VIRTUAL REALITY AND MUSIC THERAPY'S IMPACT ON PEOPLE'S PSYCHOLOGICAL WELL-BEING

by

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A THESIS

Presented to the School of Journalism and Communication
and the Division of Graduate Studies of the University of Oregon
in partial fulfillment of the requirements
for the degree of
Master of Science

June 2021

THESIS APPROVAL PAGE

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Title: Virtual Reality and Music Therapy's Impact on People's Psychological Well-Being

This thesis has been accepted and approved in partial fulfillment of the requirements for the Master of Science degree in the School of Journalism and Communication by:

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Degree awarded June 2021.

THESIS ABSTRACT

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Master of Science

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June 2021

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People's psychological well-being is essential to study since past studies have indicated that negative mood can lead to many other significant health problems. Virtual reality and music therapy have both been used in the past for therapy but there is still limited research when using them together. This study examined the effectiveness of VR vs. 2D online interventions with various stimuli (audiovisual vs. visual only vs. audio only) to assess which interventions were effective. Additionally, this study examined which groups displayed the highest amount of presence to understand what elements are essential when increasing attention. The results suggest that even though VR participants generally experienced more presence and had similar benefits for positive mood, 2D groups were the only groups effective for reducing negative mood. These results suggest that there could be other psychological and theoretical considerations that may play a role into determining what online experiences are effective.

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ACKNOWLEDGMENTS

I wish to express my sincere appreciation to Professors Pimentel and Foxman for their assistance in the preparation of this manuscript during the pandemic. Additionally, special thanks are due to Professor Foxman, who graciously helped fund some of the recruitment efforts for this study.

For my parents, thank you for adopting me from Armenia many years ago, which positively impacted my life. This paper is dedicated in my hope for positively impacting other people's well-being.

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CHAPTER I

INTRODUCTION

This study explores the effects of various visual and audio enhanced therapy environments (2D and virtual reality) to understand its potential impact on people's psychological well-being. A person's psychological (subjective) well-being relates to a person's anxiety and mood levels (Moun, 1988; Schwarz & Clore, 1983; Yardley & Rice, 1991) and will be further examined in this study. Research on alleviating stress and negative mood is essential since stress can trigger and influence many diseases (Cohen et al., 2012). A more recent study also indicated that negative mood states can increase inflammation (Graham-Engeland et al., 2018), which can lead to cancer and tumor progression (Mantovani et al., 2008). In an increasingly stressful environment heightened by the Covid-19 pandemic, which has seen 40% of people reporting at least one adverse mental condition (Czeisler et al., 2020), it is essential to find solutions to deal with the mental health crisis. The use of opioids have become increasingly common among people with mental health issues (Davis et al., 2017) due to the fact they are misleadingly positively marketed (Turner et al., 2008), which is at odds with some research casting doubt on the effectiveness and harmful aspects of antidepressants for children and adults alike (Cipriani et al., 2016; Jones et al., 2018 Kirsch et al., 2008; Sullivan, 2018). The combined challenges of opioids being mostly ineffective/addictive and the inability to safely deliver in-person services for increased patient demand indicate a need for alternative solutions for in-person and online therapy.

Therefore, this study seeks to examine non-pharmaceutical solutions to mitigate people's poor mental health. Furthermore, virtual reality (VR) and music therapy (MT) may be a promising non-pharmaceutical intervention to work with when using an alternative approach aimed at increasing people's well-being since there have been encouraging results using VR (Maples-Keller et al., 2017) and MT (Pelletier, 2014) for health benefits. However, there has been limited research conducted using VR and MT together to understand if there are any additional potential health benefits for improving people's well-being.

VR represents a potential to continue to develop other non-pharmaceutical methods for improving health outcomes because it allows users to wear a head-mounted display (HMD) in order to experience a real-world sensory experience that contributes to people's perceived spatial presence of "being there" (Steuer, 1992). This creates a feeling that they are with others (i.e. social presence) in the virtual environment (Bailenson, et al., 2003). In addition, not only does VR allow for perceived presence in the environment but it also creates interactivity that allows the user to experience online simulations that appear realistic to real-world experiences (Bailenson et al., 2008). The realism that can be achieved with VR's online experiences can enhance the music and audio stimuli and create therapeutic presence and mindfulness that may not be as possible within a 2D environment. Therefore, this study seeks to build upon the theory of presence by using VR with MT together to explore VR's impact on people's psychological well-being by inducing people with deep relaxation through visual-auditory stimulation.

In chapter II, past literature on VR and MT with a focus on both of their capabilities in the health field as well as introducing the aims and research questions will be addressed. Chapter III will detail the experimental procedure undertaken to validate the research questions. Chapter IV will show the results of the study. In chapter V, the main takeaways from the results as well as limitations will be discussed. Lastly, chapter VI will end with the conclusion.

CHAPTER II

LITERATURE REVIEW

Defining music therapy

Music therapy is defined in various ways but the main goal of it is the same since it is a form of art that as the potential to affect people in a multitude of ways (Stanczyk, 2011). A major component of music therapy that will be explored in this study is the "receptive" based listening that is perceived by Biley (1992) as a method for controlled listening to music to have physiological, psychological, and emotional impact on the individual that is commonly used for treating depression and anxiety.

Music therapy benefits

Music not only is able to stimulate the brain area that regulates feeling of reward, basal ganglia (Brodal et al., 2017), but also can decrease the release of cortisol (stress hormone) such as when a person is attending a musical performance(Fancourt & Williamon, 2016). Furthermore, a number of pilot and experimental studies have focused on positive aspects of music when relieving stress for patients such as those who are terminally ill (Bolwerk, 1990; Curtis, 1986) and helping patients before surgery (Graf et al., 2009). In addition, a meta-analytic review of 22 quantitative studies indicated that music alone can be used to reduce stress and arousal. The studies highlighted were associated with treating patients or students who experienced stress. (Pelletier, 2004). While the meta-analytic review does not mention why music is beneficial, other studies have found that it lowers anxiety due to lowering blood pressure, increasing positive mood, and causing a healthier heart rate (Bradt et al., 2011). Additionally, further research has indicated positive results for people completing stress cognitive tasks and music therapy (Burns et al., 2002). Lastly, empirical evidence indicates that music therapy can help benefit people with cognitive and psychological problems (Gomez & Gomez, 2017; Ray & Mittelman, 2017).

Type of music most beneficial

Research has also focused on what kind of music and sound are beneficial for participants. Listening to “soothing and calming music” was measured to be more effective in reducing stress than listening to nature sounds such as rippling water (Thoma et al., 2013, p. 4). Additional research has concluded that classical music and designer music (music that is designed to have an effect) showed the most promising results for relaxation and mental clarity (McCraty et al., 1998). Classical music is effective due to the sympathetic nerve being more suppressed compared to rock music (Umemura & Honda, 1998). Other peer-reviewed studies reviewed this hypothesis and confirmed that classical music, such as listening to Mozart’s *Eine Kleine Nachtmusik*, was stress-relieving for participants (Smith & Joyce, 2004).

Additionally, other research focused on the effectiveness of preferred music of people versus non-preferred music and concluded that while preferred genres and artists by people are significantly more effective at reducing pain (Mitchell & Macdonald, 2006), preferred music was not significantly more stress-relieving than non-preferred music. However, they were more effective than not listening to music in general (Walworth, 2003).

Defining virtual reality

Definitions for virtual reality have varied due to the ever-evolving nature of the technology itself. Many have characterized VR as head-mounted displays (HMDs, three-dimensional (3D), or 360-degree video virtual environments to more broader systems that encompasses any technological system that immerses a user (Gregg & Tarrier, 2007). While there are some differences in defining this technology, many regard VR as a method for allowing users to explore and engage within computer generated worlds that generate a sense of presence, "losing oneself" (Fox et al., 2009). VR research have indicated that the immersive environments can create strong feelings of "presence for participants" (Riva et al., 2011; Riva & Waterworth, 2014). In addition, Lombard and Ditton (1997) have studied the various components of presence, which includes (1) realism, (2) transportation, (3) immersion, and (4) social richness. VR has continued to develop into a technology that has increased in presence for people due to substantial improvements in technology such as: (1) computer graphics, (2) processing power and (3) head-mounted displays (Gregg & Tarrier, 2007), which results in higher levels of interactivity between the environment and people (Ryan, 1999; Bailenson et al., 2008).

