iadt
DUN LAOGHAIRE

Presence and Nature Connectedness in Virtual Reality:

A Comparison between 360-VR and CG-VR

Sara Curran

N00211839

Supervisor: Robert Griffin

Dissertation submitted as a requirement for the degree of BSc (Hons) in Applied Psychology, Dun Laoghaire Institute of Art, Design & Technology, 2025.

Declaration

☑ I, <u>Sara Curran</u> [student name], hereby declare that the work that I have submitted for / contributed to the assessment specified above is entirely my own work. Where I have drawn from the work of others, including Generative AI systems, I have clearly indicated this within my submitted work. I recognise that Generative AI creations, no matter how small, may not be permissible within my submitted work and have checked this specific assessment brief for the admissible use of such software. I have read and complied with the IADT Academic Integrity Policy for this submission and recognise that breaches of this policy in my work may result in penalties, up to and including disqualification from IADT.

☑ I, <u>Sara Curran</u> [student name], hereby declare that I recognise that IADT staff may provide feedback on assessment via a range of methods, depending on the nature of the assessment and the preference of the staff member. I recognise that any grades issued by a lecturer are provisional but are not negotiable. Final grades will be issued following the relevant exam board meeting and information on appeals procedures is available on the IADT website. I agree to abide by the IADT Mutual Respect Policy in all of my communications with and regarding all IADT staff members.

Signed: Sara Curran

Date: 10/04/2025

Word count: **4994**

Acknowledgements

I am eternally grateful for all the help I have received from IADT throughout the course of completing my Major Research Project. I would especially like to thank my supervisor, Robert Griffin, who has been extremely resourceful, reliable, knowledgeable, patient and supportive in helping me to complete my research project.

I would like to thank Sean Henriques for his resourcefulness and efficiency in organizing VR equipment loans and lab appointments. Sean has been extremely supportive and accommodating. I would like to thank Dr. Christine Horn for the extensive help and support she provided me with in statistics. I would also like to thank Cyril Connoly for providing me with extra help and support in data visualization.

I would like to thank Dr. Grainne Kirwan for the immense support she provided to me in completing my thesis. Grainne was very patient in answering any questions I had, no matter how small.

Furthermore, I would like to thank Dr. Liam Challenor, Dr. John Greaney, and Grainne Carol, for providing further support to me through allowing me to recruit participants from their classes for my research project. I would like to thank everyone who participated in my research experiment.

I would like to thank Dr. Matthias Winfried Kleespies for providing me with information and answering my queries in relation to the Illustrated Version of Nature in Self Scale (IINS).

Of course, I cannot forget about all the support provided to me by peers, family and close friends. The year group has been extremely supportive of one another, and I am very grateful for that. I would like to give a special thanks to my mam Rosaleen, my dad George and my brother Robert for all their patience and support throughout the year. I would like to thank my friend Melia, who supported me through my final year with regular phone calls, coffee breaks, and plenty of laughter! I would also like to thank my cat Sky, for providing me with plenty of emotional support throughout the year.

Table of Contents

Table of Tables

Table of Figures

List of abbreviations

Abbreviation	Definition
VR	Virtual Reality
360-VR	360°-video Virtual Reality
CG-VR	Computer-Generated Virtual Reality
HMD	Head Mounted Display
2D	Two-Dimensional
3D	Three-Dimensional
NC	Nature Connectedness
IVN	Immersive Virtual Nature
PQ	Presence Questionnaire
IINS	Illustrated Inclusion of Nature in Self Scale
INS	Inclusion of Nature in Self Scale
PEC	Psychology Ethics Committee
IADT	Institute of Art Design and Technology

Abstract

A review of relevant literature identified presence and nature connectedness as key factors in eliciting wellbeing.

The aim of this study was to examine the difference between two Virtual Reality (VR) simulation types on sense of presence and nature connectedness. Due to the increase in urbanization, access to nature is becoming less available. As a result, it is vital to find alternatives for nature accessibility, and to further understand the role of presence in VR simulated nature. To examine this further, an experiment was conducted comparing the differences in nature connectedness and presence between a 360° video of nature (360-VR) and a computer-generated nature environment (CG-VR), both experienced through a head mounted display (HMD). The experiment employed a 'between-subjects' design, with 42 participants, mostly undergraduate/postgraduate students at the Institute of Art Design and Technology (IADT).

This study explored the relationship between presence and nature connectedness and found a positive correlation between the two. The results of this study indicate no difference in presence or nature connectedness across the VR environments. Limitations were discussed, including a limited timeframe. This study holds practical implications for VR developers and educators through highlighting alternative VR based methods to support nature accessibility.

Introduction

Accessibility to nature is known to be highly important for wellbeing, promoting physical and mental health (Li et al., 2021). Despite the known benefits, time spent in nature has decreased significantly (Leung et al., 2022). The rise in digital media and increase in urbanisation has led to people engaging in outdoor nature much less frequently (Mahato & Ekka, 2023). According to Zheng et al. (2023), 55% of the global population currently live in urban areas. Many individuals have limited access, including the elderly and people living with chronic illness and physical disabilities (Browning et al., 2019). During COVID-19, nature deprivation was associated with decreased wellbeing (Zheng et al., 2023). Virtual reality may substitute as an alternative for nature access (Li et al., 2021). This research aims to explore differences between a 360° video and computer-generated nature scenario in VR on Presence and Connectedness to Nature.

The use of VR as an accessible nature alternative has increased in recent years (Li et al., 2021). Despite not being as effective as real nature (Reese et al., 2022), VR nature alternatives can provide many health benefits (Bohil et al., 2011; Mattila et al., 2020). VR nature simulations can support attention restoration, cognitive performance and even reduce physical pain (Browning et al., 2019; Mattila et al., 2020). Past research has examined the differences between VR simulation types. However, it is still unclear as to which simulation type is most effective for nature exposure (Li et al., 2021).

Previous research indicates that the benefits of traditional 2D media are minimal in comparison to 3D media, as 2D media may not provide the same level of engagement visually (Jo et al., 2019). Nature environments in 3D virtual reality have been found to be immersive. Despite this, research comparing VR simulation types on both presence and nature connectedness is lacking (Li et al., 2021). Therefore, this study aims to address this gap in research.

To the extent of the knowledge of the researcher, only two studies have directly examined the difference between CG-VR and 360-VR on these factors (Yeo et al., 2020; Link, 2023). The current study aims to address this gap in knowledge by examining the effects of two simulation types on both factors individually. Secondly, research indicates that presence may mediate the relationship between VR simulation type and nature connectedness (Yeo et al., 2020). To address this gap in knowledge, the effects of two VR simulation types will be

explored. Yeo et al. (2020) found that presence plays a role in eliciting nature connectedness. Therefore, this study aims to examine the relationship between presence and nature connectedness. The following literature review will discuss the evolution of VR, realism, presence and nature connectedness in VR.

Literature Review

Evolution of Immersive Virtual Reality

Virtual reality can be defined as an immersive 3D virtual environment, allowing for interactivity with a simulated environment (Melinda & Widjaja, 2022; Verma et al., 2021). Rising in popularity in the 1980's, today VR is more widely available (Ambrosio & Fidalgo, 2020). This is largely due to a drop in price of VR devices (Ambrosio & Fidalgo, 2020). Virtual environments are commonly viewed through Head Mounted Displays (HMDs). HMDs can create a sense of presence through auditory and visual sensory nature stimuli. (Li et al., 2021). Recently, VR nature has been viewed through 360° videos (360-VR), based on real scenes and Computer-Generated Scenarios (CG-VR), based on computer generated images (Li et al., 2021). Another factor which is highly important in creating user engagement within VR is realism (Gonçalves et al., 2022).

Realism

Higher realism in VR can elicit positive user engagement (Gonçalves et al., 2022). Verhulst et al. (2021) found that VR experiences evoke higher realism, spatial presence and enjoyment than augmented reality (Verhulst et al., 2021). Newman et al. (2021) found a relationship between visual realism and increased presence. However, there have been conflicting views in this area.

Jung and Lindeman (2021) indicated that increased realism does not always correlate with a sense of presence. While 360° videos in VR can provide a photorealistic view of real environments (Ritter & Chambers, 2021), CG-VR could be effective in eliciting perceived realism (Jin et al., 2021). Newman et al. (2021) discovered that despite the low realism of 3D objects in VR, participants brains perceived "cartoonish objects" as normal.

Sense of Presence in VR

"Place illusion" refers to the level at which people respond to a VR environment as though it was real (Slater, 2018). Feeling more present in a VR world can lead to more engagement (Slater & Wilbur, 1997). Different types of presence can be elicited in virtual environments, including spatial, social and self-presence (Green & McAllister, 2020). Spatial presence refers to the psychological sensation of being present in a simulated environment (Green & McAllister, 2020).

Recommendations have been given as to how long to spend in VR environments. Brambilla et al. (2024) discovered that presence was most effective during exposure to less than 5 minutes of VR.

Past research examined the effects of VR type on sense of presence. There are conflicting results surrounding which type elicits presence most effectively. CGVR allows for interactivity which can increase presence, while 360-VR creates a more passive but realistic view of environments (Brambilla et al., 2024). Moore et al. (2019) found that 360-VR elicited a higher sense of presence compared to CG-VR. Furthermore, Higuera-Trujillo et al. (2017) discovered that 360° panoramas induced higher psychological presence compared to photographs or interactive CG-VR. In contrast to these findings, Brivio et al. (2020) compared sense of presence in a 360° panorama with a computer-generated relaxation video, both displayed in VR. No difference was found between the environments in inducing presence. However, CG-VR elicited the highest physiological presence (Higuera-Trujillo et al., 2017). Another psychological construct which can be elicited through VR is nature connectedness (Leung et al., 2022).

Nature Connectedness for Wellbeing

The biophilia hypothesis suggests that humans are innately drawn to nature (Kellert & Wilson, 1993). Nature Connectedness (NC) is highly beneficial for wellbeing (Martin et al., 2020). Nature can reduce anxiety and regulate mood (Martyn & Brymer, 2014). Nature connectedness has been found to be more effective in improving mood than nature exposure alone (Liu et al., 2022). Furthermore, NC which is elicited through VR can encourage pro-

environmental behaviors (Martin et al., 2020; Spangenberger et al., 2023). These findings highlight the importance of nature connectedness for wellbeing. Research indicates that presence could play a role in eliciting nature connectedness through VR (Yeo et al., 2020)

Presence and Nature Connectedness in VR

A study by Caloguiri et al (2023) found that there were no differences between nature connectedness in CG-VR and 360-VR. However, this study had a relatively small sample size which could have impacted on the generalizability of the study.

In contrast, other research has found CG-VR to be most beneficial in eliciting presence and nature connectedness. A systematic review by Brambilla et al. (2024) examined the impact of immersive virtual nature (IVN) on nature connectedness amongst healthy adults and students in the general population. The review examined 6 papers in which IVNs were compared. Results of a meta-analysis showed that IVN effectively increased nature connectedness across all conditions, however CG-VR was more effective than 360-VR.

Furthermore, Yeo et al. (2020) aimed to examine the role of VR type in mood improvement. The study's aim was to examine how types of IVN could increase positive affect and decrease boredom. 96 adult participants took part in the study, and were assigned to one condition: TV (control condition), a 360° video viewed through a HMD, or an interactive computer-generated scenario. Positive and negative affect, nature connectedness and presence scores were taken. Results of the study found that while presence and nature connectedness increased across both VR conditions in comparison to television, both were highest in the CG-VR condition. Increased positive affect and decreased negative affect was highest in the CG-VR condition, mediated by presence and nature connectedness. Presence mediated the relationship between VR type and nature connectedness. It is important to note that this study included footage from the BBC's *Blue Planet II* series, which could have been quite "awe inspiring" and therefore impacted the outcomes of the study (Yeo et al., 2020).

The mediating role of presence on nature connectedness could be explained by the illusion of non-mediation (Lombard & Ditton, 2006), which suggests that when users perceive a medium such as VR as "invisible", they perceive the environment as real. Thus, heightening emotional and cognitive engagement and allowing users to engage more authentically with

the environment, increasing their connectedness to nature despite being in a simulated environment (Lombard & Ditton, 2006).

The final review of literature corresponds to the study by Yeo et al. (2020). An undergraduate study by Link (2023) examined the effect of simulation type (3D-VR vs 360-VR) on affect levels, presence and nature connectedness in university students. 49 participants were exposed to one of the two conditions for five minutes. Presence was found to be higher in the 3D-VR than the 360-VR scenario. In contrast to Yeo et al. (2020) there was no difference in nature connectedness. However, the study did not employ any interactivity in the 3D-VR scenario, which could have had an impact on varying results compared to Yeo et al. (2020).

This research study aims to address key gaps in the current research by identifying which type of virtual reality (VR) experience is most effective in eliciting a sense of presence and nature connectedness. The research will also explore the relationship between presence and nature connectedness. Additionally, by focusing on an Irish population with varying levels of urbanisation, the study seeks to provide insights that are currently underrepresented in the literature. To finalise, the limited number of studies presented in this literature review highlights the importance of further investigating the effect of VR type on sense of presence and nature connectedness.

Research Questions and Hypotheses

RQ 1: Will there be a difference in sense of Presence and Nature Connectedness in CG-VR when compared to 360-VR?

RQ 2: Will there be a correlation between Presence and Nature Connectedness?

Hypothesis 1: There will be a significant difference in Sense of Presence in CG-VR, in comparison to 360-VR.

Hypothesis 2: There will be a significant difference in Nature Connectedness in CG-VR, in comparison to 360-VR.

Hypothesis 3: There will be a correlation between Sense of Presence and Nature Connectedness

Method

Design

The current study utilized quantitative data from an online questionnaire, to test the effect of VR environment (Independent variable with 2 levels: 360-VR and CG-VR) on Presence (Dependent variable 1) and Nature Connectedness (Dependent variable 2). A 'between-subjects' design was employed to conduct an independent t-test comparing Presence between the environments. A Mann-Whitney U test was conducted to compare Nature Connectedness between the environments. Furthermore, a Spearman's Correlation was conducted to examine the relationship between the dependent variables.

Group A (360-VR) viewed a 360° of real nature, viewed on YouTube through a HMD, while Group B (CG-VR) interacted with a similar computer-generated nature environment in the application Spatial. The CG-VR environment was viewed through a HMD, using a handheld controller. Both groups spent 5 minutes in VR. Participants were then asked to complete two questionnaires to analyze sense of presence and nature connectedness and given a textbox for qualitative feedback (Appendix A).

- **Presence Questionnaire (PQ)** (Witmer & Singer, 1998)
- **Illustrated Inclusion of Nature in Self Scale (IINS)** (Kleespies et al., 2021)

Participants

The research was conducted across an academic setting. Details can be found in the information sheet (Appendix B), supplied to participants. Participants were recruited using convenience sampling, most were students at IADT. Participants were randomly assigned to either Group A (360-VR) or Group B (CG-VR). 20 posters were displayed, and 15 flyers were handed out in IADT to attract participants (Appendix C). The final sample consisted of 42 participants (N = 42; 38% male, 55% female, 5% non-binary, 2% preferred not to say; with an age range of 18-64). Twenty-eight participants (66.7%) had used VR before, and fourteen participants (33.3%) had not. Participants were treated in accordance with the ethical guidelines of the Psychological Society of Ireland and the Psychology Ethics Committee (PEC).

- 5 participants for the pilot study
- 21 undergraduate/postgraduate students, faculty members, peers and relatives for the 360-VR environment (Group A)
- 21 undergraduate/postgraduate students, faculty members, peers and relatives for the CG-VR environment (Group B)

Materials

Information Sheet (Appendix B)

The information sheet was included at the beginning of the Microsoft Forms Survey. The sheet included a title, researcher's name and project supervisor, a summary of the study's aim, what is involved in taking part, answers to queries, contact information, and information about ethics, data protection and anonymity. The information sheet was following by demographic questions (Appendix D)

Disclaimer Form (Appendix E)

A paper copy of a VR disclaimer form provided by IADT was given to all participants. The form highlighted the risks involved in participating in VR. Forms were signed and dated by participants in case of any harm during the experiment and were stored separately from participant data.

