THE EFFECT OF VIRTUAL REALITY IMMERSION LEVEL ON MOOD, ENJOYMENT LEVEL, AND INTENTIONS OF FUTURE ENGAGEMENT IN EXERGAMES

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By
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CERTIFICATION OF APPROVAL

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DEDICATION

I would like to express my thanks to my parents for the sacrifices they have made to give me the opportunity succeed in my life. This document is as much a recognition of my achievement as it is a reflection of your patience and belief in me. I will always be grateful for all of your support and for allowing me to find my own path in life.

I would also like to express my gratitude to Dr. AnaMarie Guichard for being a constant source of support throughout my academic career and for pushing me to be a better student. Without you, I don’t think I would have believed in myself enough to achieve what this document represents.

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ABSTRACT

Previous research has examined the connection between exercise, games, and virtual reality. The present study examined the influence of augmented reality exergaming on positive and negative affect, intentions for future engagement, and enjoyment. Participants were randomly assigned to one of two conditions, a more immersive condition that utilized a virtual reality (VR) headset for the exergames or a less immersive condition that utilized a large screen. Participants' positive and negative affect were measured using the Positive and Negative Affect Schedule (PANAS), and their enjoyment was measured using the Physical Activity Enjoyment Scale (PACES). Contrary to what was hypothesized, there were no significant differences in pre- and posttest positive and negative affect between conditions. In addition, there were no significant differences in intentions for future engagement in the exergame. Furthermore, greater enjoyment of the exergame was not reported by participants who engaged in less regular exercise. Finally, participants did not underestimate the amount of time they engaged in the exergame. Future researchers might focus on extending the intervention length or manipulating the immersion level to a greater degree.

CHAPTER I

INTRODUCTION

Exercise is a recreational activity that many people engage in for fun or to attain health benefits, but exercise may be associated with even more positive effects than those. Exercise can positively influence an individual's mind and mood, and several studies have found significant differences between those who engage in regular exercise and those who do not. For example, physical activity has been linked to decreased rates of agoraphobia, depression, panic attack, social anxiety, and specific phobia (Goodwin, 2003).

The U.S. Department of Health and Human services (USDH) has set physical activity goals for achieving health benefits. The USDH (2008) set a goal for adults to achieve at least 150 minutes of moderately intense physical activity or 75 minutes of vigorous physical activity per week to gain minimal health benefits. Data from the Centers for Disease Control and Prevention (CDC, n.d.) found that, in 2015, only an estimated 50.9% of American adults met this standard of physical activity. In other words, almost half of American adults are failing to meet the minimum physical activity standards, so an intervention may be useful at helping more adults to meet this standard.

The failure of many individuals to meet the minimum health standards of the USDH may be a contributing factor to high obesity rates in the U.S. A body mass index (BMI) score is on common way of assessing one's obesity levels. BMI is calculated by dividing one's metric weight by their squared, metric height. An individual with a BMI score under 18.4 is considered underweight, a score of 18.5-24.9 is categorized as within the normal weight range, scores of 25-29.9 are considered overweight, and scores above 30 are considered within the obese range. Information provided by the CDC on obesity rates in 2016 (n.d.) estimated that the United States' national, adult obesity rate was 29.6%, and a separate report by the CDC (n.d.) estimated that, in 2016, the percentage of adults aged 18 and older considered overweight, but not obese, was 35.2%. Furthermore, the CDC (n.d.) found that an estimated 25.9% of the population failed to engage in any notable non-occupational exercise.

Physical Activity

The significant number of obese and overweight individuals in U.S. raises several questions concerning the barriers that are preventing individuals from engaging in the recommend amount of physical activity. Among college students, it was found that the most frequently reported reasons for lack of exercise were lack of time, energy, and willpower (Kulavic, Hultquist, & McLester, 2013). For many people, the barriers to engaging in physical activity may be multifaceted and require more than a single solution.

Engagement in and enjoyment of physical activity can be enhanced by certain factors, including music and videos. One study found that, compared to control conditions without music or visual stimuli added, adding only music or music and video to exercise produced significantly higher levels of enjoyment in participants compared to other conditions (Jones, Karageorghis, & Ekkekakis, 2014). Other studies have found that the addition of music and video together resulted in greater exercise pleasure than music or video implementation alone (Bird, Hall, Arnold, Karageorghis, & Hussein, 2016).

Effects on Affect

Some studies have found connections between engagement in regular, physical activity and symptoms of anxiety and depression. A study by Broman-Fulks and Storey (2008) found that engaging in aerobic exercise corresponded with decreases in anxiety sensitivity scores, but the study had sample had ethnic and gender limitations. In a different study, using a moderately depressed, female sample, it was found that combined, aerobic exercise and pharmacological intervention decreased the majority of participants' depression down to minimal levels compared to pharmacological interventions alone (de la Cerda, Cervelló, Cocca, & Viciana, 2011). This research suggests that physical activity can serve as a complimentary factor to facilitate affective clinical change.

Some connections have been found between physical activity and improvement in moods of participants who were not experiencing clinical psychological distress. In a study of sedentary women, it was found that symptoms of generalized anxiety disorder (GAD), but were not given a diagnosis, significantly decreased with resistance-based (using weights) and aerobic exercise treatments compared to those in a waitlist condition who did not receive treatment (Herring, Jacob, Suveg, Dishman, & O'Connor, 2011). In a study by Plante, Cage, Clements, and Stover (2006), one group of participants walked along a path, a second group was asked to watch a video of the same path while walking on a treadmill, and a third group only watched a video of the walking path while sitting. Participants reported that walking the path outdoors was the most enjoyable condition, but those who did the indoor, treadmill exercise reported the most relaxed scores. The researchers concluded that features of outdoor exercise (e.g., fresh air, sounds, etc.) may have resulted in increasing energy in participants, while the indoor exercise's relaxation effect may have resulted from minimal distractions in the environment. Lovell, Huntsman, and Hedley-Ward (2015) found positive correlations between exercise and mood in mothers from Australia and New Zealand. They found that regular exercise was correlated with the greatest difference in psychological distress, depression, and stress scores on the Depression Anxiety Stress Scale compared to those who did not engage in exercise, but the effect sizes were quite small (d = 0.21 – 0.32). Another study involving Dutch twins and their families found that engaging in exercise was correlated with lower scores for anxiety, depression, and social problems (Hassmén, Koivula, & Uutela, 2000). In summary, there have been several studies which found positive correlations between exercise and positive mood, and other studies that have found that regular physical activity is beneficial for mood.

