The Influence of Virtual Out-of-Body Experiences on Fear of Death

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Abstract

Virtual reality (VR) has a demonstrated capacity to embody participants in a virtual avatar and induce body ownership illusions. Previous research has leveraged avatar embodiment to create virtual out-of-body experiences (OBEs) for participants. These induced experiences have subsequently been linked to influencing participants' fear of death (FOD). Because perceptions of mortality have important clinical implications for palliative and hospice care, there has been growing research interest in the efficacy of utilizing VR technologies to influence FOD. This exploratory study extends this line of research by examining the impact of VR OBEs on FOD in a between-groups experiment with three conditions: (1) a control condition where participants remained in control of the avatar body; (2) an out-of-body (OBE) experimental condition in which participants drifted out of the avatar body and lost visuotactile contact with their avatar; and (3) a "drifting body" (DBE) experimental condition in which participants drifted out of the avatar body but retained visuotactile contact with their avatar. Preliminary data analysis revealed non-significant reductions in FOD in the OBE and DBE experimental conditions. Furthermore, qualitative measures indicated that participants were more disturbed by the OBE condition than by the DBE condition. We provide a discussion of these results, as well as study limitations and future continuation of research under ideal conditions.

Chapter 1: Introduction

1.1 Out-of-Body Experiences

Out-of-body experiences (OBEs) are one of the key phenomenological characteristics of near-death experiences (NDEs), or altered states of consciousness that typically occur during clinical death (Parnia, Waller, Yeates, & Fenwick, 2001). Survivors of NDEs have described OBEs as "experience[s] in which a person seems to be awake and see his body and the world from a location outside the physical body" (Blanke, Landis, Spinelli, & Seeck, 2004). Because patients experiencing OBEs have also reported reduced fear of death (FOD) and enhanced belief in life after death, research has focused on investigating the correlation between OBEs and perceptions of mortality (Van Lommel, Van Wees, Meyers, & Elfferich, 2001).

The relationship between OBEs and the idea of survival after death has various accounts in literature, with previous reports linking naturally occurring OBEs with enhanced belief in life after death (Metzinger, 2005). Those undergoing an OBE retain sensory perception, which illustrates the possibility of the existence of consciousness outside a physical body. Because of this implicit evidence that survival beyond the body is possible, research has linked OBEs to a reduction in FOD (Tassell-Matamua & Lindsay, 2016). Recent advances in virtual reality have now raised the possibility of virtually replicating OBEs in a controlled environment. Therefore, this study induced OBEs in a research setting to examine whether an experience in which the center of perception was located outside a participant's body might influence a participant's FOD.

1.2 Virtual Reality

The recent proliferation of immersive virtual reality (VR) tools has presented the opportunity to study OBEs within a controlled environment.

VR creates a perceptual illusion of "presence" in a virtual environment by utilizing a head-tracked stereo head-mounted display, real-time motion capture, and multisensory stimulation. A study by Bourdin, Barberia, Oliva, and Slater (2017) successfully simulated OBEs within virtual environments, and found that the experimental group (i.e., participants experiencing OBEs) had lower FOD than of the control group. Similarly, a 2018 exploratory study in Cornell University's Virtual Embodiment Lab utilized consumer VR technology to examine the implications of exploiting virtual embodiment to improve end-of-life clinical care; interestingly, the study linked greater feelings of embodiment over the virtual body with greater FOD in an OBE condition (Chan, Hwang, Sun, Birckhead, & Won, 2020). The contradictory findings and non-uniform methodology across these studies were particular points of emphasis when preparing the study procedure (1.4 *Research Overview*).

Utilizing the methodology from Bourdin et al. (2017), a perceptual illusion of ownership over the virtual body will be induced via visuotactile and visuomotor synchrony. These techniques have been well documented to reproduce body ownership illusion within VR (Kilteni, Maselli, Kording, & Slater, 2015). Visuomotor synchrony is induced as real-time motion capture from the Oculus Quest virtual reality headset allows the virtual body to move synchronously with the real body. Visuotactile stimulation is a technique borrowed from the rubber-hand illusion in which participants see a virtual brush stroking their virtual hand as the researcher synchronously brushes the participant's hand (Botvinick & Cohen, 1998). Past studies have confirmed that participant self-location in VR is systematically biased to where a visual–tactile event is seen (Lenggenhager, Mouthon, & Blanke, 2009).