Virtual reality's impact on mental health

VR has been increasingly studied in a diverse amount of online environments (Annerstedt et al., 2013; Anderson et al., 2017) as a health relief for people, even though it is a relatively newer technique in the field (Rizzo & Kim, 2005). A 2017 review of VR literature within the medical health setting indicated that its use has been relatively safe and resulted in patient satisfaction (Dascal et al., 2017) indicating that further examination is appropriate for immersive technologies to be applied in therapeutic contexts (Maples-Keller et al., 2017). There are two main approaches when exploring VR relaxation and stress reduction such as those that create "generic environments" for passive users and those that require users to be active with interaction in the VR environment to train emotion regulation (Pizzoli, et al., 2019). This study seeks to explore the first approach regarding music-enhanced virtual therapy. VR research has been extensively studied when promoting stress relief for PTSD and most studies indicate a 66%-90% success rate since the technology overcomes many of the other problems of imaginal exposure (repeated and systematic recounting of a memory) due to its external visual and auditory stimuli for patients (Wiederhold & Wiederhold, 2008). Further research involving VR showed effective results for therapy for relieving phobias such as public speaking (Harris et al., 2004) as well as relieving stress and increasing positive mood states (Baños et al., 2004; Riva et a., 2007) A newer study confirmed the positive capabilities of VR in counteracting anxiety during a blood draw and those with the VR group increased in positive mood states (happiness, calmness) and a reduction of negative mood states like tension and fatigue (Tarrant, et al., 2019).

Music and sound enhanced virtual reality

While there are exciting possibilities with music in VR environments such as live concerts (Charron, 2017) and people indicating high satisfaction in those environments that have music (Brungardt et al., 2021; Deacon et al., 2017), there has been limited research within this area for therapy. Past research includes studies focusing on nature sounds having a positive effect on people in virtual environments (Annerstedt, et al.,

2013) and increasing enjoyment for exercise during VR with music (Bird et al., 2021). In addition, music therapy has also been taught within immersive experiences to create better learning outcomes (Story, 2014). Other research has examined using VR with music in pain management (Honzel, 2019) and kids with autism (Lima & Castro, 2012). Research that used VR and music found success in rehabilitation of memory-related cognitive processes (Optale et al., 2006) and anxiety with phobias such as heights (Seinfield, et al., 2016). There is very limited research when it relates to examining positive mood, but one study examined how MT and VR can help patients during chemotherapy improve their mood states and alleviate anxiety. While Chirico et al., (2020) focused on using music therapy in VR environments as a therapeutic distraction during chemo, this study will continue to expand knowledge about online environments and music therapy by examining people who are in a passive environment and are not specifically going through treatment to understand which environments (VR or 2D) and stimuli (visual and/or audio) are most beneficial for improving mood states for people in general.

Aims and research questions

In light of the preceding literature review which presented the gap in knowledge concerning music combined with VR therapeutic treatment (experiences that increase positive mood states and lower negative mood states) and discussion as to which elements of VR (visual and audio stimuli) are most helpful for therapy, the following research questions are proposed:

RQ1: Are there any differences across the VR and 2D environments with people experiencing MT and their well-being?

RQ2: What is the relationship between 2D and VR's audio and visual components and someone's perceived well-being?

RQ3: What is the relationship between 2D and VR's audio and visual components and someone's perceived presence?

CHAPTER III

METHODS

Design

To understand how delivering music therapy through VR may contribute to someone's mental well-being, the current study employed a 2 (modality: VR vs. 2D) x 3 (media richness: audio only vs. visual only vs. audiovisual) between-subjects experimental design. The study used a pretest and posttest with participants experiencing either one of the 2D groups (2D audiovisual, 2D visual only, or 2D audio only) or VR groups (VR audiovisual, VR visual only, or VR audio only). While there was no control group in this study, participants were randomly assigned to one of six conditions based on questions assessing their certain criteria, such as their access/use of VR equipment. Informed Consent and University Institutional Review Board approval was obtained before collection.

Participation and recruitment.

Participants were recruited via convenience sampling between April 4 - April 10 (2021) and were older than 18 years of age. They were recruited online from Amazon Mechanical Turk (online crowdsourcing website) due to restricted effects from recruiting and conducting the study in-person due to the current covid-19 pandemic. Participants received $2.50 by completing the study. Ultimately, we recruited 90 participants (56 males, 33 females, 1 prefer not to say) internationally. Full participant demographics are available in Table 1.

Table 1 Characteristics of included participants

Variables	2D groups (n = 45)	%	VR groups (n = 45)	%	Total	%
Gender						
Male	27	60%	29	64%	56	62.2%
Female	17	38%	16	36%	33	36.7%
Prefer not to say	1	2%	0	0%	1	1.1%
Age						
18-24	5	11%	2	4%	7	7.8%
25-34	21	47%	25	56%	46	51.1%
35-44	9	20%	12	27%	21	23.3%
45- 55	5	11%	5	11%	10	11.1%
55- 64	3	6%	1	2%	4	4.4%
65+	2	4%	0	0%	2	2.2%
Race						
Asian	16	36%	4	9%	22	22.2%
African American	2	4%	12	27%	14	15.6%
White	24	53%	27	60%	51	56.7%
Native Hawaiian	0	0%	1	2%	1	1.1%
Biracial	3	7%	1	2%	4	4.4%

The sample size calculation was carried out using G*Power software and was determined that a minimum sample size of 90 participants would provide 96% power at a two-sided 95% confidence interval, divided equally between the six groups and two measures, would provide 96% power at a two-sided 95% confidence interval (CI).

We did not formally screen participants for mental or physical health ailments, though we did screen for participants susceptible to simulation-sickness, which is a factor in shaping evaluations of VR content and is when there is a conflict between visual motion information and the VR scene that causes blurred vision and vertigo (Nooij et al., 2017; Nesbitt et al., 2017). Any participant who answered" somewhat likely" to "very likely" to the simulation-sickness question item concerning experiencing simulation-sickness was excluded from the VR groups.

Additionally, to attain valid responses, participants were also excluded if they failed the attention check question describing what online experience was presented (e.g. if they experienced the 2D visual and audio but said they experienced another experience). See Figure 1 for a full inclusion/exclusion participant flow.

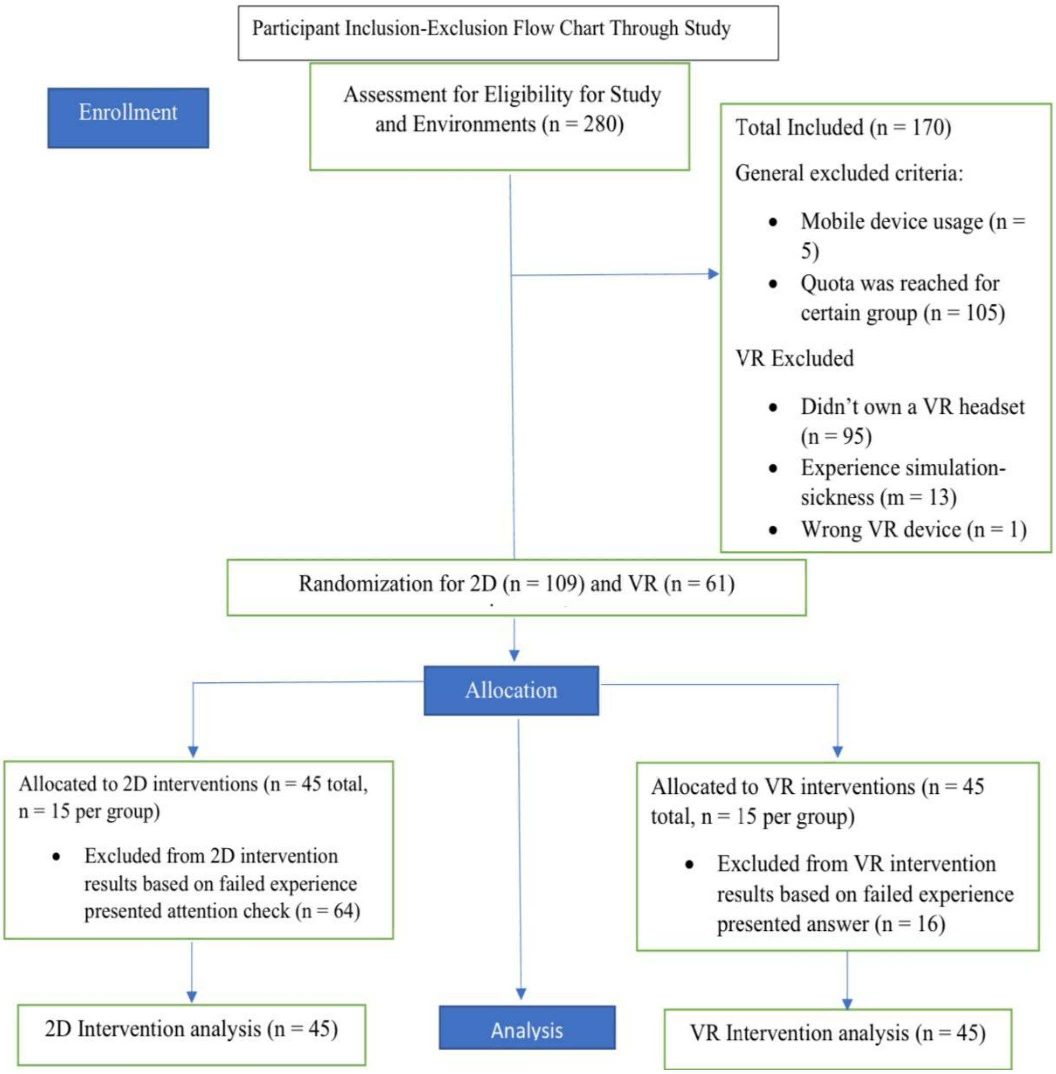

Figure 1 Inclusion/exclusion participant flow.