Consent form (Appendix F)

In accordance with the PEC guidelines, a consent form was provided in the Microsoft forms. The form included five questions, which ensured that participants were over the age of 18, and agreed to take part in the study. Participants were asked to create their own unique identifier code, should their data need to be removed. The consent form was followed by demographic questions relating to the age and gender of participants, and if they had previously used VR.

Presence Questionnaire (Appendix G)

22 of 24 questions from the Presence Questionnaire by Witmer & Singer (1998) were included in the Microsoft forms. It is a 7-point Likert Scale with 7 subscales. The subscale

"Haptic" was excluded as this was outside the scope of the study. The scale has a high reliability score, with a Cronbach's Alpha of $\alpha = 0.835$, see Appendix H. For scoring details, see Appendix G.

The Illustrated Inclusion of Nature in Self Scale (Appendix I)

The Illustrated Inclusion of Nature in Self Scale (IINS) by Kleespies et al. (2021), is a one-item, 7-point Likert scale questionnaire, based on the original Inclusion of Nature in Self Scale (Schultz, 2001) and altered to include illustrations representing feelings of connectedness to nature in virtual environments. The scale includes 7 Ven diagrams interlinking a person 'me', and 'nature' (a forest, sun, clouds, flowers and a river). Kleespies et al. (2021) found no significant difference between the IINS and the original Inclusion of Nature in Self Scale (INS). The scale ranges from A to G (weakest to strongest) measuring feelings of connectedness to nature in a Virtual Environment.

Debrief (Appendix J)

After completing the experiment and two questionnaires, a debrief was provided in Microsoft Forms. The debrief highlighted the aim of the study and how the information would be used. See Appendix J.

Oculus Quest 2 Headsets

Oculus Quest 2 (Meta Quest 2) is a VR headset developed in 2020 by Meta Platforms. Both groups were required to use an Oculus Quest 2 headset. The applications YouTube and Spatial were utilized through the headset.

Pilot Study

Prior to commencing the experiment, a pilot study was conducted using B.Sc. Applied Psychology Students ($N = 5$), to test the practicality and reliability of the experiment. Participants were provided with the same forms as the final experiment. Three participants took part in the CG-VR, while two participants took part in the 360-VR.

The 360-VR worked effectively, however there were some issues with internet connection and interruptions from the VR sensor. It was noted that these issues must be addressed. The CG-VR environment worked effectively; however, it was noted that a demonstration of how to use the VR controller to move around within the environment should be given to participants prior to the experiment, to ensure comfort.

Ethics (Appendix K)

Prior to commencing data collection, approval was granted by the PEC. The study was of high ethical standard and in line with the guidelines of the Psychological Society of Ireland, see Appendix K. Participation in the study was completely voluntary, no rewards were offered for participation. All participants were informed that they could withdraw their information from the study. The data received will remain confidential and anonymous. Prior to data collection, all participants were informed of background information to the research. They received an information sheet, consent form, disclaimer form, two questionnaires and a debrief form. Contact information was provided to all participants should they have any questions or wish to withdraw their data. No deception was used within this study and all necessary information was provided in the information sheet.

Procedure: 360° Video Environment

To test the 360° video environment (360-VR) in VR, convenience sampling was used to recruit participants through posters, flyers, social media and word-of-mouth. Participants (N = 21) were required to spend 5 minutes viewing a 360° video of real nature, taken on an Insta 360 and displayed through a HMD. The video included: trees, grass, sky, a water stream, birds and nature sounds. Participants were instructed to either sit or stand as they wished for the duration of the video and could rotate their heads to view the video from all angles. After viewing the video, participants were asked to complete two questionnaires. A text box was provided for participants to give optional feedback. See Figure 1 (Appendix L).

Figure 1

Images from the 360-VR environment, and demonstration of the headset in use

Procedure: Computer Generated Video Environment

      To test the Computer-Generated environment in VR (CG-VR), convenience sampling was used to recruit participants through posters, flyers, social media and word-of-mouth. Participants (N= 21) were required to spend 5 minutes surveying a computer-generated nature environment, viewed through a HMD. The computer-generated environment depicted a forest, similar to the 360-VR environment, including: trees, birds, grass, logs, a waterfall, a water stream, a bridge and nature sounds. The environment was from the application Spatial. Participants were encouraged to use a handheld controller to allow for interactivity while navigating the virtual world. See Figure 2 (Appendix M).

Figure 2

Images from the CG-VR environment, and demonstration of the headset in use

Results

Overview

   The study employed an experimental between-groups design. The independent variable was VR environment (360-VR and CG-VR), and the two dependent variables were Presence and Nature Connectedness. Data analysis was performed in IBM SPSS Statistics (Version 29.0.1.0; IBM Corp., 2023). An independent t-test was conducted for Hypothesis 1, and a Spearman's Correlation was conducted for Hypothesis 3. It was planned to conduct a one-way MANOVA, however due to the ordinal nature of the variable Nature Connectedness (A one item scale, scored 1 to 7), a Mann-Whitney U test was conducted for Hypothesis 2. There were no outliers detected across the 360-VR or CG-VR environments

Hypothesis 1

Descriptive Statistics

   For participants descriptive statistics based on overall presence by VR environment (360-VR or CG-VR), see Table 1 (Appendix N).

Table 1

Descriptive Statistics for Presence by VR Environment

	360-VR			CG-VR		
	N	*M*	*SD*	*N*	*M*	*SD*
Presence	21	114.71	19.32	21	114.43	12.87
Total	42	114.57	16.21			

Note. N = Number of participants; M = Mean; SD = Standard deviation.

Figure 3 (Appendix O)

Boxplot of participant's Presence scores filtered by VR environment (360-VR and CG-VR)

Boxplot of Total Presence Scores by VR Environment
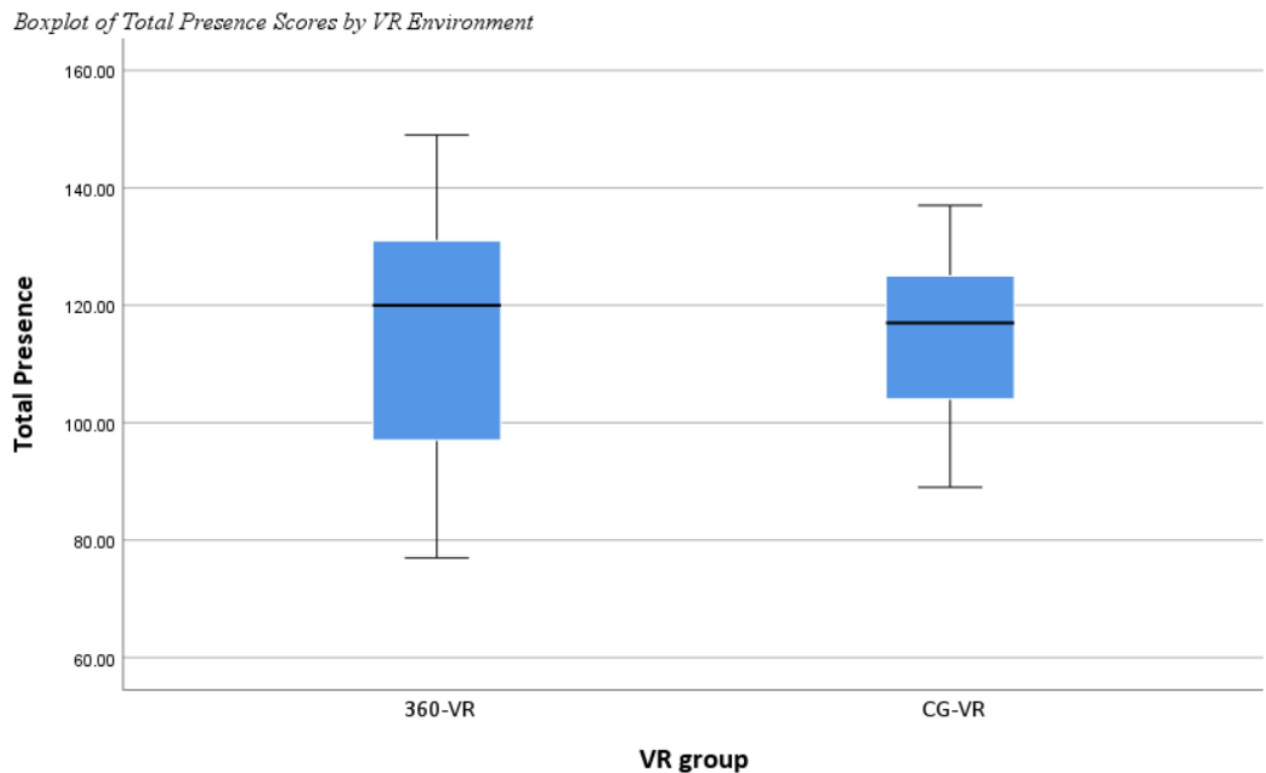
Inferential Statistics

An independent t-test was conducted in SPSS to test for difference between VR environment (360-VR and CG-VR) on overall presence. The assumption of normality was tested across both VR groups. In 360-VR, $W(21) = 0.963$, $p = .582$, and in CG-VR, $W(21) = 0.979$, $p = .903$. Therefore, the assumption of normal distribution is met across both groups, see Table 2 (Appendix P)

The assumption of homogeneity of variances was violated, $F(1, 40) = 4.45$, $p = .041$. Therefore, Welch's t-test was used, see Table 3 (Appendix Q).

Additionally, the overall difference in Presence across the two VR environments was not statistically significant, $t(34.83) = .056$, $p = .955$. Therefore, Hypothesis 1 is rejected, and the null hypothesis is accepted of no significant difference in Presence between 360-VR and CG-VR, see Table 4 (Appendix R).

A post-hoc power analysis was conducted using G*Power Analysis, the power achieved was very low (5.03%), see Appendix S.

Hypothesis 2

Descriptive Statistics

For participants descriptive statistics based on overall nature connectedness by VR environment (360-VR or CG-VR), see Table 5 (Appendix T).

Table 5

Descriptive Statistics for Nature Connectedness by VR Environment

	360-VR			CG-VR		
	N	*Md*	*IQR*	*N*	*Md*	*IQR*
Nature Connectedness	21	5.00	2	21	5.00	2

Note. N = Number of participants*; Md* = Median*; IQR* = Interquartile Range

Figure 4 (Appendix U)

Boxplot of participant's Nature Connectedness scores filtered by VR environment (360-VR and CG-VR)

Simple Boxplot of Nature Connectedness by VR group
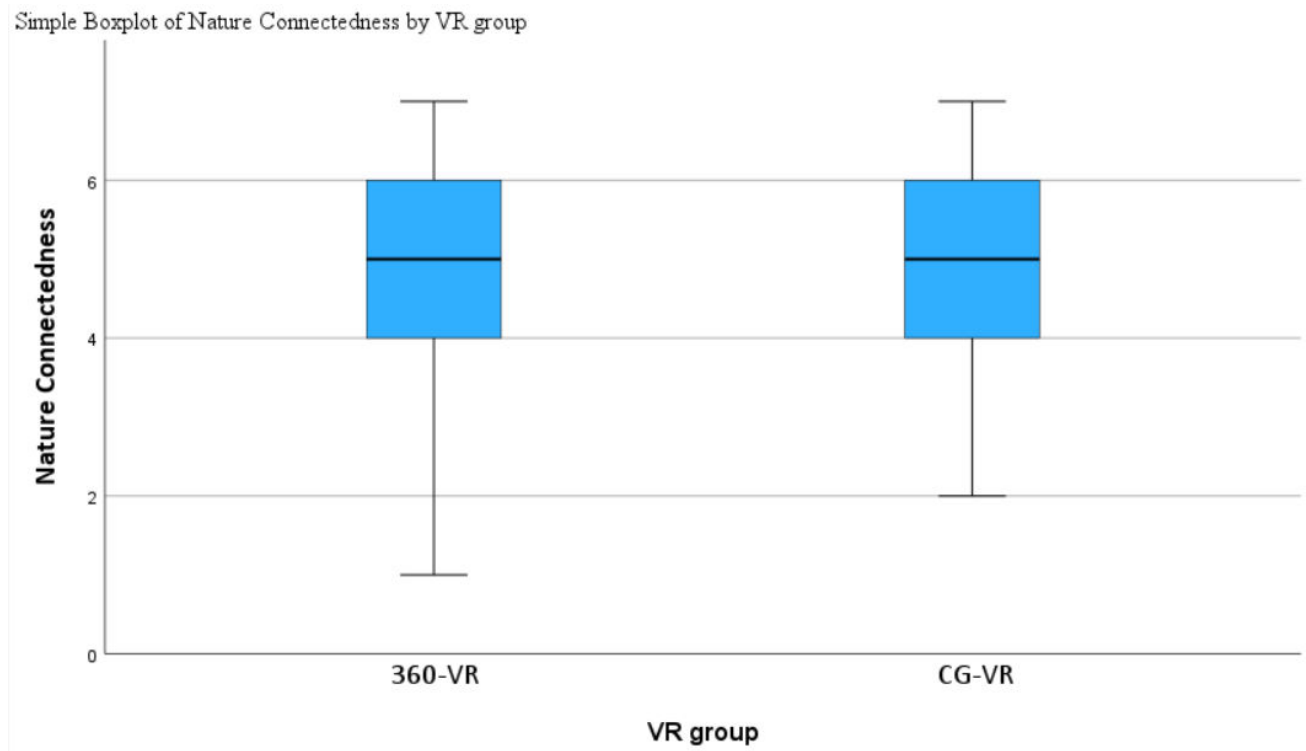
Inferential Statistics

A Mann-Whitney U test was conducted in SPSS to test for difference between VR environment on nature connectedness.

The overall difference in Nature Connectedness across the two VR environments was not statistically significant $U = 214.50$, $Z = -0.16$, $p = .877$. Therefore, Hypothesis 2 is rejected, and the null hypothesis is accepted of no significant difference in Nature Connectedness between 360-VR and CG-VR, see Table 6 (Appendix V.

A post-hoc power analysis was conducted using G*Power Analysis, the achieved power was very low (5.1%) (Appendix W)

Hypothesis 3

Descriptive Statistics

For participants descriptive statistics based on overall presence and nature connectedness, see Table 7 (Appendix X).

Table 7

Descriptive Statistics for Presence and Nature Connectedness

	N	*M*	*SD*
Presence	42	114.57	16.21
Nature Connectedness	42	4.81	1.45

Note. N = Number of participants; M = Mean; SD = Standard deviation

Inferential Statistics

A Spearman's Correlation was conducted to examine the relationship between Total Presence ($M = 114.57$, $SD = 16.21$) and Total Nature Connectedness ($M = 4.81$, $SD = 1.45$).

A moderate, positive relationship was identified between the two variables, $rs = .480$, p = .001, 95% CI [.197, .689], see Table 8 (Appendix Y). The effect size ($rs = .48$) suggests a moderate to strong positive relationship. Therefore, the null hypothesis is rejected, and Hypothesis 3 is accepted.