Virtual Reality

As technological innovation has continued, new pieces of equipment and strategies have been applied to problems and situations that may have not been considered previously, including exercise. Previous researchers have used exercise bikes, treadmills, and a variety of auditory and visual apparatuses to immerse participants in virtual and augmented reality environments, but it may be that technological innovations such as virtual reality (VR) could prove to be more effective conduits for change than these previously used methods. In previous research, VR implementation was described as using a screen to place an individual in an artificial environment, but as technology has evolved, so has the accepted definition of VR.

Current implementations of VR involve the use of a head-mounted display (HMD) utilizing a cellular or smart phone to act as a display and track movement or an HMD, wired or wirelessly, connected to a game console or personal computer (PC). The individual enters a computer-generated environment, and these environments provide visual, auditory, and, in some cases, interactive components. Augmented reality (AR) is like a virtual reality system, but AR modifies the environment through alteration of the camera's images to add new items to the displayed image. For example, AR implementations may use projection onto walls to augment the environment, or some cell phones and hand-held game consoles have used the device's camera to alter what is seen through the device's camera. Several years ago, VR and a head-mounted display (HMD) may have been far too expensive for the average consumer or researcher to afford, but in recent years, VR and HMDs have become more affordable pieces of technology. Virtual and AR games can now be purchased more easily by consumers, and a variety of HMDs are available for well under one-thousand U.S. dollars. The shift in availability may warrant a change in the direction of research concerning VR.

Exercise and AR/VR Experiences

Many previous entries into VR-based research may be more appropriately labeled AR experiences. Previously, one of the most often utilized methods for VR-based research has been the use of an exercise bike or a treadmill and a screen. In a study by Van Schaik, Blake, Pernet, & Fencott (2008), participants rode exercise bikes while puzzles were displayed on a screen in front of them, and participants were asked to indicate answers by increasing or decreasing their speed on the exercise bike. The researchers found that participants preferred exercise with a screen and mathematic or environmentally-based puzzles compared to traditional exercise. If some individuals prefer a more engaging exercise environment that uses puzzles instead of exercise alone, perhaps that is a way of engaging those who may avoid exercise because of lack of engagement.

Older studies that utilized less sophisticated AR/VR methods found that these methods were effective at treating certain disorders and reducing the symptoms of those disorders. For example, a hospital room with video-based graphics projected onto the room’s walls were not using a HMD to achieve AR, yet the virtual environment still resulted in promising outcomes (Li, Chung, & Ho, 2011). Anderson et al. (2013) utilized a VR-based treatment for social anxiety, in which they compared practicing speeches in a virtual environment to giving a speech in a real environment. In the VR condition, the environment and audience size could be manipulated to cause more or less participant fear, while the other condition required participants to engage in in-vivo exposure therapy by giving a speech in front of others. The researchers found that VR-based exposure therapy and group exposure therapy did not produce significantly different results from each other, and both conditions were found to be more effective than a waitlist condition. These results suggest that VR-based treatments can produce similar results to typical therapeutic interventions compared to waitlists and be immersive enough to treat the client's problem.

Video Games

VGs are available in many forms and on many devices in the United States, such as on cell phones, standalone consoles, PCs, and on some televisions. The growth of the VG industry has resulted in a greater amount of exposure for video games in society. In a report done by the Entertainment Software Association (ESA, 2016), it was noted that the average U.S. female gamer is about 44 years old, and the average male gamer is roughly 35 years old. The ESA found that there was a relatively equal distribution of gamers both under 35 and over 35 years old, and it was estimated that 63% of households contain an individual that engages in videogaming weekly. The ESA also estimated that in 2015 consumers spent more than 23 billion dollars on the VG industry. The sheer number of households that have gaming access means that many individuals know a VG player. The percentages mentioned earlier concerning regular physical activity focused on adults, therefore, some of the less physically active adults may be avid or casual video gamers.

VGs do not have to provide deeply engaging experiences in order to give benefits to or influence the individual, and some research suggests that VG experiences can have beneficial effects. Thin, Hansen, and McEachen (2011) found that individuals preferred the exertion involved in movement-based VGs compared to similar exercise on a stationary bike. If individuals can draw pleasure from a VG and still achieve a certain level of physical exertion, perhaps VGs can attract groups that do not regularly engage in physical activity. It is not only physical VGs that can produce positive changes in individuals. It was found that some casual video games can decrease an individual's anger, fatigue, and tension levels (Russoniello, O'Brien, & Parks, 2009). The effectiveness of video games in positively affecting mood may be a notable benefit, but the effect of video games on time estimates may be beneficial too. Van Schaik et al. (2008) found that individuals underestimated the time engaged in game- and VR-based exercise by an average of 38%. An individual's underestimation of time spent with video games may provide an indication of how immersive these experiences may be and that they may spend more time in VR.

