# Reducing Anxiety Through a Virtual Reality Experience Inducing Awe

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Abstract

This study examined the effectiveness of the VR experience *Between the Suns* as an anxiety-reducing and awe-inspiring intervention for an undiagnosed population. Between the Suns involves interacting with simple stimuli in panoramic, surreal, and natural, backgrounds in virtual reality. Participants provided physiological and self-report indicators of anxiety as well as measures of experienced awe, positive and negative affect. The study revealed that participants' anxiety decreased significantly after experiencing 3 minutes of *Between the Suns,* and that the experience induced awe, particularly by creating a smaller sense of self and a slower sense of time.

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Virtual reality offers a powerful therapeutic tool for introducing emotional and cognitive interventions into homes, workplaces, and clinical settings. One experience that VR is particularly well-suited to deliver is that of awe, wonder, or the sublime, because of VR's capacity to produce vast and immersive environments. While research identifies awe as a powerful positive cognitive and emotional experience, awe's therapeutic utility is limited by the practical problem of bringing truly awe-inspiring stimuli into our day-to-day environments. VR offers a solution to this limitation. In the present work, we examine the awe-inducing and anxiety reducing qualities of a novel VR experience, titled *Between the Suns*.

### *Virtual Reality for Therapeutic Purposes*

Virtual reality, or VR, is an immersive computer-generated technology that offers presence and interaction in virtual worlds on a personal, social, and environmental level. In past research, experiments have used VR to create simulated natural environments ranging from waterfalls, beaches, campfires and more (Gorini et al., 2010). The human mind perceives VR simulations in much the same way they would everyday reality. As such, VR offers an avenue for providing a nearly limitless range of impactful experiences with relative ease. Taking advantage of this, VR therapy was first introduced in 1994 and has been developing since. Psychologists and counselors worldwide use VR to treat various psychological disorders in controlled and safe environments, bringing users new perspectives and personal narratives. In this way, VR therapy is analogous to psychedelic therapy, as both methods hold the power to change users' sense of material and psychological realities. VR games, however, offer more control to the therapist in terms of audiovisual material and time. By using virtual spaces for

therapy, health professionals can tap into unlimited resources and scenarios to trigger rapid behavioral and psychological change.

Although the technology is still relatively new, therapeutic applications for VR have been explored in many domains. VR therapy has been used to treat anxiety disorders through exposure therapy, CBT, and DBT (Oing & Prescott, 2018)( Lindner, 2020) (Nararro-Haro, 2016). The power of immersion and embodiment in VR has been used to distract patients from pain, as well as to expose them to challenging situations (Oing & Prescott, 2018). Additionally, VR interventions have been used to treat anxiety disorders including, PTSD, various phobias, and generalized anxiety disorder (Maples-Keller et al. 2017; Gorini et al., 2010). VR also offers wide applications for integration with other therapeutic tools. Gorini et al. (2010) have examined the impact of biofeedback and companion apps to strengthen the results achieved through VR. In a parallel vein, gamification and storytelling are touted for their therapeutic benefits (Lindner, 2020). Both qualities can easily translate into VR since it is a highly immersive medium, with tailored interactions that can create new worlds and help build new stories. While researchers, theorists, and therapists widely acknowledge the therapeutic potential of VR, new techniques and mechanisms for promoting wellness with VR are still under development and study. One therapeutic emotional experience achievable with VR, but relatively understudied is that of Awe.

***Anxiety and Awe in VR***

Keltner and Haidt (2003) propose that awe is a reaction to stimuli characterized by two features: perceptual vastness and the need for (cognitive) accommodation. That is, awe tends to be evoked by stimuli that are large (physically or by scope of their implication) and which challenge one's existing understanding of the world. Awe can emerge in both positive (wonderful) or negative (terrifying) forms (Shiota et al., 2007). Typical elicitors of awe include

panoramic natural scenes, emotionally affecting music, or even philosophical ideas and concepts. The experience of awe that results from such stimuli can have powerful psychological effects.

Awe's psychological effects may have important implications for promoting well-being. Theorists suggest "Experiencing awe can dampen the body's stress response and can change how people process information" and that these psychological properties make awe an invaluable experience for promoting wellbeing (ASU news, 2019). Indeed, many such effects have been documented in empirical research. After experiencing awe, people have a more communal sense of self and adopt more inclusive values (Bai et al, 2017; Krause & Hayward, 2015). Likewise, experiences of awe increase openness to experience, reduce need for cognitive closure, and reportedly *challenge one's worldview* (Campos, et al., 2013; Shiota, et al., 2006; Shiota et al., 2007). Awe also prompts people to view the world as more guided and less arbitrary (Valdesolo & Graham, 2014). Following from this evidence, theorists posit that awe is adaptive in that it reduces people's over-reliance on existing schemas and promotes the assimilation of new information (Shiota, et al., 2014). As such, awe experiences offer great therapeutic promise, by encouraging a sense of connection, guidance, and adoption of new ways of thinking.