Figure 5 (Appendix Z)

The relationship between Total Presence and Total Nature Connectedness, displayed in a Scatterplot

Scatter Plot of Total Presence by Nature Connectedness
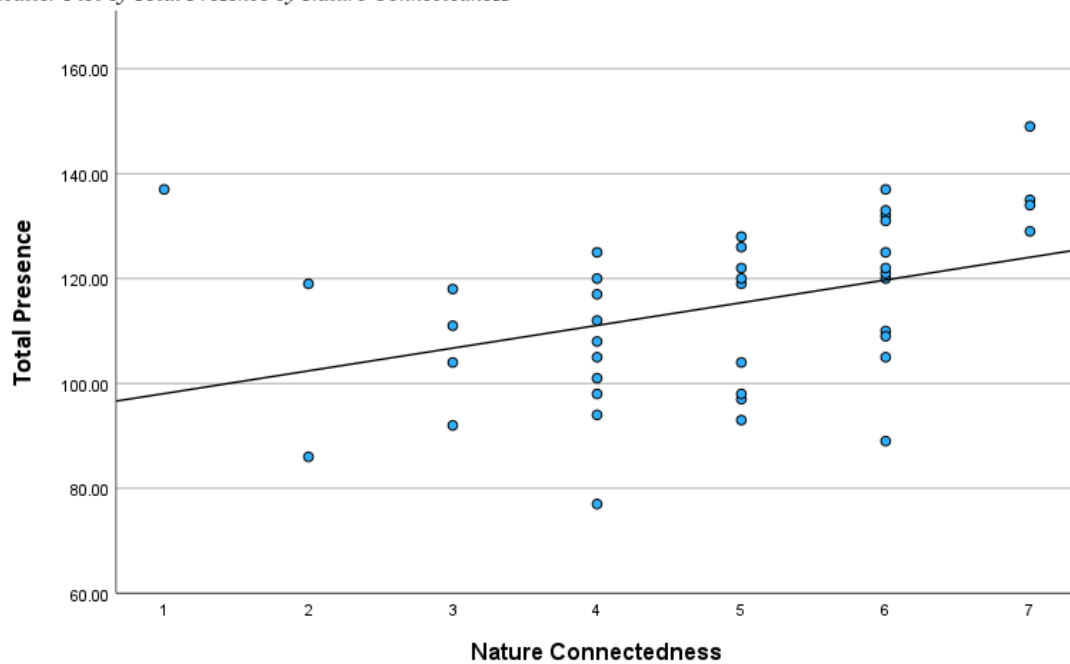
 Note. There was a moderate to strong positive correlation between presence and nature connectedness., r = .480, p = .001.

Additional Findings

Descriptive statistics

For participant descriptive statistics based on previous VR use and presence, see **Table 9 (Appendix AA)**

Table 9

Descriptive Statistics for Previous VR use and Presence

Presence	N	M	SD
Previous VR use	28	110.32	15.76
No previous VR use	14	123.07	14.00

Note. N = Number of participants; *M* = Mean; SD = Standard deviation

Inferential statistics

Additionally, an independent t-test was conducted to test for differences in participants who had previous VR use (yes or no) on Presence. In the previous VR use group, W (28) = 0.952, p = .22, and in the no previous VR use group, W (14) = 0.945 p = .493. Therefore, the assumption of normal distribution is met across both groups, see Table 10 (Appendix AB).

The assumption of homogeneity of variance was met, F (1,40) = 0.54, p = *.468*, see Table 11 (Appendix AC).

The independent t-test revealed a higher sense of Presence for participants with no previous VR use (M = 123.07, SD = 14.00) than participants who had previous VR use (M = 110.321, SD = 15.76) t (40) = -2.560, p = .014. See Table 12 (Appendix AD).

Figure 6 (Appendix AE)

Boxplot of Presence by Previous VR use

Simple Boxplot of Total Presence by Previous VR use
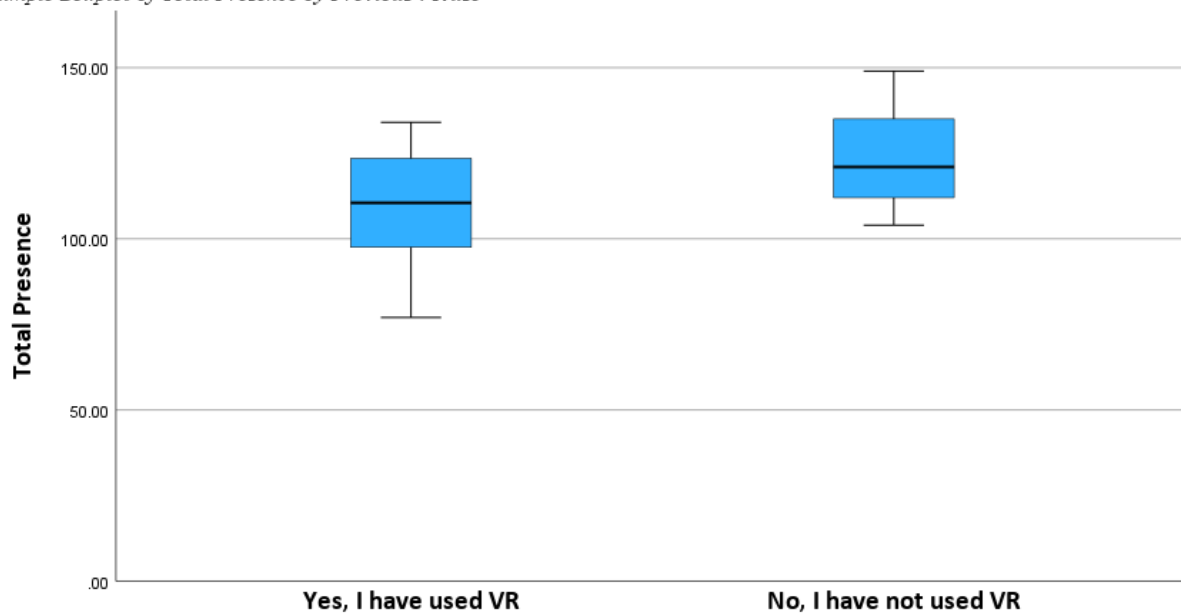
Discussion

Original Aims and Findings

The aim of this research was to examine the difference in presence and nature connectedness between 360-VR and CG-VR, and the relationship between presence and nature connectedness. The goal was to add to the existing body of knowledge (Yeo et al., 2020; Li et al., 2021; Brambilla et al., 2024) of VR as an alternative for nature, and to further understand presence in VR. Previous literature was limited (Yeo et al., 2020; Link, 2023) in exploring differences between VR simulation types.

The relationship between presence in VR environments and nature connectedness lacks research (Yeo et al., 2020). CG-VR appears to be the most effective type of VR for eliciting each of these variables (Yeo et al., 2020; Brambilla et al., 2024). Yeo et al. (2020) found that presence played a role in eliciting nature connectedness through VR, this study aimed to further examine the relationship between presence and nature connectedness.

The evidence provided points towards a gap in literature regarding comparisons between virtual reality simulation types. The results of this study indicate that there was no difference in presence or nature connectedness between 360-VR and CG-VR environments. The findings are in line with previous research (Brivio et al., 2020) which found no difference in presence and no difference in nature connectedness across 360-VR and CG-VR (Calogiuri et al., 2023; Link, 2023). The results of this study indicate that there is a relationship between sense of presence and nature connectedness, this is in line with the findings of Yeo et al. (2020).

Based on the feedback provided by participants, there were seven key themes identified in relation to both environments, see Appendix AF. In the 360-VR and CG-VR, participants reported feeling a sense of immersion from sounds. Across both environments participants felt a sense of realism, despite the CG-VR being "animated". In CG-VR participants found the controllers and headset to be relatively user friendly. Participants reported feeling relaxed in both environments.

Limitations

Using a head mounted display poses challenges such as adjusting the headset and running the content. As a result, the setup of the VR experiment was time intensive. The experiment also required allocating time to setting up the participants' area to move around. This cost 15-20 minutes. Some participants opted to sit rather than stand for both experiences, which could have influenced the level of presence they felt. The quality may have had an influence on participants' experience, as quality of VR is dependent on both the HMD and the video resolution (Orduna et al., 2020).

Some participants had never used VR before, therefore the novelty factor may have influenced sense of presence, as findings of this study showed that those with no previous VR use experienced higher presence.

Unlike previous studies (Yeo et al., 2020; Link, 2023), this study did not examine baseline nature connectedness. Another confounding factor was the inclusion of water in VR. In contrast to Yeo et al., 2020, the study excluded a control group. The sound used in both VR environments is slightly different, which may have impacted participants' experiences. Furthermore, due to the scope of the study, the role of presence as a mediator in VR on nature connectedness could not be explored.

Strengths

The strengths of this study suggest that it is a novel experiment, in an area which requires further research. The study addressed a gap in research in relation to VR simulation types, indicating that both types are equally effective in eliciting presence and nature connectedness.

Another strength is that participants experienced VR for no longer than the recommended 5 minutes (Brambilla et al., 2024). There was an equal number of participants assigned to each group. The study also had a large age range, 18-64, in comparison to previous research (Link, 2023). A final strength of this study is the use of reliable scales, the PQ (Witmer & Singer, 1998) has a strong reliability score.

Theoretical and Practical Implications

Slater (2018), refer to presence as "the illusion of being there", which is not solely dependent on realism, but other sensory factors. Therefore, despite 360-VR having a higher level of visual realism, no difference was found in presence or nature connectedness between the two

environments. CG-VR allowed for interactivity, and included sounds, which may have supported Place Illusion. Furthermore, the illusion of non-mediation (Lombard & Ditton, 2006) could explain the relationship found between presence and nature connectedness, as participants who viewed the VR as "invisible" may have felt more present and cognitively engaged, increasing their sense of nature connectedness.

The findings suggest that VR is a suitable alternative for nature access, which can be accessed remotely through an HMD. The findings suggest no difference between 360-VR and CG-VR; therefore, it is important to consider the lower cost, and ease of creation of 360-VR (Cinnamon & Jahiu, 2023). The findings have practical implications across medical and educational and urban settings where access to nature may be limited.

Future Research

In accordance with previous literature (Yeo et al., 2020; Link, 2023) future studies should continue to explore the differences between VR simulation types. The sample size should be considered as a larger sample size (> 100), with more diverse participants with varying degrees of nature access, which may show a greater variety in results. The quality of VR environment and type of HMD used should also be considered (Orduna et al., 2020).

A longitudinal study could also show more variability in results. It is also important to recognize that to compare participants' presence and nature connectedness, it may be necessary to employ a 'within-subjects' design. In the CG-VR, tasks could be given to participants to complete, or mini-games could be incorporated to see if level of interactivity has an impact (Li et al., 2021). Haptic feedback could be employed during the experiment, as previous research has found that this can improve users' presence in VR (Gibbs et al., 2021; Venkatesan & Wang, 2023). In line with the findings of Spangenberger et al. (2023) who discovered that embodying a tree meditated the relationship between presence and nature connectedness, multisensory stimuli could be employed.

In future research, the choice given to participants to sit or stand should be considered, as this may have had an impact. In accordance with the findings of Yeo et al. (2020), the role of presence as a mediator between VR environment and nature connectedness could be further explored. The current study examines psychological presence, however Higuera-Trujillo et al. (2017) found that physiological presence could be elicited through VR, this could be further examined. Finally, in line with the research of Link (2023), the relationship between presence, nature connectedness and wellbeing could be further explored.

Conclusion

In conclusion, the aim of this research was to expand upon previous studies (Yeo et al., 2020; Li et al., 2021; Brambilla et al., 2024) in regard to further understanding presence, and providing an alternative for nature access through Virtual Reality. This research employed the concepts of presence and nature connectedness, examining differences in 360-VR and CG-VR as a means of building on past research regarding VR simulation types. The research hypothesized that there would be a relationship between presence and nature connectedness. A positive relationship was identified between the two variables. The research hypothesized that CG-VR would create a higher sense of presence and nature connectedness. The results of this experiment convey no significant difference in presence or nature connectedness across the two VR simulation types.

As described by Lombard and Ditton (2006), the illusion of non-mediation may explain the lack of difference between 360-VR and CG-VR, as participants felt equally present and connected to nature despite the lack of realism in CG-VR. The findings of this study offer practical implication for designing cost-effective VR nature experiences across educational, urban and therapeutic settings. Access to nature hosts benefits for everyone regardless of where they live. VR could be the key to exploring these benefits.

References

Ambrosio, A. P., & Fidalgo, M. I. R. (2020). Past, present and future of Virtual Reality: Analysis of its technological variables and definitions. *Culture & History Digital Journal, 9*(1), 010. https://doi.org/10.3989/chdj.2020.010

Bohil, C. J., Alicea, B., & Biocca, F. A. (2011). Virtual reality in neuroscience research and therapy. *Nature Reviews Neuroscience, 12*(12), 752–762. https://doi.org/10.1038/nrn3122

Brambilla, E., Petersen, E., Stendal, K., Sundling, V., MacIntyre, T. E., & Calogiuri, G. (2024). Effects of immersive virtual nature on nature connectedness: A systematic review and meta-analysis. *Digital Health, 10*. https://doi.org/10.1177/20552076241234639

Brivio, E., Serino, S., Cousa, E. N., Zini, A., Riva, G., & De Leo, G. (2020). Virtual reality and 360° panorama technology: a media comparison to study changes in sense of presence, anxiety, and positive emotions. *Virtual Reality, 25*(2), 303–311. https://doi.org/10.1007/s10055-020-00453-7

Browning, M. H. E. M., Mimnaugh, K. J., Van Riper, C. J., Laurent, H. K., & LaValle, S. M. (2020). Can simulated nature support mental health? comparing short, Single-Doses of 360-Degree nature videos in virtual reality with the outdoors. *Frontiers in Psychology, 10*. https://doi.org/10.3389/fpsyg.2019.02667

Calogiuri, G., Petersen, E., Haile, A., Flaten, O. E., Fröhlich, F., & Litleskare, S. (2023). The impact of visualization techniques of immersive virtual scenarios in promoting nature connectedness: A blind randomized controlled trial with mixed-methods approach. *Journal of Environmental Psychology, 90*, 102102. https://doi.org/10.1016/j.jenvp.2023.102102

Cinnamon, J., & Jahiu, L. (2023). 360-degree video for virtual place-based research: A review and research agenda. *Computers Environment and Urban Systems*, *106*, 102044. https://doi.org/10.1016/j.compenvurbsys.2023.102044

Gibbs, J. K., Gillies, M., & Pan, X. (2021). A comparison of the effects of haptic and visual feedback on presence in virtual reality. *International Journal of Human-Computer Studies*, *157*, 102717. https://doi.org/10.1016/j.ijhcs.2021.102717

Gonçalves, G., Coelho, H., Monteiro, P., Melo, M., & Bessa, M. (2022). Systematic Review of Comparative studies of the Impact of Realism in immersive virtual experiences. *ACM Computing Surveys, 55*(6), 1–36. https://doi.org/10.1145/3533377

Green, M. C., & McAllister, C. A. (2020). Presence. *The International Encyclopedia of Media Psychology, 1*, 1–5. https://doi.org/10.1002/9781119011071.iemp0058

Higuera-Trujillo, J. L., Maldonado, J. L., & Millán, C. L. (2017). Psychological and physiological human responses to simulated and real environments: A comparison between Photographs, 360° Panoramas, and Virtual Reality. *Applied Ergonomics, 65*, 398–409. https://doi.org/10.1016/j.apergo.2017.05.006

Jin, X., Meneely, J., & Park, N. (2021). Virtual Reality versus Real–World Space: Comparing Perceptions of Brightness, Glare, Spaciousness, and Visual Acuity. *Journal of Interior Design, 47*(2), 31–50. https://doi.org/10.1111/joid.12209

Jo, H., Song, C., & Miyazaki, Y. (2019). Physiological Benefits of Viewing Nature: A Systematic review of indoor experiments. *International Journal of Environmental Research and Public Health, 16*(23), 4739. https://doi.org/10.3390/ijerph16234739

Jung, S., & Lindeman, R. W. (2021). Perspective: Does realism improve presence in VR? Suggesting a model and metric for VR experience evaluation. *Frontiers in Virtual Reality, 2*. https://doi.org/10.3389/frvir.2021.693327

Kellert, S. R., & Wilson, E. O. (1993). The biophilia hypothesis.

