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Inducing the Overview Effect Using Virtual Reality

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ABSTRACT

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by Nhat Le

Astronauts who return from space missions have reported and demonstrated a significant increase in their feelings of connection to humanity and the planet. This shift towards a more humanistic, global perspective in astronauts was termed the "overview effect" by White (2014). There is a lack of research on the overview effect despite the significant, positive changes in those who have experienced it. This study aims to provide empirical evidence of and a possible induction method for the overview effect. We hypothesized that it might be possible to induce the overview effect using virtual reality (VR). In the current study, 81 SJSU participants were randomly assigned to one of three stimulus conditions: urban, nature, or space. Each participant watched a five-minute video using VR equipment to provide a wide field-of-view experience, and completed self-report measures that indirectly measured the overview effect both before and after VR stimulus exposure. While we found no evidence to support the induction of the overview effect in the present study, we did find evidence for reduced negative affect and increased feelings of awe after watching VR videos, regardless of stimulus condition. We also found evidence for increased identification with the nation after watching the urban VR video. In conclusion, we were not successful in inducing the overview effect in our current sample, however we did find possible positive effects of VR on emotion and identification with people at a national level.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Introduction

When astronauts venture into space and turn away from the cosmos to look behind them, seeing the Earth produces a profound sense of connection to humanity and the planet, which often leads these astronauts to pursue humanitarian and environmental causes upon their return to the planet's surface. White (2014) dubbed this phenomenon "the overview effect." Despite documentation of the overview effect from as far back as the 1980s, there is a lack of scholarly research on this phenomenon. Yet, the sense of connection to humanity and the planet produced by this phenomenon may warrant further exploration into its psychological effects and possible benefits.

This study aimed to investigate the overview effect with an empirical methodology. In what follows, we examine the description of the overview effect by White and extract key elements of the effect from that description. We then review research on psychological constructs similar to the extracted key elements. Finally, we describe an experiment in which we attempted to induce the overview effect on Earth using virtual reality (VR).

The overview effect

White (2014) defined the overview effect as:

> A cognitive shift in awareness reported by some astronauts and cosmonauts during space flight, often while viewing the Earth from orbit, in transit between the Earth and the moon, or from the lunar surface. It refers to the experience of seeing firsthand the reality that the Earth is in space, a tiny, fragile ball of life, 'hanging in the void,' shielded and nourished by a paper-thin atmosphere. The experience often transforms astronauts' perspective on the planet and humanity's place in the universe. Some common aspects of it are a feeling of awe for the planet, a profound understanding of the interconnection of all life, and a renewed sense of responsibility for taking care of the environment. (p. 2)

From this definition, a few elements of the overview effect can be identified. The effect occurs when viewing the Earth from orbit. The changes stemming from it include a view of the Earth as fragile, and a new perspective on the connection between humanity, the planet, and each other. In particular, the feelings of awe, a connection to humanity and the environment, and a sense of responsibility toward the environment are of note as these are established areas of research in psychology.

White (2014) discussed aspects of the space flight experience that may be necessary to produce the overview effect. The first is the salience of the visual experience of actually seeing Earth from space. According to White, astronauts have an intellectual understanding of the Earth, as they have seen pictures, videos, and literature about the planet, but their understanding is disconnected from them until they see the Earth during their space flight. Then the idea of Earth as a planet "clicked" with the astronauts, and their understanding moved beyond the mere intellectual and into the experiential. According to interviewed astronauts, the experience and its emotional impact of seeing the Earth from outside the atmosphere cannot be fully communicated through words, pictures, or videos, as it seems to be something that needs to be experienced in person. It is interesting that the comprehension of Earth as a planet came after distancing from the planet itself, and distance was not the only "disconnection" astronauts experienced.

White (2014) also described a "disconnection" in the perception of time during spaceflight. Time as most experience it on Earth does not apply to astronauts in space and on the moon. They do not follow the rotation of the Earth, so their experience of time becomes separated from those on the surface of the planet. In space, astronauts

experience “faster” time as they travel more quickly than the rotation of the Earth, so their day/night cycles are drastically shorter (e.g., the International Space Station [ISS] travels around the Earth in roughly 90 minutes). Astronauts on the moon described their experience of time as opposite that of those in orbit: “On the moon, time seems to slow down, as the distance from the Earth creates a noticeable sense of disconnection; the flow of events on the planet does not affect those on the moon” (White, 2014).

Compounding the disconnection from the perception of time on Earth, astronauts also experience a form of sensory deprivation during some parts of their time in space. One part of this deprivation is the near absolute silence of space. The vacuum of space sharply reduces the amount of noise available in that environment. As such, astronauts experience a much different form of silence than is possible on Earth. This profound silence is combined with the experience of weightlessness from the near absence of gravity in space to produce a “dreamlike” state for astronauts, especially those on spacewalk missions (White, 2014). In essence, an astronaut during a spacewalk mission would experience something akin to a sensory deprivation chamber, combined with an extraordinary view. Those on space stations and shuttles experience something similar but with less intensity.

Astronauts who return to Earth with this profound experience have attempted to communicate it to those on the surface, but communicating the full experience of witnessing the Earth from space is difficult (White, 2014). White compared it to being the first aquatic creature to walk on land, who then returned to tell the other creatures in the water. Such an alien experience would have no words that fully describe it, nevertheless

astronauts have done their best with analogies and metaphors. However, even with some semblance of an idea about the experience of astronauts, the gap between their new perspective and that of those who never left the Earth's surface continued to be a significant one. Yet, even a sliver of understanding of the experience has managed to attract much attention.

Interest in the overview effect began and has steadily grown since the late 1970s, and the advances in information sharing technology in the 2010s accelerated this growth to a remarkable degree (White, 2014). One example is a short film about the overview experience that was posted online in 2012 that garnered over six million views within eighteen months (White, 2014). In psychological research, interest in the overview effect has also grown with a few journal articles examining the psychological factors underlying the effect.

