Ijaz, K, Wang Y, Milne D. and Calvo RA Competitive vs Affiliative Design of Immersive Exergames. In (Eds.). (2015). Serious Games: Second Joint International Conference, JCSG 2016, Brisbance, Australia, JSeptember 26-27, 2016, Proceedings. LNCS Springer.

Competitive vs Affiliative Design of Immersive VR Exergames

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Abstract. Virtual reality (VR) can provide compelling experiences which might enhance users' engagement with physical activity. Despite the known health benefits of exergaming, there is a limited understanding of how various game designs impact user experience. This work proposes VR Rides, a virtual reality exergaming platform that combines a recumbent tricycle, real-world panoramic images, an Oculus Rift headset and a Microsoft Kinect camera, where the player can navigate real locations in a safe virtual environment. We further compare two game designs: a competitive guessing game and affiliative tour. This pilot study with both young and older adults indicates that task enjoyment (r = 0 .721, p = 0.000), motivation (r = 0.565, p = 0.009) and connectedness (r = 0.697, p = 0.001) is higher in the competitive variant. Participants in both variants were highly engaged, likely due to the use of immersive VR. Descriptive analysis suggests that participants showed similar connectedness in affiliative tour (63%) and competitive design (62%).

Keywords: Virtual Reality, Immersive VR Games, Exergames, Game Design.

1 Introduction

Physical activity is widely recognized as key for reducing risk of many health issues and to improve overall wellbeing. According to World Health Organization's report, lack of physical activity is the fourth leading risk factor for mortality causing an estimated 3.2 million deaths worldwide [1]. An active life style is particularly vital to control rising medical costs for those suffering various cognitive and physical problems who often have great difficulty navigating and recognizing familiar locations [2]. There is also alarming obesity rates among children, teenagers and adults globally [3]. In addition, age has a profound effect on mobility and can turn a simple walk around the neighborhood into a frustrating and frightening experience. Many seniors live an understandably sedentary life.

Exergames—games that encourage physical motion have grown in popularity recently. Health professionals use them as an alternative form of treatment and to promote an active lifestyle [4]. Some of these games were initially designed for entertainment [5], while others were specifically designed to motive people to change their sedentary behavior [6]. Lieberman [7] describes exergames as highly appealing, motivating and fun; and that provides exciting game challenges, a way to perform athletic or expressive activity and to socialize.

Over the last few years, virtual reality technology has been attracting a lot of interest in academia and industry alike. VR headsets such as the Oculus Rift can provide extremely rich and immersive virtual environments. This could be combined with exergames that already aim to capture natural motions [8], to create experiences that are vastly more engaging than traditional desktop or console games [9].

In this study, we compare two different strategies for motivating players to play a VR exergame: a competitive design that motivates players by competing against others to achieve certain goal, and affiliative design in which the motivational driver is to provide new ways for the player to connect with family/friends (e.g. sharing the game experience with them). Most games predominantly follow a competitive design approach [10–12] and although this might be effective for a young audience, it might not work for an older one. Age Invaders is one of the few exergames that involve affiliation rather than competition [13]. Nevertheless, the effectiveness of affiliative game designs requires further investigation.

In this paper, we present VR Rides, a combination of technologies that allows the user to safely cycle around almost any real-world location in an immersive virtual reality environment. We aim to compare competitive and affiliative game designs through a pilot study with both young and old adults. Moreover, we intend to collect feedback about VR Rides and how immersive virtual reality environment is perceived among various demographic groups.

2 Related Work

This project fits into an area of game design that seeks to engage and improve the health of both young and older players. Most games that encourage physical exercise are built around the Nintendo Wii [5], Microsoft Kinect [8] and Dance Pads [14]. When paired with careful game design, these sensors allow players to use natural body movements to safely simulate familiar real-world activities. Exergames for the elderly are most successful and acceptable when they allow players to operate at their own pace; i.e. Wii bowling is a better choice than tennis or boxing [15]. Ijsselsteijn et.al [16] argue that perceived health benefits of the underlying exergame should be clear in addition to good usability while designing for group such as older adults. Similarly, Sinclair and colleagues [17] emphasized that a good balance between factors such as game's attractiveness and effectiveness is important to design successful exergames.