Kleespies, M. W., Braun, T., Dierkes, P. W., & Wenzel, V. (2021). Measuring Connection to Nature—A illustrated extension of the inclusion of nature in self scale. *Sustainability*, *13*(4), 1761. https://doi.org/10.3390/su13041761

Leung, G. Y., Hazan, H., & Chan, C. S. (2022). Exposure to nature in immersive virtual reality increases connectedness to nature among people with low nature affinity. *Journal of Environmental Psychology, 83*, 101863. https://doi.org/10.1016/j.jenvp.2022.101863

Li, H., Zhang, X., Wang, H., Yang, Z., Liu, H., Cao, Y., & Zhang, G. (2021). Access to nature
via Virtual Reality: A Mini-Review. *Frontiers in Psychology, 12*.
https://doi.org/10.3389/fpsyg.2021.725288

Link, V. M. (2023). *360° view of nature: Virtual reality 3D nature environments versus 360°
nature videos and their effects on positive and negative affect levels, sense of presence,
and nature connectedness in university students* [Bachelor's thesis, University of
Twente]. University of Twente Student Theses. https://essay.utwente.nl/94248/

Liu, H., Nong, H., Ren, H., & Liu, K. (2022). The effect of nature exposure, nature
connectedness on mental well-being and ill-being in a general Chinese population.
Landscape and Urban Planning, 222, 104397.
https://doi.org/10.1016/j.landurbplan.2022.104397

Lombard, M., & Ditton, T. (2006). At the Heart of It All: The Concept of Presence. *Journal of
Computer-Mediated Communication*, *3*(2), 0. https://doi.org/10.1111/j.1083-
6101.1997.tb00072.x

Mahato, A., & Ekka, M. (2023). Nature within us: A sustainable lifestyle approach to connect
with nature. *International Journal of Advanced Biochemistry Research*, *7*(2S), 85–88.
https://doi.org/10.33545/26174693.2023.v7.i2sb.191

Martin, L., White, M. P., Hunt, A., Richardson, M., Pahl, S., & Burt, J. (2020). Nature contact,
nature connectedness and associations with health, wellbeing and pro-environmental
behaviours. *Journal of Environmental Psychology, 68*, 101389.
https://doi.org/10.1016/j.jenvp.2020.101389

Martyn, P., & Brymer, E. (2014). The relationship between nature relatedness and anxiety. *Journal of Health Psychology, 21*(7), 1436–1445. https://doi.org/10.1177/1359105314555169

Mattila, O., Korhonen, A., Pöyry, E., Hauru, K., Holopainen, J., & Parvinen, P. (2020). Restoration in a virtual reality forest environment. *Computers in Human Behavior, 107*, 106295. https://doi.org/10.1016/j.chb.2020.106295

Melinda, N. V., & Widjaja, N. A. E. (2022). Virtual reality applications in education. *International Transactions on Education Technology (ITEE), 1*(1), 68–72. https://doi.org/10.34306/itee.v1i1.194

Moore, H. F., Eiris, R., Gheisari, M., & Esmaeili, B. (2019). Hazard Identification Training Using 360-Degree Panorama vs. Virtual Reality Techniques: A Pilot Study. *Computing in Civil Engineering, 55–62*. https://doi.org/10.1061/9780784482421.008

Newman, M., Gatersleben, B., Wyles, K., & Ratcliffe, E. (2021). The use of virtual reality in environment experiences and the importance of realism. *Journal of Environmental Psychology, 79*, 101733. https://doi.org/10.1016/j.jenvp.2021.101733

Nukarinen, T., Istance, H., Rantala, J., Makela, J., Ronkainen, K., Surakka, V., et al. (2020). "Physiological and psychological restoration in matched real and virtual natural environments," *Proceedings of the Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing*, (Honolulu, HI: CHI). https://doi.org/10.1145/3334480.3382956

Orduna, M., Perez, P., Diaz, C., & Garcia, N. (2020). Evaluating the influence of the HMD, usability, and fatigue in 360VR video quality assessments. *2022 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW)*, 682–683. https://doi.org/10.1109/vrw50115.2020.00192

Reese, G., Stahlberg, J., & Menzel, C. (2022). Digital shinrin-yoku: Do nature experiences in virtual reality reduce stress and increase well-being as strongly as similar experiences in a physical forest? *Virtual Reality, 26*(3), 1245–1255. https://doi.org/10.1007/s10055-022-00631-9

Ritter, K. A., & Chambers, T. L. (2021). Three-dimensional modeled environments versus 360 degree panoramas for mobile virtual reality training. *Virtual Reality, 26*(2), 571–581. https://doi.org/10.1007/s10055-021-00502-9

Schultz, P. W. (2001). The structure of environmental concern: Concern for self, other people, and the biosphere. *Journal of Environmental Psychology, 21*(4), 327–339. https://doi.org/10.1006/jevp.2001.0227

Slater, M., & Wilbur, S. (1997). A Framework for Immersive Virtual Environments (FIVE): Speculations on the Role of Presence in Virtual Environments. *Presence: Teleoperators and Virtual Environments, 6*(6), 603–616. https://doi.org/10.1162/pres.1997.6.6.603

Slater, M. (2018). Immersion and the illusion of presence in virtual reality. *British Journal of Psychology, 109*(3), 431–433. https://doi.org/10.1111/bjop.12305

Spangenberger, P., Freytag, S., & Geiger, S. M. (2023). Embodying nature in immersive

virtual reality: Are multisensory stimuli vital to affect nature connectedness and pro-

environmental behaviour? *Computers & Education, 212*, 104964.

https://doi.org/10.1016/j.compedu.2023.104964

Venkatesan, T., & Wang, Q. J. (2023). Feeling connected: The role of haptic feedback in VR

concerts and the impact of haptic music players on the music listening experience.

Arts, *12*(4), 148. https://doi.org/10.3390/arts12040148

Verhulst, I., Woods, A., Whittaker, L., Bennett, J., & Dalton, P. (2021). Do VR and AR

versions of an immersive cultural experience engender different user experiences?

Computers in Human Behavior, 125, 106951.

https://doi.org/10.1016/j.chb.2021.106951

Verma, P., Kumar, R., Tuteja, J., & Gupta, N. (2021). Systematic Review Of Virtual Reality &

Its Challenges. *2021 Third International Conference on Intelligent Communication

Technologies and Virtual Mobile Networks (ICICV)*.

https://doi.org/10.1109/icicv50876.2021.9388631

Witmer, B. G., & Singer, M. J. (1998). Measuring presence in virtual environments: A

presence questionnaire. *Presence: Teleoperations and Virtual Environments,* 7(3), 225-

240 https://doi.org/10.1162/105474698565686

Yeo, N., White, M., Alcock, I., Garside, R., Dean, S., Smalley, A., & Gatersleben, B. (2020).

What is the best way of delivering virtual nature for improving mood? An

experimental comparison of high definition TV, 360° video, and computer generated virtual reality. *Journal of Environmental Psychology*, *72*, 101500. https://doi.org/10.1016/j.jenvp.2020.101500

Zheng, C., Yan, Y., & Liu, Y. (2023). Prospects of EVTOL and modular flying cars in China urban settings. *Journal of Intelligent and Connected Vehicles*, *6*(4), 187–189. https://doi.org/10.26599/jicv.2023.9210029

Appendices

Appendix A – Optional Feedback (Microsoft Forms)

Appendix B – Information Sheet (Microsoft Forms)

Measuring Presence and Nature Connectedness in VR : A comparison between 360-VR and CG-VR

Part of a Major Research Project by Sara Curran

Information sheet

Title of project: *Presence and Nature Connectedness in Virtual Reality: Comparing CG-VR (Computer Generated) and 360-VR (360° video) nature environments.*

You are being invited to take part in the research project: Presence and Nature Connectedness in Virtual Reality. This research will compare the effects of Computer Generated and 360º video in Virtual Reality, on sense of presence and nature connectedness. This project is being undertaken by Sara Curran for our major research project as part of the BSc (Hons) in Applied Psychology, IADT.

Before you decide whether you wish to take part, it is important for you to understand why this research is being done and what it will involve. Please take time to read this information carefully and discuss it with someone you trust. If there is anything that is unclear or if you would like more information please ask, our contact details are at the end of this information sheet. Thank you for reading this.

What is the purpose of the project?

Accessibility to nature is known to be beneficial to wellbeing. However, due to the recent rise in digital media people are spending less time in nature. An increase in urbanization has further led to decreased nature accessibility for all. Individuals with long term health, psychological conditions or disabilities may have limited nature access. Therefore, it is important to find an alternative. This research aims to understand if virtual reality could influence two key variables, sense of presence and connectedness to nature in a nature environment.

Why are you being invited to take part?

You are being invited to take part in this study because you are over the age of 18. This study is for members of the general population and university students who may have varying degrees of access to nature.

Measuring Presence and Nature Connectedness in VR : A comparison between 360-VR and CG-VR

Information Sheet Continued

What is involved?

If you choose to participate, you must first fill out the following disclaimer and consent form. You will then be asked a variety of demographic questions relating to your age and gender. After completing these, you may commence the experiment. Depending on which group you are assigned to you will be asked to view either a) a 360° video or b) a computer-generated scenario of nature. This will last approximately 5 minutes. You will then be asked to complete two questionnaires, a presence questionnaire and a nature connectedness questionnaire. Both will measure your experiences in relation to VR. You will be asked to give some feedback on your experience. After the experiment is completed, you will be debriefed. This will take approximately 15 to 20 minutes in total. The information sheet must be read and both consent and debrief forms completed to commence the experiment.

Do I have to take part?

You are free to decide whether you wish to take part or not. If you do decide to take part, you will be asked to sign a consent form that lets us know you have read this information sheet and understand what is involved in the research. You are free to withdraw from this study at any time and without giving reasons. Choosing to take part or not take part in the study will have no impact on students' marks, assessments or future studies.

What are the disadvantages and risks (if any) of taking part?

You do not have to answer any of the following questions, should they make you uncomfortable. When using the VR headset there is a risk of motion sickness and/or potential seizures. A screening, using a disclaimer form, will take place to limit the chances of these conditions occurring. If you are prone to motion sickness and/or seizures, please refrain from taking part in the study.

Measuring Presence and Nature Connectedness in VR : A comparison between 360-VR and CG-VR

Information Sheet Continued

What are the possible benefits of taking part?

We cannot promise the study will benefit you, but the information we get from the study will add to a growing body of knowledge surrounding nature access through Virtual Reality. The collection of information will effectively be used to represent the comparisons that exist between 360° degree video and Computer-Generated Scenarios, in inducing sense of presence and nature connectedness through VR. The study will also further the understanding of a need for future research into the ways in which types of VR which induce presence and nature connectedness, which could potentially be used to aid nature accessibility.

How will my information be used?

Your identity will remain anonymous throughout the process of the experiment. Your responses to the questionnaire will be combined with all other participants data and statistically analyzed. No individual's data will be identifiable in the final report. The results of this analysis will be reported in the thesis for the BSc (Hons) in Applied Psychology in the Dun Laoghaire Institute of Art, Design & Technology. This can be requested through the library at IADT, or by emailing the researcher Sara Curran or supervisor Robert Griffin at n00211839@iadt.ie and robert.griffin@iadt.ie. This study may also be published in an academic journal article and may be written about for blog posts or media articles, and these can be requested from the researcher.

Measuring Presence and Nature Connectedness in VR : A comparison between 360-VR and CG-VR

Information Sheet Continued

How will my data be protected?

Under the EU General Data Protection Regulation (GDPR) the legal basis for collecting data for scholarly research is that of public interest. The regulations regarding the protection of your data will be followed. Only data which is needed for analysis will be collected. By giving your consent to take part in the study you are consenting to the use of your data as detailed in this information sheet.

The data will be retained by the researcher for at least one year and may be retained for up to 7 years if the results of the study are published in certain capacities (e.g. in a journal article). There is also a possibility that the fully anonymised dataset may be submitted to a journal and made available to other researchers and academics worldwide for verification purposes, but if this occurs it will be ensured that you are not identifiable from the data.

As the supervisor of this project, I, Robert Griffin, am responsible for ensuring that all datasets will be stored in accordance with GDPR regulations and those which are not submitted to a journal will be fully deleted on or before 1/01/2032.

The data will only be accessible to Sara Curran (the researcher), Robert Griffin (supervisor), and the statistics support lecturer, Cyril Connolly (cyril.connolly@iadt.ie). All data will be securely stored on a password protected computer. If a data breach were to occur, the data protection officer in IADT will be informed immediately. The data will be coded. The data will be securely disposed of after data collection.

You will find contact information for IADT's Data Protection Officer, Mr Bernard Mullarkey, and more information on your rights concerning your data at https://iadt.ie/about/your-rights-entitlements/gdpr/

Measuring Presence and Nature Connectedness in VR : A comparison between 360-VR and CG-VR

Information Sheet Continued

Who has reviewed the study?
This study has been approved by the IADT Psychology Ethics Committee.

What if you have any questions or there is a problem? If you have a concern about any aspect of this study, you may wish to speak to the researcher(s) who will do their best to answer your questions. You should contact Sara Curran (project researcher) Email: n00211839@iadt.ie, or their supervisor Robert Griffin, Email: robert.griffin@iadt.ie.

Thank you for taking the time to read the information sheet.

Date: 1/01/25

Appendix C – Posters for Participants Recruitment

Appendix D – Demographics (Microsoft Forms)

Measuring Presence and Nature Connectedness in VR : A comparison between 360-VR and CG-VR

* Required

Demographics

Study title : Presence and Nature Connectedness in Virtual Reality: Comparing CG-VR and 360-VR nature environments

Name of researcher : Sara Curran

2

Please provide us with an **anonymized code** which we can use to identify your data if you later wish to have it removed from our dataset. Please do so by answering the following two questions:

- What are the **second and third letters of your address?** (For example, if your address is Maple Road, these letters would be 'AP')

- What are the **last three digits/letters** of your **eircode?**

*

Enter your answer

3

Gender : I identify as: *

◯ I prefer not to say

◯ Other

4

Age : I am *

- ◯ Under 18 years
- ◯ 18 - 24 years
- ◯ 25 - 34 years
- ◯ 35 - 44 years
- ◯ 45 - 54 years
- ◯ 55 - 64 years
- ◯ 65 - 74 years
- ◯ 75 years or older
- ◯ I prefer not to say

5

Which group have you been assigned to? *

- ◯ Group **A** - 360-VR
- ◯ Group **B** - CG-VR

6

Have you ever used VR before? *

- ◯ Yes
- ◯ No

Appendix E – Disclaimer Form

Institute of Art, Design and Technology

This form sets out some of the potential risks in participating in this activity. If any of the below applies to you, or if at any time you are uncomfortable with participating in this activity, you should either not participate or cease your participation, if you have commenced the activity.

DISCLAIMER FORM

Some people may experience motion sickness, nausea, disorientation, blurred vision or other discomfort while viewing virtual reality (VR) content. If you experience any of these symptoms, stop using immediately and remove the VR headset. People diagnosed with epilepsy, who suffer motion sickness or balance problems, get migraines, have implanted medical devices and/or who are pregnant are advise not to engage with virtual reality.

WARNING: RISK OF PHOTOSENSITIVITY/EPILEPSY SEIZURES

A very small percentage of individuals may experience epileptic seizures or blackouts when exposed to certain light patterns or flashing lights. Exposure to certain patterns or backgrounds
on a television screen or when playing video games may trigger epileptic seizures or blackouts in these individuals. These conditions may trigger previously undetected epileptic symptoms or seizures in persons who have no history of prior seizures or epilepsy. If you, or anyone in your family has an epileptic condition or has had seizures of any kind, consult your physician before playing.
I have read the above guidance and advisory notes, and I clearly understand that by signing this
Disclaimer Form, I am aware of the potential risks mentioned above and consent to use the VR equipment at my own discretion.