1.3 Clinical VR Therapy

There is increasing interest in incorporating VR within clinical settings. Early clinical VR studies leveraged the technology in exposure therapy (Rothbaum, Hodges, Watson, Kessler, & Opdyke, 1996) where VR helped patients gain a sense of control by allowing them to feel like they were present in simulated fear-provoking environments. Since then, VR has also been used in other various clinical contexts, such as treatment for posttraumatic stress disorder, schizophrenia, and complex regional pain syndrome (Cukor, Spitalnick, Difede, Rizzo, & Rothbaum, 2009; Rus-Calafell, Garety, Sason, Craig, & Valmaggia, 2018). The potential of VR for therapy has also led several medical centers to develop VR therapy teams (Delshad, Almario, Fuller, Luong, & Spiegel, 2018).

Simulating OBEs within VR holds an important clinical implication for palliative and hospice care. In addition to mitigating physical symptoms, palliative and hospice care also encompass a psychosocial and spiritual component where clinicians help patients achieve a sense of meaning and control while preparing for death (Rome, Luminais, Bourgeois, & Blais, 2011). During these discussions, patients typically undergo a therapeutic life review involving the meaning of life, resolving lingering conflicts, legacies, as well as perceptions of future life (Keall, Clayton, & Butow, 2015).

Within these contexts, VR OBEs offer an end-of-life intervention that may influence patient perception of mortality and death. Because experiencing OBEs has been linked to a reduced FOD and enhanced belief in life after death, VR provides a mechanism to artificially create these OBE experiences for patients (Van Lommel et al., 2001). Additionally, current therapeutic life review interventions are not widely practiced, partially because of their time-consuming nature; VR OBEs may aid in streamlining the standard discussions in palliative and hospice care.

Despite recent advances in leveraging VR treatment as a non-pharmacological therapy, there is still limited research exploring the clinical capabilities of this technology. A major hindrance to the advancement of clinical VR has been the commercially available technology; a majority of the randomized, controlled studies described in literature have utilized computer-tethered VR headsets, such as the Oculus Rift and HTC Vive, or even more immersive systems that involve full-body tracking (Bourdin et al., 2017; Dascal et al., 2017). While studies showed promising results, these expensive, high-end VR systems will be difficult to utilize in health care settings widely. Ultimately, the progression of VR into widespread clinical viability will be dependent upon advancement in both VR scientific literature and availability of consumer technology.

1.4 Research Overview

Bourdin et al. (2017) demonstrated a viable methodology of replicating OBEs within a VR environment. The study utilized two study conditions: (1) an out-of-body (OBE) condition, in which participants drifted out of the avatar body and lost visuotactile contact with their avatar, and (2) a "drifting body" condition (DBE), in which participants drifted out of the avatar body but *retained* visuotactile contact with their avatar. Results found that the experimental OBE group had lowered FOD compared to the control DBE group. Notably, whereas the Bourdin et al. (2017) study design intended for the DBE condition to serve as the control for the study, participants assigned to the DBE condition arguably still underwent an out-of-body experience.

With this in mind, Chan et al. (2020) replicated Bourdin et al. (2017) with two study conditions: (1) an OBE condition, with a similar implementation to the Bourdin et al. (2017) OBE condition, and (2) a control condition, in which participants remained in the avatar body and retained visuotactile contact with their avatar. Additionally, Chan et al. (2020) sought to leverage consumer VR technology; the study's VR simulation was developed with the Oculus Go — a standalone headset that sacrifices graphical resolution and processing power for a portable, lighter, and non-tethered VR experience. This study ultimately revealed an indirect effect of perceived virtual embodiment *increasing* FOD through a heightened degree of reported OBE in the experimental condition.

This study extends the line of research examining the impact of VR OBEs on FOD. Our contributions are as follows:

- We examine the pairwise comparison of each of the conditions mentioned above (OBE, DBE, and control).
- We report the results of a qualitative interview with participants.
- Building off Chan et al. (2020), we assess the clinical viability of the Oculus Quest — a successor to the Oculus Go with superior performance hardware, no requirement for thether to a PC, inside-out tracking, 6 degrees of freedom movement, and hand tracking.

Chapter 2: Methods

2.1 Participants

A total of thirteen participants (six men, seven women) were recruited from a large northeastern university and received cash or course credit points for participating. The original study was set up as a single factor between-groups design with a minimum of 16 participants in each of the three study groups, in other words, a minimum of 48 total participants. However, because of university closure due to the global COVID-19 pandemic, only a total of thirteen participants were successfully run. Participants' ages ranged from 19-23 years (mean = 20.38), including one American Indian/ Alaskan Native, 4 Asian Americans, 3 Asians/ Pacific Islanders, and 6 European/European Americans. All participants consented, and the IRB approved all procedures.

