and evaluation guidelines for design of the virtual experience of the Overview Effect from Stepanova et al. (2019).

1. From Design Guidelines	
a. Embodied experience and self-relevance	The feeling of being in the virtual environment and having a first-person experience of it (as opposed to watching a movie), that can be facilitated though a full-body experience and a perception of being an agent in the environment
b. Privacy and social space	A combination of a private physical space, where the virtual experience is experienced, to facilitate immersant's comfort and openness to the experience, and a social space following the virtual experience to facilitate the process of accommodation
c. Vastness	Creating virtual stimuli that can facilitate the experience of something that is much greater than oneself
d. Suspending disbelief through aesthetics.	Using imagination-provoking imagery to assist the suspension of disbelief and openness to experience
e. Initial fear	Including a fear-inducing part at the beginning of the emotional journey to imitate the emotional trajectory that astronauts go through when being shot in a rocket into space
f. Weightlessness	Facilitating sense of floating or weightlessness to imitate zero gravity environment
g. Personal connection	Providing familiar elements into the environment to help immersants establish personal connection with them, that then can be extrapolated into a larger feeling of global interconnectedness
2. From Evaluation Methods	
a. Weightlessness	Feeling of weightlessness or floating
b. Changed perception of space	Altered perception of the relative size, distances and positions of celestial objects and geographic locations as well as the relative position of oneself in relation to them
c. Awe	Emotion of awe that can be evident from introspective, physiological or implicit measures
d. Interconnectedness	The feeling of or a realization of global interconnectedness of all people, living species, or the planet at large. Transcendence of one's perceived boundaries of self and the feeling of belonging to something greater
e. Increased responsibility for earth	The concern for and desire to protect the environment and all of the inhabitants of our Earth

connectedness of nature and self was attributed to the *"AWE,"* and how much of it was a personal trait. Implementing IAT as a pre- and post-test measure could be a possible approach to tackling this challenge (as in Peck et al. (2013) in the context of racial bias), but as a reaction time measure, IAT scores are greatly influenced by learning effects, and therefor repeated tests become difficult to interpret as a measure of change. IAT is very rarely implemented as a pre- and post-test measure, and as in Peck et al. (2013) it requires inviting participants to visit the lab multiple times, and still expects to observe a strong learning effect. The qualitative data in our study, however, showed some promising indications of moments of realization of interconnectedness.

As traditionally the records of the overview effect are describing a moment during the spaceflight, it is difficult to separate which components of a spaceflight experience might be contributing to the Overview Effect and which ones are unrelated. Until this relationship is clarified, we will have to target both the components of the spaceflight and the Overview Effect experiences in VR experience design. In our data we observed some indications of some components of an experience of a spaceflight: change in perception of space and weightlessness, but not the change of perception of time and silence. However, we did not explicitly try to measure them.

4.2. Comparing to Other VR Awe-Inspiring Experiences

Here, we want to compare the current VR experience and study with other research attempting to elicit awe and Overview Effect through the use of VR. This comparison allows us to speculate about the role that the aspects of the VR experiences and research tools had on the obtained results, thus informing future research in this field. Chirico et al. (2017), Chirico et al. (2018a), and Chirico et al. (2018b) have shown that an immersive experience of awe-inducing stimuli were associated with a self-reported awe measured with a questionnaire, however these studies used less interactive environment than in our study, and did not perform an extensive qualitative analyses of how a participant's experience in VR unfolded, what some key components of it were, and how they relate to aspects of the virtual environments. Our study is most similar to Gallagher et al. (2015) and Quesnel and Riecke (2018), who also used a VR experience of a spaceflight/orbiting the Earth and collected qualitative interview data. They reported participants' experiences of awe in those VEs across 34 consensus categories defined by Gallagher et al. (2015) hermeneutic analysis, and compared participants' reports of the virtual experience to real-life accounts from astronauts, with some similarities identified. However, the environments used in both of these studies were aiming to provide a realistic representation of the view of the Earth from outer space, and did not have a strong narrative component unlike *"AWE."* Conversely, with *"AWE"* we were not aiming to provide a direct, realistic representation of the astronauts' actual experience, but rather wanted to integrate specific design features (artistic strategies and narratives) to create a target emotional journey in a research prototype. Our installation has elicited less observable goosebumps than Google Earth used in Quesnel and Riecke (2018), which could be due to a lower-fidelity quality of the Earth model and usability issues in *"AWE."* Another reason might be that in Quesnel and Riecke (2018) participants had a choice of their destination in Google Earth and would often travel