Materials and Measures

Online experience footage

The music therapy experiences consisted of 2D or VR experiences that were designed to be as similar as possible, with the obvious exception that some people would only view the online footage on their 2D screens while others would experience it in a VR 360-degree environment. Additionally, there were differences among sensory richness in which some groups had both audiovisuals while other groups were restricted to only viewing the experience with either visuals or audio only.

The six groups consisted of a choice of music based on empirical studies and theories of music that are associated with slow tempo and low pitches as being beneficial for reducing anxiety (de la Torre-Luque et al., 2017). The footage for this interaction was originally taken from a YouTube video named "Nocturnes by Candlelight - Deep Sleep and Relaxation", which included the instrumental song, *Piano at Midnight*, composed by Andrew Holdworth (2014). The full video on Youtube was imported into Adobe Premiere Pro to create a video of lasting only 3 minutes and 13 seconds long while also creating the three environments (audiovisual vs. visual only vs. audio only) that varied in sensory richness. Additionally, this video was selected due to the specific color shades and movement to fit with beats of the song in order to achieve the emotional purpose of the song (relaxation). The 2D experience consisted of only these elements (Fig 2). Conversely, The VR experience was created from using the above approach while additionally using Adobe Premiere Pro to create visuals to be on every side as the participant moves their head around as if they are in a 360-degree video (Fig 3).

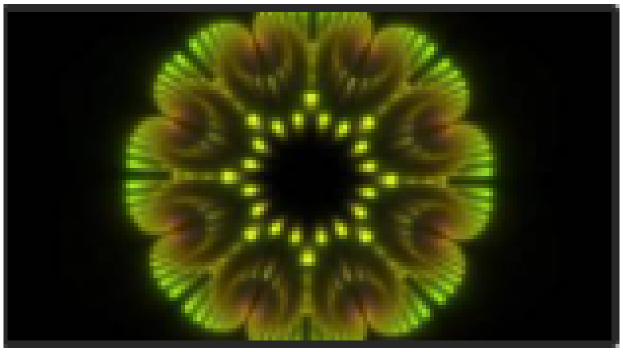

Figure 2: One frame from the 2D experience

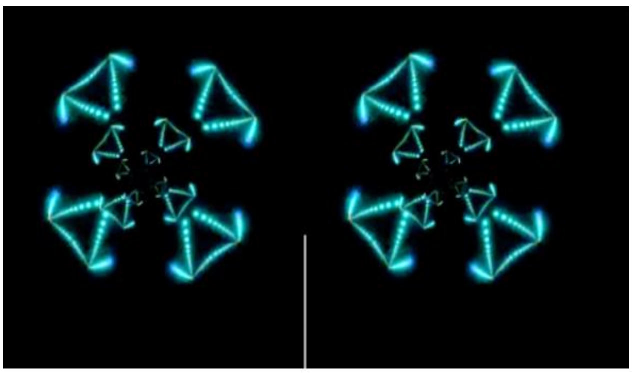

Figure 3 One frame from the 360-degree VR experience

Device used to access survey

The one-item question collected the participants' device that was used to access the study on Amazon Mechanical Turk to assess their eligibility for continuing the study. Participants who did not select "laptop" or "desktop" were dropped from the study due to the study needing a bigger screen to fully view the experience in 2D and understand the questions asked of them.

Demographic questionnaire

The demographics questionnaire served as a means of collecting information relating to the participant's gender identity, age, and racial identity. These variables were measured to understand our audience's background and roughly even distribution between VR and 2D groups and if there was a need to conduct further analysis.

VR inclusion/exclusion assessment questionnaire

To assess if participants were eligible to be in one of the three VR conditions (audiovisual, visual only, or audio only), participants answered up to three questions regarding owning a VR headset. If participants met all three conditions, they were randomly placed into one of the three VR conditions. Participants were asked if they currently own a VR headset and if they indicated "Yes," they continued to the next VR question. The next one-item question was collected as a means of identifying any group of potential VR simulation sickness symptoms (e.g., nausea and dizziness) that could cause a negative reaction for the participant. The item was assessed on a 4-point Likert scale and any participant who selected "somewhat likely" or "very likely" to experience simulation-sickness was randomly assigned to one of the VR groups. Conversely, any participant who selected "somewhat unlikely" or "very unlikely" was randomly assigned to one of the 2D groups (audiovisual, visual only, or audio only). Additionally, the last question related to what VR device they owned and if they selected "Other," they were randomly assigned to one of the 2D conditions instead of continuing to the VR experience due to the YouTube VR App only being compatible with certain VR devices.

Measurement of mood

To evaluate participant's perceived mood and psychological distress, all participants completed the Abbreviated Profile of Mood States Questionnaire (POMS) before and after the online 2D or VR experience. The POMS (Grove & Propavessis, 1992) consists of seven mood dimensions but one dimension, confusion, was dropped from the study due to past studies indicating that it was less reliable (Curran et al., 1995). In addition, this questionnaire was shortened due to concerns with the reliability of data collected through Amazon Mechanical Turk (Thomas & Clifford, 2017) to reduce measurement bias (Weisberg, 2005, p. 129).

The abbreviated POMS consists of a 5-point Likert scale with 35-items that evaluates the current emotional mood state of participants in terms of their level of tension, anger, fatigue, depression, esteem-related affect, and vigor. The total mood distance (TMD) is calculated by [tension + depression + anger + fatigue] - [vigor + esteem-related affect]. Overall, higher scores for TMD and negative mood states indicate higher negative mood while higher scores for positive subscales indicate better mood outcomes for participants. Reliability coefficients (Cronbach's alpha) scores for pre-test POMS subscales ranged from ($\alpha = 0.65$) to ($\alpha =0.93$) while the post-test subscales ranged from ($\alpha =0.75$) to ($\alpha =0.95$).

Measurement of spatial presence

To evaluate participants' perceived sense of being in the virtual space (spatial presence), participants completed the Spatial Presence Experience Scale (SPEC) after completing the experience and post-test POMS. The SPEC (Harmann et al., 2015) consists of 8-items on a 5-point Likert scale. The Spatial Presence Experience Scale was calculated by taking the average of the 8-items. Higher scores for the participants indicate higher perceived presence. The reliability coefficient (Cronbach alpha) for the scale was very reliable ($\alpha = .93$).

Procedure

The duration of the study from start to completion for each participant was approximately estimated to be between 15-25 minutes and all participants completed the study individually. Participants provided online written informed consent upon entering the study from Amazon Mechanical Turk. After agreeing to the informed consent form, participants completed the demographic and inclusion/exclusion questions that assessed what environment (2D or VR) they would be randomly placed into for the rest of the study.

Furthermore, VR participants completed additional questions to determine how much experience they had in virtual environments. After completing the initial stage questions, participants completed the abbreviated POMS scale (pre-test) and then were evenly randomly assigned to one of the following: (1) 2D groups (audiovisual, visual only, or audio only) or (2) VR groups (audiovisual, visual only, or audio only). Participants in the 2D conditions completed the experience after reading instructions that told them to select full-screen mode in the web browser they used to access the study on Amazon Mechanical Turk. Participants in the VR conditions were given more detailed instructions to follow than the 2D conditions since they had to find their 360-degree video on the YouTube VR App using their VR headset. VR participants completed the following instructions: (1) Downloaded the YouTube VR App, (2) Searched on the App with the experience link given to them and (3) Selected the full-screen mode and VR 360 setting and removed any toolbars. Participants in the VR conditions then watched and/or listened to the experience in their VR headsets.