2.2 Virtual Environment

The virtual environment was designed via Unity3D and delivered in an Oculus Quest head-mounted display (HMD). The virtual bodies used were a male and a female character. To ensure participants feel connected to their avatars, the characters were programmed to customize skin tones from a scale of 1 (*very light*) to 10 (*very dark*).

The built-in sensors in the Oculus Quest HMD and Touch controllers tracked movement data in order for the virtual avatar to mirror the participant's real life head and hand movements (Appendix A.1). Additionally, an inverse kinematics script was applied in order to determine the joint parameters that provide the desired positions of the avatar's other limbs.

2.3 Procedure

Participants were first asked to complete an online questionnaire a few days prior to their arrival at the lab, at which time they also provided informed consent. This pre-study survey measured participants' baseline FOD and demographic data.

During the experiment day, participants came to the lab for the experimental session in VR. Upon arrival, they were instructed about the experimental procedures and again provided consent. Afterward, they were randomly assigned to one of the three conditions: control, OBE, or DBE. Participants were assisted in putting on the VR headset and shown how to hold the hand controller. A researcher stood next to the participant to give instructions for the duration of the experiment.

Drawing from Bourdin et al. (2017), the virtual reality portion of this study was divided into two phases.

In the first phase, all participants experienced the control condition consisting of an in-the-body phase. The overall strategy was to induce the participant's initial embodiment of the avatar. Each experimental session began with the researcher describing the virtual environment to help the participant become familiarized with it. Participants saw a reflection of their avatar body in a virtual mirror seated on a comfortable chair in a virtual room. Because participants were seated, they observed their avatar in approximately the same posture and position as their real body. Participants were also asked to look around and test their wrist movements in order to observe the synchronous visuomotor correlation between real and virtual body movements (Figure 2.1).

Figure 2.1: Control condition. Participant is seated on a chair and view a reflection of their avatar body in a virtual mirror.

To further induce avatar embodiment, participants were asked to use their virtual hand to stroke a cloth placed in front of their avatar in the virtual environment. Simultaneously, the researcher placed a piece of cloth in front of the participant's hand so that visuotactile synchrony could be achieved. Participants felt the cloth touching their hand as they moved their hand, and they could also see these movements represented by their avatar. The virtual model of the cloth was animated so that it moved when contacted by the hand of the avatar. Participants were asked to stroke the cloth for a minute in order to achieve avatar embodiment.

To evaluate if we successfully embodied participants in their avatars, we utilized methodology adapted from Lenggenhager et al. (2009), where a mental ball-dropping exercise was shown reflect the participant' vestibular system and time perception during OBEs. In this exercise, participants were asked to imagine how long it would take for an imaginary ball dropped from their hand to reach the floor. Participants were asked to hold a stopwatch (Figure A.2 in Appendix A) and click a button on the stopwatch, first when releasing the imaginary ball and second when they estimated that the ball would reach the floor. All participants were asked to complete this task five times at the start of the in-the-body phase. These values were recorded, with the average drop times reported as *Drop1* in the results section.

After completing the mental ball dropping exercise, participants entered the second phase of the experiment. This phase lasted for two minutes. During the first minute, participants once again experienced the in-the-body phase. During the second minute, VR experiences differed depending on the assigned condition.

Participants in the control condition remained in the first-person perspective of the avatar. They continued to stroke the cloth and see their avatar hands move in accordance with their movements for another minute.

Participants in the OBE condition had their perspective lifted out of their virtual body to the ceiling room; participants also lost control over their avatars, with their physical movements no longer mapping to their avatars virtual movements. At the same time, the researcher moved the cloth away from the participants' hand to end visuotactile synchrony. Even if participants continued to move their wrists, they could no longer see their avatar's wrist movements nor feel the touch from the cloth. The ultimate final result was that participants viewed their avatar from above and behind the avatar's unmoving body (Figure 2.2).

In the DBE condition, the viewpoints of the participants were also lifted out of their virtual body to the ceiling room. Participants viewed themselves above and behind their avatar body as in the OBE condition, but in this case, their physical body movement continued to map onto their virtual body. The participants continued to move their wrists while the researcher continued to hold the cloth in front of their hands. This condition split perception between a visual point of view behind the avatar and the continuing tactile sensation on the hand (Figure 2.2).

At the end of this second phase, the participant's avatar embodiment was evaluated again using the mental ball-dropping exercise. All participants were asked to carry out the task five times. These values were then recorded, with the average of the drop times reported as *Drop2* in the results section.