However, awe is a relatively impractical intervention to deliver in the context of a lab, home, office, or therapy session. Indeed, truly affecting awe experiences often require vast spaces and extra-ordinary stimuli. Virtual reality offers a novel and powerful method by which awe can be experienced in almost any setting. Chirico et al. (2016) emphasize that VR creates an authentic sense of presence among vast and complex stimuli of exactly the kind that could evoke awe. Inducing awe during therapy sessions with VR could help clients open up and be more comfortable, shifting their preconceived notions about therapy when there is resistance to treatment or healing.

Relatively few studies have investigated the use of VR as a tool for therapeutically inducing awe. The present study fills this gap by examining the awe-inducing and anxiety-reducing effects of *Between the Suns*, a novel therapeutic VR game. Physiological and self-report indicators of anxiety were assessed in addition to reports of positive affect, negative affect, and awe. We expected that, compared to pre-test levels, participants would experience reduced anxiety after completing a brief session in *Between the Suns.* Further, we predicted that participants would rate the experience as awe-inspiring and that degree of awe felt would relate to the experience's anxiety reducing capacity, such that greater awe diminishes anxiety. In all, this work will help expand our understanding of VR and awe as therapeutic tools.

## Method

We report how we determined our sample size, all data exclusions (if any), all manipulations, and all measures in the study. Methods were approved by institutional review board. All data, analysis code, and research materials are available at [stable link to repository]. Data were analyzed using R, version 4.1.2 (R Core Team, 2020) and JASP version 0.16. This study's design and its analysis were not pre-registered.

### Between the Suns

*Between the Suns*, a therapeutic VR game created by Pia Behmuaras in 2021, introduces three environments with different levels of gameplay and interactivity. Overall, the experience involves observing immersive abstract, surreal, and aesthetically pleasing landscapes, while listening to music. Importantly, the scenes involve unusual, but non-threatening stimuli designed to elicit the sense of challenge or surprise that characterizes positive awe.

The virtual storyline takes place starting from between the clouds, going down to sea level, and then under the sea (See figure 1). Users may switch between scenes by pointing their

controller at the arrow buttons, and each scene offers different objects and vibrant backgrounds. The user is alone in all the environments, accompanied by instrumental music in each scene. The sea-level sunset scene has interactive fish that change color when clicked, whereas the environment under the sea has less stimulus and is more relaxing. *Between the Suns* aims to be a game that treats the symptoms of anxiety, allowing participants to dive deeper into the root causes of anxiety and change their ways of thinking by creating new mental anchors. The experience could be used with quantitative and qualitative analysis by a therapist, or as a standalone app to relieve people of anxiety.

Some VR experiences tend to be overwhelming, so *Between the Suns* utilizes simple, minimal text, sounds, and actions so as not to cause distress, confusion, or anxiety. The software is designed to be pleasant but also challenging. It is not rewarding by itself and cannot be consumed for the same benefits repeatedly, rendering it non-addictive. The game is not meant for self-diagnosis, self-treatment, or self-medication. It is not accessible to the public.

**Participants**

Forty-three students (28 female, 11 male, and 4 non-binary) from a small liberal arts institution the Northeast United states participated in exchange for a $50 raffle or course credit. The sample self-identified as 72% white, 12% Asian, 16% other and were 19.6 years old on average (SD = 1.35). Apriori power analyses determined that a sample size of 34, $\alpha = .05$, power = .8, would be sufficient to detect within subjects differences of a medium effect size (effect size $d = .5$), assuming a strong to moderate correlation ($r = .5$) among measurement points. There were no data exclusions, however due to equipment failure or failure to follow directions complete data was only obtained for 39 participants.

**Apparatus**

The main apparatus for delivering the VR experience was the Oculus Quest 2 and one controller. The only active button was the trigger button.

A BIOPAC MP160 amplifier collected measurements of galvanic skin response electrodermal activity (EDA), with a gain of 10 μS/V and a recording rate of 10 hz. The primary physiological measure of anxiety was the slope of participants' galvanic skin response waveform recorded over the duration of their time in the VR experience. As galvanic skin response indicates sympathetic nervous system activation a negative slope would indicate decreasing arousal, whereas a positive slope indicates increasing arousal.