Several other researchers have used a stationary cycle as a game controller [6, 10–12]. In these studies, players were able to navigate a landscape, compete with an avatar or play a puzzle game through pedaling. Authors in these studies report use of existing video games [11], competing virtual tours [6] and used uncomfortable cycle as game controller in a way that raise the safety concerns for groups such as old adults

[10]. These studies have used display screen or monitors to interact with game environment and to display physical activity data. McCallum [18] divides health games into three broad categories: games for physical health (that require movement), cognitive health (that require reasoning) and social/emotional health (that encourage connectedness). Existing cycling based exergames facilitate physical and cognitive health, but largely ignore social aspects.

There are many factors that influence whether a game is engaging. Among younger players, the primary themes appear to be emotional arousal, challenge, competition, diversion, social interaction and fantasy [19]. However, it is not clear to what extent these motivations translate to older audiences. For example, authors in [15] outline that overly challenging an older player may be harmful, that social interaction should be limited to people that are already well known, and that simplicity and intuitiveness is key. Lindley et al [20] suggest that the social interaction should be deeply personal rather than lightweight.

Przybylski et al [21] show that self-determination theory explains the strong appeal of video games. The theory states that one’s motivation to perform an activity depends on whether it satisfies three basic needs: competence (one’s sense of skill), autonomy (one’s sense of personal agency) and relatedness (one’s sense of connection to others). VR Rides has been designed with these needs in mind. For example, the affiliative mode allows players with limited mobility to confidently navigate a city (competence), leaves them free to decide the direction and content of a tour (autonomy), and helps them to share significant locations and memories with loved ones (relatedness).

3 The VR Rides Platform

The main components of the VR Rides platform are shown in Fig. 1. It starts with a recumbent tricycle, which provides a safe, stable platform for physical exercise, and exerts minimal strain on the user’s back. The rear (driving) wheel is suspended to keep the bike stationary.

A smartphone is attached to the handlebars, so that its internal compass captures the steering angle. The phone also communicates with a sensor attached to the rear wheel, to capture speed. The user’s speed and direction are sent to a laptop computer running the VR Rides game, which we developed in Unity. This game communicates with Google’s streetview service, to fetch full 360^{o} panorama images of real-world locations.

This imagery is presented to the user via an Oculus Rift VR headset, which allows them to freely look around their environment. We also track the user’s gestures via a Microsoft Kinect IR camera, so they can point at landmarks within the game.

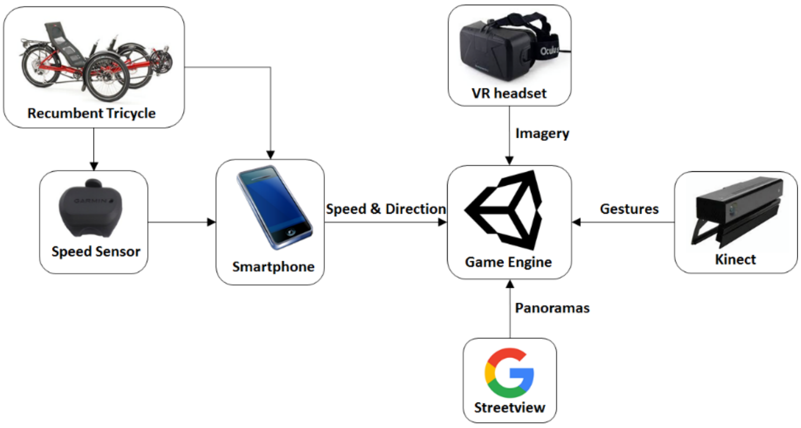

Fig. 1. VR Rides Architecture

4 The VR Rides Games

Having established the platform described above, the key challenge is to translate it into an experience that players with various age groups will find appealing. Young and old adults who do not have competitive mindset are unlikely to engage with technology simply for technologies sake, and may not respond well to traditional game mechanics. Consequently, we developed two distinct game modes:

4.1 A Competitive Guess Game

At the beginning of a level, the player is teleported to an unknown location within an unknown city. An onscreen compass and map point out locations of various landmarks they can cycle to, which might give them an idea of where they are. The level ends when they successfully guess the name of the city. This game has four levels, which increase in difficulty as the landmarks become less well-known and more distant from each other. The game starts with an in-game tutorial which describes the different game components. As shown in Fig. 2, players are assisted by a compass bar across the top of the screen, and a large map that can be viewed simply by looking down. There are also audio cues that indicate when landmark is nearby and when a wrong guess is made.

We need to be careful that players do not over-exert themselves, so the contest is not a race. It is instead a strategic guess game that requires players to predict where the nearby landmarks are located, and plan an efficient route between them. The player is asked to make verbal guess during the game and if the answer is correct it unlocks the next level and gains high points as per distance travelled. The score degrades with each unnecessary location (s)he visits.