At the conclusion of the experiment, participants were assisted in removing the VR equipment. All participants completed a post-study survey with the measures described in the following measures section. Finally, the researcher conducted a short qualitative interview with those assigned to the experimental OBE and DBE conditions.

Figure 2.2: OBE and DBE conditions. Participant has their perspective lifted out of their virtual body to the ceiling room.

Chapter 3: Measures

3.1 Embodiment

At the conclusion of the VR portion of the study, participants were asked to complete a post-experimental survey. The first questions were adapted from the standard questionnaire proposed by Gonzalez-Franco and Peck (2018) to measure avatar embodiment. A subset of these questions were nearly identical to those in the original Bourdin et al. (2017) study; these are noted in italics.

At the conclusion of the study, participants completed a post-experimental survey evaluating three components (Appendix F):

- *Avatar embodiment:* adapted from Gonzalez-Franco and Peck (2018) and Bourdin et al. (2017).
- *Out of body experience:* adapted from Bourdin et al. (2017).
- *Fear of Death:* adapted from the Collett-Lester Fear of Death scale, which has demonstrated reliability and factorial congruence (Lester, 1990; Lester & Abdel-Khalek, 2003). The pre-study survey took these same FOD measures, alongside demographic data to establish the participant's FOD baseline.

In order to control for extraneous variables, we collected data on participants' self-esteem and religious convictions, with the intention of comparing responses compared between groups (Appendix D & E). Unfortunately, a sufficient analysis of the impact of these variables was unable to be conducted due to the small sample size (Limitations).

After completing all the surveys, the researcher had a short conversation with the participant covering the participant's lived experience, etc. These qualitative measures were analyzed for any noticeable trends.

- Did you feel in ownership of the virtual body during this study? If yes, why so?
- Briefly describe the experience of leaving your body. What was going through your mind?
- Did this experience make you think about death? How so?

Chapter 4: Results

The statistical software R was used to determine all descriptive statistics and analyses for this study.

Due to the small sample size of this study (Limitations), many considerations were made in the statistical testing and analysis portion of this study. Firstly, we were unable to assume normal distributions and therefore used nonparametric testing. Additionally, a majority of the statistical comparisons returned non-significant results; instead, a power analysis has been conducted to inform future research of the smallest sample size necessary to detect significance. Discussion of sample sizes for future research is also provided.

4.1 Mental Ball Dropping Task

To establish that the experimental methodology is valid, we utilize the ball drop test to show that the participants successfully underwent an out-of-body experience.

As described in the methodology, participants were asked to conduct a mental ball dropping task twice throughout the experiment, with each task consisting of five trials. *Drop1* designates the mean of the first five trials, which were recorded at the beginning of the experiment. *Drop2* designates the mean of the last five trials, which were recorded at the end of the experiment. *Drop1* was used as the baseline comparison for *Drop2*.

The Kruskal-Wallis *H* test was used to determine if there were statistically significant differences between *Drop1* and *Drop2* (Figure 4.1). There was no significant difference in *Drop1* and *Drop2* of the control condition (H= 0.08, p= .77) and OBE condition (H= 2.08, p= .15). The DBE condition returned a significant difference (H= 6.82, p= .009); a Dunn's Multiple Comparison posthoc test affirmed these significant differences (z= -2.61, p= .0045).

These results support the idea the participants in the DBE condition may have had their sense of location shifted above and out of the body. Although the differences between pre- and post- trials for the OBE condition were not significantly different, the data visually displayed in the box plot (Figure 4.1) suggests differences in perceptions of embodied location for this condition. To inform further research, a power analysis was conducted with power (1 - β) set at 0.80 and α = 0.05, proposing a minimum of 14 participants will be needed to reach a statistically significant, medium effect size (*E.S.*= 0.5) for this measure.