to their hometown, which was eliciting nostalgia, which could have contributed to awe. Another explanations might include limitations in the wearable goosebump recording instrument, which changed in prototype design from Quesnel and Riecke (2018) to the present study; see section 4.4 below. However, it should be noted that hermeneutic analyses of interviews have produced comparable distributions of reports related to awe categories between current and Quesnel and Riecke (2018) studies, meaning that while goosebump recording may have failed to detect physical indications of awe, the qualitative analysis has shown some reliability. The observed differences in distribution of awe categories can be explained through specifics of the design of the experience, as discussed above.

Even though our *"AWE"* installation in its current state did not elicit profound transformative experience in participants, it showed promising results supporting the premise that VR installations can elicit authentic emotional experiences and induce minor cognitive shifts in some participants. This study has also revealed some important aspects of an experience participants have when experiencing this type of immersive installation: specifically the safety and fear of the environment, familiarity and novelty, affects and bodily sensations were prominent themes in participants' descriptions.

4.3. Key Outcomes

The elicited fear and the relief from it were an especially interesting part of the experience of many participants. Astronauts also describe a similar transition including the association of the release from fear with the feeling of weightlessness and silence experiences when floating in space (Stepanova et al., 2019). This suggests an intriguing opportunity that a narrative in VR affords: where we could replicate some part of an emotional journey associated with a spaceflight with a use of a different but more familiar and visceral metaphor. If we have had recreated in VR an actual spaceflight experience, that probably wouldn't have achieved the same intensity of an emotional response as a jump into the lake did. This could also be indicated by an observation that most participants found the lake or the forest to be the environments they felt most emotionally connected to. However, when designing a VR experience seeking a profound emotional reaction, we should be cautious with inducing fear to avoid prompting a traumatic experience (Madary and Metzinger, 2016). It's important to learn from the variety of the experiences that participants had and to design the virtual journey in a way that facilitates the relief after the minimal fear induction.

To the best of our knowledge the role of psychological relief on inducing the feeling/illusion of physical weightlessness hasn't been discussed in the context of VR experience design. However some VR experiences were able to induce the feeling of floating or weightlessness. For instance, a meditation walk through a virtual forest for chronic pain management was able to elicit the sensation of weightlessness at least in one participant of Tong et al. (2016). Their study doesn't report on what might have triggered that sensation, but possibly it was a similar mechanism of *relief/release*, but in their case from some of the chronic pain. Jain et al. (2016) discussed that some of the divers participating in their virtual scuba-diving simulation felt weightless. However, it's hard to determine what have triggered it: it might have been that the familiarity of the environment brought back participants' memories of past diving experiences, or that the physical set-up of the simulation that was involving a swiveling torso support and harnesses for the limbs was responsible for the sensation, as participants were more or less suspended in the air. These type of set-ups dedicated to specific floating experiences are arguably a little cumbersome and expensive, as they often include large physical structure, moving platforms or strapping participants into harnesses, for instance: flying interface such as Birdly (Rheiner, 2014), skydiving (Eidenberger and Mossel, 2015) or swimming (Fels et al., 2005). Even though these interfaces often provide very compelling experiences, some simpler and cost effective solutions are desirable. Learning from the reports of our participant's describing the moments when they suddenly felt weightless could provide new strategies for developing VR experiences inducing the feeling of floating and weightlessness without the complicated physical set-ups.