After the experience was completed, participants completed the online experience attention check question. Only if participants selected the right answer based on their experience, they completed the abbreviated POMS scale (post-test) and then short-form SPEC. After participants completed the post-test questions, all participants filled out three additional questions concerning their experience and if they had additional questions.

CHAPTER IV

RESULTS

4.1 Data analysis strategy

All of the analyses for the three research questions were performed using SPSS 27 application (IBM Corporation, Somers, New York, USA). Additionally, all participants who completed the pre-test and post-test were included in the analysis. Individual participant scores for the pre-test and post-test were averaged and differences in means were compared to create the mood change variables used for the analysis. To assess differences in mood across the experimental groups, a one-way ANOVA was conducted. The results demonstrated that there were no significant differences across Time1(pre-test) Mood Disturbance, [$F(5, 84) = 1.66$, $p = .15$]. Further analysis using pairwise comparisons revealed that participants in the 2D audio group ($M = .14$, $SD = 5.19$) started with significantly lower mood disturbance than participants in the VR visuals only ($M = 3.78$, $SD = 2.73$) group ($p = .037$). Given this difference, the subsequent analyses included mood at Time1 as a covariate.

To address RQ1 (understand if 2D and VR groups were significantly different from one another), a two-way repeated-measures analysis of covariance (ANCOVA) was applied to compare the pre-test and post-test group mean scores (mood change) between the six (3 VR vs. 3 2D) groups from the psychological test questionnaires(POMS).

To address RQ2 (understand relationship between 2D and VR's audio and visual and perceived well-being), a series of pairwise comparisons using Fisher's LSD test were conducted from the same data used from the two-way analysis of covariance (ANCOVAs) to examine differences in mood disturbance over time across the experimental conditions. Furthermore, analysis using post-hoc pairwise comparisons using Fisher's LSD test for all groups were conducted to further understand what experimental condition was needed for effective therapy and if any conditions were more effective than others when reducing total mood disturbance.

Additional analyses using post-hoc pairwise comparisons using LSD test were conducted to understand which (if any) intervention(s) were more effective when reducing negative mood subscales (anger, tension, depression, and fatigue) and increasing positive mood subscales (vigor and esteem-related effect) compared to other groups. Higher means scores for mood change indicated a worse mood change while lower scores in the post-test indicated that the intervention was effective.

To address RQ3 (understand relationship between 2D and VR's audio and visual and perceived presence), a two-way ANCOVA was used to assess if there were any significant differences across online interventions and a person's perceived presence. Further analyses using post hoc pairwise comparisons using Fisher's LSD tests were also conducted to further illustrate which groups experienced the most presence compared to other groups.

Differences in VR and 2D environments

The pre-test and post-test group score changes across the six conditions. Overall, the results of the two-way repeated measures ANCOVA showed a significant difference in interaction effect between online experiences and total mood disturbance ($p < .001$, see Table 2). Conversely, the Time 1 mood covariate was nonsignificant ($p = .06$).

Table 2 Univariate Effects for the two-way ANCOVA analysis

Dependent variable	Effects	DF	F	*p* Value	n_p^2
Total Mood Disturbance	T1_covariate	1	3.628	.060	.042
	Mood change * Online experience*	1	3.177	.011	.161

a. Computed using alpha = .05
b. *Significant

Sensory richness and modality differences with online experiences

The study then investigated whether (modality: VR vs. 2D) and/or (media richness: audio only vs. visual only vs. audiovisual) influenced the magnitude of mood change among online interventions across time (mood change) to understand which online interventions were effective. A series of pairwise comparisons were conducted and the results indicated a main effect of modality on mood disturbance such that participants in the 2D conditions experienced a significant decrease in mood disturbance, whereas there were no significant change in the VR conditions (Table 3).

Table 3 Descriptive statistics for total mood disturbance levels (as measured by the POMS questionnaire) for each time group by online intervention, and indication of significant difference from pairwise comparison

Intervention	Time	Mean	SD	95% CI		Comparison *p* value
				LL	UL	
2D Audiovisual*****	pre-test	2.758	4.137	.664	4.852	<.001
	post-test	.013	4.070	-2.047	2.073	
2D Visual only*****	pre-test	.789	3.426	-7.746	9.324	<.001
	post-test	-1.197	3.885	-3.163	.769	
2D Audio only*****	pre-test	.138	5.187	-2.487	2.763	.001
	post-test	-1.518	5.384	-4.243	1.207	
VR Audiovisual	pre-test	3.004	4.627	.663	5.436	.132
	post-test	2.139	4.669	-.224	4.502	
VR Visual only	pre-test	3.778	2.727	2.398	5.158	.636
	post-test	3.374	2.236	2.242	4.506	
VR Audio only	pre-test	2.616	4.743	.216	5.016	.081
	post-test	1.664	4.828	-.779	4.107	

a. Computed using alpha = .05
b. *Significant

Moreover, pairwise comparisons indicated that there was significantly less mood disturbance between 2D audiovisual group and all of the VR groups such as VR audiovisual (p = .011), VR visual only (p <.001), and VR audio only (p =.017). Additionally, 2D visual only had significantly less mood disturbance than VR visual only (p = .014). Lastly, 2D audio only had significantly less mood disturbance than VR visual only (p = .035). There were no other significant differences between any of the other groups. Figure 4 reports the mood disturbance estimated means for each of the online experiences between pre-test and post-test.

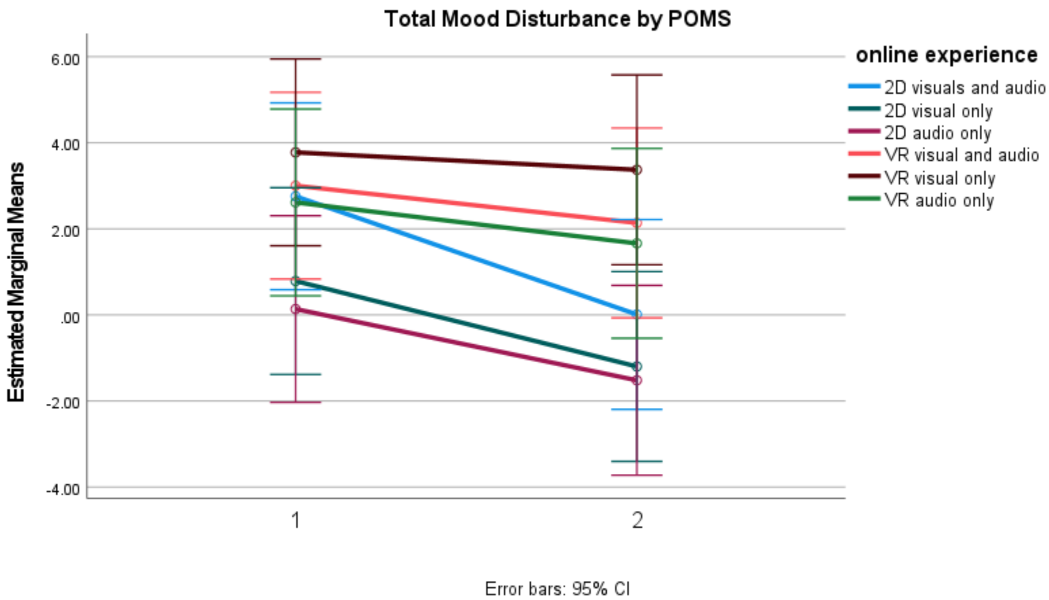

Figure 4 Mood Disturbance measured by POMS by online experience

Mood subscale results

Additionally, a series of repeated measures analysis of covariance (ANCOVAs) with the levels of the six mood states, as measured by the POMS (i.e. tension, depression, anger, fatigue, vigor and esteem-related affect) and online experience were conducted using the ANCOVA test. Results of the univariate effects from the analysis of covariance (ANCOVAs) are reported in Table 4.

The results from the univariate analysis of covariance of the subscales indicated that an interaction between the time (mood change) and across online experiences was only significantly different for both tension and fatigue subscales ($p < .05$, see Table 4). Conversely, the interaction between mood change and the covariate played a significant role in causing a non-significant result across conditions for both depression and esteem-related affect (p <.001, see Table 4).