Exergaming

A fusion of exercise and video games resulted in the development of exergaming. Exergaming involves a variety of game types that require the individual to become physically active or physically engaged with the gaming experience. Exergaming engagement is often accomplished through interactions between some combination of controllers, motion sensors, and cameras. Some of the most recent iterations of exergaming have been on Nintendo's Wii platforms, Sony's PlayStation platforms, Microsoft's Xbox platforms, various PC platforms, and cellphones. A growing range of modalities and the lower cost of VR equipment may mean that access to exergaming is more affordable and convenient.

While the research has shown mixed results for using exergaming to change less active individuals' attitudes toward exercise, these studies did garner some insights into the characteristics of exergamers. A study of nicotine-dependent, Canadian teens found that females were more likely than males to believe that exergaming could be beneficial in adding physical activity to their lives, and male exergamers were more likely than their female counterparts to prefer exergames to engaging in traditional sports (Kakinami et al., 2015). This sample, while not typical, indicates some preference for and positive attitudes toward exergaming over engagement in other forms of physical activity.

Not all research, however, has shown exergaming to be effective at changing the attitudes of participants. A study using a Taiwanese sample found that exposure to exergaming only improved the attitudes of participants that already had positive attitudes toward exercise, while those who seldom exercised reported less intention to exercise (Van Nguyen et al., 2016). It is possible that exercise engagement only reinforced the attitudes participants already had, or it could be that the intervention was not enough to change the minds of less-active participants. Researchers have found that engaging in exergaming resulted in a greater likelihood of participating in future exergaming rather than other physical activities (Garn, Baker, Beasley, &

Solmon, 2012). Exergaming may not be the way to improve attitudes toward exercise for all individuals.

Purpose and Hypotheses

As VR methods have become more advanced and costs have decrease, more individuals are able to utilize this technology to improve physical and psychological well-being. The goal of this study was to use VR and AR to assess whether the positive outcomes were greater for more a more immersive intervention than a less immersive one. Greater access for the general population has resulted in a new type of exergame that seeks to immerse people into VR by utilizing HMDs. Earlier VR-based studies found significant effects using less advanced methods, so more advanced methods may find similar, or even stronger, results. To assess for changes in VR implementations, the study looked at the effects of VR immersion on mood and intention for future exercise.

Hypotheses:

1. The HMD-based VR exercise (i.e., more immersive) activity will produce more positive changes in positive and negative mood scores than the less immersive task
2. Participation in the more immersive task will result in participants indicating they would like to engage in the exergaming again more often than in the less immersive task
3. Greater enjoyment will be reported in less physically active participants compared to those that are more physically active

4. Participants in the more immersive task will underestimate the amount of time they spent exercising to a greater degree than will those in the less immersive task

CHAPTER II

METHODS

Participants

Data were collected from a total of 33 participants from California State University, Stanislaus, and descriptive statistics for participants can be found in Table 1. All participants were between the ages of 18 and 29 years old and had an average age of 21.56 years old. The sample was composed of eight male and twenty-five female participants. All participants were recruited via SONA, through psychology class announcements, and referral. The sample was composed of three Black/African Americans, six Caucasians (White/Non-Hispanic), twenty-two Hispanic/Latinos, and two participants indicated that they were “mixed” or “biracial”. Six participants were college freshman, four were college sophomores, twelve were college juniors, eight indicated they were college seniors, and three were graduate students. Participants engaged in an average of 136.85 minutes of physical activity each week. Each participant was compensated with ten dollars for participation.

Table 1

Participant Characteristics

	Less Immersive *N* = 14	More Immersive *N* = 19	Total *N* = 33
	M(*SD*)	*M*(*SD*)	*M*(*SD*)
Age	22.07(3.69)	21.17(2.94)	21.56(3.26)
BMI	26.19(8.09)	26.00(6.34)	26.08(7.06)
Exercise/Week (minutes)	108.25(87.71)	136.85(103.37)	124.59(96.32)
Video Games/Week (hours)	6.21(10.12)	4(6.51)	4.94(8.17)
	Frequency (%)	Frequency (%)	Frequency (%)
Gender			
Female	9 (64.3%)	16 (84.2%)	25 (75.8%)
Male	5 (35.7%)	3 (15.8%)	8 (24.2%)
Ethnicity			
Black/African American	2 (14.3%	1 (5.3%)	3 (9.1%)
Caucasian (White/Non-Hispanic)	3 (21.4%)	3 (15.8%)	6 (18.2%)
Hispanic/Latino	7 (50%)	15 (78.9%	22 (66.7%)
Other	2 (14.3%)	-	2 (6.1%)
College Standing			
Freshman	2 (14.3%)	4 (21.1%)	6 (18.2%)
Sophomore	1 (7.1%)	3 (15.8%)	4 (12.1%)
Junior	5 (35.7%)	7 (36.8%)	12 (36.4%)
Senior	5 (35.7%	3 (15.8%)	8 (24.2%
Graduate Student	1 (7.1%)	2(10.5%)	3 (9.1%)

Materials

VR Materials

The apparatus used for VR implementation was the HTC Vive HMD that was released in 2016. The Vive headset is connected to the front of a person's face, and the apparatus displays a virtual environment using two 1080x1200 screens to project video for each of the individual's eyes (HTC Corporation, 2017). The apparatus blocks out most of the light outside of the HMD and projects a 3-dimensional environment for the individual to interact with. The Vive utilizes a headset, controllers, and motion trackers to assess an individual's movement and interaction within a play space. The headset utilized the Deluxe Audio Strap released in 2017. Disposable face masks and antibacterial wipes were used to keep the headset clean for each session.

Audioshield (Fitterer, 2016) is a rhythm-based, VR program available on the Vive. The program translates individual songs into colored spheres and trails within the game. As the song progresses, the spheres approach the player to the rhythm of the song. Each participant is presented with shields that he or she uses to block the oncoming spheres. Participants were informed that Audioshield is a rhythm-based, music game and that the information on screen will be tailored to the music being played. Participants were told that colored spheres will appear in front of them, and it will be their job to block the oncoming spheres. The right hand will correspond to the orange shield and the left with a blue shield, and the purple shield can be achieved by placing one's hands together. Participants will be asked to attempt to punch or strike the incoming spheres whenever they feel that it is possible.