**Procedure and Measures**

Participants first completed pre-test surveys of state anxiety using the ten item State subscale of the State Trait Anxiety Inventory (STAI; Spielberger, et a., 1983) in addition to pre-test measures of positive and negative affect, using the 20-item positive and negative affect scale (PANAS; Watson, D., et al., 1988). Participants also completed demographic measures at this stage.

Next, the experimenter attached two electrodes to the participant's index and middle fingers on their non-dominant hands and explained the VR procedure. While EDA was recorded, participants experienced three minutes of undirected activity in *Between the Suns*. At the end of the VR experience, EDA recording was halted.

Subsequently, participants were guided through a brief grounding exercise asking them to verbally list five things they see, four things they can touch, three things they can hear, two things that they smell, and one emotion that they feel. Subsequently, participants completed post-test measurements of Anxiety and positive and negative affect, using the same scales. Finally, participants answered a single item assessing the degree of felt awe in response to the experience

and then completed 24 items of the Awe Experience Scale in regards to the experience (AWE-S; Yaden Et al., 2018). This scale includes subscales for perception of slowed time, perception of self-diminishment, perception of exterior vastness, sense of connection, physiological signs of awe (e.g. goosebumps), and need for accommodation. All the scales had four-point Likert scales ranging from "not at all" to "very much". Finally, there were four open-ended questions at the end of the survey where participants reported what they thought and felt in an open response format. **Results**

Means, standard deviations, reliability and correlations are reported in table 1. Notably, reported awe and the slope of galvanic skin response over the experience were significantly related, such that greater awe corresponded to a steeper drop in physiological arousal. Additionally we calculated change scores for anxiety (Postest – Pretest) and calculated the correlation bewteen awe and self-reported anxiety change. There was a significant negative relationship between anxiety change and awe, $r$ = -.353, $p$ = 0.02, indicating that greater awe predicted a steeper decline in self-reported anxiety as well.

**Anxiety**

Within subjects t-tests showed that from before to after the VR experience there were significant drops in self-reported anxiety ($t(40) = 4.30$, $p < .001$, $d = 0.67$) and negative affect ( $t(40) = 4.02$, $p < .001$), but no significant change in positive affect ( $t(40) = -0.26$, $p = .80$, $d = 0.63$). Additionally, the average galvanic skin response slope of the sample was negative (-0.002, $SD = 0.003$) and this slope differed significantly from a slope of zero ( $t(39) = -3.85$, $p < .001$, $d = -0.62$), indicating that the sample experienced a significant decrease in average physiological arousal while in the VR experience.

**Awe**

We examined the amount of awe participants reported during the virtual experience. While reports of awe and all awe subscales (time slowing, self-diminishment, connection, perceived vastness, physiological responses, and need for accommodation) differed significantly from the lowest point on the scale (1 = not at all), only perceptions of slowed time ($t(39) = 3.79$, $p < .001$) perceptions of external vastness ($t(40) = 3.15$, $p = .003$), and the overall assessment of felt awe were significantly greater on average than the second point on the scale and no measures were significantly greater than the scale midpoint (see figure 2).

A qualitative examination of the feelings that participants reported in a free response description of their impression of the activity revealed that 26 of the participants reported feeling calm, relaxed, or content, 5 were confused or nervous, 2 were intrigued, and 4 had other responses such as "happy". In the open-ended questions, many participants said that they were confused at first but then impressed by the visuals and relaxed, and one participant reported feeling a sense of ego death. Some participants expressed confusion concerning what they should do during the VR experience because there was no clear goal like in a video game. Thirty-nine participants said that they enjoyed the experience.

## Discussion

Previous work suggests that experiences of awe may have beneficial effects on anxiety and that virtual reality offers a powerful tool to induce awe in a clinical setting. The present work tested a novel virtual reality awe-inspiring intervention and in line with predictions, found that participants experienced some awe. Although average experienced awe did not reach the highest range of the scale and we lack a baseline comparison, it seems reasonable to conclude that achieving even moderate levels of awe in a rather mundane office setting speaks to the potential of this intervention. This point is supported by the relatively high number of free response

reports of awe or awe-like feelings. Furthermore, although participants did not experience a gain in positive emotion, in line with our main prediction they displayed less anxiety and negative affect after the intervention, as assessed by both physiological and self-report indices. The fact that anxiety decreased after the VR experience is especially noteworthy because people might expect to be excited by VR as it is a powerful novel experience. Importantly, the degree of awe felt related to the degree of anxiety reduction, suggesting that awe may be a key mechanism for the treatment.