Table 4 Univariate effects for analysis of covariance (ANCOVA), considering the subscales of the Profile of mood States (POMS)

Effect	Dependent variable	DF	F	p Value	n_p^2
Mood change	Tension	1	.820	.368	.010
	Depression*	1	7.482	<.001	.083
	Anger	1	.328	.569	.004
	Fatigue	1	.376	.542	.005
	Vigor	1	2.054	.154	.024
	Esteem-related Affect*	1	234.004	<.001	.738
Mood change * T1_Covariate	Tension	1	3.765	.056	.043
	Depression*	1	14.478	<.001	.149
	Anger	1	1.040	.311	.012
	Fatigue	1	1.289	.260	.015
	Vigor	1	2.473	.120	.029
	Esteem-related Affect*	1	10.357	<.001	.111
Mood change * Online experience	Tension*	5	6.186	<.001	.271
	Depression	5	2.069	.078	.111
	Anger	5	2.057	2.057	.079
	Fatigue*	5	3.090	.013	.157
	Vigor	5	.340	.887	.020
	Esteem-related Affect	5	1.037	.402	.059

a. Computer using alpha = .05
b. *Significant

Furthermore, a series pairwise comparisons were conducted to understand more specifically what online experiences were most effective for certain positive and negative subscale mood states. Full results for both positive and negative subscales are reported in Table 5 (see pages 31-32**)** as well as mean differences between online experiences reported in figures 5-10.

Tension

Pairwise comparisons showed significant reductions in the tension levels between the pretest and posttest for all the 2D groups. Conversely, result showed significant increase in anxiety levels for 2D visuals only and no other significant differences for the other two VR groups (Table 5). Moreover, pairwise comparisons indicated the 2D audiovisual group had significantly less tension than VR audiovisual (p =.009), VR visual only ($p < .001$), and VR audio only ($p = .033$). Additionally, 2D visual only group was significantly less in tension than VR audiovisual ($p = .018$) and VR (visual only ($p < .001$). There were no other significant differences between any of the other groups. Figure 5 reports the tension estimated means for each of the online experiences

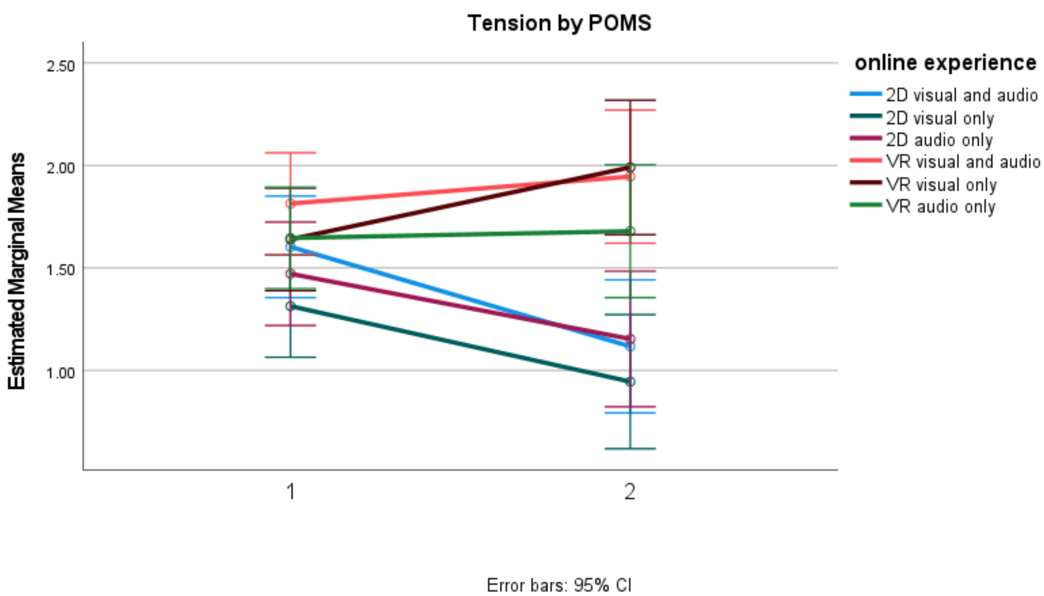

Figure 5 Tension measured by POMS by online experience

Anger

Pairwise comparisons showed significant reductions in the anger levels between the pretest and the posttest for only the 2D audiovisual group as no other groups significantly reduced or increased in anger (Table 5). Moreover, pairwise comparisons showed 2D audiovisual group having significantly less anger than 2D audio only (p = .034) and VR audio only (p = .010). Additionally, 2D visual group had significantly less anger than VR audio only (p = .048). There were no other significant differences between any of the other groups. Figure 6 reports the anger estimated means for each of the online experiences between pre-test and post-test.

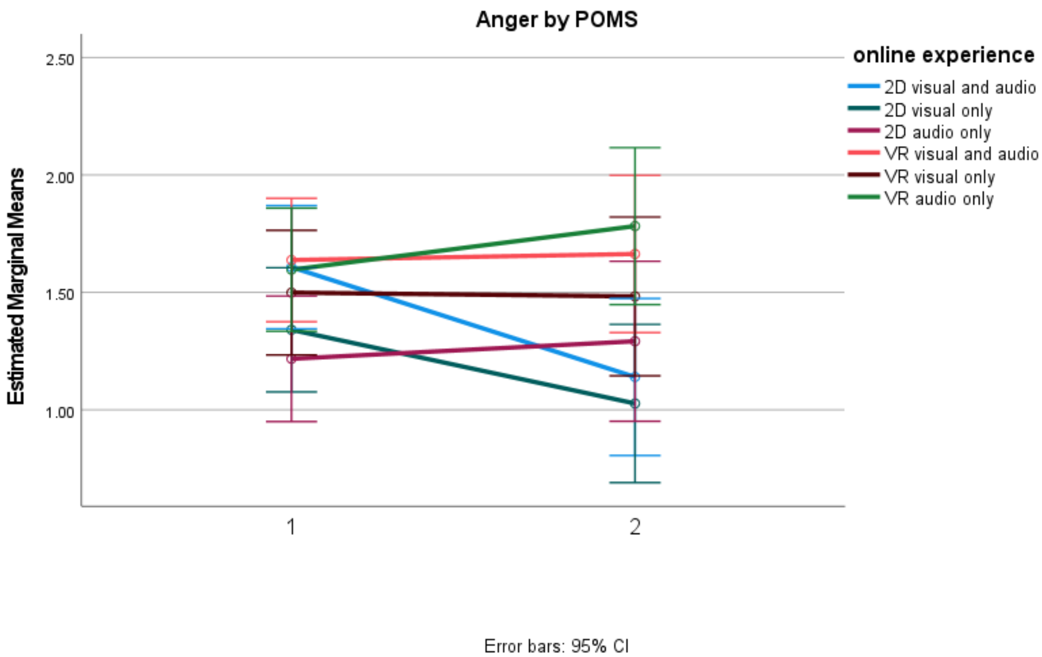

Figure 6 Anger measured by POMS by online experience

Depression

Pairwise comparisons showed significant reductions in the depression levels between the pretest and the posttest for only the 2D audiovisuals and 2D audio only groups as no other group had a significant decrease or increase in depression over time (Table 5). Moreover, pairwise comparisons showed 2D audiovisuals group having significantly less depression than VR audiovisual (p = =0.13), VR visual only (*p* = .012), and VR audio only (*p* = .009). There were no other significant interventions or differences among the groups for depression. Figure 7 reports the depression estimated means for each of the online experiences between pre-test and post-test.