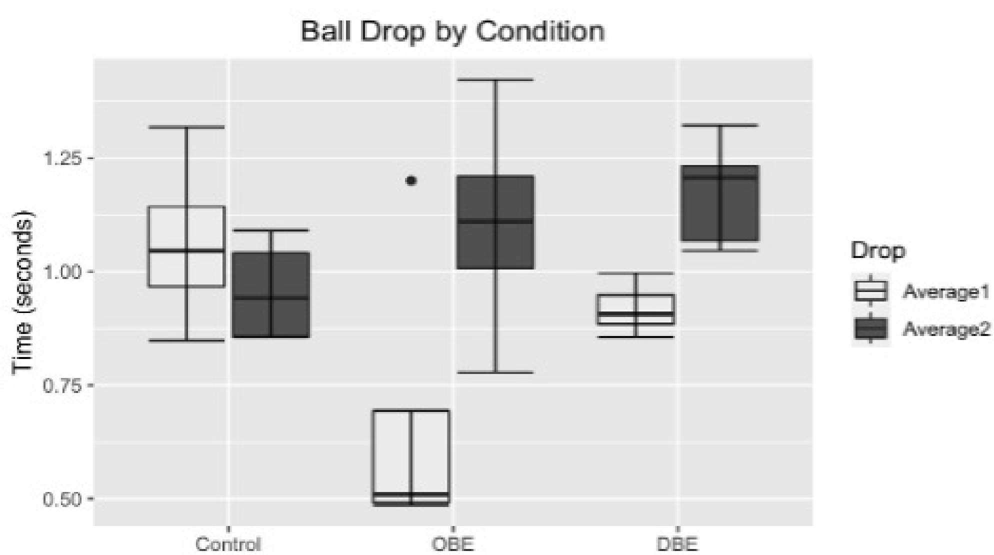

Figure 4.1: Box plots for *Drop1* and *Drop2* by condition.

4.2 Fear of Death

The pre and post-experimental surveys contained eight questions relating to the perception of death adapted from the Collett-Lester Fear of Death (Lester, 1990; Lester & Abdel-Khalek, 2003). An aggregate score was calculated for each participant by adding up participant responses for each of the eight questions. In the following figures, *FOD1* refers to the aggregate pre-experimental FOD score, and *FOD2* refers to the aggregate post-experimental FOD score.

Kruskal-Wallis *H* tests were used to compare the *FOD1* and *FOD2* scores within each study condition (Figure 4.2). No significant differences were found between the *FOD1* and *FOD2* scores in either the control (H= 0.02, p= .88), OBE (H= 1.71, p= .19), or DBE (H= 0.54, p= .46) conditions. Although there were non-significant differences between pre- and post scores for all three conditions, on visual inspection the trends are in the expected direction.

The recorded data suggest that a larger sample size could yield significant differences between reported FOD for the OBE and DBE conditions in the future. A power analysis was conducted with power (1 - β) set at 0.80 and α = 0.05. This revealed that in future research, the study will need a minimum sample size of 7 participants to identify differences between pre and post scores in the OBE condition, or 44 participants in the DBE condition.

The changes in FOD score within each condition, defined as (*FOD1 - FOD2*), were calculated for further analysis. Kruskal-Wallis *H* tests were used for pairwise comparisons of FOD differences between the three conditions (Figure 4.3). No significant differences were found between the changes in FOD between control and OBE (H= 2.55, p= .11), control and DBE (H= 2.67, p= .10), and OBE and DBE (H= 1.86, p= .17).

Although there were non-significant results in the FOD differences, on visual inspection these results might indicate a gradual divergence between the three conditions. As discussed before, future research could investigate whether these differences are significant with larger sample sizes.

4.3 Qualitative Measures

At the conclusion of the survey, the researcher conducted a short interview with the participants in the OBE and DBE conditions. Generally, all participants reported feeling "connected" to the avatar body, which reflected successful embodiment in the in-the-body phase. Participants commonly agreed that their

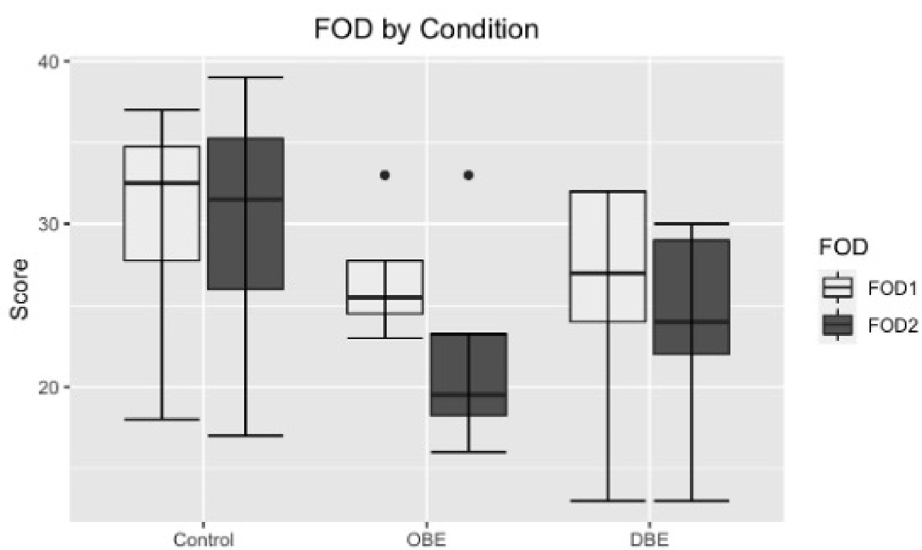

Figure 4.2: Box plots showing the total FOD score by condition.