Yaden and colleagues (2016) reviewed astronauts' accounts of the overview effect and proposed several possible psychological constructs making up the experience, and other psychological processes that may explain the large changes in astronauts after experiencing the effect. Yaden and colleagues proposed that the feeling of awe and the state of self-transcendence are the two psychological constructs at work during the experience, which will be explored in later sections of this document. After seeing the Earth from space, astronauts experience a profound emotion, awe, and perceive the world beyond themselves, self-transcendence. Yaden and colleagues pointed to the overview effect as part of a larger area of study on the psychological effects, specifically the positive effects, of space flight. Their proposal was a good start for a psychological study

of the overview effect, and they described some possible directions for empirical studies focusing on the feelings of awe and self-transcendence. The article also places the study of the overview effect into the larger context of the psychological effects of space flight, which opens the way for connecting the overview effect to a grander understanding. Furthermore, Yaden and colleagues also proposed that the overview effect may be able to alleviate the psychological stress of living in space.

Taking a step forward from Yaden et al. (2016), Kanas (2018) had astronauts who had been on space missions complete a questionnaire designed specifically to assess changes in their perceptions and attitudes after returning from space. The results from the questionnaire seem to support the qualitative observations that White (2014) expressed in his description of the overview effect. Kanas noted that the greatest changes seem to be an increase in humanistic attitudes, and while little change seemed to be present in the spiritual aspect, participants indicated that their spirituality had already peaked before their space missions. The survey had high internal reliability (overall Cronbach alpha of .95). However, as the questionnaire was designed specifically for that study, its validity remained in question. In general, Kanas (2018) conducted the first study to provide quantitative evidence of the overview effect from astronauts who had experienced spaceflight.

With increasing interest in studying the overview effect from a psychological perspective, there is a need to better understand the psychological constructs in play that produce the effect. One potential construct that has received much interest and study in

recent decades is the emotion of awe, a fascinating emotion that may explain much of what has been observed in the overview effect.

Awe as an Underlying Construct

The theoretical structure of awe was proposed by Keltner and Haidt (2003) after examining the literature on awe from religion, philosophy, sociology, and psychology. In their proposal, awe was described as a peak emotion comprised of a sense of vastness and a need to psychologically accommodate the awe-generating stimulus. The emotion stems from the inability to assimilate a current experience into pre-existing schemas or mental structures, and, as such, the observer can only accommodate the experience. Keltner and Haidt further proposed five types of experience that account for variations of awe (i.e., threat, beauty, exceptional ability, virtue, and the supernatural).

While awe remains a less studied emotion than others (e.g., happiness), there are studies that have investigated the components of awe, and the effect of awe on peoples' psychological well-being.

Shiota, Keltner, and Mossman (2007), for example, conducted a series of studies that tested and expanded the theoretical proposal of Keltner and Haidt (2003). The first and second study investigated the aspects of awe that separate it from happiness and pride. In the first study, researchers found that when recalling awe events, participants remembered more information-rich aspects than social aspects (e.g., panoramic nature views versus social interactions). In the second study, compared to recalling prideful events, participants focused more on the environment rather than the self when recalling awe events. In the third and fourth studies, Shiota and colleagues assessed the correlation

between the frequency of feeling awe and other self-concepts (e.g., physical characteristics, social relationships, etc.) (study three) and the effect of experimentally induced awe on various self-concepts (study four). They found that people who experienced awe frequently have less need for cognitive closure (e.g., less need for clear rules and order), and both awe-prone people and those who had been induced to experience awe have an increased emphasis on "universal" membership. The mixed qualitative and quantitative design studies by Shiota et al. (2007) showed promising results that supported and expanded on the original theory of Keltner and Haidt (2003) by comparing awe to other emotions (i.e., happiness and pride), examining the relationship between self-concepts and feeling awe, either naturally occurring or experimentally induced.

The Need to Accommodate

The feeling of awe involves a need to cognitively accommodate something that does not fit into pre-established mental structures. Cappellen and Saroglou (2011) found that religious/spiritual people who recalled awe-inducing events were more likely than those who recalled pride-inducing or neutral events to be willing to travel to a religious/spiritual location (e.g., Tibet) rather than a pleasurable location (e.g., Haiti). The increase in willingness to travel to a religious/spiritual location may have been facilitated by the need to accommodate the experience that produced the feeling of awe. Furthermore, similar to the emphasis of "universal" membership found in Shiota et al. (2007), Cappellen et al. (2011) found that the induction of awe also increases the feeling of oneness with those close to oneself (e.g., family and friends) and people in general.

However, the feeling of oneness with friends and other people may vary based on the type of stimulus (e.g., nature versus spiritual) that induced awe. In a series of experiments by Valdesolo and Graham (2014), participants who experienced awe had a decrease in tolerance for uncertainty, an increase in supernatural belief and intentional-pattern perception, which are tendencies to interpret events as coming from intelligent design or design with a purpose. These findings supported the idea that the awe inducing experience is something that cannot fit into the current schema of the observer, and the experience "breaks" the pre-existing schema, or frame of reference about the world. Possibly, this "break" of schema leads the observer to need to make sense of this intense new experience. The increases in supernatural belief and intelligent design are evidence for this need, and the decrease in tolerance for uncertainty is evidence for the "break" of schema because the lack of a cohesive schema may lead to feeling of anxiety, which in turn reduces tolerance for uncertainty.

The Sense of Vastness

Sensing vastness, an aspect of awe, refers to an experience in which a person encounters a stimulus that expands his or her usual frame of reference (Shiota et al., 2007). Interestingly, the evidence for the sense of vastness during the feeling of awe has been indicated indirectly by the presence of self-diminishment, or a perception of the self as smaller or less significant (Piff, Dietze, Feinberg, Stancato, & Keltner, 2015; Stellar et al., 2018). Furthermore, the presence of awe has also been shown to increase prosocial attitudes and behaviors (Joye & Bolderdijk, 2015; Piff et al., 2015; Rudd, Vohs, & Aaker, 2012), which seem to be mediated by the perception of a small self (Piff et al., 2015). Of

note, Piff and colleagues (2015) tested the negative variant of awe, specifically threat-based awe (e.g. war, natural disaster), and still found self-diminishment in awe-induced participants compared to neutral-induced participants. Perhaps also as part of the sense of vastness experienced during awe, participants who experienced awe had an expanded perception of time (Rudd et. al., 2012), in which they felt that they had more time available to them. Current research seems to indicate that the positive variant of awe has overall beneficial effects such as an increase in prosociality, mood, humility, and well-being (Joye et. al., 2015; Piff et. al., 2015; Rudd et. al., 2012; Stellar et. al., 2018). However, negative variations of awe also exist, and they seem to have some distinct differences from their positive counterpart.