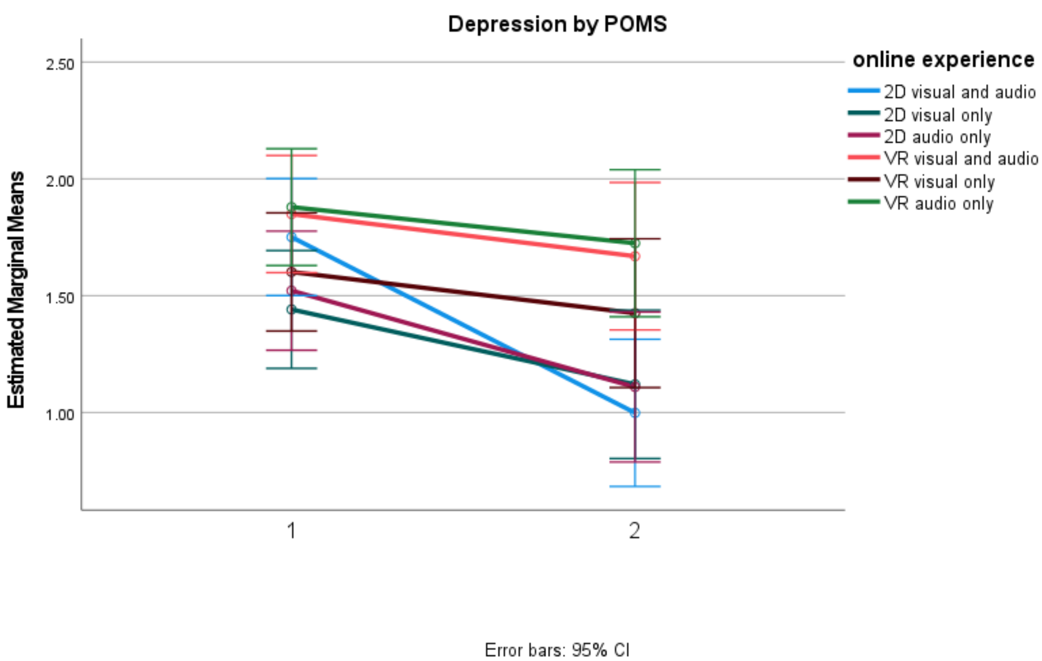

Figure 7 Depression measured by POMS by online experience

Fatigue

Pairwise comparisons showed significant reductions in the fatigue levels between the pretest and the posttest for only the 2D audiovisuals while the VR visuals only group significantly increased in fatigue (Table 5). Moreover, pairwise comparisons showed every group other than VR audio only had significantly less fatigue than VR visual such as 2D audiovisual ($p < .001$), 2D visual only ($p = .008$), 2D audio only, ($p = .008$), and VR audiovisual ($p = .019$). There were no other significant interventions or differences among the groups for depression. Figure 8 reports the fatigue estimated means for each of the online experiences between the pre-test and post-test.

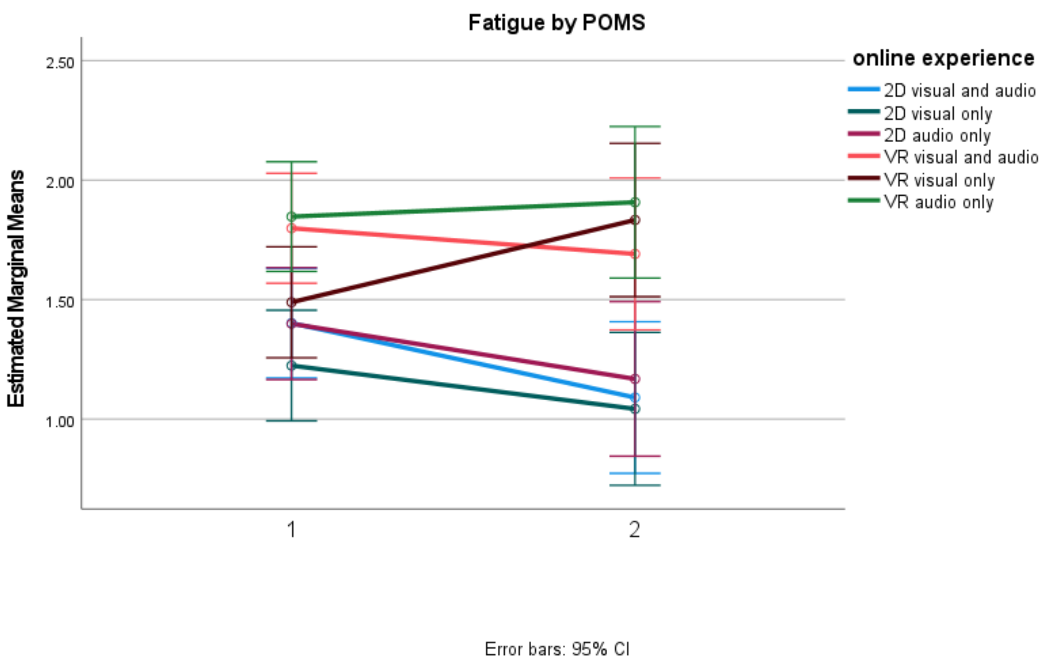

Figure 8 Fatigue measured by POMS by online experience

Vigor

Pairwise comparisons showed no significant reductions or increases in vigor levels between the pre-test and post-test for any of the 2D or VR groups (Table 6). Moreover, pairwise comparisons indicated that there were no significant differences between any the groups in vigor levels. Figure 9 reports the vigor estimated means for each of the online experiences between pre-test and post-test.

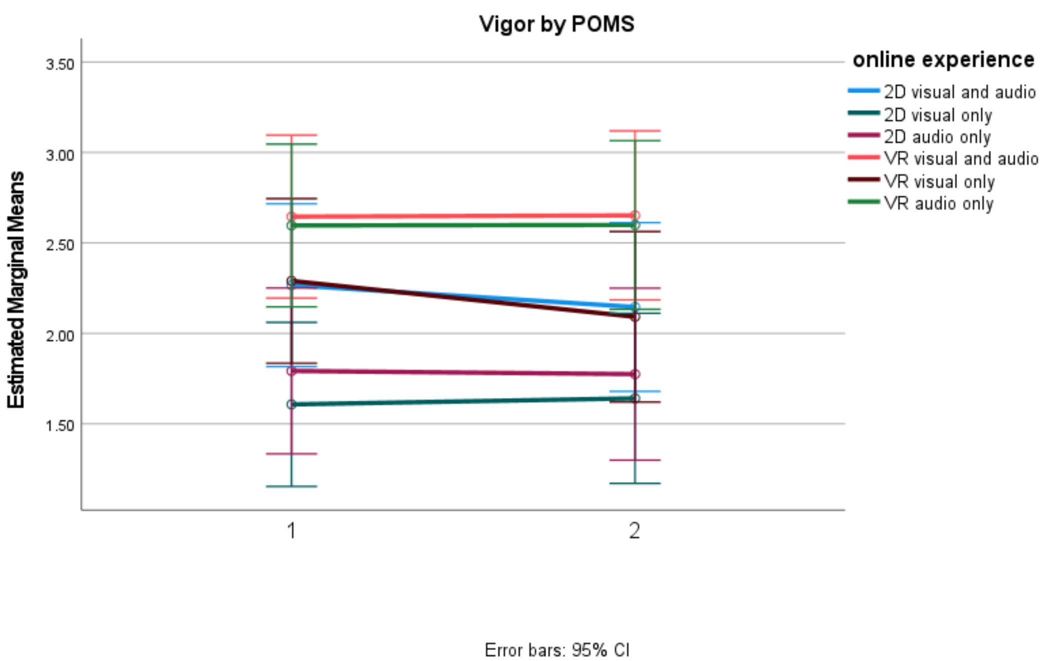

Figure 9 Fatigue measured by POMS by online experience

Esteem-related affect

Pairwise comparisons showed significant increases in esteem-related affect levels between the pretest and the posttest for every VR and 2D group (Table 6). Moreover, pairwise comparisons indicated that there were no significant differences between any of the groups in esteem-related affect. Figure 10 reports the esteem-related affect estimated means for each of the online experiences between pre-test and post-test.

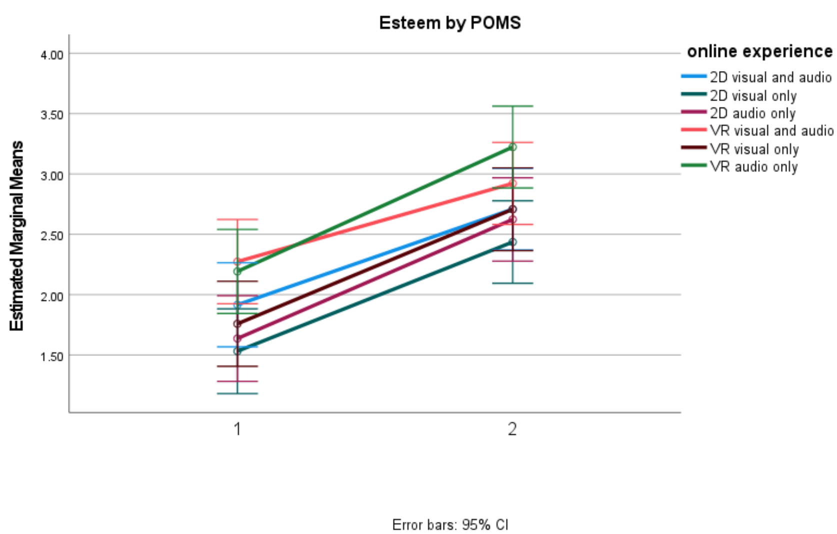

Figure 10 Esteem-related affect measured by POMS by online experience

Table 5 Descriptive statistics for the Profile of Mood States for every subscale, for each group by the time factor, and significance differences from pairwise comparisons