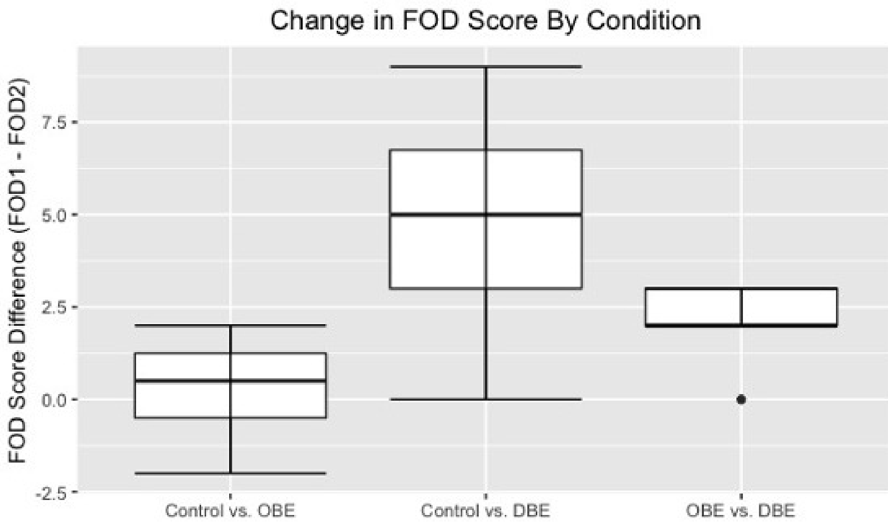

Figure 4.3: Box plots showing differences in FOD score by condition. Greater differences in FOD score indicate a greater decrease in FOD.

real movements mapping onto the avatar, as well as touching the piece of cloth, elicited an increased sense of embodiment in the avatar. The following enumerate selected quotes from participants reflecting perceived embodiment in the first phase of the study.

- *Participant 2:* When I had the controllers, the body moving around in virtual reality was important. And when I touched the cloth, I felt how it actually touched me in real life which was immersive.
- *Participant 4:* When [the researcher] told me to touch the cloth, I felt that my gestures were controlling that. When I moved my head with the VR headset, I also felt in control of my actions in the environment.

Responses from participants for the second phase of the experiment varied between the conditions. Generally, those in the DBE condition felt some initial discomfort, but quickly adapted to the third-person point of view. In contrast, those in the OBE condition were more disturbed by their experience, describing it as intimidating. Once again, we list participants' feedback on the experimental stimulus below.

- *Participant 1 (OBE Condition):* I'm pretty scared of heights ... and heights are something I associate with fear ... so there was something there.
- *Participant 7 (OBE Condition):* I thought I was on a higher point of view... [death] might be like that a little bit, just looking down on yourself like that.
- *Participant 3 (DBE Condition):* [The experience] didn't exactly feel I left my body. It felt more like I was just looking at a birds-eye view of my body ... I still felt control over my body, it was just from a different [view] point.
- *Participant 6 (DBE Condition):* [Moving out of the body] was a weird feeling, but I think after moving and realizing I could still control myself, I felt more normal.

Chapter 5: Discussion

5.1 Implications

This study primarily sought to further lines of research regarding VR OBEs in studies such as Bourdin et al. (2017) and Chan et al. (2020). In Bourdin et al. (2017), researchers utilized a similar methodology presented in this study and found that overall FOD was lower in the OBE condition than in the DBE condition. In Chan et al. (2020), researchers once again utilized a similar methodology presented in this study and found that participants with a greater embodiment of their avatars experienced greater FOD in the OBE condition than the control condition. Although this study returned insignificant results, insights from the small sample data may be drawn.

The Bourdin et al. (2017) and Chan et al. (2020) studies each used two conditions: OBE/DBE and OBE/control, respectively. This study incorporated all three conditions (OBE/DBE/control) into the study methodology, and preliminary results appear to support the findings from Bourdin et al. (2017). Both the OBE and DBE conditions were correlated with a reduction in FOD, with OBE having a medium effect size and DBE having a small effect size.