The Dark Side of Awe

When speaking about awe, the commonly associated experiences are ones with positive emotions (e.g., beautiful nature, grand architecture), but awe experiences associated with negative emotions also exist (e.g., natural disaster, war, existential threat). Although there are not many studies investigating the negative variations of awe, the available evidence indicates some differences between negative and positive awe. Gordon and colleagues(2016) conducted a series of studies to assess the effect of negative awe, specifically threat-based awe, on a variety of psychological measures. Results indicated that negative awe produced more feelings of powerlessness, more negative feelings, activated the sympathetic nervous system, and did not lead to feelings of better well-being. However, the effect of negative awe may be moderated by the self-esteem of the experiencer. In two studies conducted by Hornsey, Faulkner, Crimston, and

Moreton (2018), participants were exposed to information regarding the enormity of the universe compared to the size of Earth, which could present a psychological threat, then measures of self-esteem, emotions, identification with others, empathy, and egalitarianism were administered. Across these two studies, researchers found that participants with low self-esteem had more negative emotions, less identification with others, less empathy for victims of disasters, and lower egalitarianism than did participants with high-esteem after exposure to the enormity of the universe. These findings suggest that self-esteem may act as a buffer to the negative effects of threat-based awe.

Overall, research on awe has shown an overlap with the overview effect. Specifically, awe has been commonly found to increase prosocial attitudes and behaviors, and astronauts, who experienced the overview effect, often describe a feeling of connection to humanity, which can be interpreted as a prosocial attitude. However, there has not yet been any studies providing evidence that awe can increase feelings of connection to nature or the planet. Furthermore, there has not yet been any evidence that awe can induce the same degree of behavioral and attitude changes as the overview effect, where astronauts who experienced the effect went on to participate heavily in humanitarian and environmental causes (White, 2014). This difference in influence between awe and the overview effect suggests that there are some factors present in the overview effect

beyond the experience of awe. In consideration of the overlap between the two, we decided to investigate awe as a component of the overview effect.

Current Study

The purpose of this study was to explore one potential method to induce the overview effect, even if to a lesser extent, in a non-astronaut sample. Virtual reality (VR) has demonstrated greater exposure effects than more traditional media (e.g. projector, monitor, television) in physical therapy exercises and exposure therapy for social anxiety (Chesham, Malouff, & Schutte, 2018; Rose, Nam, & Chen, 2018). Furthermore, researchers have found that VR is a viable method to induce awe and may be more effective than 2D media (Chirico et al., 2017; Chirico et al., 2018). As such, VR could serve as a better method for inducing the overview effect by creating a more immersive experience than other forms of indirect exposure. Based on the description of the overview effect by White (2014), we proposed two hypotheses regarding evidence for the presence of the overview effect:

Hypothesis 1: Viewing the Earth from space in VR will induce greater feelings of connection to nature and humanity than viewing an urban stimulus in VR.

Hypothesis 2: Viewing the Earth from space in VR will induce greater feelings of connection to nature and humanity than viewing a nature stimulus in VR.

Based on the literature on awe, we also hypothesized that the emotion of awe may explain the connection to humanity aspect of the overview effect, as experiencing awe often increases pro-social attitudes (Cappellen & Saroglou, 2011; Joye & Bolderdijk,

2015; Piff, Dietze, Feinberg, Stancato, & Keltner, 2015; Rudd, Vohs, & Aaker, 2012; Shiota, Keltner, & Mossman, 2007).

Hypothesis 3: Awe will mediate the relationship between the overview effect and connection to humanity.

The findings of Hornsey and colleagues (2018) suggested that self-esteem may moderate the influence of the overview effect on the feeling of connection to nature and humanity. Those with low self-esteem may have negative experiences when exposed to the size of the Earth, thus their feeling of connection may actually decrease after seeing the Earth from space.

Hypothesis 4: Self-esteem will moderate the relationship between the overview effect and the feeling of connection to nature and humanity.

We created a hypothesis model (see Figure 1) to help elaborate the relationships between the constructs being examined in this study, as well as a table (see Table 1) to show the dependent variables of interest for each hypothesis. We hoped to contribute to a growing scholarly interest in this phenomenon by providing empirical evidence for VR's ability to induce the overview effect and how the phenomenon connects to the larger body of research on the emotion awe.