Measure	Intervention	Time	Mean	SD	95% CI		Comparison *p* value
					LL	UL	
Tension	2D Audiovisuals*	pre-test	1.733	1.083	1.185	2.282	<.001
		post-test	1.233	1.010	.722	1.744	
	2D Visuals only*	pre-test	1.000	.992	.498	.602	.006
		post-test	.667	.951	.185	1.148	
	2D Audio only*	pre-test	1.011	1.209	.399	1.623	.019
		post-test	.744	1.134	.170	1.318	
	VR Audiovisuals	pre-test	2.000	1.148	1.426	2.574	.314
		post-test	2.111	.742	1.736	2.486	
	VR Visuals only*	pre-test	2.000	.779	1.606	2.394	.009
		post-test	2.311	.742	1.935	2.687	
	VR Audio only	pre-test	1.744	1.130	1.172	2.316	.779
		post-test	1.767	1.190	1.165	2.369	
Anger	2D Audiovisuals*	pre-test	1.744	1.278	1.097	2.391	<.001
		post-test	1.267	1.218	.651	1.883	
	2D Visuals only	pre-test	1.011	1.188	.410	1.612	.079
		post-test	.722	1.085	.173	1.271	
	2D Audio only	pre-test	.733	1.109	.172	1.294	.677
		post-test	.722	1.341	.043	1.401	
	VR Audiovisuals	pre-test	1.833	1.208	1.222	2.444	.833
		post-test	1.844	1.181	1.246	2.442	
	VR Visuals only	pre-test	1.878	.825	1.461	2.295	.928
		post-test	1.833	.611	1.524	2.142	
	VR Audio only	pre-test	1.700	1.075	1.156	2.444	.292
		post-test	1.878	1.193	1.274	2.482	
Fatigue	2D Audiovisuals*	pre-test	1.533	1.036	1.009	2.057	.023
		post-test	1.213	1.021	.697	1.730	
	2D Visuals only	pre-test	.907	.928	.437	1.377	.184
		post-test	.747	1.024	.229	1.265	
	2D Audio only	pre-test	.933	1.102	.375	1.491	.095
		post-test	.733	1.081	.186	1.280	
	VR Audiovisuals	pre-test	1.987	1.175	1.392	2.582	.426
		post-test	1.867	1.158	1.281	2.453	
	VR Visuals only*	pre-test	1.853	.863	-434.900	436.700	.013
		post-test	2.173	.919	1.708	2.638	
	VR Audio only	pre-test	1.947	1.215	1.332	2.562	.656
		post-test	2.000	1.290	1.347	2.653	

Table 5 (continued).

Measure	Intervention	Time	Mean	SD	95% CI LL	95% CI UL	Comparison *p* value
Depression	2D Audiovisuals*	pre-test	1.911	1.352	1.227	2.595	<.001
		post-test	1.124	1.144	.545	1.703	
	2D Visuals only	pre-test	1.056	1.080	.477	1.635	.049
		post-test	.819	1.143	.241	1.397	
	2D Audio only*	pre-test	.956	1.391	.352	1.560	.013
		post-test	.667	1.151	.084	1.249	
	VR Audiovisuals	pre-test	2.078	1.536	1.301	2.855	.261
		post-test	1.848	1.293	1.194	2.502	
	VR Visuals only	pre-test	2.044	.878	1.600	2.488	.276
		post-test	1.771	.887	2.322	3.200	
	VR Audio only	pre-test	2.000	1.252	1.366	2.634	.333
		post-test	1.819	1.090	1.267	2.371	
Esteem-related Affect	2D Audiovisuals*	pre-test	1.911	.684	1.565	2.257	<.001
		post-test	2.678	.683	2.332	3.024	
	2D Visuals only*	pre-test	1.544	.853	1.112	1.976	<.001
		post-test	2.511	.689	2.162	2.860	
	2D Audio only*	pre-test	1.656	.790	1.256	2.056	<.001
		post-test	2.733	.881	2.287	3.179	
	VR Audiovisuals*	pre-test	2.267	.666	1.930	2.604	<.001
		post-test	2.878	.717	2.541	3.215	
	VR Visuals only*	pre-test	1.744	.462	1.510	1.978	<.001
		post-test	2.878	.619	1.336	4.420	
	VR Audio only*	pre-test	2.189	.450	1.068	3.310	<.001
		post-test	2.622	.520	1.327	3.917	
Vigor	2D Audiovisuals	pre-test	2.253	.996	1.749	2.757	.433
		post-test	2.147	.927	1.678	2.616	
	2D Visuals only	pre-test	1.640	1.085	1.091	2.189	.839
		post-test	1.640	1.020	1.124	2.156	
	2D Audio only	pre-test	1.840	.923	1.373	2.307	.910
		post-test	1.773	1.178	1.117	2.369	
	VR Audiovisuals	pre-test	2.627	.855	2.194	3.060	.964
		post-test	2.653	.890	2.203	3.103	
	VR Visuals only	pre-test	2.253	.648	1.924	2.581	.203
		post-test	2.093	.751	1.713	2.473	
	VR Audio only	pre-test	2.587	.648	2.259	2.915	.985
		post-test	2.600	.524	2.335	2.865	

a. Computed using alpha = .05
b. *Significant

Online Interventions and perceived presence

In order to assess if any of the online intervention groups had a significant impact on someone's perceived presence, a two-way analysis of covariance (ANCOVA) was conducted and the results indicated that there were significant differences across the various online intervention therapy groups and someone's perceived presence [$F(5, 83) = 7.55$, $p < .01$, $n_p^2 = .313$)]. Moreover, pairwise comparison showed the VR audiovisuals and VR audio only group experiencing significantly higher perceived presence than 2D visual only and 2D audio only ($p < .001$). Additionally, the VR visual only group experienced significantly higher perceived presence than 2D visual only and 2D audio only ($p = .001$). Conversely, 2D audiovisual group was significantly higher than 2D visuals only (p = 003). Figure 11 for online experience by presence.

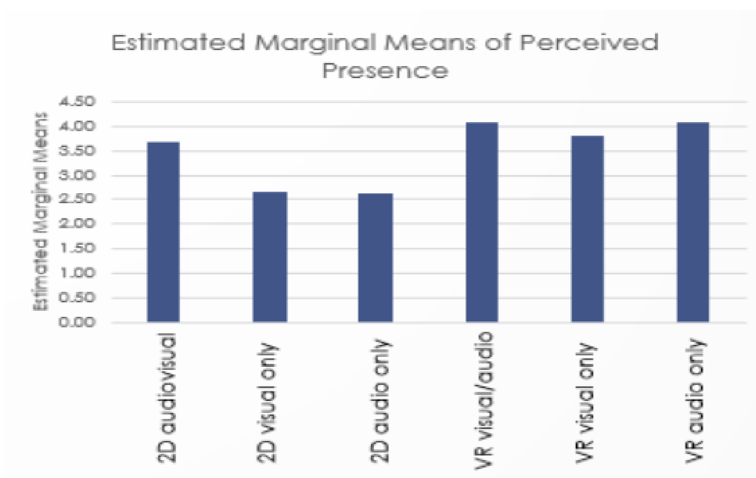

Figure 11 Estimated means difference for perceived presence by online experience

CHAPTER V

DISCUSSION

In this study, participants were asked to put themselves in various online environments to understand if there were any differences between the experimental conditions and mood. Overall, the results from the various statistical analyses indicated that broadly speaking, there were significant differences across the 2D and VR groups, which indicated that modality and media richness may play a role in people's music therapy experience **(RQ1)**.

Furthermore, additional analysis showed that 2D environments were the only conditions to significantly reduce total mood disturbance (TMD). Examining the results more closely showed significant benefits for the participants who were in the 2D audiovisual group as that condition led to every negative mood subscale significantly decreasing over time. 2D audio only was the next most effective group when reducing negative mood but that group of participants only benefited from decreasing tension and depression. Conversely, no VR group significantly reduced any negative mood states. In fact, VR visual only was the worst online treatment since participants had adverse effects in which participants increased their tension and fatigue levels.

Despite these counterintuitive findings for reducing negative mood, both 2D and VR groups were effective when significantly increasing positive mood such as esteem-related affect. These findings indicate that modality and media richness do play a significant role into what therapy is effective but runs counter to the prior assumption that these conditions would make VR therapy more effective **(RQ2)**.