The number of fear responses observed in the interviews stressed the high importance of understanding the personal background of participants, and that each individual's experience would be very different. Experience with video-games tend to help with objective performance measures in VR simulations, e.g., in a surgical simulation (Grantcharov et al., 2003). In our observations, gaming experience has not only influenced how quickly participants were able to learn the interface and efficiently navigate through environment, but it also significantly shaped what expectations participants brought in. We propose (and explore in our ongoing studies) for affective VR installations to design a pre-VR environment to help create appropriate expectations of the VR experience being an experiential piece as opposed to a game that is presenting a challenge that a gamer often seeks when entering a 3D environment.

Also, the individual experiences with forest and water environments were key for how the virtual experience unveiled. Some of participants had diving, cliff-jumping and camping experiences, while others also reported getting lost in a dark forest in childhood or being afraid of jumping from heights. All of them formed a connection between their personal experiences and being in the VE, which greatly effected their experience. Given everyone's different backgrounds at the design stage it was difficult to predict the distribution of the reactions of participants. Similarly, Shin (2018) in his study showed that personal traits and predispositions of immersants may have a larger effect on individual's experience of an empathy-provoking VR (specifically level of embodiment and empathy elicited), than the specifics of the VR environment and interface. In Quesnel and Riecke (2018) that used Google Earth VR we also observed that the innate experiences of each participant were completely different, and that their personal background and life experience factored into their experience of positive emotions in the study. However, the trend (that can be generalized across participants) is that they experienced more awe in VR when they had a personal connection to the virtual location. Even though some generalizable trends can be identified, the substantial role of the personal background

presents a challenge for designing profound VR experiences as well as to the interpretation of results of studies with them, especially quantitative results. Both designers and researchers need to develop strategies for addressing this challenge. Including interviews and demographic surveys, as well as pilot tests with varied demographics should be an integral part of the development of affective immersive installations in order to be able to understand participant's experiences, and what was the contribution of the installation to the affective state achieved by the participant. Studies of complex experiences and emotions that only collect quantitative data face a risk of not having the tools to disambiguate the responses they observe that stem from different participants' backgrounds and mis-attribute it to the components of the virtual system. This also raises the issue of whether 'one size fits all approach' could be suitable for immersive affective installations. It will be interesting to explore if procedural content generation in combination with bio-responsive environments can help create a more customized journey for each participant building on their personal background and reactions to the elements of the environment.

4.4. Limitations

There were likely some biases resulted from being a participant in the study. Even though participants were provided with limited information about the purpose of the study, the description given within the consent form could have shaped their expectations. Another bias stemmed from participants being purposefully recruited as experts in interactive exhibits and culture spaces, and consequently they were inclined to provide a lot of feedback on the quality of the installation. This feedback is exceptionally useful, however the focus on providing a critic might have distracted some participants from being in a more experiential state. This is also likely the reason why usability was the most frequent topic in the interviews, whereas usability concerns were not as prominent in previous tests of the prototype with a different demographic. Having to wear the goosebump camera sensors also might have presented a bias in participant's expectations. Only one participant had explicitly discussed how she was expecting something to jump out at her to give her goosebumps, but other participants possibly have also formed some expectations.

4.4.1. Usability Issues and Navigation Interface

One of the main limitations of this study in terms of assessing the potential of VR installation to induce an experience similar to an Overview Effect, is the usability issues with the "*AWE*." Even though most of the participants generally liked the installation, there are several technical aspects that need to be improved. Many participants wanted to have more control of their movement, especially in the underwater and space part of the experience and be able to move faster. Contrary, a few participants were experiencing motion sickness from movement through the forest scene, where they had the most freedom and the fastest movement. Also, some participants wanted to have full freedom to explore the virtual environment on their own and not to be guided in any obvious way through the narrative. Some also pointed that qualities of some virtual models can be improved and larger variety of models can be added to populate the virtual environment, especially in the underwater scene. The choice of soundtrack also was questioned by some participants, while appreciated by others. These, and many other usability related concerns were limiting the ability of the "*AWE*" installation to provide environment for a profound awe-inspiring experience leading to cognitive shifts.