These differences in effect size may be attributed to differences in sensory arousal and experience between the OBE and DBE conditions. Although participants in both conditions drifted out of their body, the DBE condition allowed for participants to continue receiving external sensory information through the cloth and retain control over their virtual avatar. In the post-experimental qualitative interview, many participants expressed quickly adapting to the condition, referring to it as essentially a "third person point-of-view." Conversely, the OBE condition removed all sensory information and avatar control, which may have more realistically simulated an out-of-body experience.

In evaluating the clinical viability of the Oculus Quest, this study lent support to the HMD's ability to create portable and immersive OBE experiences. The qualitative interview revealed that participants perceived embodiment in their virtual avatars, with those in the experimental conditions reporting varying levels of disturbance once they shifted out of their body. Nevertheless, in order to ascertain these effects, further research with the Oculus Quest must be conducted in clinical contexts and with palliative and hospice patients.

5.2 Limitations

Limitations of this research primarily lie in the methodology used to complete the study. Most notably, this study contains a small sample size; the researcher was regretfully unable to recruit and run a sufficient amount of participants because of Cornell University's closure due to the global COVID-19 pandemic.

Additionally, because this study was conducted amidst the global COVID-19 pandemic, it is important to note that fear of death may have been particularly salient among participants. These unusual circumstances may have served as a confounding factor in this study.

The methodology could also be adjusted to obtain clearer results from participants. During research sessions, it was never measured whether participants had experience in virtual reality or other immersive technologies. Because the experience level of the participants may have affected avatar embodiment, it may have also served as a confounding factor in this study.

It is important to note that while this study adds to the discussion of the potential of out-of-body experiences for reducing fear of death, it does not, and was not intended to, directly replicate the study conducted by Bourdin et al. (2017). As elaborated above, there are several fundamental differences between the two studies. Instead, it was meant to extend this line of research. We also acknowledge the limitations in using portable devices to create an out-of-body experience.

Furthermore, while this study refers to possible future use in clinical contexts, the participants were not meant to be representative of a clinical population. As noted above, the participants were healthy college undergraduate students from Cornell University with a mean age of 20.38 years; this is in contrast to the more advanced age populations who have a terminal diagnosis and would be under palliative or hospice care. As alluded to before, the Cornell student population may have more experience with immersive technologies; additionally, older populations contrast with Cornell students in terms of life experiences, age-associated physical and mental ailments (i.e., Alzheimer's, dementia, visual impairments), and other factors. Each of these components may serve as a moderating or mediating factor. Ultimately, although this study supports existing literature on inducing embodied experiences in portable VR devices, further investigation within a clinical setting will be needed to determine what aspects of an embodiment experience affect FOD.

5.3 Future Research

There are several opportunities to further investigate out-of-body experiences in VR and their effect on individuals' fear of death.

Future work replicating OBEs in VR may allow more time to establishing the participant's embodiment and attachment to their virtual avatar. Additionally, it would be beneficial to add contextual cues such that participants are more aware that they are experiencing the death of their character. These changes would help in addressing feedback from participants which indicated minimal embodiment and confusion as to whether they were dying. A methodology to model future studies is described in Barberia, Oliva, Bourdin, and Slater (2018), where the researchers embody participants in a body on a beautiful island with two companions; participants are then allowed to explore the island and carry out tasks together over the course of a longitudinal study.

Researchers can compare active and passive tactile feedback while they attempt to achieve visuotactile synchrony and embody participants during the in-the-body phase. In this study, participants actively moved their avatar hand and brushed against the cloth that the researcher held. This is qualitatively different from a passive-touch experience, where the participant would passively hold their hand still as the researcher holds the hand controller and use it to animate an object that touches the participant's hand in the real world.

Additionally, it would be interesting to examine the relationship between participants' out-of-body experience and their FOD responses when there are additional sensory cues for the leaving-the-body phase of the stimulus. It would also be intriguing to assess how different environmental factors (e.g. higher vs. low sensory arousal) could impact sensory perception and affect the VR out-of-body experience.

Regarding quantitative measurement, future work might seek advice from clinicians or experts to extend the FOD questionnaire in capturing more dimensions of participant FOD. We can examine whether and when an experimental stimulus itself may induce fear or anxiety. Post-stimulus survey questions should also capture the degree to which participants attend to cues of body ownership as well as visuomotor contradiction.

Regarding qualitative measurements, future work might incorporate interviews with participants from the control condition rather than solely from the experimental OBE and DBE conditions.

5.4 Conclusion

In this study, we created an out-of-body experience in the Oculus Quest loosely based on previous studies examining VR OBEs. The study examined the effect of OBEs on participant FOD in three conditions: control, OBE, and DBE., Although there were observable differences between the pre and post-experimental FOD scores of the OBE and DBE conditions, these divergences were non-significant. A power analysis was provided to inform future studies on the number of participants needed to return significant results for this study. Future research is also advised to focus on factors that lead to different degrees of sensory cues, visuomotor contradiction, and stimulus arousal to comprehend the best practices for creating VR OBEs using the simplest possible paradigm.