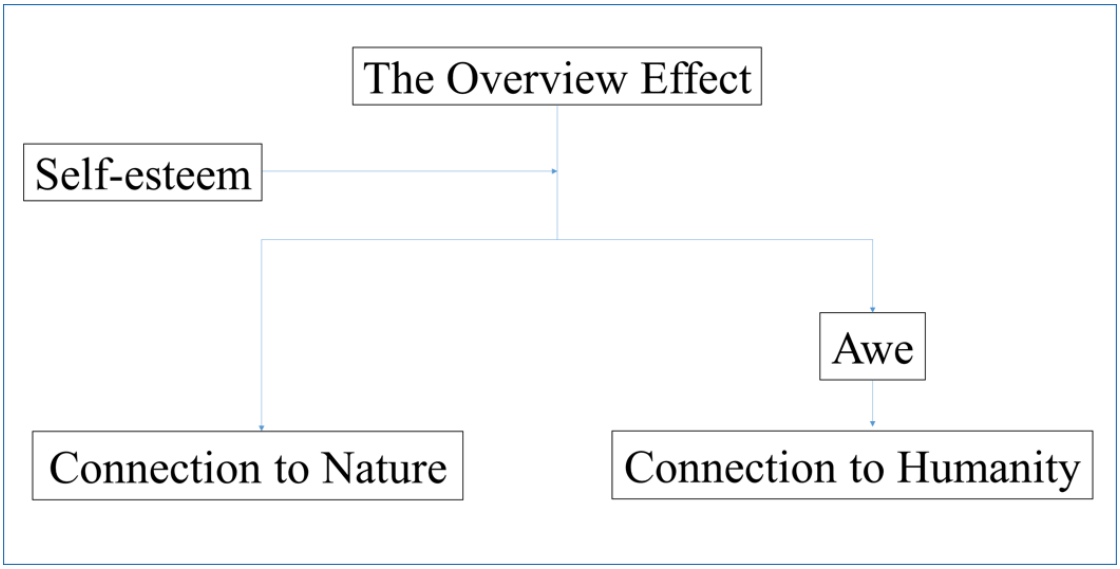

Figure 1
Hypothesis model.
We hypothesize that the overview effect results in increased feelings of connection to nature and humanity, with self-esteem moderating the effect; while awe mediating between the effect and connection to humanity.

Method

The study was approved by San José State Institutional Review Board. Informed consent was obtained from participants before testing.

Participants

Participants consisted of 81 San José State undergraduate students (females = 53, males = 28; mean age = 19.44, *SD* = 2.01). They were randomly assigned to one of three conditions: (a) urban (*n* = 27; females = 17, males = 10; mean age = 19.33, *SD* = 1.47), (b) nature (*n* = 29; females = 18, males = 11; mean age = 19.24, *SD* = 2.36), and (c) space (*n* = 25; females = 18, males = 7; mean age = 19.8, *SD* = 2.1). An *a priori* power analysis, *F* test, ANOVA omnibus one-way, with three groups, power set at .80, alpha at .05, and effect size at .30, suggested that the minimum number of participant should be 120 in total, with 40 participants in each group (G*Power; Faul & Erfelder, 1992). We only tested 81 participants because the COVID-19 global pandemic occurred during data collection and we were unable to continue the study and reach our planned sample size of 120 participants due to the mandatory quarantine.

Materials

Virtual Reality Headset

Stimuli were displayed through the Oculus Rift VR headset, which has a 2160 x 1200 resolution, refresh rate of 90 Hz, and as close to a 172.66-degree field of view as possible.

Pre-stimuli Measures

Participants completed two measures before being exposed to the stimuli. The first measure, the self-liking/self-competence scale (SLSCS) (Tafarodi & Swann, 1995), was designed to measure self-esteem. It consists of two 10 item sub-scales: self-liking and self-competence. Each item is rated on a 5 point Likert-type scale (1 = Strongly Disagree to 5 = Strongly Agree; minimum score = 10, maximum score = 50). Self-esteem was measured by adding the total scores from both sub-scales with higher scores indicating higher self-esteem.

The second measure, International Positive and Negative Affect Schedule Short Form (I-PANAS-SF) (Thompson, 2007), was designed to measure mood and general emotion. For the purposes of this study, the wording of the instructions and rating scale of the I-PANAS-SF was changed to measure emotion in the present state rather than in general ("Thinking about yourself now and how you currently feel, to what extent do you feel at this moment …"). Furthermore, the emotion "awe" was added to the schedule to check for its presence in participants. This modified version consisted of 11 items that were rated on 5 point Likert-type scales (1 = not at all to 5 = very much so; minimum score per affect = 5, maximum score per affect = 25). The score for positive/negative affect was calculated by adding the scores of their respective items, with higher scores indicating greater feelings of the respective affect. The score of Awe was the answer given by participants on the single item, with higher scores indicating greater feelings of awe.

Stimuli

The stimuli were presented in the form of videos. There was one video for each condition. The space condition consisted of a five-minute video showing a view of the Earth from the ISS as it travels on its orbital path. The nature condition consisted of a five-minute video showing a boat traveling down a river in Canada from the point of view of the rower. For the urban condition, the five-minute video showed the back window view of a car as it traveled through an area of Los Angeles, California in the 1940s. Each video was retrieved from online sites and edited to have the same play time, though they were not validated by any prior study.

We selected the video for the space condition first. The video was chosen because it contains uninterrupted moving footage of Earth from the perspective of the International Space Station, and the footage captured both Earth and empty space without obstruction from the appendages of the station. The videos in the other two conditions were selected to match as many elements in the space video as possible while still being actual footage representing their respective conditions (i.e., urban and nature). As such, all three videos featured the viewer traveling in a first-person perspective with minimal to no camera shaking. The nature video was selected to have minimal human presence. The urban video was selected to invoke a neutral reaction from participants without falling into boredom, and to have minimal overlapping elements with the nature video. A screenshot for each video is included in Figure 2.

Figure 2.
Stimuli screenshots.
From left to right: space, nature, urban.

Post-stimuli measures

After stimulus exposure, participants completed three more measures and provided their demographic information. The first measure, the Connectedness to Nature Scale (CNS) (Mayer & Frantz, 2004), was designed to measure the levels of feeling emotionally connected to the natural world. Similar to the I-PANAS-SF, the wording of the instructions and some items were changed to measure the present emotional state rather than general emotional state. The modified CNS consisted of 14 items rated on five point Likert-type scales (1 = Strongly Disagree to 5 = Strongly Agree; minimum score = 14, maximum score = 70); three items were reversed scored (numbers 4, 12, and 14 in the scale). CNS was calculated by adding the scores of all items with higher scores indicating greater feeling of connection to nature.

The second measure, the Identification With All Humanity scale (IWAH) (Farland, Webb, & Brown, 2012), was designed to measure the extent to which an individual identifies with all of humanity. The scale consists of nine items rated on five point Likert-type scales, with each item asking participants to rate how much the statement (e.g.,

"How close do you feel to each of the following group?"; 1 = almost nothing to 5 = very much; minimum score per sub-scale = 9, maximum score per sub-scale = 45) applies to their feeling toward: (a) people in my community, (b) Americans, and (c) people all over the world. Each statement represents a sub-scale, and each sub-scale was calculated by adding the scores of the respective statements from the nine items. Higher scores in one sub-scale indicate greater identification with the group of that sub-scale. The same I-PANAS-SF used in the pre-stimuli phase was also used here.