To foster a sense of competition, the player can see their score directly compared against two other opponents. These opponents may be real or virtual, or even the "ghost" of the player's previous performance. For the study described in Section 5, all players were aware that they were competing with virtual opponents. A leaderboard is presented on each level and before the game is exited, to reinforce the player's sense of competition and personal accomplishment.

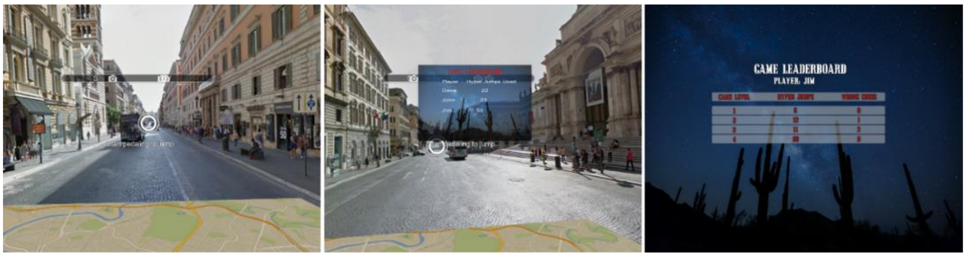

Fig. 2. Competitive Game Environment and Leaderboards

4.2 An Affiliative Virtual Tour

In the affiliative design, players take a bike tour by cycling in different cities, listening to the introduction audio of major landmarks and taking photos of the views. This virtual tour game has three cities for players to choose from (Fig. 3), and three places of interest within each city. The tour starts with an in-game tutorial that describes the different game components. As shown in Fig. 3, players can use the compass bar and map to orient themselves and locate the landmarks. As they cycle towards a landmark, the distance and time taken are shown above the compass bar. When they get close to a landmark, an audio clip plays automatically to describe it. With the help of Kinect, players can also take snapshots by using right hand to point to the red camera icon. The green circle shows the position of hand.

Fig. 3. Affiliative Virtual Tour

The affiliative virtual tour gives the players same feeling as a sightseeing bus tour in a famous city: the virtual tourist can visit different landmarks, listen to historical information, and take pictures as a memento, all while exercising by cycling. The photo album generated during the tour can later be shared with family and friends. In contrast to the competitive design, this affiliative tour does not require players to achieve any particular goal, compete with others or improve performance during game play.

5 A Preliminary Evaluation of VR-Rides

5.1 Participants

Forty-three male and female participants of age between 18 to 92 years (21 females and 20 males, 21 = competitive group, 20 = affiliative group M = 47.29, SD = 22.8) registered for pilot study over period of two weeks. The recruitment was conducted in two separate locations; older participants (all aged over 60) were recruited from a local community center, while younger participants were recruited from undergraduates at the authors' university. One older participant had to be excluded after they experienced discomfort with the VR headset, and a young participant was excluded due to a technical issue. The remaining 41 participants were stratified by age group and then randomly assigned to the affiliative and competitive groups. Each game condition was allocated approximately ten older and ten younger participants.

5.2 Method

Each participant was allocated a time slot of 30 minutes to complete the study. On arrival, participants were briefed about the study and were requested to provide informed consent. They filled out screening and personality information in pre-test section of the questionnaire. Data was collected through a Likert scale questionnaire that included multiple questions for personality preferences, task enjoyment, motivation, and willingness to participate in future sessions. Participants were assisted into the recumbent trike and the VR headset, and given two minutes to become accustomed to them. Following this, players engaged with an interactive tutorial that explained the basic mechanics of the game variant they were assigned to, and were then left to play the game.

5.3 Results

Participants' competitiveness preference

Competitiveness index [22] (pre-test) and psychological (post-test) responses were collected through a questionnaire. This competitiveness index measures both enjoyment of the competition and contentiousness (diligence and being thorough). Investigating competitive nature of the participant's personality may help us find potential bias towards a particular game design. Based on the participants' responses, independent samples median test revealed that younger adults were significantly more competitive than older adults (p = 0.002, M = 3.25, N = 40). However, both young and old age groups shown no significant difference for contentiousness or conflicting situations ($p > 0.05$). Findings suggest that younger participants were more competitive in nature. Therefore, we might expect that traditional competitive game mechanics (scores, leaderboards etc.) could be less effective for seniors. Figure 4 shows the boxplots of competitiveness index across the age groups.