Appendix A

Materials

Figure A.1: Oculus Quest HMD and Touch Controllers.

Figure A.2: Stopwatch Timer

Appendix B

Research Setting

Trials for this study were conducted in a designated room in the Virtual Embodiment Lab at Cornell University. This room was a 380cm X 450cm room with a ceiling height of 321cm. During each trial, at least one researcher was always in the room to run the study and for safety reasons.

Figure B.1: Research Setting

Appendix C

Demographics

Participant demographics were taken in the pre-study survey.

1. How old are you? Please specify: __________

2. What is your gender?
   - Male
   - Female
   - Other gender identity, Please specify: ________________

3. How do you typically describe yourself?
   - American Indian or Alaskan Native
   - African-American, of African descent, African, or Black
   - Asian or Pacific Islander
   - Asian American
   - Hispanic, Latino, or Latina
   - Native Hawaiian or other Pacific Islander
   - European-American, of European descent, or European (but not of
   - Hispanic descent or Hispanic)
   - Biracial/bi-ethnic or multiracial/ multiethnic
   - Other (specify)

4. What is your year in school?
   - 1st year undergraduate
   - 2nd year undergraduate
   - 3rd year undergraduate
   - 4th year undergraduate
   - 5th year undergraduate or more
   - Other; please specify: _______________

Appendix D

Self-Esteem

Self-esteem was identified as an extraneous variable in this study. This study's measure of self-esteem was adapted from the Rosenberg Self Esteem Scale (Rosenberg, 1965). Participants were asked to rate on a Guttman scale of 1 (*Strongly agree*) to 5 (*Strongly disagree*) when responding to the following statements:

- On the whole, I am satisfied with myself.
- At times I think I am no good at all.
- I feel that I have a number of good qualities.
- I am able to do things as well as most other people.
- I feel do not have much to be proud of.
- I certainly feel useless at times.
- I feel that I'm a person of worth.
- I wish I could have more respect for myself.
- All in all, I am inclined to think that I am a failure.
- I take a positive attitude toward myself.

Appendix E

Religious Conviction

Religious conviction was identified as an extraneous variable in this study. Drawing from the methodology in Bourdin et al. (2017), participants were asked to respond to the question *What is your religious preference?* and given the following options to select:

- Believer and practicing
- Believer non-practicing
- Agnostic
- Atheist
- Other

Appendix F

Avatar Embodiment

- *I felt as if the virtual body I saw when I looked down was my body.*
- *It felt as if the virtual body I saw was someone else.*
- It seemed as if I might have more than one body.
- *I felt as if the virtual body I saw when looking in the mirror was my own body.*
- *I felt as if the virtual body I saw when looking at myself in the mirror was another person.*
- It felt like I could control the virtual body as if it was my own body.
- The movements of the virtual body were caused by my movements.
- I felt as if the movements of the virtual body were influencing my own movements.
- I felt as if the virtual body was moving by itself.
- It seemed as if I felt the touch of the cloth in the location where I saw the right hand of the avatar touched.
- It seemed as if the touch I felt was located somewhere between my physical body and the virtual body.
- It seemed as if the touch I felt was caused by the virtual cloth touching the virtual hand.
- It seemed as if my hand was touching the virtual cloth.
- I felt as if my body was located where I saw the virtual body.
- I felt as if my (real) body were drifting out of the virtual body or as if the virtual body were drifting out of my (real) body.

Out of Body

Participants were asked to rate on a Likert scale of 1 (*I did not feel that at all*) to 7 (*I felt it to the maximum intensity*) when responding to the following statements:

- I felt as if the body I was seeing was my own body.
- I felt as if the body I was seeing belonged to someone else.
- I felt as if I was floating in air.
- I felt as if I was in an elevated position in the room.
- I felt a connection with the body, as if I was looking down at myself.
- I felt as if I had an invisible body.
- I felt out of my body.

Fear of Death

Participants were asked to rate on a Likert scale of 1 (*Not at all*) to 5 (*Very much*) on how disturbed or made anxious they felt by the following aspects of death:

- The total isolation of death
- The shortness of life
- Missing out on so much after you die
- Dying young
- How it will feel to be dead
- Never thinking or experiencing anything again
- The possibility of pain and punishment during life-after-death
- The disintegration of your body after you die

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