Design

The main aim of the study was to test the differences in feelings of connection to nature and humanity between participants who have been exposed to different stimuli. The stimuli consisted of space, nature, or urban videos. Connection to nature was measured with the CNS (Mayer & Frantz, 2004). Connection to humanity was measured with the IWAH (Farland, Webb, & Brown, 2012). The International Positive and Negative Affect Schedule Short Form (I-PANAS-SF) (Thompson, 2007) was used to measures the emotional state of participants with the addition of "awe" as an item in the measure. Self–esteem was measured with the self-liking/self-competence scale (SLSCS; Tafarodi & Swann, 1995). The CNS, IWAH, and demographic information were collected only after stimulus exposure to avoid biasing participants. The I-PANAS-SF was collected both before and after exposure to measure changes within groups rather than just overall group differences (see Table 1 for a summary of the study design).

Table 1
Hypotheses Testing Design

Hypotheses	Dependent Variables	Measures	Statistical Analysis	Effect Size
1. Viewing the Earth from space will induce a greater feeling of connection to nature and humanity than viewing an urban stimulus.	Connection to Nature, Connection to Humanity	Connectedness to Nature Scale (CNS), Identification With All Humanity (IWAH)	One-way between-subjects ANOVA	Eta Squared
2. Viewing the Earth from space will induce a greater feeling of connection to nature and humanity than viewing a nature stimulus	Connection to Nature, Connection to Humanity	Connectedness to Nature Scale (CNS), Identification With All Humanity (IWAH)	One-way between-subjects ANOVA	Eta Squared
3. Awe mediates the relationship between the overview effect and connection to humanity.	Awe, Connection to Humanity	International Positive and Negative Affect Schedule Short Form (I-PANAS-SF), Identification With All Humanity (IWAH)	Regression with mediation	Beta
4. Self-esteem moderates the relationship between the overview effect and the feeling of connection to nature and humanity.	Self-esteem, Connection to Nature, Connection to Humanity	Self-Liking/Self-Competence Scale (SLSCS), Connectedness to Nature Scale (CNS), Identification With All Humanity (IWAH)	2X3 between-subjects ANOVA	Eta Squared

The connectedness to nature scale (CNS) (Mayer & Frantz, 2004) was designed to measure the general feeling of connection to nature. However, for the purposes of this study, a measure of the connection in the present was more appropriate. As such, a modified version of the CNS was created with the wording changed to emphasize feelings in the moment (e.g. “I often feel…” vs “I am feeling…”). We conducted a pilot study to test whether the two versions are significantly difference from each other. The results of the study was inconclusive, as the two versions did not significantly differ from each other. As such, this study will use the original version of the CNS, as it is the more validated measurement.

Procedure

Prior to the experiment, a set of identifier numbers (e.g., 1001, 1002, 1003, etc.) was randomized into one of the three condition groups using a randomizer formula in

Microsoft Excel. Then, the identifier was assigned to participants on a first-come, first-served basis. Participants completed the experiment individually. The experiment took place on a computer in the LAVA lab VR room at SJSU using a Qualtrics survey and a VR video player program. In the pre-stimulus part of the experiment, participants were briefed on the experiment, then they completed the pre-stimulus measures. After that, they watched a video in VR based on their assigned condition group. The videos were five minutes in length. Once the video finished, participants completed the post-stimulus measures and demographic information. Participants were debriefed and offered a chance to ask any questions they had about the experiment.

Statistical Analyses

The anlysis plan included two one-way between-subjects analyses of variance (ANOVAs) to compare CNS and IWAH scores between the three conditions (space, nature, and urban). The first and second hypothesis would be supported if the space condition had significantly higher CNS and IWAH than the other two conditions.

To test for the mediating effect of awe, a mediation analysis using the SPSS PROCESS program, with 10,000 bootstrapping samples, was conducted to test whether the overview effect influences IWAH through awe. The mediation analysis conducted in the SPSS program follow the four-step approach of Baron and Kenny (1986) with the bootstrapping method to test the indirect effect. Bootstrapping is a sampling procedure in which statistical analysis is conducted on a number of subsamples taken from the main sample. The distribution of the statistics from these subsamples form a confidence interval to indicate the probability that the effect exists in the population. The third

hypothesis would be supported if the test yielded significant mediation by the awe emotion.

Two 2 (Self-esteem: High and Low) X 3 (Video type: Space, Nature, and Urban) between-subjects ANOVAs were used to test whether self-esteem levels moderated the scores of the CNS and IWAH dependent variables after exposure to the videos. Self-esteem data were transformed into high and low categories by performing a median split of the data. The analysis first tested whether there was a significant interaction between self-esteem levels and video type, followed by the main effects and simple effects in the interaction itself. The first main effect was the video type (i.e., space, nature, urban), and the second main effect was the self-esteem levels (i.e., high self-esteem, and low self-esteem). The simple effects were the six combinations of the levels between self-esteem and video type. The fourth hypothesis would be supported if the levels of the transformed self-esteem variables had significant interactions with the video type, and there were significant simple effects between the space video and self-esteem levels with low self-esteem levels reversing the direction of the relationship between the space video and CNS/IWAH.

Three mixed ANOVAs were planned as exploratory analyses to compare changes in positive affect, negative affect, and awe between the three conditions.

Results

CNS

A one-way between subjects ANOVA was conducted to compare the effect of VR videos on feeling connected to nature for the space, nature, and urban conditions. The assumption of homogeneity was violated $F(2, 78) = 3.24$, $p = .044$, and the Welch's analysis of variance was used to account for the violation. There was no significant effect of VR videos on feeling connected to nature at the $p < .05$ level for the three conditions $F(2, 49.61) = .40$, $p = .67$, $\eta^2 = .01$ (See Table 2).