Additionally, the leaning interface used in this study, even though useful for navigation and spatial orientation as supported by previous research (Nguyen-Vo, 2018), was found awkward by some participants and likely was not supporting the sensation of floating. Alternative interfaces, designed for flying (Rheiner, 2014; Eidenberger and Mossel, 2015) could have supported the feeling of floating, which might be useful for providing environment in which an experience of an Overview Effect can occur. In our current iteration of *"AWE"* we are integrating the Limbic Chair interface (Patrik Kunzler, 2019) to hopefully support the feeling of floating. However, all of these interfaces are fairly complex and expensive, and thus a more affordable solution of supporting the feeling of floating in VR would be desirable.

4.4.2. Lack of Goosebumps

A low number of occurrences of goosebumps in our study is likely associated with a number of usability issues in the prototype, which would be improved for future studies, including the resolution of the HMD, the quality of models and soundscape. However, it is also possible that some goosebumps or shivers did not register on our camera. There are limitations to our second prototype goosebump recording device used. In this case, the goosebump recording device touches nearby skin that is being recorded, and our concern is that goosebumps that would have otherwise appeared are thus suppressed by the recording device itself. The first prototype used in Quesnel and Riecke (2018) was bulkier, but instead touched the underside of the forearm, leaving the top of the forearm (the recorded surface) out of contact. This may have allowed for that study's 43% goosebump elicitation rate in line with previous studies also between 40 and 43% (Benedek and Kaernbach, 2011; Sumpf et al., 2015; Wassiliwizky et al., 2017). Our most recent goosebump instrument prototype now records the back of the participant's neck.

Interestingly in this study, the participant that had the moment of shivers, had a slightly negative connection between Self and Nature. Even though this is only one instance and no strong inferences can be drawn, this could be an indication that participants with a lower connection of Self and Nature could be more likely to have a stronger emotional reaction from observing awe-inspiring view of the Earth as they would have a stronger need for accommodation than participants who already feel a strong connection to nature and the experience easily assimilates into their worldview (Lorini and Castelfranchi, 2007; Gaggioli, 2016). However, the relationship between the strength of awe and the need for accommodation was not supported in the study by Schurtz et al. (2012), where the measure of the need for accommodation did not predict the

measure of awe. However, their study was investigating awe in the social context, not nature, and their measure of the need of accommodation wasn't validated, and as such, the results do not eliminate the possibility of the relationship between the degree of the need of accommodation and the intensity of awe.

4.4.3. Gender Effects

Noteworthy, some gender differences were apparent in the descriptions of evoked emotions in the experience, that were less readily discussed by male participants than female, which is aligned with the research on gender differences in use of affective language (Goldshmidt and Weller, 2000). Micro-phenomenological interviews might be useful for guiding male participants to bring their attention to the affective dimension and assist them with verbalizing their feelings.

4.5. Comparing the Interview Methods

The two interview techniques—cued-recall debrief and micro-phenomenology—were successful in helping participants provide a detailed account of their experience, with more thorough and deep description than a semi-structured interview or a survey could have achieved. This is evident from comparing the richness and precision of the descriptions collected in this study with our earlier pilot tests, that used semi-structured interviewers. Unsurprisingly, the cued-recall method was a little better at encouraging the feedback about the system/installation and the micro-phenomenology the feedback about the progression and dimensions of individual experience. However, both methods have limitations: the micro-phenomenological interviews are zooming in only on a few moments, and thus don't address experience as a whole and provide little light on the portions of the experience that were not chosen, while cued-recall debrief doesn't provide as much depth in descriptions and is less rigorously structured, meaning that there might be more bias introduced by interviewer. We can also observe some trends in what type of responses are more likely to be provided within a given interview: for instance, from **Figure 7** we can see that body change responses are more likely to be reported in a micro-phenomenological interview, while intellectual appreciation in a cued-recall interview. This is anticipated given the interview structure.