This has some limitations stemming from its design. Without experimental manipulation of variables questions about causal mechanisms are unanswered, however the pre-test / post-test design strongly suggest that the intervention may increase awe and that feelings of awe are responsible for decreases in anxiety. Similarly, it is unclear from this work alone whether the virtual reality experience combined with the grounding exercise or either on their own is most responsible for the observed outcomes. However, the decrease in physiological arousal measured over the VR experience, but before the grounding exercise highlights the effects of the VR experience on its own. As a follow-up study, future? could conduct the experiment in a clinical setting, and possibly with people who are already anxious before the study or have an anxiety disorder. An experiment comparing a randomly assigned control group to a treatment group would provide evidence for causal mechanisms.  Additionally, it would be important to examine this effect among a clinical population, who might have more severe anxiety reactions. However, we expect the findings from college students should be largely applicable to people from an educated background in Western countries. As VR technology becomes mainstream and evolves in nature, the experiments would have to be conducted with a larger and broader sample to see if the social effects of VR impact how this VR game impacts perception and awe. Additionally,

different cultural values might interact with *Between the Suns* based on people's relationship with nature, technology, games, and art.

In conclusion, experiencing *Between the Suns* produced enough awe to decrease anxiety. When people felt awe, they were also less aroused, and reported feeling less anxiety. This study extends the possibilities of therapy and VR therapy, demonstrates the usability of a specific VR experience, and shows the benefits of exposing participants to VR in a safe and empowering space. Furthermore, it can broaden the range of approaches taken to treat anxiety disorders or feelings of anxiety during therapy sessions. Since the study of awe in VR is only in its beginnings, this study will add to the research on how awe in VR compares to awe in the physical world.

## References


ASU News. (2019, January 3). *Research that takes your breath away: The impact of awe*. ASU News. Retrieved November 25, 2021, from https://news.asu.edu/20190103-research-takes-your-breath-away-impact-awe.

Allen, S. (2018). The Science of Awe. *Greater Good Science Center*.

Bai, Y., Maruskin, L. A., Chen, S., Gordon, A. M., Stellar, J. E., McNeil, G. D., ... & Keltner, D. (2017). Awe, the diminished self, and collective engagement: Universals and cultural variations in the small self. Journal of personality and social psychology, 113, 185.

Campos, B., Shiota, M. N., Keltner, D., Gonzaga, G. C., & Goetz, J. L. (2013). What is shared, what is different? Core relational themes and expressive displays of eight positive emotions. *Cognition & emotion*, *27*(1), 37-52.

Chirico, A., Yaden, D. B., Riva, G., & Gaggioli, A. (2016). The potential of virtual reality for the investigation of awe. *Frontiers in Psychology*, *7*. https://doi.org/10.3389/fpsyg.2016.01766

Keltner, D., & Haidt, J. (2003). Approaching awe, a moral, spiritual, and aesthetic emotion. *Cognition and Emotion*, *17*, 297–314. https://doi.org/10.1080/02699930302297

Krause, N., & Hayward, R. D. (2015). Assessing whether practical wisdom and awe of God are associated with life satisfaction. *Psychology of Religion and Spirituality*, *7*, 51.

Lindner, P. (2020). Better, virtually: The past, present, and future of Virtual Reality Cognitive Behavior therapy. *International Journal of Cognitive Therapy*, *14*, 23–46. https://doi.org/10.1007/s41811-020-00090-7

Maples-Keller, J. L., Bunnell, B. E., Kim, S.-J., & Rothbaum, B. O. (2017). The use of virtual reality technology in the treatment of anxiety and other psychiatric disorders. *Harvard Review of Psychiatry, 25*, 103–113. https://doi.org/10.1097/hrp.0000000000000138

Nararro-Haro, M. V., Hoffman, H. G., Garcia-Palacios, A., Sampaio, M., Alhalabi, W., Hall, K., & Linehan, M. (2016). The use of virtual reality to facilitate mindfulness skills training in dialectical behavioral therapy for borderline personality disorder: A case study. *Frontiers in Psychology*, *7*. https://doi.org/10.3389/fpsyg.2016.01573

Oing, T., & Prescott, J. (2018). Implementations of virtual reality for anxiety-related disorders: Systematic review (preprint). https://doi.org/10.2196/preprints.10965

Gorini, A., Pallacivini, F., Algeri, D., Repetto, C., Gaggioli, A., & Riva, G. (2010). Virtual Reality in the Treatment of Generalized Anxiety Disorders . *Studies in Health Technology and Informatics*, *154*.