Steam (Valve Corporation, 2017a) is a PC program that functions as an online, distribution platform for selling VGs and programs, and it also acts as repository for individual games. The implementation of the HTC Vive's VR experience is accomplished through the SteamVR program (Valve corporation, 2017b). The SteamVR program acts as a mediator for VR experiences that are found on the Vive. Steam and SteamVR must both be running on the PC connected to the Vive for the device to display the output for Audioshield.

Computer hardware. The Vive was powered through the utilization of an Intel-based processor and Nvidia-based graphics processing unit. The headphones attached to the Deluxe Audio Strap were used for the more immersive condition, and in the less immersive condition, the speakers available in the research room were used instead.

Video Materials

An example video was created that reflects the first-person view of a person engaging in a single session of Audioshield. The video clearly displayed how the virtual environment appeared, and the video was used to prepare participants how the virtual environment was composed. The video lasted approximately 35 seconds, and the song used for this introductory video was “Dreamer (Alpha 9 Remix)” by Axell /\ Ingrosso. The video was recorded using the “Normal” difficulty setting in Audioshield.

Assessments

Mood. The Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988; see Appendix A) is a 20-item, self-report assessment that has two subscales to assess an individual’s positive and negative mood. The PANAS uses a 1-5 Likert-style scale to indicate how much participants have felt a certain emotion over the past week. Responses range from 1, which indicates “very slightly or not at all”, to 5, which indicates “extremely”. On the PANAS, positive mood items include words like “active” and “alert”, and negative mood is assessed with terms like “afraid” or “nervous.” Both the positive and negative scales are scored by adding up the total scores for each subscale, and on both scales, higher scores indicate more positive or negative affect. The PANAS has been found to have good reliabilities for its positive scale (PS; α = .89 Crawford & Henry, 2004; α = .88 for adults, Molloy, Pallant, & Kantas, 2001; α = .90 Serafini, Malin-Mayor, Nich, Hunkele, & Carroll, 2016) and negative scale (NS; α = .85 Crawford & Henry, 2004; α = .87 for adults, Molloy, Pallant, & Kantas, 2001; α = .91 Serafini, Malin-Mayor, Nich, Hunkele, & Carroll, 2016), and it was found to have test-rest reliability (PS α= .80, NS α = .76 Serafini, Malin-Mayor, Nich, Hunkele, & Carroll, 2016). The present study found high internal consistency on the PS (pretest α = .91 and posttest α = .92) and NS (pretest α = .82 and posttest α = .91), and there was high test-retest reliability for the PS (α = .86, $p < .001$) and the NS (α = .63, $p = .001$). Participants completed two randomized versions of the PANAS for this study, and the scale was modified to extend from 1 to 100 using an online slider. Higher scores indicated that the participant is feeling more of that emotion. Mean scores were used to calculate overall positive and negative affect.

Enjoyment. The Physical Activity Enjoyment Scale (PACES; Kendzierski & DeCarlo, 1991; see Appendix B) is a self-report measure used to assess participants’ attitudes toward a physical activity. The assessment uses a bipolar, 1-to-7 Likert-style scale that asks respondents to indicate attitudes toward physical activity. Poles are responses like “I find it energizing” to “I find it tiring”. An error in survey creation resulted in the survey using a 1-to-8 Likert-style scale. The PACES has been found to have high internal consistency (α = .87, Moore et al., 2009). The present study found high internal consistency (α = .88).

Demographics and attitudes. A questionnaire was used to assess each participant's previous experiences with exergaming, video games, and VR, and knowledge of rhythm-based VGs (See Appendix C). This questionnaire assessed for participant demographics, including age, gender, ethnicity, class standing, height, and weight. The questionnaire required participants to indicate how many minutes they engage in moderate-intensity, physical activity each week. Time estimation was assessed with a single, open-ended item that asked, "How long would you estimate you have been playing the game? (in minutes)". Intent for future exergaming was assessed with a single item that asked, "Would you be interested in playing more of this game?" The options for answers were "Yes", "no", or "Maybe".

Other

Bottles of water and hand towels were provided free for participants to utilize as needed in this experiment. Each participant's heart rate was monitored with a heart rate monitor produced by Fitbit. If a participant's heart rate exceeded 85% of her or his calculated, max heart rate, the experiment would have been stopped, and the participant would have been debriefed. No participant met the criteria for this intervention. Each participant's maximum heart rate was calculated as 220 minus each participant's age. Prior to engaging in the activity, a brief description of

Audioshield was provided to participants (See Appendix D). Informed consent (See Appendix E) and debriefing forms (See Appendix F) were provided to participants.

Design

This study utilized a between-subjects design to assess whether there were differences in reported mood, overall enjoyment of each activity, willingness to engage in the activity again, and estimated time spent exergaming. Each participant was assigned to either the more immersive or less immersive condition and asked to complete the PANAS.

Condition Levels

In this experiment, the manipulation was the immersion level provided for participants, with the groups separated into high- and low-immersion conditions. The high-immersion condition is defined as completing a single session of Audioshield by being fully immersed using the Vive HMD, headphones, and controllers. This condition auditorily and visually separated participants from the real world with the HMD. The less-immersive condition utilized room speakers and the Vive's controllers, but participants played the game by following along on a large projection screen, rather than using the HMD. Participants in both conditions were first exposed to an introductory video that outlined the basics of Audioshield. Participants were informed that they would be participating in a rhythm-based, music game, and they would be required to block oncoming spheres using shields available within the game. In both conditions, the song used for gameplay was "Hyperwave (Radio Edit)" by Steve Brian that was 3 minutes and 23 seconds in length, and the difficulty was be placed on "Normal."