5. CONCLUSIONS AND FUTURE WORK

This study indicated that a virtual experience, inspired by the Overview Effect and designed to elicit awe, despite some usability concerns, was able to invite minor transformative experiences in some participants, including the main aspects of it: the appreciation of beauty and vastness (Keltner and Haidt, 2003), realization of interconnectedness (Yaden et al., 2016) and a potential intent to change one's behavior based on that realization (White, 2014; Stepanova et al., 2018). We have also discovered some unique opportunities VR technology affords for a design of a profound experience: the opportunity to create a journey taking the participant through induction of a minimal fear in a safe environment and a following release from it; and the opportunity to explore the mind-body connection and the effects of shifting the strength and the locus of control within it.

The qualitative data of participants' experiences in this study inspires some research hypotheses that can be tested with experimental studies. A few of the hypotheses generated as a result of this study are:

1. Designing for a transition between environments eliciting feelings of safety and fear can induce shifts in those states and these shifts, can be associated with bodily sensations and perceived separation of mind and body.
2. Familiarity and Novelty of the virtual environment are important parameters that effect the affective experience of the virtual world. Designing familiar environments would elicit experiences of safety, comfort and trust, while novel environments will elicit curiosity and excitement.
3. Creating or providing familiar objects or characters in VR, helps immersants cope with uncomfortable experiences.
4. A familiar visceral experience simulated in VR, such as a jump into water will induce stronger emotional reaction than more dangerous, but unfamiliar experience such as a simulation of flying in a rocket.
5. Seeing rotating Earth and day and night happening on Earth at the same time from first person perspective gives a novel perspective and understanding of the world.

Giving the reliance of this line of research on deep emotional responses and importance of individual background, we see two important directions for future development of this project: first, extensive demographics information and interviews are required when using quantitative methods of assessment in order to be able to explain results in the context of a personal experience; second, more flexible, bio-responsive and personalizable experience, that can adapt to the immersant's state is desirable and will be able to create a smoother journey to the desired emotional response.

In the future work we are planning to integrate more physiological sensors (Quesnel et al., 2018a) and automatizing the goosebump detection (Uchida et al., 2018), combined with interviews of the events identified from the physiological data. This will allow us to develop deeper understanding of progression of one's experience in an immersive affective installations, and identify what elements of the journey might be triggering the specific responses in the participants.

VR experiences, inspired by natural phenomena, provide us with an exciting opportunity to study an individual's experience in detail and establish the relation between the experience and the environment. However, we argue that a profound experiences mediated through technology should be seen as its own category of phenomena that requires more exploration. To build this body of knowledge more studies need to explore how profound affective VR personal experiences unfold. This knowledge would inform future design of positive transformative VR experiences that would make such desirable experiences more accessible to the public.

ETHICS STATEMENT

The ethics approval was granted by Simon Fraser University Office of Research Ethics (Study#: 2017s0269). Consent form was signed digitally by each participant upon arrival to the study space.

AUTHOR CONTRIBUTIONS

ES, DQ, and BR contributed conception of the project and design of the virtual experience and the study. ES coordinated the study. ES and DQ lead the data collection process. ES transcribed most of the interviews with the help of other members of the research group. ES and DQ developed the coding scheme and analyzed the interview data. ES was responsible for the thematic analyses, while DQ for the awe consensus categories analyses. ES implemented and analyzed IAT test. DQ designed goosebump camera instrument. DQ and ES coded the goosecamera recordings. ES wrote the majority of the manuscript. DQ contributed several sections, specifically related to hermeneutics analyses and goosebump camera. All authors revised and contributed to manuscript. BR supervised the whole project. This work appears in ES's thesis (Stepanova, 2018).

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