_____

[participant's name]

_____

[participant's signature]

_____

[date]

Appendix F – Consent Form (Microsoft Forms)

Measuring Presence and Nature Connectedness in VR : A comparison between 360-VR and CG-VR

* Required

Consent form

Please tick the box at the end to indicate you agree with all the following statements

Study title : Presence and Nature Connectedness in Virtual Reality: Comparing CG-VR and 360-VR nature environments

Name of researcher : Sara Curran

All information will remain completely anonymous. No associations will be made to any of the participants involved, and all date collected will be unidentifiable as your own. The final conclusion of this study will be available to all participants of the study.

1

Please tick all of the boxes *

☐ I confirm that I have read and understand the information sheet for the above study and have had the opportunity to ask questions

☐ I understand that my participation is voluntary and that I am free to withdraw at any time

☐ I understand that data collected about me during this study will not be identifiable when the research is published

☐ I am over 18 years of age

☐ I agree to take part in this study

Appendix G – Presence Questionnaire and Scoring (Witmer & Singer., 1998)

PRESENCE QUESTIONNAIRE
(Witmer & Singer, Vs. 3.0, Nov. 1994)*
Revised by the UQO Cyberpsychology Lab (2004)

Characterize your experience in the environment, by marking an "X" in the appropriate box of the 7-point scale, in accordance with the question content and descriptive labels. Please consider the entire scale when making your responses, as the intermediate levels may apply. Answer the questions independently in the order that they appear. Do not skip questions or return to a previous question to change your answer.

WITH REGARD TO THE EXPERIENCED ENVIRONMENT

1. How much were you able to control events?

| NOT AT ALL | SOMEWHAT | COMPLETELY |

2. How responsive was the environment to actions that you initiated (or performed)?

| NOT RESPONSIVE | MODERATELY RESPONSIVE | COMPLETELY RESPONSIVE |

3. How natural did your interactions with the environment seem?

| EXTREMELY ARTIFICIAL | BORDERLINE | COMPLETELY NATURAL |

4. How much did the visual aspects of the environment involve you?

| NOT AT ALL | SOMEWHAT | COMPLETELY |

5. How natural was the mechanism which controlled movement through the environment?

| EXTREMELY ARTIFICIAL | BORDERLINE | COMPLETELY NATURAL |

6. How compelling was your sense of objects moving through space?

| NOT AT ALL | MODERATELY COMPELLING | VERY COMPELLING |

7. How much did your experiences in the virtual environment seem consistent with your real world experiences?

| NOT CONSISTENT | MODERATELY CONSISTENT | VERY CONSISTENT |

8. Were you able to anticipate what would happen next in response to the actions that you performed?

| NOT AT ALL | SOMEWHAT | COMPLETELY |

9. How completely were you able to actively survey or search the environment using vision?

| NOT AT ALL | SOMEWHAT | COMPLETELY |

10. How compelling was your sense of moving around inside the virtual environment?

| NOT COMPELLING | MODERATELY COMPELLING | VERY COMPELLING |

11. How closely were you able to examine objects?

| NOT AT ALL | PRETTY CLOSELY | VERY CLOSELY |

12. How well could you examine objects from multiple viewpoints?

| NOT AT ALL | SOMEWHAT | EXTENSIVELY |
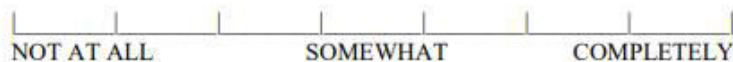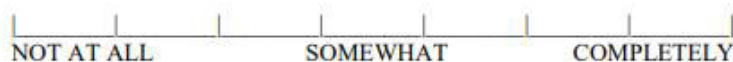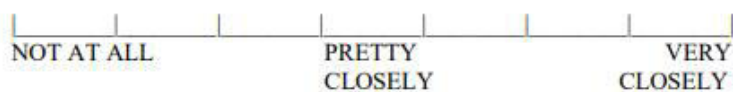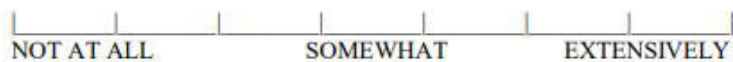
13. How involved were you in the virtual environment experience?

| | | | | | | | | | |
NOT   MILDLY   COMPLETELY
INVOLVED   INVOLVED   ENGROSSED

14. How much delay did you experience between your actions and expected outcomes?

| | | | | | | | | | |
NO DELAYS   MODERATE   LONG
                    DELAYS   DELAYS

15. How quickly did you adjust to the virtual environment experience?

| | | | | | | | | | |
NOT AT ALL   SLOWLY   LESS THAN

                                ONE MINUTE
16. How proficient in moving and interacting with the virtual environment did you feel at the end of the experience?

| | | | | | | | | | |
NOT   REASONABLY   VERY
PROFICIENT   PROFICIENT   PROFICIENT

17. How much did the visual display quality interfere or distract you from performing assigned tasks or required activities?

| | | | | | | | | | |
NOT AT ALL   INTERFERED   PREVENTED
                 SOMEWHAT   TASK PERFORMANCE

18. How much did the control devices interfere with the performance of assigned tasks or with other activities?

| | | | | | | | | | |
NOT AT ALL   INTERFERED   INTERFERED
                 SOMEWHAT   GREATLY

19. How well could you concentrate on the assigned tasks or required activities rather than on the mechanisms used to perform those tasks or activities?

| | | | | | | | | | |
NOT AT ALL   SOMEWHAT   COMPLETELY

IF THE VIRTUAL ENVIRONMENT INCLUDED SOUNDS:

20. How much did the auditory aspects of the environment involve you?

|___|___|___|___|___|___|___|___|___|
NOT AT ALL   SOMEWHAT   COMPLETELY

21. How well could you identify sounds?

|___|___|___|___|___|___|___|___|___|
NOT AT ALL   SOMEWHAT   COMPLETELY

22. How well could you localize sounds?

|___|___|___|___|___|___|___|___|___|
NOT AT ALL   SOMEWHAT   COMPLETELY

IF THE VIRTUAL ENVIRONMENT INCLUDED HAPTIC (SENSE OF TOUCH):

23. How well could you actively survey or search the virtual environment using touch?

|___|___|___|___|___|___|___|___|___|
NOT AT ALL   SOMEWHAT   COMPLETELY

24. How well could you move or manipulate objects in the virtual environment?

|___|___|___|___|___|___|___|___|___|
NOT AT ALL SOMEWHAT   EXTENSIVELY

Questionnaire sur l'État de Présence (QÉP)
Laboratoire de Cyberpsychologie de l'UQO

Validation of the French-Canadian version developed by the UQO Cyberpsychology Lab:

➤ 101 participants completed the questionnaire following an immersion in a virtual environment;
➤ Cronbach's Alpha = .84
➤ Now 19 items (for VEs without sound/touch) et 24 items (for VEs with sounds/touch)

Scoring :

Total : Items 1 to 19 (reverse items 14, 17, 18)

- « Realism » : Items 3 + 4 + 5 + 6 + 7 + 10 + 13
- « Possibility to act » : Items 1 + 2 + 8 + 9
- « Quality of interface » : Items (all reversed) 14 + 17 + 18
- « Possibility to examine » : Items 11 + 12 + 19
- « Self-evaluation of performance » : Items 15 + 16
- « Sounds* » : Items 20 + 21 + 22
- « Haptic* » : Items 23 + 24

* NOTE : Scoring of « *sounds* » and « *haptic* » are not part of the factor analysis of the French version.

Norms (French version) :

	Moyenne	**Écart type**
Total	104.39	18.99
« Realism »	29.45	12.04
« Possibility to act »	20.76	6.01
« Quality of interface »	15.37	5.15
« Possibility to examine»	15.38	4.90
« Auto-évaluation de la performance »	11.00	2.87

Last version : March 2013

8

Presence Questionnaire

Please indicate your answer in response to the following questions on a **scale of 1-7**. Please **consider the entire scale** when making your responses, as the intermediate levels
may apply.

Please answer the questions independently in the order that they appear. **Do not skip questions** or return to a previous question to change your answer.

With regard to the experienced environment : *

	Not at all - 1	2	3	Somewhat - 4	5	6	Completely - 7
How much were you able to control events?	○	○	○	○	○	○	○

9

*

	Not responsive -1	2	3	Moderately Responsive - 4	5	6	Completely Responsive- 7
How responsive was the environment to actions that you initiated (or performed)?	○	○	○	○	○	○	○

10

*

	Extremely Artificial - 1	2	3	Borderline - 4	5	6	Completely Natural - 7
How natural did your interactions with the environment seem?	○	○	○	○	○	○	○

11

* 📖

	Not at all - 1	2	3	Somewhat - 4	5	6	Completely - 7
How much did the visual aspects of the environment involve you?	◯	◯	◯	◯	◯	◯	◯

12

* 📖

	Extremely Artificial -1	2	3	Borderline - 4	5	6	Completely Natural - 7
How natural was the mechanism which controlled movement through the environment?	◯	◯	◯	◯	◯	◯	◯

13

* 📖

	Not at all - 1	2	3	Somewhat - 4	5	6	Very Compelling - 7
How compelling was your sense of objects moving through space?	◯	◯	◯	◯	◯	◯	◯

14

* 📖

14

* 📖

	Not consistent - 1	2	3	Moderately Consistent - 4	5	6	Very Consistent - 7
How much did your experiences in the virtual environment seem consistent with your real world experiences?	○	○	○	○	○	○	○

15

* 📖

	Not at all -1	2	3	Somewhat - 4	5	6	Completely - 7
Were you able to anticipate what would happen next in response to the actions that you performed?	○	○	○	○	○	○	○

16

* 📖

	Not at all - 1	2	3	Somewhat - 4	5	6	Completely - 7
How completely were you able to actively survey or search the environment using vision?	○	○	○	○	○	○	○

17

*

	Not compelling- 1	2	3	Moderately Compelling 4	5	6	Very Compelling 7
How compelling was your sense of moving around inside the virtual environment?	○	○	○	○	○	○	○

18

*

	Not at all - 1	2	3	Pretty closely - 4	5	6	Very closely - 7
How closely were you able to examine objects?	○	○	○	○	○	○	○

19

*

	Not at all - 1	2	3	Somewhat - 4	5	6	Extensively - 7
How well could you examine objects from multiple viewpoints?	○	○	○	○	○	○	○

20

*

	Not involved - 1	2	3	Mildly involved - 4	5	6	Completely engrossed - 7
How involved were you in the virtual environment experience?	○	○	○	○	○	○	○

21

*

	No delays - 1	2	3	Moderate delays -4	5	6	Long delays - 7
How much delay did you experience between your actions and expected outcomes?	○	○	○	○	○	○	○

22

*

	Not at all - 1	2	3	Slowly - 4	5	6	Less than one minute - 7
How quickly did you adjust to the virtual environment experience?	○	○	○	○	○	○	○

63

23

*

	Not proficient - 1	2	3	Reasonably proficient - 4	5	6	Very proficient - 7
How proficient in moving and interacting with the virtual environment did you feel at the end of the experience?	○	○	○	○	○	○	○

24

*

	Not at all - 1	2	3	Interfered Somewhat - 4	5	6	Prevented task performance - 7
How much did the visual display quality interfere or distract you from performing assigned tasks or required activities?	○	○	○	○	○	○	○

25

*

	Not at all - 1	2	3	Interfered somewhat - 4	5	6	Interfered greatly - 7
How much did the control devices interfere with the performance of assigned tasks or with other activities?	○	○	○	○	○	○	○

26

*

	Not at all - 1	2	3	Somewhat - 4	5	6	Completely - 7
How well could you concentrate on the assigned tasks or required activities rather than on the mechanisms used to perform those tasks or activities?	○	○	○	○	○	○	○

27

Based on the sounds in the virtual environment : *

	Not at all -1	2	3	Somewhat - 4	5	6	Completely - 7
How much did the auditory aspects of the environment involve you?	○	○	○	○	○	○	○

28

*

	Not at all - 1	2	3	Somewhat - 4	5	6	Completely - 7
How well could you identify sounds?	○	○	○	○	○	○	○

29

*

	Not at all - 1	2	3	Somewhat - 4	5	6	Completely - 7
How well could you localize sounds?	○	○	○	○	○	○	○

Appendix H – Cronbach's Alpha for the Presence Questionnaire

Reliability Statistics

Cronbach's Alpha	N of Items
.835	22
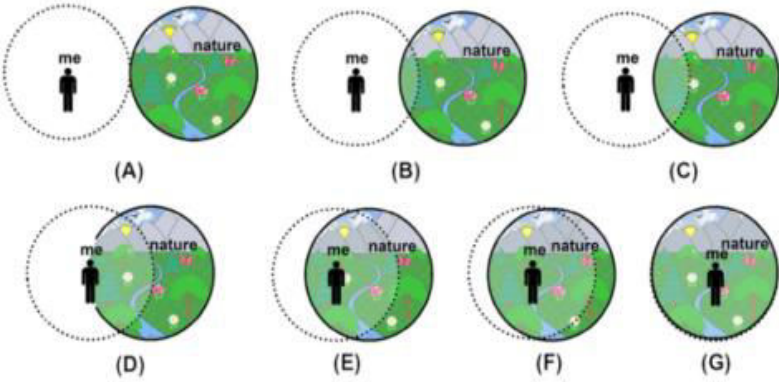
Appendix I – The Illustrated Inclusion of Nature in Self Scale (IINS)
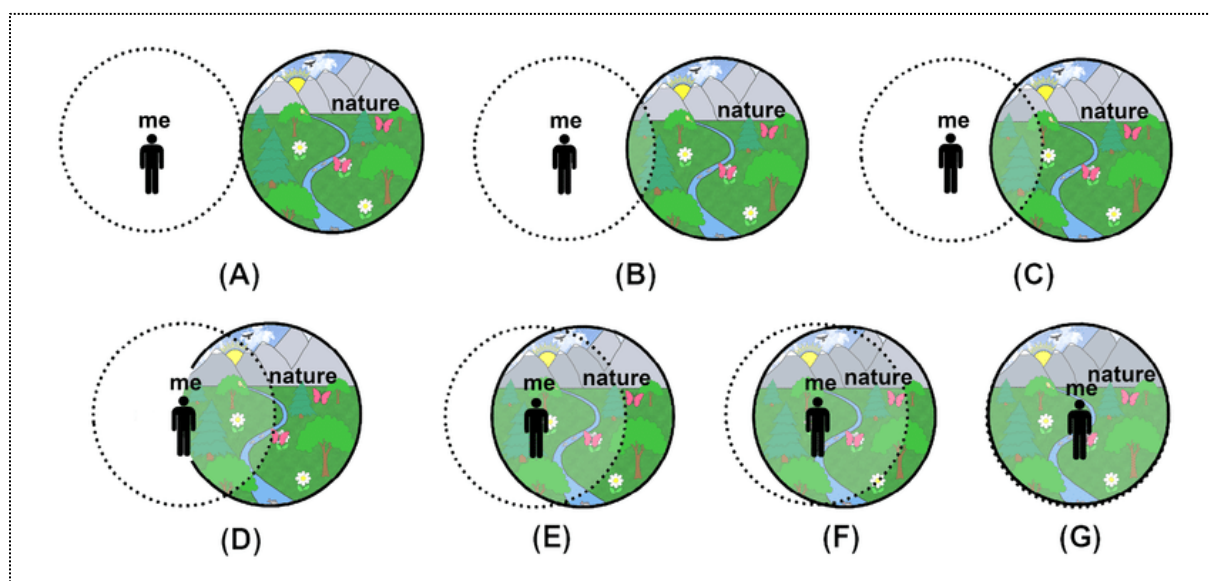
Appendix J – Debrief Form (Microsoft Forms)

Confirmation of Consent

Measuring Presence and Nature Connectedness in VR : A comparison between 360-VR and CG-VR

* Required

Confirmation of consent

`31`

Having completed the questionnaire: *

⦿ I consent to the researchers using my answers for their research

◯ I wish to have my answers removed from the research

Measuring Presence and Nature Connectedness in VR : A comparison between 360-VR and CG-VR

Debrief

Title of Project: Presence and Nature Connectedness in Virtual Reality: Comparing CG-VR and 360-VR nature environments

Name of Researcher: Sara Curran

Thank you very much for taking part in this research study. This study is designed to investigate the difference between a Computer-Generated Scenario and a 360º video of a nature scene in virtual reality, on sense of presence and nature connectedness.