Shiota, M. N., Keltner, D., & John, O. P. (2006). Positive emotion dispositions differentially associated with Big Five personality and attachment style. *The journal of positive psychology*, *1*, 61-71.

Shiota, M. N., Keltner, D., & Mossman, A. (2007). The nature of awe: Elicitors, appraisals, and effects on self-concept. *Cognition and Emotion*, *21*, 944–963. https://doi.org/10.1080/02699930600923668

Shiota, M. N., Thrash, T. M., Danvers, A. F., & Dombrowski, J. T. (2014). Transcending the self: Awe, elevation, and inspiration. In M. M. Tugade, M. N. Shiota, L. D. Kirby, M. M. Tugade, M. N. Shiota, L. D. Kirby (Eds.), *Handbook of positive emotions* (pp. 362-377). New York, NY, US: Guilford Press.

Valdesolo, P., & Graham, J. (2014). Awe, uncertainty, and agency detection. *Psychological science*, *25*, 170-178.

Yaden, D. B., Kaufman, S. B., Hyde, E., Chirico, A., Gaggioli, A., Zhang, J. W., & Keltner, D. (2018). The development of the AWE Experience Scale (AWE-S): A multifactorial measure for a complex emotion. *The Journal of Positive Psychology*, *14*, 474–488. https://doi.org/10.1080/17439760.2018.1484940 ,

Table 1

Means, Standard Deviations, Correlations, and Reliability Among Measured Variables

| | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. | 11. | 12. | 13. | 14. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. EDA slope | — | | | | | | | | | | | | | |
| 2. Anxiety Pretest | -0.01 | — | | | | | | | | | | | | |
| 3. Anxiety Posttest | -0.10 | 0.49* | — | | | | | | | | | | | |
| 4. Negative Affect Pretest | 0.18 | 0.74* | 0.34* | — | | | | | | | | | | |
| 5. Negative Affect Posttest | 0.09 | 0.43* | 0.71* | 0.47* | — | | | | | | | | | |
| 6. Positive Affect Pretest | -0.41* | -0.51* | -0.28 | -0.34* | -0.21 | — | | | | | | | | |
| 7. Positive Affect Posttest | -0.10 | -0.43* | -0.25 | -0.21 | -0.16 | 0.72* | — | | | | | | | |
| 8. Time Slowing | -0.28 | 0.21 | 0.17 | 0.29 | 0.28 | -0.02 | 0.01 | — | | | | | | |
| 9. Self-diminishment | -0.43* | 0.16 | 0.23 | 0.26 | 0.10 | 0.14 | -0.06 | 0.47* | — | | | | | |
| 10. Connection | -0.05 | -0.25 | -0.21 | 0.01 | -0.14 | 0.32* | 0.35* | 0.22 | 0.11 | — | | | | |
| 11. Percieve Vastness | -0.01 | 0.01 | 0.00 | 0.24 | 0.02 | 0.15 | 0.07 | 0.41* | 0.37* | 0.58* | — | | | |
| 12. Physioloigical awe | -0.27 | -0.11 | -0.17 | 0.20 | -0.11 | 0.49* | 0.40* | 0.17 | 0.45* | 0.29 | 0.27 | — | | |
| 13. Accommodation | 0.07 | 0.10 | 0.48* | 0.24 | 0.45* | 0.07 | 0.13 | 0.04 | 0.20 | -0.03 | 0.06 | 0.16 | — | |
| 14. Awe | -0.48* | -0.01 | -0.09 | 0.15 | 0.1 | 0.44 | 0.18 | 0.3 | 0.39 | 0.40 | 0.45* | 0.47* | 0.04 | — |
| Mean | -0.002 | 1.93 | 1.60 | 1.39 | 1.19 | 2.19 | 2.22 | 2.41 | 2.16 | 1.93 | 2.40 | 1.42 | 2.17 | 2.60 |
| SD | 0.003 | 0.54 | 0.42 | 0.34 | 0.27 | 0.52 | 0.59 | 0.68 | 0.77 | 0.67 | 0.82 | 0.45 | 0.76 | 0.83 |
| Alpha | NA | 0.89 | 0.84 | 0.75 | 0.8 | 0.87 | 0.9 | 0.83 | 0.84 | 0.84 | 0.84 | 0.61 | 0.86 | NA |

*Note:* * $p < .05$

Figure 1

Images from Between the Suns VR experience

Figure 2

95% Confidence Intervals Around Awe Scale Means