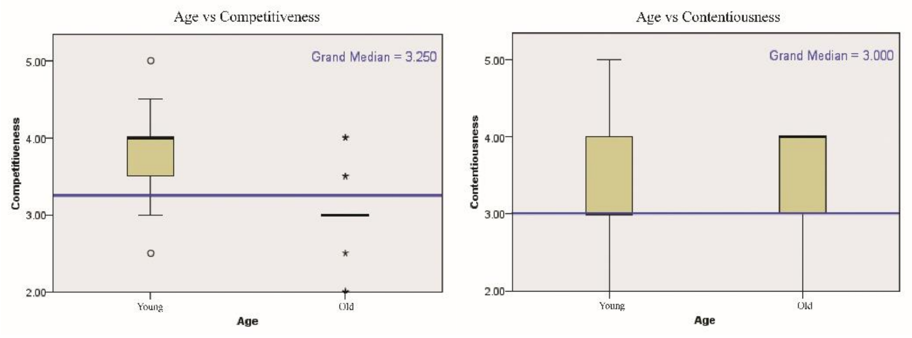

Fig. 4. Competitiveness Index Across the Age Groups

An aggregate frequency of participants' responses was calculated (see Table 1.). For each psychological factor (task enjoyment, motivation, performance measure, competence and connectedness), post-test responses were combined within category. Generally, participants rated agreed (50%, 46%, 44%) and strongly agreed (34%, 16%, 13%) for task enjoyment, motivation and performance measure respectively. In terms of connectedness, participants in affiliative design felt more connected (agree = 50% and strongly agree = 13%) in contrast to the competitive design (agree = 38% and strongly agree = 24%).

Table 1. Frequency of Participants' Responses

Factors	**Strongly Disagree (%)**	**Disagree (%)**	**Neutral (%)**	**Agree (%)**	**Strongly Agree (%)**
		n (%)			
Task Enjoyment	0(0)	2(5)	5(11)	21(50)	14(34)
Motivation	0(0)	4(10)	12(28)	19(46)	7(16)
Performance Measure	0(1)	3(7)	15(36)	18(44)	5(13)
Competence	0(1)	6(14)	14(35)	16(38)	5(12)
Connectedness(Comp.)	0(0)	3(14)	5(24)	8(38)	5(24)
Connectedness(Aff.)	0(0)	1(3)	7(35)	10(50)	3(13)

* numbers be added to greater than 100% of the sample due to rounding.

Most (80.5 %) participants showed interest in participating in future sessions in contrast to 18.1 % who reported unwillingness. Similarly, 55% participants both young and old were interested to pay for the affiliative game. Whereas, fewer (33.33%) in the competitive game group mentioned their willingness or interest to pay money to play. In competitive design, young adults were more open to pay than old adults (young = 6, old = 1). Box plots of two age groups with respect to psychological factors are shown in Fig. 5.