The study was conducted to help further our understanding of the difference between both VR mediums in inducing presence and nature connectedness. The findings could be useful for indicating an alternative means of nature accessibility.
 If you have any questions or concerns about this study or you wish to withdraw your data from the study, please contact the researcher via email: n00211839@iadt.ie. Alternatively, you can contact my supervisor, Robert Griffin, at robert.griffin@iadt.ie.

Measuring Presence and Nature Connectedness in VR : A comparison between 360-VR and CG-VR

Debrief Continued

Withdrawal information

If you have any questions about this study, or if you would like to withdraw your data from the study, please contact the researcher or supervisor at n00211839@iadt.ie or robert.griffin@iadt.ie. In your email let them know your unique ID code (created by entering the second and third letters of your address, and the last three digits of your eircode). If you submit a request for data removal, all data collected from you will be securely deleted. You will be able to remove your data from the study until February 14th, 2025, when the data will be combined and analysed. Data removal will not be possible after that date.

Data Protection Please keep a copy of this information in case you wish to remove your data after leaving this screen. Your data will be treated according to GDPR regulations. You will find contact information for IADT's Data Protection Officer, Mr Bernard Mullarkey, and more information on your rights concerning your data at https://iadt.ie/about/your-rights-entitlements/gdpr/

Support resources

If you have been affected by the content of this study in any way, the organizations below may be of assistance.

- If you are an IADT student, you can access the **student counselling service** through the email: studentcounselling@iadt.ie

- Contact **Jigsaw:** The National Centre for Youth Mental Health in Dublin City, by email: dublincity@jigsaw.ie, or by phone: 01 658 3070

- Contact **Niteline** by phone: 1800 793 793, or email: info@niteline.org

- Free text HELLO to 'Text about it' at **50808**

- If you experienced any negative health effects from this experiment, you could contact the **IADT Student Health Centre** by phone: 01-239 4760 or email: studenthealth@iadt.ie

Measuring Presence and Nature Connectedness in VR : A comparison between 360-VR and CG-VR

Thank you very much for taking part in this study

If you have any questions about this study, please contact the researcher or supervisor at n00211839@iadt or robert.griffin@iadt.ie.

Appendix K – PEC Ethics Application Form

IADT Psychology Ethics Committee (PEC)

Application Form 2024-25

Instructions:

1. Please read all sections carefully, include all the information relevant to your project, and include all necessary appendices.
2. All students must complete Sections 1, 2, 3, and 4. You will also need to complete at least one other section, depending on the type of research that you plan to do.
3. Email the completed form to your supervisor for approval. They will then complete Section 0 below.
4. Your supervisor will then forward the application to the ethics committee.
5. If your application is under the Red Route, then you may also be required to submit four printed copies of your application (including all appendices). You will be advised closer to the deadline if this is necessary or not.
6. If your study changes from how you have described it in this form, then you will need to reapply for approval from the PEC. The PEC does not guarantee that a revised project will be approved, even if the original project was approved.
7. All communication between students and the PEC will occur via the student's project supervisor.
8. The PEC will consider all the information provided in the form when making their decision. Incomplete forms (including forms which do not include all the necessary Appendices) will be rejected.
9. If the PEC's decision is that a revised application must be made, then they will provide a list of required changes which are necessary to ensure participant wellbeing. Even if all of these are followed, the PEC makes no commitment to approve a revised application.
10. It is highly recommended that 'Red Route' students continue to formulate ideas for projects which fit the criteria for 'Green Route' and 'Amber Route' submissions until they are advised that their application has been approved. This is to ensure that the student can still complete the module, even if their 'Red Route' project does not receive approval from the PEC.
11. There is an obligation on the researcher to bring to the attention of the PEC any issues with ethical implications not clearly covered by the checklist in Section 6 of this form.
12. If you are submitting a Red Route application, you are required to submit an alternative Amber or Green Route project.
13. Please be aware of the marking guidelines for the work associated with your submission and the ramifications of a breach in ethics if relevant in your programme handbook or CA guidelines.
14. 'Signatures' may be typed, scanned in, or digitally signed.

Section 0: For Completion by the Supervisor

I confirm that this application to the PEC by _   (student name) accurately reflects all of the ethical implications in the project.

Application type (tick all that apply for mixed methods):   Green Route   _____

Amber Route

Red Route

Signed _____   Date: _____

Section 1: Project Information

Student Name: Sara Curran

Student Email Address: n00211839@iadt.ie

Supervisor Name: Robert Griffin

Working Project Title: Presence and Nature Connectedness in Virtual Reality: Comparing CG-VR and 360-VR nature environments

Main Variables Being Investigated: Effects of Virtual Reality (CG-VR vs 360-VR), Sence of Presence, Nature Connectedness

Section 2: External Agencies

Does your project involve recruitment from any external agency (e.g. a school, sports club, medical centre, voluntary organisation, or any other organisation outside of the IADT)?	Yes*	No X

* You must include a letter from a senior manager of each organisation stating that you have approval to collect data within that organisation. Include copies of each of these letters in the Appendices to your application. If the organisation has its own ethical review board (which is very common in some settings, such as hospitals), then you are also required to get ethical approval from that board prior to starting data collection, and to submit notice of this approval to your supervisor so that it can be forwarded on to the ethics committee. Some online forums also require permission to post requests for participants – make sure to check the relevant forum/organisation's code of conduct or terms and conditions. You do not need to include approval letters if you are conducting recruitment using mainstream social media routes (e.g., Twitter, Instagram, Facebook, Snapchat, TikTok) to your own followers, and/or snowball sampling/word of mouth recruitment.

Section 3: Project Methodology – Please tick which type of project you are seeking approval from the PEC for. If your project involves mixed methods, then tick all which apply.

Route Type	Methodology	Tick here
Green Route (no direct contact with participants required, and no data is collected/recorded which could identify participants)	Theoretical paper / systematic literature review / Rapid Structured Literature Review (RSLR)	
	Novel analysis of an existing dataset gathered by another researcher or group which you are certain has abided by appropriate ethical procedures for the relevant discipline	
	Observation of participants in a public place in which they could reasonably be expected to be observed by strangers or in an online space which does not require users to log in to access.	
	Content analysis of material which is publicly available and does not require users to log in to access content.	
	Other method without direct contact with participants **	
Amber Route (direct contact with participants, but no additional ethical considerations beyond the minimum requirements)	Requirements gathering for and/or user testing of a prototype which is highly unlikely to cause any harm or distress to participants and which does not aim to collect data from a potentially vulnerable group	
	An experiment which is highly unlikely to cause any harm or distress to participants and which does not aim to collect data from a potentially vulnerable group	X
	A survey/questionnaire design which is highly unlikely to cause any harm or distress to participants and which does not aim to collect data from a potentially vulnerable group	X
	An observational study which is highly unlikely to cause any harm or distress to participants and which does not aim to collect data from a potentially vulnerable group	X
	Content analysis research which is highly unlikely to cause any harm or distress to participants and which does not aim to collect data from a potentially vulnerable group	X
	Interviews and/or focus groups which are highly unlikely to cause any harm or distress to participants and which do not aim to collect data from a potentially vulnerable group	
	Other method which is highly unlikely to cause any harm or distress to participants and which does not aim to collect data from a potentially vulnerable group **	
Red Route (direct contact with participants, including one or more project aspects which require special	Requirements gathering for and/or user testing of a prototype which may cause harm or distress to participants and/or which involves collecting data from any potentially vulnerable group	
	An experiment which may cause harm or distress to participants and/or which involves collecting data from any potentially vulnerable group	
	A survey/questionnaire design which may cause harm or distress to participants and/or which involves collecting data from any potentially vulnerable group	

Section 4: Checklist of Attached Appendices and Other Completed Sections

Applicable Project Ethics Route Colour Guide		Section / Item	I have attached this item/completed this section	I have checked with my supervisor and we have agreed that this item/section is not relevant to my project
	1	Section 1	X	
	2	Section 2	X	
	3	Section 3	X	
	4	Section 4	X	
	5	Letters of permission from any external agencies to be used for data collection		
	6	Statement of approval from ethical review boards in external agencies	X	
	7	Section 5 (Green Route Projects only)		
	8	Section 6 (Amber and Red Route Projects only)	X	

	9	Section 7 (Amber Route Projects only)	X	
	10	Section 8 (Red Route Projects only)		
	11	Section 9 (Red Route Projects only)		
	12	Evidence of why you need to complete a Red Route Project (see note in Section 8)		
	13	Project Information Sheet (Red Route Projects only)		
	14	Project Consent Form (Red Route Projects only)		
	15	Project Demographic Questionnaire (Red Route Projects only)		
	16	All Other Questionnaires and Data Collection Materials (Red Route Projects only)		
	17	Project Debrief (Red Route Projects only)		
	18	I have an alternative Amber or Green Route Project for Consideration (Red Route Projects only)		

Section 6: Confirmation of Adherence to Basic Ethical Principles for Amber and Red Route Projects

Complete the Table below with guidance from your supervisor. If you need to tick any of the 'red' boxes, then your project must be submitted under the 'Red Route'.

		Yes	No	N/A
6.1	I will describe the main research procedures to participants in advance so that they know what to expect. I will use the sample Information Sheet provided by PEC to do this.	X		
6.2	I will tell participants that their participation is voluntary.	X		

6.3	I will obtain written consent from participants using a 'tick' consent form which follows the current template provided by PEC prior to starting data collection.	X		
6.4	I will verify that participants still wish to include their data in online studies by including a final indicator of consent at the end of the questions.	X		
6.5	If my research involves content analysis or observation in any private or partially private setting then I will ensure to obtain informed consent prior to collecting data.	X		
6.6	I will explain to participants that they can withdraw from the study at any time and for any reason.	X		
6.7	I will ensure that participants know that they can refrain from answering any question that they don't want to, even if this is part of a psychometric scale.	X		
6.8	If using an online data collection method I will ensure that the only questions which require answers in order to proceed are the questions relating to providing informed consent, and I will ensure that participants are provided with an option which indicates that they do not give their consent.	X		
6.9	I will inform participants that their data will be treated with full confidentiality, and that, if published, it will not be identifiable as theirs.	X		
6.10	I will debrief participants at the end of their participation (i.e. give them a brief explanation of the study, whether or not deception was involved) following the current template provided by PEC	X		
6.11	I will obtain passive consent from parents/guardians for studies involving people aged between 16 and 18 years, as well as active consent from the participant and their school/organisation			X
6.12	I will obtain active consent from parents/guardians for studies involving people aged under 16 years. Where feasible I will also obtain active consent from the participant themselves. I will ensure that the parent/guardian or their nominee (e.g. a teacher) will be present throughout the data collection period.			X
6.13	I will ensure that my project supervisor has full access to the data that I collect and will only use data collection software which permits this.	X		
6.14	I will ensure that my project supervisor retains full rights to the data collected, including the ability to delete all data at any time, and that third-parties (e.g., software companies) will not 'own' the data collected.	X		
6.15	I will ensure that participants in studies involving Virtual Reality (VR) are not susceptible to extreme motion sickness or other physical conditions which may result in harm to the participants. I will ensure that a chaperone is present during VR sessions, and that the participant has the option of also having a nominee of their choosing present as well.	X		
6.16	I will ensure that any equipment used in this study is cleaned and disinfected after each participant, and that appropriate hygienic barriers (e.g. masks) are used by all participants	X		

6.17	Is there any realistic risk of any participant experiencing either physical or psychological distress or discomfort?		X	
6.18	I plan to use animals as part of my research study		X	
6.19	I plan to tell participants their results on a task or scale which I am using in my research.		X	
6.20	I am researching a sensitive topic which may cause some participants distress (such as, but not limited to, religion, sexuality, alcohol, crime, drugs, mental health, physical health, parenting, family relationships)		X	
6.21	One or more aspects of my study is designed to change the mental state of participants in a negative way (such as inducing aggression, frustration, sadness, etc.)		X	
6.22	My study involves deception or deliberately misleading participants in some way.		X	
6.23	My target population includes people who have learning or communication difficulties		X	
6.24	My target population includes patients (either inpatient or outpatient)		X	
6.25	My target population includes people in custody		X	
6.26	My target population includes people who may feel under personal or professional pressure to take part in my research (for example, close friends; family; employees or staff of managers or school principals who may support the research).		X	
6.27	My project includes the use of any illegal materials or substances as part of the materials for the study, regardless of methodology employed.		X	
6.28	My project includes the use of any dangerous materials or substances as part of the materials for the study, regardless of methodology employed.		X	

6.29	My project employs ethnographic or autoethnographic methodologies.		X	

Section 7: Declaration of an Amber Route project

I hereby declare that [all of / this aspect of (delete as appropriate)] my project involves no risk of physical, emotional, social or cognitive harm to participants; that I will obtain full informed consent from all participants and provide a full debrief afterwards (using the templates provided); that I will provide full anonymity and/or confidentiality to participants; and that my participants are not a potentially vulnerable population. In addition, I will ensure that all data which I gather is held in a manner which is compliant with GDPR, and will be deleted once it is no longer required (and definitely within 6 years of collection). At all times my study will be conducted in adherence to the ethical policies of the Psychological Society of Ireland and the British Psychological Society.

Student Signature: Sara Curran

Appendix L – Images from the 360-VR Environment and Demonstration

Figure 1

Images from the 360-VR environment, and demonstration of the headset in use

Link to 360-VR YouTube Video: https://youtu.be/Zn1vtwPBfVM

Appendix M – Images from the CG-VR Environment and Demonstration

Figure 2

Images from the CG-VR environment, and demonstration of the headset in use

Link to CG-VR environment in Spatial: https://www.spatial.io/s/Berkeley-Forest-674a6468c177088a69b3af74?share=5661001845758778168

Appendix N – Descriptive Statistics for Presence by VR group

Table 1

Descriptive Statistics for Presence by VR group

					Statistic	Std. Error
			Descriptives			
	VR group				Statistic	Std. Error
Nature Connectedness	Group A - 360-VR	Mean			4.81	.335
		95% Confidence Interval for Mean	Lower Bound		4.11	
			Upper Bound		5.51	
		5% Trimmed Mean			4.90	
		Median			5.00	
		Variance			2.362	
		Std. Deviation			1.537	
		Minimum			1	
		Maximum			7	
		Range			6	
		Interquartile Range			2	
		Skewness			-.835	.501
		Kurtosis			.655	.972
	Group B - CG-VR	Mean			4.81	.306
		95% Confidence Interval for Mean	Lower Bound		4.17	
			Upper Bound		5.45	
		5% Trimmed Mean			4.84	
		Median			5.00	
		Variance			1.962	
		Std. Deviation			1.401	
		Minimum			2	
		Maximum			7	
		Range			5	
		Interquartile Range			2	
		Skewness			-.230	.501
		Kurtosis			-.794	.972

Appendix O – Boxplot of Presence Score by VR environment

Figure 3

Boxplot of participant's Presence scores filtered by VR environment (360-VR and CG-VR)

Appendix P – Assumption of Normal Distribution for Presence by VR Environment

Table 2

Test of Normality for Presence by VR environment, Normal Distribution is assumed

		Tests of Normality					
		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	VR group	Statistic	df	Sig.	Statistic	df	Sig.
Total Presence	Group A - 360-VR	.159	21	.176	.963	21	.582
	Group B - CG-VR	.103	21	.200[*]	.979	21	.903

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Appendix Q – Violated Assumption of Homogeneity of Variance for Presence by VR environment

Table 3

Violation of Homogeneity of Variance for Presence by VR environment

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | 95% Confidence Interval of the Difference | |
		F	Sig.	t	df	One-Sided p	Two-Sided p	Mean Difference	Std. Error Difference	Lower	Upper
Total Presence	Equal variances assumed	4.445	.041	.056	40	.478	.955	.28571	5.06515	-9.95134	10.52277
	Equal variances not assumed			.056	34.826	.478	.955	.28571	5.06515	-9.99893	10.57036

Independent Samples Test

Appendix R – Independent t-test output

Table 4

Independent t-test output and confirmation of no difference in Presence based on VR environment

T-Test

Group Statistics

	VR group	N	Mean	Std. Deviation	Std. Error Mean
Total Presence	Group A - 360-VR	21	114.7143	19.31875	4.21570
	Group B - CG-VR	21	114.4286	12.86690	2.80779

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means		Significance		Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
		F	Sig.	t	df	One-Sided p	Two-Sided p			Lower	Upper
Total Presence	Equal variances assumed	4.445	.041	.056	40	.478	.955	.28571	5.06515	-9.95134	10.52277
	Equal variances not assumed			.056	34.826	.478	.955	.28571	5.06515	-9.99893	10.57036

Independent Samples Effect Sizes

		Standardizer[a]	Point Estimate	95% Confidence Interval	
				Lower	Upper
Total Presence	Cohen's d	16.41297	.017	-.588	.622
	Hedges' correction	16.72895	.017	-.576	.610
	Glass's delta	12.86690	.022	-.583	.627

a. The denominator used in estimating the effect sizes.
Cohen's d uses the pooled standard deviation.
Hedges' correction uses the pooled standard deviation, plus a correction factor.
Glass's delta uses the sample standard deviation of the control (i.e., the second) group.