Table 2
Connection to Nature Analysis Results

	Sum of squares	***F***	***df1***	***df2***	***p***	η^2
Welch's ANOVA	20.46	0.40	2	49.61	0.671	0.01

Descriptive Statistics	**Mean**	***SD***	***N***
Nature	46.62	7.10	29
Space	47.80	4.68	25
Urban	46.85	3.67	27

IWAH

A one-way between subjects ANOVA compared the effect of VR videos on identification with the world, a sub-scale of the IWAH, for the space, nature, and urban conditions. The assumption of homogeneity was violated $F(2, 78) = 4.65$, $p = .012$, and Welch's ANOVA was used to account for the violation. There was no significant effect of VR videos on identifying with all of humanity at the $p < .05$ level for the three conditions $F(2, 48.18) = 1.37$, $p = .26$, $\eta^2 = .03$.

The IWAH contained two other sub-scales that measured identification with people at the community and national level. A one-way between-subjects ANOVA was conducted to compare the effect of VR videos on each of the sub-scales. There was no significant effect of VR videos on feeling identified with the community at the $p < .05$ level for the three conditions $F(2, 78) = .29$, $p = .75$, $\eta^2 = .01$. There was, however, a significant effect of VR videos on feeling identified with the nation for the three conditions $F(2, 78) = 4.73$, $p = .012$, $\eta^2 = .11$. Pairwise comparisons of the means using Tukey's *post hoc* test indicated that participants in the urban video group identified with the nation more than participants in the nature video group ($p = .014$, $d = .79$), and the space video group ($p = .05$, $d = .68$). The nature and space groups did not differ significantly ($p = .92$, $d = .10$) (See Tables 3 and 4).

Table 3

Connection to Humanity Analysis Results

Sub-scale	Sum of squares	*F*	*df1*	*df2*	*p*	η^2
Identification with world	61.94	1.37	2	48.14	0.263	0.03
Identification with nation	323.05	4.73	2	78	0.012*	0.11
Identification with community	18.74	0.29	2	78	0.752	0.01

Note. Identification with world was analyzed with the Welch's ANOVA to account for a violation of homogeneity.

Table 4

Connection to Humanity Descriptive Statistics

Condition	*N*	Identification with world		Identification with nation		Identification with community	
		Mean	*SD*	Mean	*SD*	Mean	*SD*
Nature	29	28.79	3.84	26.55	6.11	34.3	6.2
Space	25	29.12	4.68	27.16	6.26	34.2	5.6
Urban	27	30.78	3.67	31.04	5.11	35.3	5.3

Mediation Analysis

The mediation effect of feeling awe on the relationship between the overview effect (viewing the space VR video) and identification with all of humanity was tested using the

PROCESS macro in SPSS with 10,000 bootstrapped samples. The overview effect was not significantly related to feeling awe b = .24, t = .95, p = .35, and the feeling of awe was not significantly related to identification with all of humanity b = -.21, t = -.34, p = .73. Finally, the overview effect was not significantly related to identification with all of humanity b = -.58, t = -.43, p = .67. Since the 95% confidence interval of the indirect effect (-.55, .41) contained zero, it was concluded that awe did not significantly mediate the relationship between the overview effect and identification with all of humanity (See Figure 3).

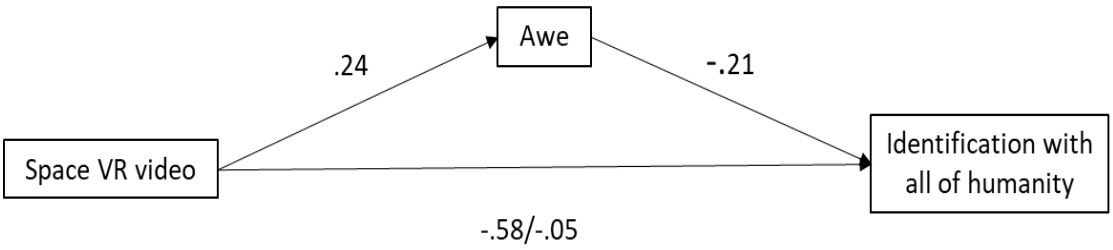

Figure 3
Mediation model of hypothesis 3.
Awe was predicted to mediate the relationship between the space virtual reality (VR) video, which represented the overview effect, and connection to humanity.

Moderation Analysis

A 2 X 3 factorial ANOVA was conducted to assess the impact of self-esteem levels (high and low) and VR videos (nature, space, and urban) on connection to nature. There was no significant interaction effect between self-esteem levels and VR videos $F(2, 75) = .09$, $p = .92$, $\eta^2 = .002$. There was no main effect for VR videos $F(2, 75) = .36$, $p = .70$, $\eta^2 = .01$. There was no main effect for self-esteem levels $F(1, 75) = 2.72$, $p = .10$, $\eta^2 = .04$ (See Tables 5 and 6 and Figure 4).

Table 5
Connection to Nature Moderation Analysis Results

	Sum of squares	*F*	*df1*	*df2*	*p*	η^2
VR videos	21.28	0.36	2	75	0.697	0.01
Self-esteem	79.70	2.72	1	75	0.104	0.04
Condition*Self-esteem	5.17	0.09	2	75	0.916	0.00

Table 6
Connection to Nature Moderation Descriptive Statistics

Condition	*N*	High Self-esteem		Low Self-esteem	
		Mean	*SD*	Mean	*SD*
Nature	29	47.77	6.02	45.69	7.94
Space	25	49.27	4.52	46.64	4.63
Urban	27	47.70	4.22	46.35	3.33