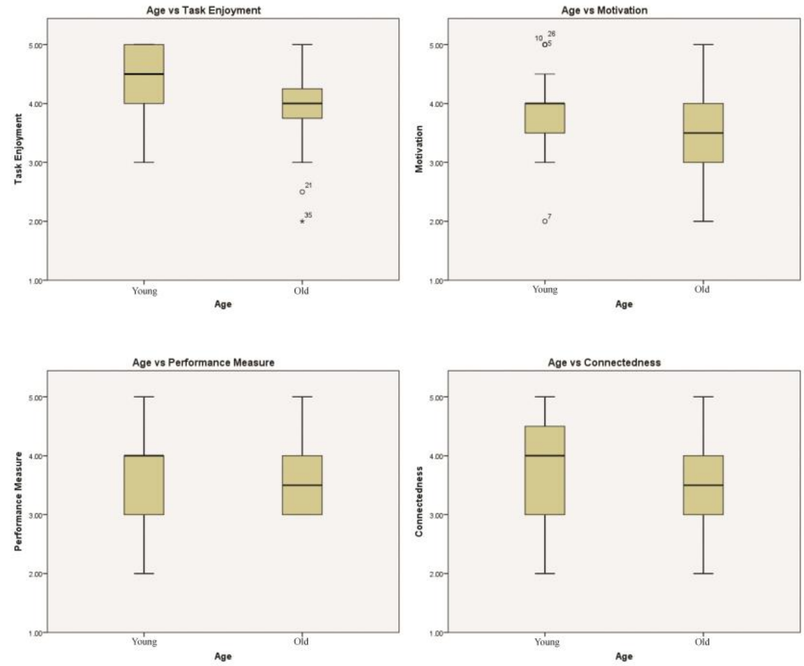

Fig. 5. Participants' Behavior in Different Age Groups

Game preference

Pearson correlation method shows that in both game designs (competitive, affiliative), competitiveness was positively correlated with participants' enjoyment, motivation and connectedness. In competitive game design, task enjoyment ($r = 0.721$, $p = 0.000$), motivation ($r = 0.565$, $p = 0.009$) and connectedness ($r = 0.697$, $p = 0.001$) were strongly correlated with competitiveness. In contrast, although there was a strong correlation, competitiveness of affiliative game design group was only marginally statistically significantly correlated with task enjoyment ($r = 0.402$, $p = 0.08$) and connectedness ($r = 0.402$, $p = 0.08$) and significantly correlated with motivation ($r = 0.459$, $p = 0.04$). Participants with competitive personality were substantially more biased towards the competitive than affiliative game design as shown in Table 2 Competitiveness was also correlated with age in both the competitive ($r = -0.544$, $p = 0.01$) and affiliative design groups ($r = 0.739$, $p < 0.001$). However, it was not associated with participant ratings of task enjoyment, motivation or connectedness.

Table 2. Role of Competitiveness for Game Preference

	Competitive (*r*)	Affiliative (*r*)
Task Enjoyment	0.721	0.402
Motivation	0.565	0.459
Performance Measure	0.125	0.092
Connectedness	0.697	0.402
Age	-0.544	-0.739

There was small to medium negative correlation of age with task enjoyment, motivation and connectedness that suggest young participants reported slightly more task enjoyment, motivation, and connectedness in both games as shown in Table 3. Nevertheless, there was apparently small difference in relationship among these variable with respect to age for both game designs.

Table 3. Preference of Two Game Designs w.r.t Age

	Competitive (*r*)	Affiliative (*r*)
Task Enjoyment	-0.394	-0.286
Motivation	-0.146	-0.276
Performance Measure	0.107	-0.105
Connectedness	-0.37	-0.198

Mann-Whitney U test revealed no significant difference between the two game designs with respect to task enjoyment, motivation, performance, competence and connectedness. However, there was significant difference between young as opposed to old adults for task enjoyment ($U = 122.5$, $p = 0\ .015$).

5.4 Discussion and Study Limitations

This study compared two game designs (competitive and affiliative) for virtual reality exergames. VR Rides bridges all three categories of health game (physical, cognitive and social), but the emphasis differs between the two game modes. The competitive mode requires planning and spatial skills, and is focused more on cognitive than social health. The affiliative mode has a strong focus on social interaction, but also requires players to use their memory and language skills. Both modes require physical effort to move about the environment, but neither punish players for taking a relaxed pace.

Results indicate high task enjoyment and motivation levels for both age groups. We also aim to gather feedback about the VR-Rides platform that was well perceived by both young and old adults. In both game designs, participants showed equivalent interest. In contrast, it was observed that older adults connected really well during the affiliative tour which brought back personal memories. One participant mentioned, "I have never been this close to statue of liberty" while another said "Oh, I have been here but I forgot the name of this building". In this study, we mainly focus on comparing two game modes in relation to engagement, motivation, competitiveness etc. But impact of specific designs in terms of physical activity may reveal interesting behaviors. Participants of both designs showed positive response in terms of psychological factors. Nonetheless, bigger sample size would provide stronger results and much visible variance between the two game designs.

6 Conclusion and Future Work

This paper has presented VR Rides, an immersive virtual reality game that encourages both young and older adults to engage in physical and cognitive exercise. The game employs real-world imagery to provide a competitive guess game that challenges players to navigate environments, and an affiliative virtual tour that allows players to share memories and locations that are of personal significance. We deployed VR Rides into community center to evaluate in a realistic setting with wider audience. The primary measures of this study focus on motivation, connectedness, and engagement: e.g. whether players voluntarily register for future sessions with the bike. Findings suggests that VR-Rides was equally well perceived among young and old adults. Moreover, results shown that players with different personality type have different preferences in terms of game designs i.e. competitive and affiliative. However, in future we would also ideally measure whether access to these games has a lasting effect on one's motivation to adapt active life style and spatial skills.

7 Acknowledgement

We gratefully acknowledge financial support by Charles Perkin's Centre, University of Sydney. We would also like to show our gratitude to the staff of the Dougherty Community Centre for providing their facilities and assistance to conduct this study.

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