Appendix S – G*Power Analysis for Presence by VR environment

Appendix T – Descriptive Statistics for Nature Connectedness by VR Environment

Table 5

	VR group			Statistic	Std. Error
Descriptives					
Nature Connectedness	Group A - 360-VR	Mean		4.81	.335
		95% Confidence Interval for Mean	Lower Bound	4.11	
			Upper Bound	5.51	
		5% Trimmed Mean		4.90	
		Median		5.00	
		Variance		2.362	
		Std. Deviation		1.537	
		Minimum		1	
		Maximum		7	
		Range		6	
		Interquartile Range		2	
		Skewness		-.835	.501
		Kurtosis		.655	.972
	Group B - CG-VR	Mean		4.81	.306
		95% Confidence Interval for Mean	Lower Bound	4.17	
			Upper Bound	5.45	
		5% Trimmed Mean		4.84	
		Median		5.00	
		Variance		1.962	
		Std. Deviation		1.401	
		Minimum		2	
		Maximum		7	
		Range		5	
		Interquartile Range		2	
		Skewness		-.230	.501
		Kurtosis		-.794	.972

Appendix U – Boxplot of Nature Connectedness by VR Environment

Figure 4

Boxplot of participant's Nature Connectedness scores filtered by VR environment (360-VR and CG-VR)
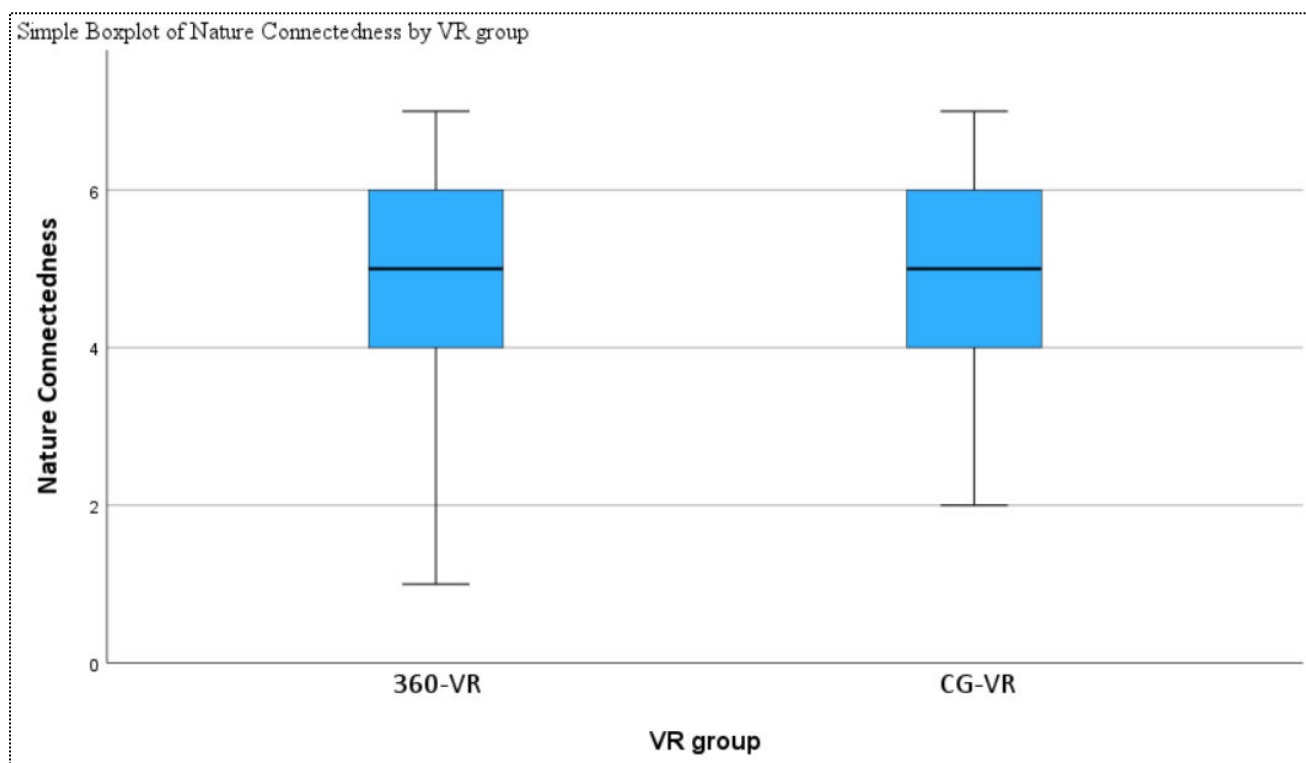
Appendix V – Mann-Whitney U test for Nature Connectedness by VR Environment

Table 6

Mann-Whitney U test for Nature Connectedness by VR Environment

NPar Tests

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Nature Connectedness	42	4.81	1.452	1	7
VR group	42	1.50	.506	1	2

Mann-Whitney Test

Ranks

	VR group	N	Mean Rank	Sum of Ranks
Nature Connectedness	Group A - 360-VR	21	21.79	457.50
	Group B - CG-VR	21	21.21	445.50
	Total	42		

Test Statistics[a]

	Nature Connectedness
Mann-Whitney U	214.500
Wilcoxon W	445.500
Z	-.155
Asymp. Sig. (2-tailed)	.877

a. Grouping Variable: VR group

Appendix W – G*Power Analysis for Nature Connectedness by VR Environment
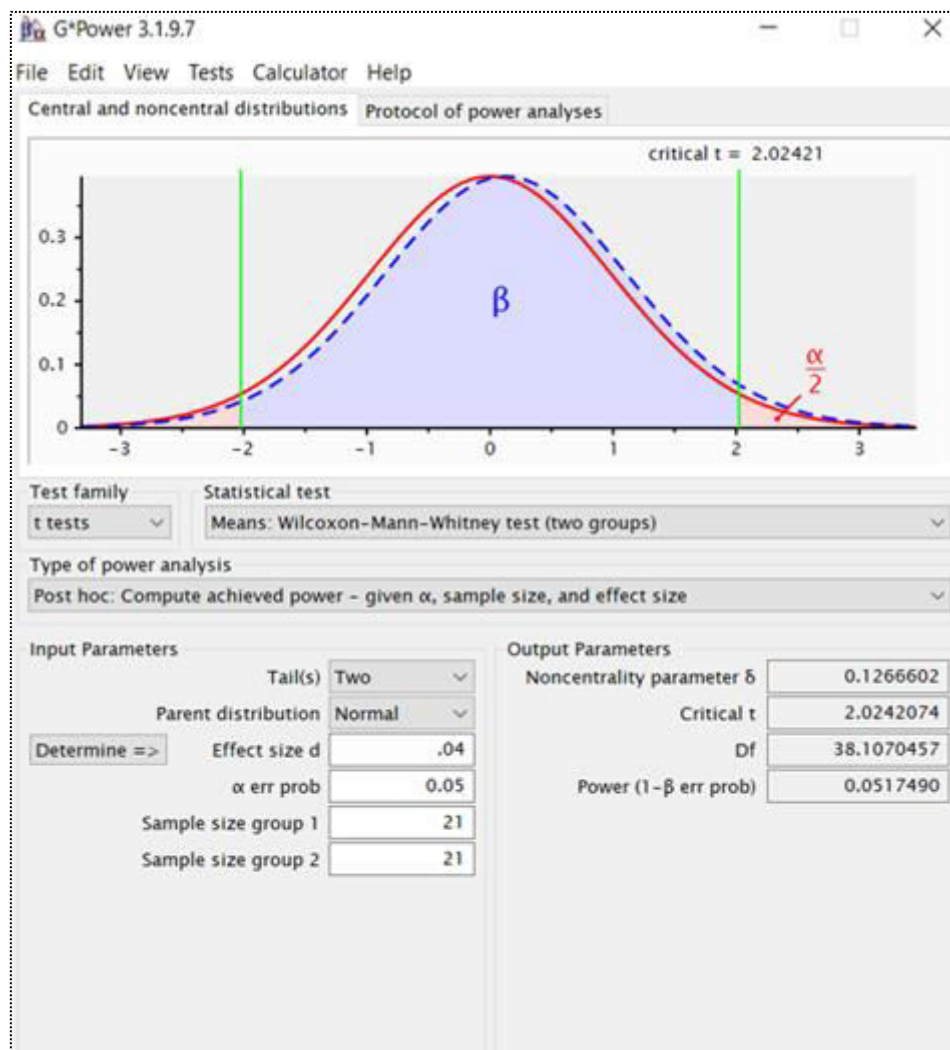
Appendix X – Descriptive statistics for Presence by Nature Connectedness

Table 7

Descriptive statistics for Presence by Nature Connectedness

Descriptives			Statistic	Std. Error
Nature Connectedness	Mean		4.81	.224
	95% Confidence Interval for Mean	Lower Bound	4.36	
		Upper Bound	5.26	
	5% Trimmed Mean		4.87	
	Median		5.00	
	Variance		2.109	
	Std. Deviation		1.452	
	Minimum		1	
	Maximum		7	
	Range		6	
	Interquartile Range		2	
	Skewness		-.554	.365
	Kurtosis		-.068	.717
Total Presence	Mean		114.5714	2.50160
	95% Confidence Interval for Mean	Lower Bound	109.5193	
		Upper Bound	119.6235	
	5% Trimmed Mean		114.8254	
	Median		118.5000	
	Variance		262.836	
	Std. Deviation		16.21222	
	Minimum		77.00	
	Maximum		149.00	
	Range		72.00	
	Interquartile Range		23.25	
	Skewness		-.234	.365
	Kurtosis		-.493	.717

Appendix Y – Spearman's Correlation for Overall Presence and Nature Connectedness

Table 8

Spearman's Correlation for Overall Presence and Nature Connectedness

Nonparametric Correlations

Correlations

			Nature Connectedness	Total Presence
Spearman's rho	Nature Connectedness	Correlation Coefficient	1.000	.480**
		Sig. (2-tailed)	.	.001
		N	42	42
	Total Presence	Correlation Coefficient	.480**	1.000
		Sig. (2-tailed)	.001	.
		N	42	42

**. Correlation is significant at the 0.01 level (2-tailed).

Confidence Intervals of Spearman's rho

	Spearman's rho	Significance(2-tailed)	95% Confidence Intervals (2-tailed)[a,b]	
			Lower	Upper
Nature Connectedness - Total Presence	.480	.001	.197	.689

a. Estimation is based on Fisher's r-to-z transformation.

b. Estimation of standard error is based on the formula proposed by Fieller, Hartley, and Pearson.

Appendix Z – Scatterplot of Overall Presence by Nature Connectedness

Figure 5

The relationship between Total Presence and Total Nature Connectedness, displayed in a Scatterplot
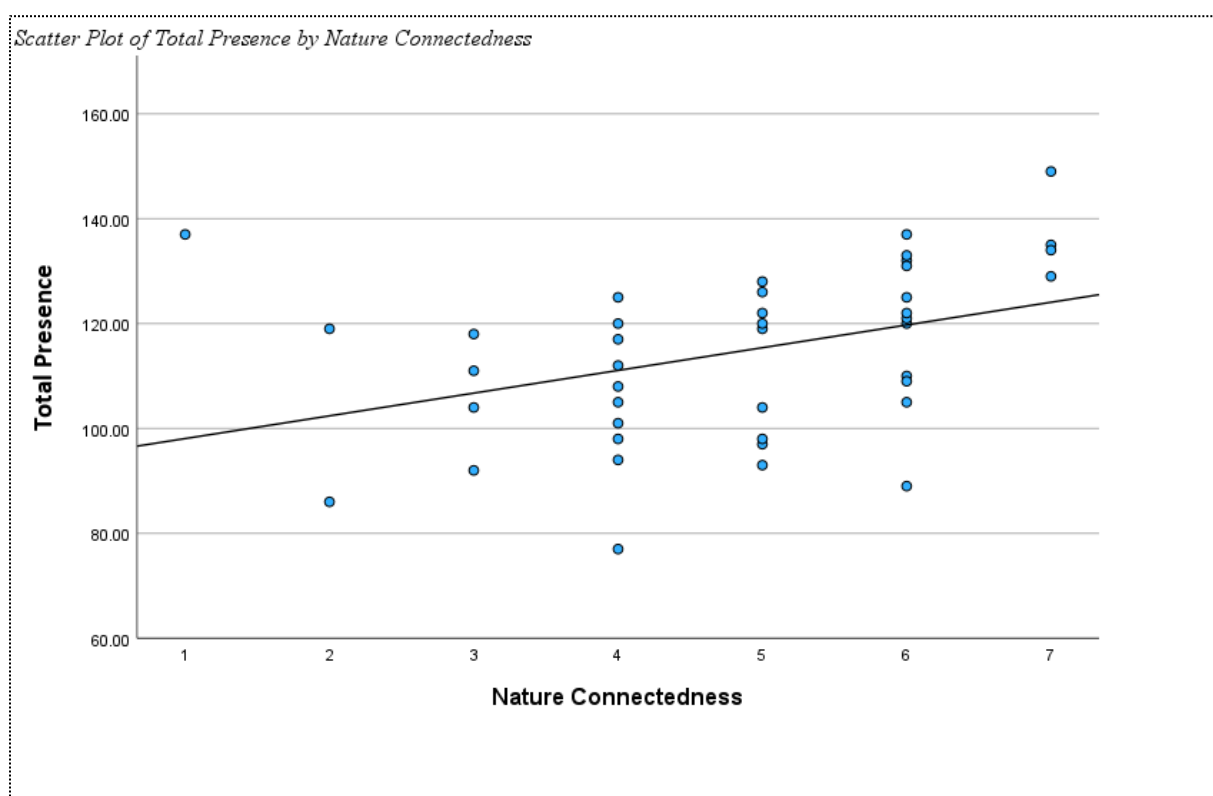
 Note. There was a moderate to strong positive correlation between presence and nature connectedness., $r = .480$, p $= .001$.