Dependent Variables

Each participant had their mood assessed pre- and post-exercise using the PANAS. Positive mood was assessed using the positive subscale of the PANAS, and negative mood was assessed using the participant's score on the negative subscale of the PANAS. Each participant's enjoyment of the activity was assessed by their score on the PACES. After completion of the activity, each participant was asked whether they would engage in the activity again. Each participant's estimation of time spent exergaming was done with a single question.

Procedure

Participants scheduled a time with the researcher or through the scheduler available on SONA. At the scheduled time, a participant arrived at the classroom, which had been set up for the study. Before participating, each participate completed an informed consent form online. Next, each participant was asked to complete a demographics questionnaire and a randomized version of the PANAS and was randomly assigned to one of the two conditions of the experiment.

To familiarize participants with Audioshield and the VR experience, each participant was shown a short, introductory video of Audioshield gameplay. Participants were informed that they will be required to engage in similar behavior to the person shown in the video.

Each participant was informed that Audioshield does not signal a loss or failure from missing spheres, and the game will allow participants to continue regardless of their performance. Upon completion of training, participants were asked to complete a single song in Audioshield that was 3 minutes and 23 seconds in length.

Upon completion of the activity, participants in both conditions were asked to complete a randomized version of the PANAS and complete the PACES. Each participant was asked if he or she would engage in the same activity again and how long they estimated they had been playing. Directly after completing the activity, participants were asked if they wanted a complimentary bottle of water or a hand towel. Upon completion of participation, participants were given the opportunity to ask questions and receive a copy of the debriefing form. After the completion of the task, the HMD was carefully cleaned for future participants.

CHAPTER III

RESULTS

To test the first hypothesis, Independent samples *t*-tests were conducted to assess for significant differences between the two conditions in pretest positive and negative mood scores on the PANAS. If a participant left three or more answers blank on her or his PANAS survey, the participant's data were removed from calculation for that test, and eight participants had their data removed from calculation from the negative affect scale of the PANAS. In addition, means, rather than sums, were used to calculate overall positive and negative affect due to missing scores from several participants. There were no significant differences between pretest positive affect score between the less immersive (M = 59.84, SD = 23.11) and the more immersive conditions (M = 59.27, SD = 21.14), $t(31) = 0.074$, $p = .941$, $d = 0.03$. The results indicated that those in the more immersive group (M = 22.19, SD = 13.74) reported higher levels of negative affect than those in the less immersive condition (M = 12.36, SD = 9.67) prior to manipulation $t(27) = -2.13$, $p = .042$, $d = 0.80$.

Repeated measures ANOVAs were calculated to assess for significant differences in participants' overall positive and negative mood differences between conditions and between pre- and post-tests and can be found in Table 2. A significant main effect was found for time for overall negative mood $F(1, 23) = 6.93$, $p = .02$, $\eta^2 = .23$ between pretests and posttests. There was no significant main effect of condition on overall negative affect $F(1, 23) = 2.03$, $p = .17$, $\eta^2 = .08$. No significant interactions were found between conditions in overall negative affect at $F(1, 23) = 2.24$, $p = .15$, $\eta^2 = .09$. A significant main effect for time on overall positive effect was found with $F(1, 31) = 41.64$, $p < .001$, $\eta^2 = .57$. No significant main effect of condition was found for overall positive affect $F(1, 31) = 0.002$, $p = .97$, $\eta^2 < .001$. No significant interactions were found between conditions in overall positive affect $F(1, 31) = .19$, $p =.67$, $\eta^2 = .01$.

Table 2

Positive and Negative Affect Schedule Scores

Mood	Less Immersive		More Immersive				
	M	*SD*	*M*	*SD*			
Positive					Time	*F*(1, 31) Condition	Inter
Pre-test	59.84	23.11	89.27	21.14	41.64**	.002	0.19
Post-test	72.01	20.66	73.19	20.76			
Negative					Time	*F*(1, 23) Condition	Inter
Pre-test	11.17	9.96	22.66	14.15	6.93*	2.03	2.24
Post-test	8.22	7.25	12.00	19.92			

**p*-value less than .05
***p*-value less than .001

To test hypothesis 2, that participants in the more immersive condition would report they would like to participate in the exergame activity again more often than those in the less immersive condition, a chi-square test was conducted. Participants had the option of answering “Yes”, “No”, or “Maybe” to the question. In the less immersive condition, 71.4% of participants indicated “Yes”, 28.6% indicated “Maybe”, and 0% indicated “No”. In the more immersive condition, 84.2% of participants indicated “Yes”, 15.8% indicated “Maybe”, and 0% indicated “No”. The sample violated the assumption that at least 5 scores would appear in each group, so a

Fisher's Exact Test was used. The results did not find significant connection between condition and desire to participate in the activity again (x^2 (1, N = 33) = .79, p = .42, ϕ_c = .155).

To test the hypothesis 3, an independent samples *t*-test was calculated to assess for significant differences between the more immersive and less immersive groups in the estimated number of minutes exercised per week. Scores of greater than 300 minutes per week were Winsorized to two standard deviation above the mean. No significant differences were between the less immersive condition (M = 108.25, SD = 84.71) and the more immersive condition (M = 136.85, SD = 103.37), t(26) = -.77, p = .45.

A correlation was calculated to assess for connections between how long participants estimated they regularly exercised and their enjoyment scores on the PACES. It was hypothesized that participants that were regularly physically active would enjoy either activity less than those who were less physically active. Results from the Pearson correlation indicated that there was not a significant correlation between estimated time spent exercising and enjoyment of the exergame activities r(28) = .30, p = .11. Upon further analyses, the correlation between how much weekly exercise participants estimated they completed and their enjoyment scores on the PACES did near significance in positive correlation in the more immersive condition r(16) = .40, p = .06. In the less immersive condition no significant correlation was found between how much exercise participants engaged in and their enjoyment scores on the PACES r(12) = .05, p = .44.