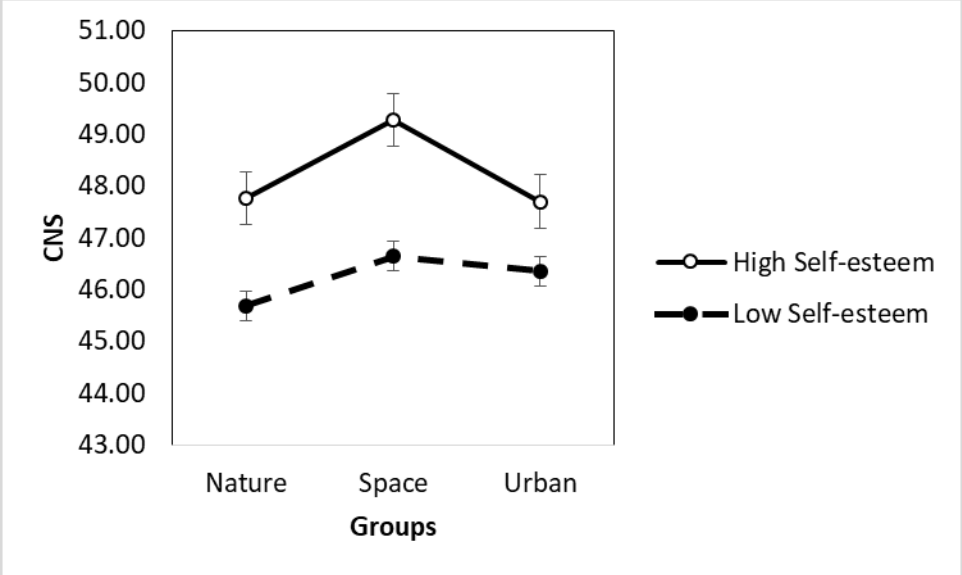

Figure 4
Moderation effect of self-esteem levels on connectedness to nature scale (CNS). Error bars represent standard error of the mean.

A 2 X 3 factorial ANOVA was conducted to assess the impact of self-esteem levels (high and low) and VR videos (nature, space, and urban) on identification with the world. There was no significant interaction effect between self-esteem levels and VR videos

$F(2, 75) = .04$, $p = .96$, $\eta^2 = .001$. There was no main effect for VR videos $F(2, 75) = .88$, $p = .42$, $\eta^2 = .02$. There was no main effect for self-esteem levels $F(1, 75) = 1.75$, $p = .19$, $\eta^2 = .02$ (See Tables 7 and 8 and Figure 5).

Table 7
Identification with World Moderation Analysis Results

	Sum of squares	*F*	*df1*	*df2*	*p*	η^2
VR videos	55.66	0.88	2	75	0.419	0.02
Self-esteem	55.27	1.75	1	75	0.19	0.02
Condition*Self-esteem	2.72	0.04	2	75	0.958	0.00

Table 8
Identification with World Moderation Descriptive Statistics

Condition	***N***	**High Self-esteem**		**Low Self-esteem**	
		Mean	***SD***	**Mean**	***SD***
Nature	29	27.62	5.81	29.75	5.79
Space	25	28.18	5.76	29.86	7.64
Urban	27	30.00	4.88	31.24	3.15

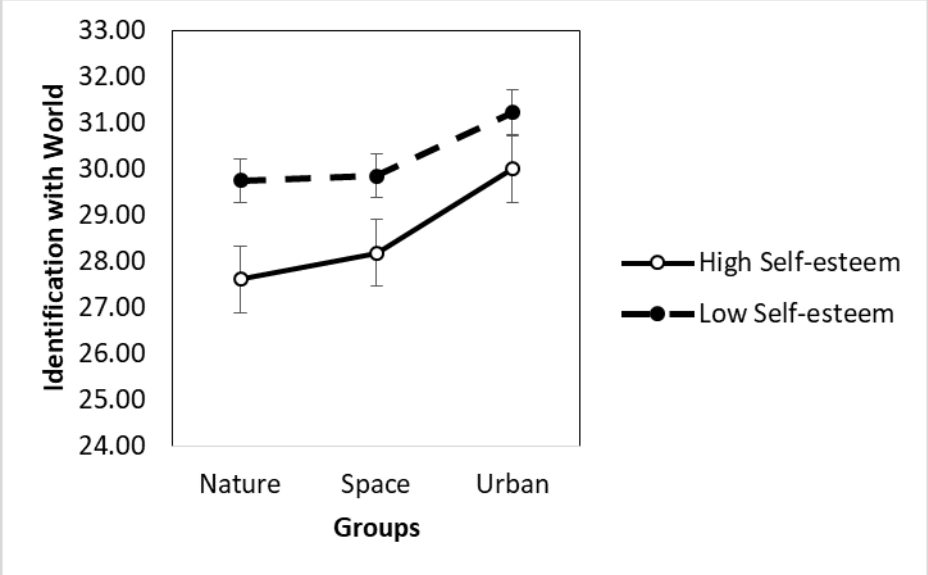

Figure 5
Moderation effect of self-esteem levels on identification with world. Error bars represent standard error of the mean.

Exploratory Analyses

Positive Affect

A mixed ANOVA was conducted on reported positive affect before and after exposure to the VR videos with time as the within-subjects factor and VR video group (space, nature, urban) as the between-subjects factor. The analysis found no significant interaction between time and VR video groups $F(2, 78) = 1.89$, $p = .16$, $\eta^2 = .01$, no significant main effect of time $F(1, 78) = 1.53$, $p = .22$, $\eta^2 = .004$, and no significant main effect of VR video groups $F(2, 78) = 1.80$, $p = .17$, $\eta^2 = .04$

Negative Affect

A mixed ANOVA was conducted on reported negative affect before and after exposure to the VR videos with time as the within-subjects factor and VR video group (space, nature, urban) as the between-subjects factor. The analysis found a significant main effect of time $F(1, 78) = 14.63$, $p < .001$, $\eta^2 = .05$, with negative affect significantly decreasing after exposure to the VR videos. No significant interaction between time and VR video groups was found $F(2, 78) = .36$, $p = .70$, $\eta^2 = .002$, and no significant main effect of VR video groups was found $F(2, 78) = 1.21$, $p = .30$, $\eta^2 = .03$. A violation of homogeneity was found in the between-subjects factor for the negative affect after exposure $F(2, 78) = 8.48$, $p < .001$.