Appendix AA – Descriptive Statistics for Presence by Previous VR use

Table 9

Descriptive Statistics for Presence by Previous VR use

Group Statistics					
	Previous VR use - Have you ever used VR before?	N	Mean	Std. Deviation	Std. Error Mean
Total Presence	Yes, I have used VR	28	110.3214	15.76460	2.97923
	No, I have not used VR	14	123.0714	14.00255	3.74234

Appendix AB – Test of Normality for Presence by Previous VR use

Table 10

Assumption of Normal Distribution is met for Presence by Previous VR use

	Previous VR use - Have you ever used VR before?	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Total Presence	Yes, I have used VR	.173	28	.031	.952	28	.222
	No, I have not used VR	.118	14	.200[*]	.945	14	.493

Tests of Normality

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Appendix AC – Levene's Test for Presence by Previous VR use

Table 11

Assumption of Homogeneity of Variance is met for Presence by Previous VR use

Independent Samples Test

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | 95% Confidence Interval of the Difference | |
		F	Sig.	t	df	Significance One-Sided p	Significance Two-Sided p	Mean Difference	Std. Error Difference	Lower	Upper
Total Presence	Equal variances assumed	.537	.468	-2.560	40	.007	.014	-12.75000	4.98006	-22.81507	-2.68493
	Equal variances not assumed			-2.665	29.076	.006	.012	-12.75000	4.78340	-22.53204	-2.96796

Appendix AD – Independent t-test for Presence by Previous VR use

Table 12

Independent t-test for Presence by Previous VR use

T-Test

Group Statistics

	Previous VR use - Have you ever used VR before?	N	Mean	Std. Deviation	Std. Error Mean
Total Presence	Yes, I have used VR	28	110.3214	15.76460	2.97923
	No, I have not used VR	14	123.0714	14.00255	3.74234

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						95% Confidence Interval of the Difference	
		F	Sig.	t	df	Significance One-Sided p	Significance Two-Sided p	Mean Difference	Std. Error Difference	Lower	Upper
Total Presence	Equal variances assumed	.537	.468	-2.560	40	.007	.014	-12.75000	4.98006	-22.81507	-2.68493
	Equal variances not assumed			-2.665	29.076	.006	.012	-12.75000	4.78340	-22.53204	-2.96796

Independent Samples Effect Sizes

		Standardizer[a]	Point Estimate	95% Confidence Interval Lower	95% Confidence Interval Upper
Total Presence	Cohen's d	15.21433	-.838	-1.500	-.166
	Hedges' correction	15.50723	-.822	-1.472	-.163
	Glass's delta	14.00255	-.911	-1.626	-.168

a. The denominator used in estimating the effect sizes.
   Cohen's d uses the pooled standard deviation.
   Hedges' correction uses the pooled standard deviation, plus a correction factor.
   Glass's delta uses the sample standard deviation of the control (i.e., the second) group.

Appendix AE – Boxplot of Presence by Previous VR use

Figure 6

Boxplot of Presence by Previous VR use

Simple Boxplot of Total Presence by Previous VR use
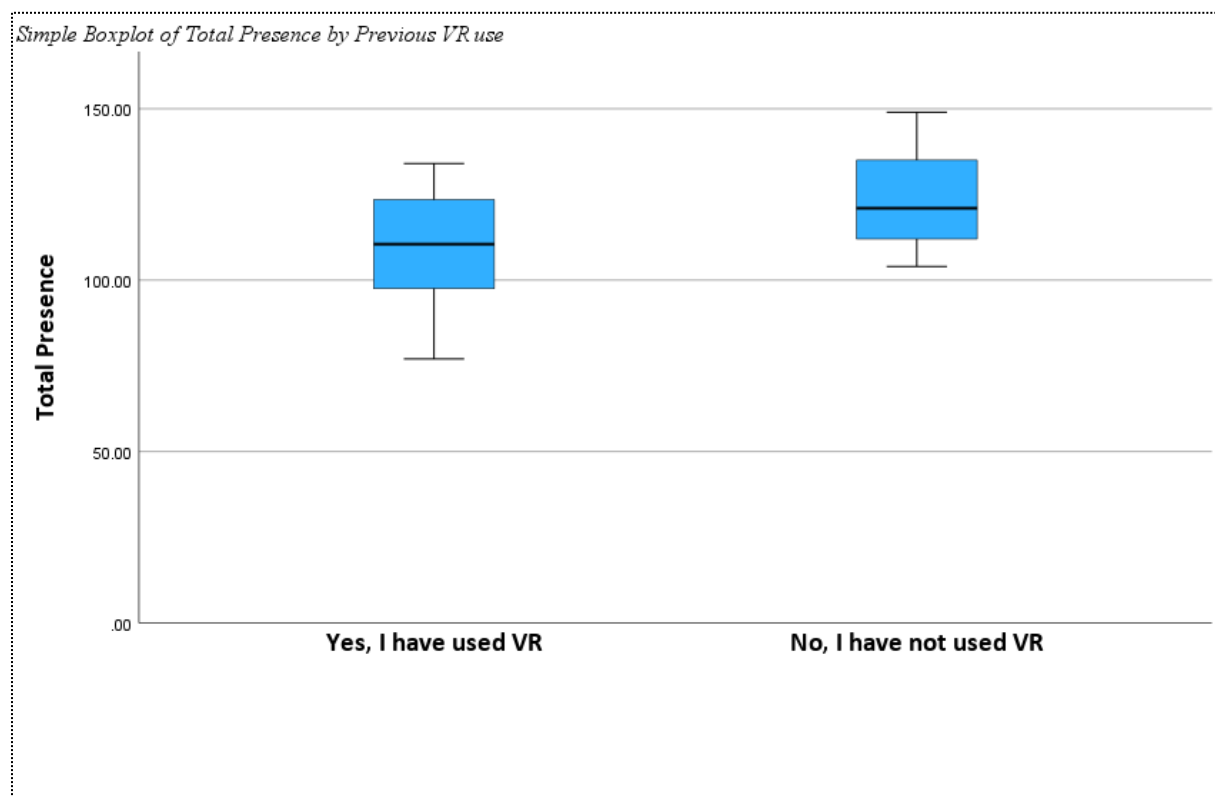
Appendix AF – Qualitative Feedback and Analysis of Key Themes

Table 13

Participants Feedback from 360-VR and CG-VR

360-video VR Environment	**Computer generated VR environment**
"I liked how the environment felt very familiar."	"I enjoyed the sounds and water." **Sounds**
"I really liked the sounds and the birds going around the place, making the experience feel more real. I felt pretty connected with nature, but I personally don't think it could be replaced." **Sounds , realism, connectedness**	"The sounds in the environment really helped to draw me in, if it was silent I don't believe that I would have been as involved. I have used a VR before, so I got a hang of the controls very quickly and easily." **Sounds, previous vr use**
"I found that VR realistically showcased a nature environment as well as it could. I would feel more immersed if the connection didn't cut out sometimes. Overall, an enjoyable study!" **Realism, quality**	"I think the sounds of nature such as the birds singing and the waterfall immersed me the most but the mechanism of moving which felt more like jumping through space felt unrealistic." **Sounds, realism**
"Even though the quality of vision was not perfect, and everything appeared a little blurry I found myself quite engrossed in the environment. The sound made it appear more realistic, while the only thing I missed was the feeling of the wind. I found it interesting that even while I knew I was sitting on a chair inside, it still felt like I was in nature at times." **Quality, sound, realism**	"I really enjoyed the experience overall. I felt immersed in the environment provided and believe **with improvements to the graphical and mechanical departments of the CG** it will become a great alternative to many difficult group tasks to plan consistently, like meetings, karaoke group nights, etc. Etc." **Quality, use as an alternative**
"I felt very **engrossed** in the scene and felt like I was sitting by the water. At first, I heard the river but couldn't see it until I turned around which I thought was really cool.	"I found the environment **more animated** than real life. Some aspects were more 2D (computer generated) than 3D (real life). I liked being able to move from place to place. I liked the sounds in the environment."

I particularly felt connected to the **movement of the water** and the little bumps in the river that water was rushing over, the movement of the trees in the wind and the fact there was a plane of something causing a line in the sky was so cool.” **Engrossed, movement**	**Realism, movement, sounds**
“I found the experience to be calming and enjoyable. The sounds of the river and birds were soothing, and the wind invoked fond memories of time spent outdoors. The VR aspect didn't detract from the experience in any way.” **Calming, sounds, memories, vr didn't distract**	“I found the experience very enjoyable. The hand controls were very easy to use and very user friendly. The visuals were good quality. I loved walking around it felt very relaxing like being inside a video game or cartoon. The VR headset was very user friendly too.” **Usability, relaxing**
“I felt like I could behave the same way I usually would in that environment minus the ability to walk around. It felt like I was sitting on a park bench bird watching the way I usually would. The VR was interesting but would break my relaxation/immersion with popups about recentering the screen when I looked to far left or right. I felt pretty present and was only drawn out of the nature by the popups and rare exterior noise in the building.” **Immersion, presence, distractions/quality**	“I liked walking around and observing the VR world! It was cool to walk across the bridge by the **waterfall** and then go to the beach and I spent a lot of time just looking up at the leaves of the trees. I think some of the **scale questions were hard to answer** as they talked about interacting with the world or completing a task where I did not really interact with the world much, moreso just walked through it and observed it, and I didn't have any task to complete. I enjoyed the experience.” **Water, difficult questions based on interaction**
“Very immersive, particularly the auditory aspects.” **Immersion, sound**	“Sitting down on the ground helped with immersiveness as I felt closer to the flowers and nature that way.” **Immersion from sitting**

|	
"It left me desiring to be in nature more than I am now. It put me in a new but familiar environment that I could believe to be true. and I think VR should be used to instill this desire for nature more often." **Nature connectedness/desire**	"It was surreal, I felt a sense of being there but also knowing it's not real. I found I was physically responding to the environment, when I landed in water, I felt a little panic but knew I was safe too. Enjoyable experience, especially the nature sounds." **Realism**
"I felt connected to nature with the mesh of natural sounds helping a lot. the visual quality does impact it from how blurry it was, but it still successfully immersed me. I felt calmer afterwards!" **Connected to nature, sounds, quality, immersion**	"Very connected, sound effects stood out and were very relaxing. Surprisingly very user friendly and had no issues." **Nature connectedness, sounds, user friendly/quality**
"I felt as if the sounds were very immersive particularly the birds and wind." **Sounds, immersion, birds**	"Sometimes things in the scene would effect performance, that took me out of the experience." **quality/performance**
"The Sounds from the video were nice to listen to and I got used to the VR after a while which made me enjoy the video more." **Sounds - enjoyable**	"Great for feeling involved in the natural landscape. Easy to learn controls." **Involvement, easy controls**
"I think once I sat down, I felt really calm and kind of like I was simulating the feeling during a nice walk outside, I think in particular for me the sounds made the experience much more engaging and relaxing, especially the wind in the branches and the birds. I also enjoyed the familiarity of the environment; it looked exactly like parks I have been walking throughout my whole life. I felt very connected to nature but still slightly aware that I was in VR due to the quality of the 360 video being slightly worse	"It was a very relaxing experience and as an urban dweller it provided me with an opportunity to connect with nature in an accessible way that I would not usually have access to. I enjoyed taking moments to sit still in the environment. I loved being on the bridge and taking time to look into the flowing water and just breath. Similarly, to sit under a grouping of trees and connect in with the movement of the branches and tune into the sounds of birds around me. I started to focus on what was in front of me rather than continually moving. I could feel my breathing relax and my heartbeat become more restful. It was a moment of calm in what is normally a hectic day."

than my eyesight. Kind of like I was on a walk with ill-suited glasses on." **Sounds, engaging, relaxing, connected to nature**	**Relaxing, nature connectedness, calm, water, sounds of birds, movement, accessibility**
"Experience was soothing, I felt I was there, I would like to continue using VR." **Relaxing, presence**	"I was surprised how quickly I was able to largely forget about my actual physical location and focus on the digital world in front of my eyes. The movement of the waterfall and the viewpoint provided by the bridges were very engaging." **Adapting, movement, engaging, water**
"It was very peaceful and relaxing, enjoying the nature and natural environment. The VR is very life-like, and helpful to use and quite comfortable to adjust to." **Relaxing, comforting**	"It felt so realistic like I was really walking past a mountain. I spent about 5 minutes in VR and it took me a minute to adjust back to the room I was actually in! This was my first time using VR and I was a bit nervous but I enjoyed it a lot" **Realistic, enjoyment**
"I found the experience very relaxing and therapeutic and almost felt sleepy during it as it was so relaxing and meditative." **Relaxing**	"I really liked the auditory aspects of the environment, when I heard the sound of the waterfall it felt relaxing." **Sounds, relaxation**
"I felt **connected to nature**, even though I was not outside. I liked the movement of the river, birds and skyline." **Connected to nature**	"I really enjoyed the experience, the environment was very relaxing and nice to look at. I enjoyed the water sounds and the sunlight. I enjoyed using VR." **Relaxing, sounds, water, enjoyment**
"Very positive experience with first time use of VR. Felt very natural and immersive." **Natural/ realistic, immersive**	"Definitely felt a connection to nature, the sounds helped. When I was near water and the sound of running was drew me in." **Sounds, nature connectedness**

	"Sense of 3D immersion in the environment was good." **Immersive**

Figure 7

Word cloud of Participant Feedback

18 respondents (46%) answered sounds for this question.

nature environment natural sounds
particularly felt   time   walk   sounds in the environment
liked   sound of the waterfall
sounds of nature   nature **sounds** environment
Definitely felt   experience   relaxing   VR   sounds and the birds
                                   connected with nature   water and the sound
aspects of the environment

Table 14

Themes identified from participants' feedback on 360-VR and CG-VR environments

Theme	360-VR Quotes	CG-VR Quotes
Auditory Immersion	"The sound made it appear more realistic" "I felt as if the sounds were very immersive particularly the birds and wind" "Very immersive, particularly the auditory aspects"	"I think the sounds of nature such as the birds singing and the waterfall immersed me the most" "The sounds in the environment really helped to draw me in, if it was silent I don't believe that I would have been as involved" "Definitely felt a connection to nature, the sounds helped"
Realism	"I found that VR realistically showcased a nature environment as well as it could" "Felt very natural and immersive" "The sound made it appear more realistic" "The VR is very life-like"	"It felt so realistic like I was really walking past a mountain" "It was surreal, I felt a sense of being there but also knowing it's not real" "I found the environment more animated than real life"

Movement and Spatial Presence	"I felt I was there" "I particularly felt connected to the movement of the water" "Sitting down on the ground helped with immersiveness as I felt closer to the flowers and nature that way"	"I liked being able to move from place to place" "To sit under a grouping of trees and connect in with the movement of the branches and tune into the sounds of birds around me" "The mechanism of moving which felt more like jumping through space felt unrealistic"
Relaxation	"I found the experience very relaxing and therapeutic and almost felt sleepy during it as it was so relaxing and meditative" "Experience was soothing" "I think in particular for me the sounds made the experience much more engaging and relaxing"	"I really enjoyed the experience the environment was very relaxing" "I could feel my breathing relax and my heartbeat become more restful" "I loved walking around it felt very relaxing like being inside a video game or cartoon"

Quality, usability and hardware	"Even though the quality of vision was not perfect...I found myself quite engrossed in the environment" "The VR aspect didn't detract from the experience in any way" "The visual quality does impact it"	"Sometimes things in the scene would effect performance, that took me out of the experience" "Surprisingly very user friendly and had no issues" "The VR headset was very user friendly too." "The hand controls were very easy to use and very user friendly"
Connectedness to nature, and a desire to spend time in nature	"I felt very connected to nature" "I felt connected to nature, even though I was not outside" "It left me desiring to be in nature more than I am now"	"Definitely felt a connection to nature, the sounds helped" "It provided me with an opportunity to connect with nature in an accessible way that I would not usually have access to"

Note. 360-VR = 360-degree video Virtual Reality; CG-VR = Computer-generated Virtual Reality