To test hypothesis 4, an independent samples t-test was calculated to assess for significant differences in estimated time (in minutes) spent engaging in the activity between conditions. Two extreme scores of 100 and 40 minutes were Winsorized to two standard deviations above the mean of all other participants. A single response did not give a numbered estimation of time spent exercising and thus was removed from data analysis. Though both groups overestimated how long they had spent completing the three-and-a-half minute song, results they did not indicate significant differences between the less immersive condition (M = 3.69, SD = 1.44) and the more immersive condition (M = 5.41, SD = 3.42), $t(25.91) = -1.957$, $p = .06$, $d = 0.66$.

CHAPTER IV

DISCUSSION

The primary purpose of this study was to assess whether there were significant affect differences between the pretest and posttest affect scores at differing levels of exergame immersion. The outcomes did not support the hypothesis that those in the more immersive condition would have significant differences between their pre- and posttest scores compared to the less immersive condition.

Exploratory analyses of the main effects of immersion levels revealed significant main effects of time for both negative and positive affect in the more immersive condition, but in the less immersive condition, a main effect of time was only found for positive affect. Improvement in negative affect does coincide with previous findings that found exercise could help improve negative mood (de la Cerda et al., 2011; Russoniello, et al., 2009). The connection between exercise and mood does align with findings that have outlined a negative correlation between regular exercise and scores of negative emotions (Hassmén et al., 2000; Lovell et al., 2015). The exergames may have been enough to affect positive mood, but it is unclear what aspect of the lower immersion level caused the lack of improvement in negative mood scores.

The analyses did not support the hypothesis that those in the more immersive condition would report they would like to repeat the activity more often than those in the less immersive condition. Though the results did not support a significant difference between immersive conditions, there is evidence to suggest that participants may have viewed both immersion levels positively. Participants were asked to indicate whether they would, would not, or might want to engage in the exergame again, and the majority of participants (approximately 79%) indicated that they would, while roughly 21% of participants indicated that they might want to engage in the activity again. None of the participants in either condition indicated that they would not want to engage in the activity again. Preferences for repeating exercise activities that includes music and video, like both immersion levels in this study, or just music has been found before (Jones et al., 2014). It is possible that both the more immersive and less immersive activities produced a reasonable amount of enjoyment for almost all participants, leading to an overall increase in interest in the exergames. It is also possible that the novelty of the experience is what prompted many participants to indicate that they would like to play more of the exergame.

The nonsignificant correlations did not support the hypothesis that there would be a negative correlation between regular exercise and enjoyment of the exergame activities, but participants report high enjoyment scores for both conditions regardless of regular exercise levels. The positive response to these exergames coincided with previous findings that a combination of audio, video, and exercise or music and exercise can improve exercise enjoyment (Bird et al, 2016; Jones et al., 2014). The nonsignificant findings did not align with previous findings that those who are more physically active would have a more positive view of an exergame (Van Nguyen et al., 2016).

Nonsignificant differences between groups did not support the hypothesis that those in the more immersive condition would underestimate the amount of time they had been playing the exergame than those in the more immersive condition. The test did approach statistical significance, but the difference was in opposite direction to the hypothesized effect. Participants in the more immersive condition tended to *over*estimate the amount of time they spent engaging in the exergame compared to those in the less immersive condition. The overestimation of time contradicts previous findings that found participants underestimated the amount of time they had been playing an exergame (Van Schaik et al., 2008). It is possible that the immersion in the activity resulted in a distortion of one's perception, and participants in the less immersive condition were better able to maintain orientation toward time than those in the more immersive condition. Distortions in one's perception time may be due to the novelty of the activity as well. There were issues that required participants' scores to be Winsorized because of extreme answers of estimated time, but estimations that exceeded 10 minutes only occurred in the more immersive group.

Limitations

A primary limitation in the present study may have be in the sample size. The number of participants narrowly passed 30 participants in over 5 months of data collection. A smaller sample size does make it more difficult to detect changes, and though some of the present study's analyses found some medium to large effect sizes, some questions did not even approach small effect sizes. The sample size can make it difficult to draw conclusions and to know whether there would have been significance with larger sample sizes.

The composition of the sample may have been a limiting factor. The composition of the sample may have limited generalizability to California State University, Stanislaus. Based on obtained demographic information, it was found that 66.7% of this study's participants identified themselves as Hispanic, but based on 2017 data, only 51.4% of California State University, Stanislaus' students identified themselves as Hispanic (California State University, Stanislaus, 2017). Furthermore, there was an imbalance in the distribution of participants between groups, so one group ended with 5 more participants than the other group. The combination of a small sample size and random assignment may have made it difficult to achieve a relatively equal balance between groups. The gender composition was heavily skewed toward female participants too, so generalizability to the male population may be limited. The sample was composed entirely of college students from California State University, Stanislaus, so the results may not be generalizable to the general population. The average age of participants in in the study was around 21.6 years old, and it could be that younger participants were more open to exergames or technology than older participants may have been.

The method of recruitment and incentives for the study may have been another limiting factor for the study. The current study was one of few in-person studies available during the 2018-19 academic school year, and the days available for participation were restricted. Increasing the availability of participation dates could have increased the number of participants that could have been recruited. The ten-dollar incentive for participants may have increased the pool of participants, but for some participants, the incentive may not have been enough to warrant spending their time participating.

Unclear responses from participants may have adversely affected the research study too. The present study had issues with participants entering unclear answers into responses, and these unclear responses required Windsorizing and elimination of scores too create a functional data set. Altering the data set and the unclear answers may have influenced whether statistically significant results were achieved.