While the results from research question 2 might predict that the 2D groups would experience the greatest amount of presence, the results indicated that VR groups experienced more presence than every 2D group other than 2D audiovisual. These results mostly align with past research indicating that people in VR would experience the most presence but these results also suggest that that if participants are in a sensory rich environment (2D audiovisual), it may not be as essential for people to only experience therapy in VR **(RQ3)**.

Theoretical and applied implications

The results from the analyses support past literature showing promising results for music therapy (McCraty et al., 1998). However, these results partly contradict past research presented in the literature indicating that VR would be an effective tool for therapy (Baños et al., 2004; Riva et a., 2007). Additionally, the results appear to mostly suggest that presence may not play as significant role in determining what experience is most effective treatment since 2D groups were overall significantly more effective.

There is still much debate among scholars about the role of presence within online environments as there could be a myriad of technological and message factors that may make immersive relaxation experiences more effective than their 2D counterparts (Moriya et al., 2019). While there is limited research comparing VR and 2D, one study examined the benefits of adapting 2D media-based health solutions to immersive platforms like VR such as mediation (Waller et al., 2021). Furthermore, discussion around presence should not solely focus on immersion of various visual and audio stimuli but also explore how users can interact more within their online environment. While past studies concerning VR, music therapy, and mood have not really explored active versus passive environments, other research using VR explored these differences when reducing pain and have found significantly more effective results when users were highly involved in the environment than those who just watched the experience (Dahlquist, et al., 2007; Gutierrez-Maldonado et al., 2011). Additionally, another researcher's study indicated that people who have personalities with tendencies toward cooperativeness and self-transcendence may experience more presence, which can result in more effective therapy than people with opposite personalities (Song et al., 2021). Even so, VR distraction has mostly been studied in specific research populations, such as chemo patients and burn wound victims (Chirico et al, 2020; Hoffman et al., 2011) indicating there should be serious inquiry into how VR can be applied to the general public.

Additionally, the results suggest that future examination is needed beyond the theoretical considerations of presence. Specifically, there are various psychological challenges when implementing VR online that are not prevalent for 2D experimental conditions in this study that could have impacted the results. Instructions for participants for VR conditions were much more strenuous than the 2D participants due to the onboarding process of downloading the YouTube app and selecting the right settings for the experience. While the instructions were not intentionally designed to be confusing, it was still a more tedious process, which could have presented a cognitive overload of information for the participant. Cognitive load theory refers to short-term or working memory having a limited capacity and if a person's memory is overloaded, the person may not be able to process anything well (Sweller, 2010). While taking this theory under consideration, it makes sense that VR groups would increase in fatigue. Thus, the increase in fatigue would impact other mood states since fatigue degrades performance and attention (Wickens et al., 2004). Therefore, while sensory richness is somewhat essential for positive results (e.g. 2D audiovisual was the most effective), ease of use may play a significant role as well.

Additionally, participants were also allowed to leave comment(s) at the end of the survey with additional feedback and some participants in the VR visual only group specifically indicated they found the visuals to have a “strobing” effect. Based on the results and some of the participants' comments, participants could have become photosensitive to the stronger visuals within VR compared than to the 2D conditions. These psychological problems suggest that examining the results through the lens of appraisal of emotion theory might also be beneficial since people may have based their emotions off their experience with the set-up resulting in a negative appraisal of response (Moors et al., 2013). More extensive research needs to be conducted but the initial results seem to suggest that the VR groups with music did not have the same significant adverse consequences with negative mood as the VR visual only group indicating that music may have mitigated some of the potentially problematic effects. See Figure 7 for possible appraisal of emotions flow chart for effective and non-effective treatment for participants.

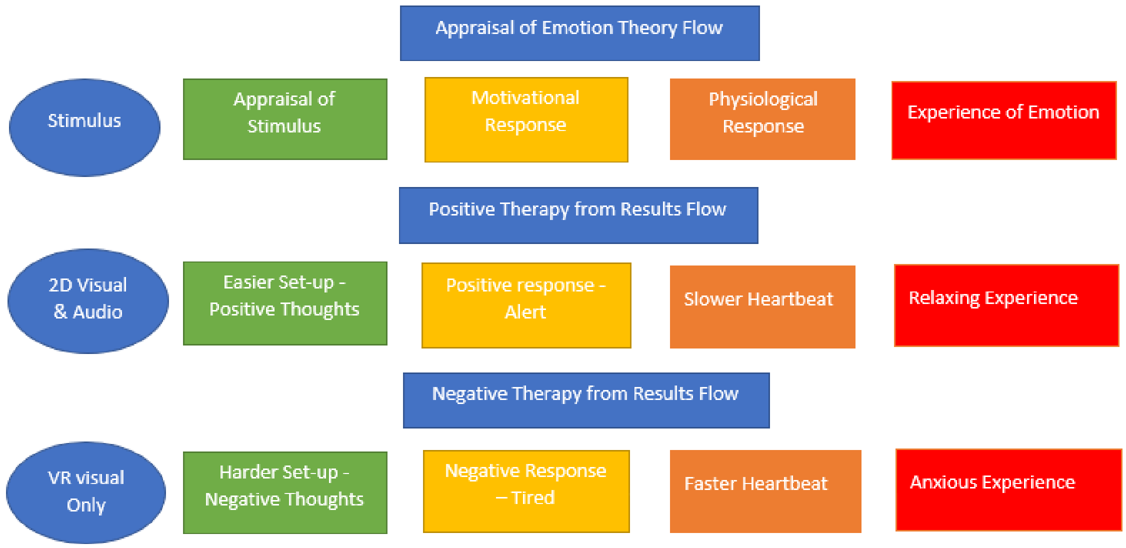

Figure 12 Appraisal of Emotion Flow chart for theory, comparison of effective and ineffective treatment results.

Limitations

There are several possible limitations in this study that should be considered when examining the results. This study is unblinded and lacks a concurrently randomized control group and, therefore, is at risk of bias even though participants were evenly randomly assigned to one the six groups.

Additionally, we were not able to control the environment atmosphere, the current condition of the VR headset, or know if there were any internet connectivity issues. While these may have been possible problems, almost all participants (97%) of participants said the experience was either “extremely clear” or “somewhat clear.”

Moreover, only self-reported measurements were analyzed and thus, future studies should explore physiological variables (such as heart rate) to provide a more comprehensive evaluation of distress (La Montagna et al., 2019) and provide potential measurement bias online.

Another limitation is that this trial analyzed only short-term effects. Measurements were taken only at two time points (pre-intervention and post-intervention) and each patient participated in only one session. While length of therapy varies upon the individual, several studies indicate that in-person sessions happen over longer time and multiple sessions (Dugas, 2003; Erekson et al., 215) for positive psychotherapy outcomes. However, longer periods of VR intervention could lose efficacy over several sessions since individuals might habituate to it and become ineffective (i.e. VR might become less effective for increasing the positive self-esteem for people). This does remain to be assessed since a past study concluded that the benefits of VR intervention were not lost across at least three sessions, thus indicating that novelty may not play a significant role in VR therapy (Indovina et al., 2018).

Future Research

To my knowledge, this was the first study of its kind to specifically examine the differences between 2D and VR online experiences with music therapy to determine effectiveness of therapy on mood. Taking into account the theoretical implications and limitations, future research should explore online therapy by finding solutions to (1) shorten instructions for the setup, (2) include videos to guide the participants more clearly pictures and/or (3) have participants join online with the researcher on a video conferencing platform (e.g. Zoom or Skype) to help them with the setup of the experience and more fully control elements that were not available in this study. Additionally, researchers could explore with focus groups visual stimuli beforehand to reduce potential photosensitive images that could possibly make the therapy not as effective.

Furthermore, these results may indicate that 2D therapy sessions could be just as beneficial as VR but further research needs to be conducted bearing in mind the limitations and psychological considerations discussed earlier. Future research should not only explore repeated exposures for online therapy but also specifically compare 2D, VR, and in-person groups to understand what is the most effective.

CHAPTER VI

CONCLUSION

The results of our study suggest that while both VR and 2D environments can be useful tools for improving mood for people, 2D environments were assessed as the most beneficial treatments for impacting people's psychological-well-being. Sensory richness played a significant role in making 2D audiovisual the most beneficial treatment of this study, but this result may be the result of psychological limitations to the VR groups. In summary, this study proposes that e-health developers and researchers should not only focus on using audiovisuals in their study but also focusing on making the onboarding process easier and exploring what visual stimuli would be most effective for therapy to meet the global clinical need for non-pharmaceutical methods.

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