Awe

A mixed ANOVA was conducted on the reported feelings of awe before and after exposure to the VR videos with time as the within-subjects factor and VR video groups (space, nature, urban) as the between-subjects factor. The analysis found a significant

main effect of time $F(1, 78) = 22.61$, $p < .001$, $\eta^2 = .08$, with participants feeling significantly more awe after exposure to the VR videos. No interaction between time and VR video groups was found $F(2, 78) = 1.7$, $p = .19$, $\eta^2 = .01$, and no main effect of VR video groups was found $F(2, 78) = .03$, $p = .97$, $\eta^2 = .001$ (See Tables 9 and 10).

Table 9

Positive Affect, Negative Affect, and Awe Analysis Results

	Sum of squares	*F*	*df1*	*df2*	*p*	η^2
Within-subjects effect						
Pos affect	9.45	1.53	1	78	0.219	0.004
*Pos affect * Condition*	23.256	1.89	2	78	0.158	0.01
Neg affect	46.71	14.627	1	78	<0.001*	0.049
*Neg affect * Condition*	2.28	0.356	2	78	0.701	0.002
Awe	12.78	22.61	1	78	<0.001*	0.08
*Awe * Condition*	1.92	0.96	2	78	0.19	0.01
Between-subjects effect						
Pos affect	76.66	1.8	2	78	0.171	0.04
Neg affect	19.80	1.212	2	78	0.303	0.03
Awe	0.083	0.03	2	78	0.971	0.001

Notes. A violation of homgeneity was found in negative affect (after)

Table 10

Positive Affect, Negative Affect, and Awe Descriptive Statistics

Time	Condition	N	Positive affect		Negative affect		Awe	
			Mean	SD	Mean	SD	Mean	SD
Before	Nature	29	16.448	2.848	7.69	2.407	1.69	0.93
	Space	25	15.32	4.279	7.16	3.145	1.56	0.917
	Urban	27	15.444	3.08	7.63	2.529	1.778	0.892
After	Nature	29	16.069	3.38	6.862	2.601	2.241	1.057
	Space	25	13.84	4.561	5.76	1.2	2.4	1.155
	Urban	27	15.852	3.949	6.63	1.925	2.074	0.958

Discussion

The overview effect is a fascinating phenomenon resulting from observing the Earth from outside its atmosphere. Reportedly, the phenomenon can produce increased feelings of connectedness to the planet and humanity, which can increase interest in getting involved in environmental and humanitarian causes. Recreation of the conditions to produce the phenomenon is a large obstacle that restricts research to the very small sample of astronauts who have returned from space missions. However, with recent advances in technology, the requirement for space travel may soon no longer be an issue. One such technology that maybe able recreate the conditions to produce the overview effect is virtual reality.

The current experimental study attempted to induce the overview effect in a non-astronaut population using VR and utilized quantitative measures to detect the presence of a simulated form of the phenomenon. The current study did not find any conclusive evidence that the overview effect had been successfully induced by VR in the sample of college students. Participants who watched footage of Earth from space did not have statistically different scores on the Connected to Nature Scale and the identified with the world sub-scale of the Identification With All of Humanity scale compared to participants who watched footage of a nature scene or an urban scene. The feeling of awe did not significantly mediate the relationship between watching the space VR video and identifying with all of humanity, and self-esteem levels did not significantly moderate the relationship between watching VR videos and CNS and IWAH scores. Therefore, the results did not support the four hypotheses of this study. However, there was a significant

increase in identification with the nation sub-scale in the urban video group, which may be due to the historical content of the urban video itself.

Exploratory analyses of changes in emotions did yield some interesting findings, however. Participants experienced an overall increase in feeling awe and an overall decrease in negative affect, but this effect did not result from any particular VR video. As such, this suggests that experiencing VR alone is sufficient for participants to experience some level of awe. The decrease in negative affect without an increase in positive affect suggested that being in VR distracted participants from negative emotions, but the experience of VR did not generate positive emotions. Furthermore, the increase in feeling awe without an increase in other positive emotions supports the idea that awe may not necessarily be a positive emotion. Rather, awe itself may be independent from the negative and positive spectrum of emotion.

Limitations

Our *a priori* power analysis suggested that the minimum number of participants should have been 120 in total, with 40 participants in each group (G*Power; Faul & Erfelder, 1992). However, the COVID-19 pandemic halted participant recruitment during the course of the study, and the study was not able to reach its initial planned sample size. This lowered the statistical power of the experiment and may be why we found so few significant results.

We decided that the study would aim to maximize ecological validity (i.e., using actual footage versus computer generated video; using virtual reality) at the risk of increasing threats to internal validity. One such risk is the differences between the

stimuli. All stimuli were kept as authentic as possible to maximize immersion. However, this created differences such as motion speed, scale, and the height of the point of view. Due to those differences not being controlled across the videos, the differences found in the measures may not have been due to the environments (e.g., space, nature, urban) shown, but rather due to one or more of the other aspects of the videos (e.g., angle of view, camera speed, resolution quality). This study also employed only self-report measures, and as such, it lacks corroborating evidence for the actual experience of the participants.

Future Studies

This study was one of the first to attempt to detect the overview effect using quantitative measures, and one of the first attempts to induce the effect in a more general population. Future studies could use different stimuli and control for aspects of the stimuli to address any perceptual differences between them (e.g., object scales, lighting, color contrast). It might be especially useful to gather neurological and biological evidence (e.g., fMRI, EEG, EKG, EDA, heart rate, heart rate variability) for the presence of the overview effect to corroborate the self-report evidence. Future studies could also test the universality of the overview effect by testing samples with more diverse demographics. The current study used a two-dimensional VR environment for the stimuli and, as such, future studies could investigate whether more immersive three-dimensional VR environments and longer exposure times are more successful in inducing the overview effect. Methods beside VR to induce the effect such as augmented reality or

physical simulation similar to that used in Gallagher et al. (2014) should also be explored in future studies.

Further advancement in technology may also offer more methods to study this effect. In particular, one of the potentials of commercial spaceflight would be to allow for direct observation of the effect in more diverse samples of participants. The overview effect may also serve as a selling point for commercial spaceflight, as the description of the effect may have appeal for many. Future studies could also observe whether personal beliefs interact with the overview effect.

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