During this study, participants that did not follow survey instructions may have caused issues. Several participants failed to follow the instructions listed on the survey materials, and subsequently, some participants moved on to materials before being exposed to either intervention level. Moving on to later material could have informed participants of the purpose of the study and skewed results. Not reading instruction could have affected participants' self-report answers and skewed the data too.

The present study lacked a true control group to compare the interventions with. Without a control group to compare to, it is possible that there were undetected confounding variables that may have influenced the dependent variable. The lack of a comparison group may make it difficult to have confidence in the results that were found in this study.

Issues with the difference between immersion levels may have been a limitation of this study. None of the study's hypotheses found statistical significance, so it is possible that the two immersion levels were not different enough to detect for significant change. It is also possible that the ceiling effect for immersion level emerged in the present study.

Conducting in-person research can be a limiting factor for a study too. Demand characteristics may have informed participants of the study's purpose and skewed results. It may be that the researcher's interactions with participants skewed the responses from participants.

Self-report data is inherently problematic for research. People are poor observers of their own behavior, and many of this study's questions asked people to estimate about how they felt, their weight, height, etc. without any way to confirm the accuracy of that information. The reliability of the data can limit generalizability and affect the results that are found.

Future Research

Future researcher may want to focus on the decay in enjoyment or intentions for future engagement. The present study did not address the possible effects the novelty of new experience could affect the dependent variables. It is unclear whether participants' scores would be maintained by a long-term intervention or the same after a long intervention, and it is possible that extended interventions could attain completely different outcomes.

Future researchers may have access to newer, different, and more immersive VR exergames than Audioshield. Newer VR exergames like Beat Saber (Beat Games, 2018) have released after the onset of this research, and newer exergames may result in different changes in a participant's affect and enjoyment level.

A possible area of future research may be the connections between perceived challenge, enjoyment, regular exercise, and intention for future exercise. In the present study, the challenge perceived by participants was not assessed, and it may be that challenge level could alter the outcomes of the dependent variables of this study. A participant's level of enjoyment may be affected by the amount of regular exercise he or she engages in and/or the perceived challenge.

Although the data did no support my hypotheses, the results suggest that, regardless of immersion level, people reported enjoying the exergame. Furthermore, no participants reported that they would not do this activity again. Finally, people in both immersion levels showed an increase in positive mood following the exergame activity, indicating that even minimal time spent exercising may be enough to boost mood.

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APPENDICES

APPENDIX A

POSITIVE AND NEGATIVE AFFECT SCHEDULE

Read each item and then mark the appropriate answer in the space next to that word. Indicate to what extent you have feel these emotions right now. Use the following scale to record your answers.

1	100
Very slightly or not at all	Extremely

Ashamed

1 100

Interested

1 100

Determined

1 100

Strong

1 100

Hostile

1 100

Enthusiastic

1 100

Inspired

1 100

Afraid

1 100

Scared

1 100

Proud

1 100

Guilty

1 100

Irritable

1 100

Active

1 100

Jittery

1 100

Distressed

1 100

Upset

1	100
Attentive	
1	100
Alert	
1	100
Excited	
1	100
Nervous	
1	100

APPENDIX B

PHYSICAL ACTIVITY ENJOYMENT SCALE

Please rate how you feel at the moment about the physical activity you have been doing.

1 2 3 4 5 6 7 8

I enjoy it — I hate it

1 2 3 4 5 6 7 8

I feel bored — I feel interested

1 2 3 4 5 6 7 8

I dislike it — I like it

1 2 3 4 5 6 7 8

I find it pleasurable — I find it unpleasurable

1 2 3 4 5 6 7 8

I am very absorbed in this activity — I am not at all absorbed in this activity

1 2 3 4 5 6 7 8

It’s no fun at all — It’s a lot of fun

1 2 3 4 5 6 7 8

I find it energizing — I find it tiring

1 2 3 4 5 6 7 8

It makes me depressed — It makes me happy

1 2 3 4 5 6 7 8

It’s very pleasant — It’s very unpleasant

1 2 3 4 5 6 7 8

I feel good physically while doing it	1	2	3	4	5	6	7	8	I feel bad physically while doing it
It's very invigorating	1	2	3	4	5	6	7	8	It's not at all invigorating
I am very frustrated by it	1	2	3	4	5	6	7	8	I am not at all frustrated by it
It's very gratifying	1	2	3	4	5	6	7	8	It's not at all gratifying
It's very exhilarating	1	2	3	4	5	6	7	8	It's not at all exhilarating
It's not at all stimulating	1	2	3	4	5	6	7	8	It's very stimulating
It gives me a strong sense of accomplishment	1	2	3	4	5	6	7	8	It does not give me any sense of accomplishment at all
It's very refreshing	1	2	3	4	5	6	7	8	It's not at all refreshing
I felt as though I would rather be doing something else									I felt as though there was nothing else I would rather be doing

APPENDIX C

DEMOGRAPHICS QUESTIONNAIRE

Instructions: Please answer the following questions.

1. What is your gender?

Female	Male	Other	Prefer Not to answer

2. What is your ethnicity?

Black/African American	Asian American	Caucasian (White/Non-Hispanic)	Hispanic/ Latino
Native American/Native Alaskan	Native Hawaiian/Pacific Islander	Other________	Prefer not to answer

3. What is your age in years?

____

4. Please indicate your college standing.

Freshman	Sophomore	Junior
Senior	Graduate student	Other___________

5. Please indicate your height in inches.

_____________ Feet ___________ inch(es)

6. Please give an estimate of your weight in pounds.

___________ pounds

7. Please estimate how many minutes per week on average you engage in moderate-intensity physical activity (e.g. brisk walking, dancing, swimming, bicycling).

______________ minutes per week

8. Please indicate which of the following devices you use for gaming (click all that apply).

Smartphone/Tablet	Microsoft Xbox One	Nintendo Switch	PC/Mac computer
Playstation 4	Web Browser	Other ___________	None

9. Please estimate how many hours of video games you play per week.

___________ hours per week

10. Please indicate how much experience you have with virtual reality systems (e.g. HTC Vive, Oculus Rift, Playstation VR, etc.).

1	2	3	4	5	6	7
Not at all Familiar						Very Familiar

11. Please indicate how much experience you have with exergames (e.g. Dance Dance Revolution, Wii Fit, etc.).

1	2	3	4	5	6	7
Not at all Familiar						Very Familiar

APPENDIX D

INTRODUCTION SCRIPT

The game you will be playing today is Audioshield. It is a rhythm-based, VR game. In the game, orange and blue balls are going to be coming toward you. What I want you to do is to block or, if you can, punch them with the shields. Blue goes to blue, and orange goes to orange. When purple balls come up, you put both hands or shields together. You cannot lose while playing, so keep playing until the song is finished.

APPENDIX E

INFORMED CONSENT

Informed Consent

1. **Summary:** This research will examine the influence that exercise in video games can have on one's functioning. If you agree to participate, you will be asked to answer questions pertaining to your current functioning, your background, and exercise frequency, and you will be asked to participate in an exercise-based video game.

2. **Your right to withdraw/discontinue:** You are free to discontinue your participation at any time without penalty. You may also skip any survey questions that make you feel uncomfortable. Even if you withdraw from the study, you will receive any entitlements that have been promised to you in exchange for your participation, such as an experimental credit in SONA.

3. **Benefits:** Participation in this research study guarantees you a choice of 4 experimental credits or a $10 gift card. Other possible benefits include the fact that you may learn something about how research studies are conducted, and you may learn something about this area of research (i.e., factors that are related to exercise's effects on one's thought and behaviors).

4. **Additional information:** You will be given additional information about the study after your participation is complete.

5. **Time commitment:** If you agree to participate in the study, it may take up to 10 minutes to complete the online survey. An in-person meeting will be required that may take up to 30 minutes to complete.

6. **Guarantee of Confidentiality:** All data from this study will be kept from inappropriate disclosure and will be accessible only to the researcher, Zach Hensley, and his faculty advisor, Dr. AnaMarie Guichard. Data collected online will be stored on a password-protected website and de-identified for analyses. The researchers are not interested in anyone's individual responses, only the average responses of everyone in the study.

7. **Risks:** The present research is designed to reduce the possibility of any negative experiences as a result of participation. Risks to participants are kept to a minimum. During this research study, it is possible that the exercise will cause you to feel fatigued, so your heart rate will be actively monitored by the researcher. If your heart rate exceeds 85% of your maximum, calculated heart

rate, the study will end, and you will be debriefed. If your participation in this study causes you any concerns, anxiety, or distress, please contact the Student Counseling Center at (209) 667-3381 to make an appointment to discuss your concerns.

8. **Researcher Contact Information:** This research study is being conducted by Zach Hensley. The faculty supervisor is Dr. AnaMarie Guichard, Associate Professor of Psychology, Department of Psychology and Child Development, California State University, Stanislaus. If you have questions or concerns about your participation in this study, you may contact the researcher Zach Hensley, at zhensley@csustan.edu, or Dr. Guichard, at aguichard@csustan.edu.

9. **Results of the study**: The results of this study will be available at the end of the 2018/2019 academic year by contacting Zach Hensley or Dr. Guichard.

10. **Psychology Institutional Review Board Contact Information:** If you have any questions about your rights as a research participant, you may contact the Chair of the Psychology Institutional Review Board of California State University Stanislaus, Dr. Jessica Lambert at PsychologyIRB@csustan.edu or (209) 667-3934.

11. **Personal Copy of Consent Form**: You may print a blank, unsigned copy of this consent form at the beginning of the study.

12. **Verification of Adult Age:** By clicking "I Agree"/signing below, you attest that you are 18 years old or older.

13. **Verification of Informed Consent:** By clicking "I Agree"/signing below, you are indicating that you have freely consented to participate in this research study and are in good enough physical health to participate.

Name ____ Date ____________

APPENDIX F

DEBRIEFING FORM

Debriefing Sheet

I appreciate your participation in the study. I was interested in the possible connections between exercise, virtual reality (VR), and mood. Studies have shown that regular exercise has been correlated with positive differences in mood compared to those who do not exercise. I wanted to see if combining virtual reality and exercise into one activity would foster similar mood improvements. Another area of interest was the influence exercise and virtual reality could have on a participant's inclination to engage in further sessions of VR exercise. I predicted that those in a more immersive experience would attain larger benefits in mood change, would be more inclined to engage in further sessions, that participants would report greater enjoyment of the task, and that sedentary people would respond more positively compared to those in the less immersive task. I also believe that those who engage in immersive VR-based exercise would underestimate the time they spent exercising to a greater degree than those doing less immersive exercise.

The information gathered during the study will remain confidential and secure, and the researcher, Zach Hensley, and his thesis supervisor will be the only ones with access to the complete information. The information gathered will be used purely for data analysis, and every effort has been made to maintain participant anonymity and to protect participant confidentiality. I am interested in fundamental differences between the groups involved in the study, and not the particular responses of any individual.

If you have questions concerning this field of research or the findings of the study, you may contact me, Zach Hensley, at zhensley@csustan.edu or my faculty sponsor, Dr. AnaMarie Guichard, College of Science, at aguichard@csustan.edu.

If you have questions about your rights as a research participant, you may contact the Chair of the Psychology Institutional Review Board, Dr. Jessica Lambert, at PsychologyIRB@csustan.edu or (209) 667-3934.

If you are interested in additional information related to VR research, you may find the following resources beneficial:

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