Detached Immersion in Exergaming

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***Abstract*—Exergaming is an emergent technology focusing on combining exercise and gaming in an attempt to motivate users to participate in a healthier lifestyle. Past research has focused on simulation type gameplay where users avatars participate in activities linked directly to the exercise users perform. Discrepancy between simulations and the real activity can be a source of discomfort and frustration to users.**

The authors propose an alternate game philosophy where gameplay is detached from real activities that users may have participated in. This allows users to detach from preconceived notions about the activity as well as improving immersion which leads to higher levels of enjoyment and motivation. The authors also explore the effect additional cognitive tasks have on the users performance and motivation.

The To evaluate the system the authors conducted a user study which compares two versions of exergaming using an exercycle. Both variants have the same piloting gameplay, while one has an additional cognitive task. Use of the additional task saw an increase in both enjoyment and use of the system when compared to the simple variant.

I. Introduction

Exercise is an important part of a healthy lifestyle and can lead to many health benefits including improving strength and flexibility as well as reducing risks of obesity, heart disease and lower blood pressure [1], [2]. Lack of exercise can be harmful and can put subjects at higher risk of obesity , heart disease, higher blood pressure and fatigue[1]. It is recommended that adults participate in 20-30 minutes of moderate exercise three to six times weekly [1] in order to gain the benefits and reduce the potential risks. Many find motivation to participate in activities that constitute moderate exercise difficult. This is due to the strenuous nature of the activities involved.

A solution to increasing motivation is by increasing the enjoyment in participating in the activities. One method of doing this is by combining exercise and video games: exergaming. Past research into exergaming has focused on simulation type gameplay, where users participate in activities which are modeled in the game usually by an avatar. This however can cause discomfort to users due to the discrepancies between the simulations and the real activities. Another source of discomfort comes from negative connotations a user may have with associated activities. With this in mind we propose a new type of gameplay that is detached from the activities that users participate in.

A literature review posted in 2008 [**?**] provides many articles supporting the positive correlation between regular exercise and improved cognitive performance, particularly in old age, during which the onset of dementia and other related diseases can be greatly reduced. We explore the effect cognitive tasks have on physical performance and motivation.

The exergame system we have built puts a user on an exercycle with a joystick controller. The user wears an oculus rift, which is a 3D headset with embedded screens which display the game. The game itself places the user's avatar in a flying craft; power to the flight mechanism is controlled by user's peddling on the cycle while flight controls are mapped to the joystick controller. Gameplay involves navigating the flying craft through a course where the user must fly through a series of gates in order to complete the course. In the cognitive variant we introduce a "Simon Says" type task. This task involves repeating a sequence. After successfully repeating a sequence it is increased by one element and must be repeated again, with the goal to complete the longest sequence possible without making a mistake.

In this paper we evaluate users response to these different task (cognitive and non-cognitive) and their effect on motivation to use the system and to exercise. We do this by monitoring user performance as well as getting users to participate in surveys to get feedback on the experience with the system.

II. Related Work

There are many exergaming systems entering the market and the research space. The most notable and widely used systems are Nintendo's wii and Microsoft's Xbox Kinect. These systems include a controller which is motion sensitive and a 3D camera respectively each with gameplay elements which utilise them. However as noted in [3] it has been found that this and other consumer systems tend not to promote vigorous activity which promotes health and wellbeing.

A. Exergaming to promote health and wellbeing

Exergaming has be shown to be an engaging way to get users to exercise. However with concentration on entertainment rather than health users do not exert enough energy to bring about benefits. For example only 33% of wii fit activities were shown to make users participate in moderate activity [4]. It is recommended adults spend 30 minutes 4-6 times weekly participating in moderate exercise [5]. Studies by Sell et al. and Chen et al. have shown that specific forms of exergaming can provide users with enough activity to reach the recommend levels of exercise [6], [3]. However it was found that exergames that provided these benefits provided poor continued use, while games with lower activity levels did not [3]. It is suggested that this is related to the construction of the exergames. Where systems with exercise added to games show better use than games added to exercise [3]. We developed a system with strong gameplay elements which rely on moderate to strenuous activity that engages users over the long term.

B. Motivation and Competition

Motivation is an important factor when designing exergaming systems to ensure continued use. As moderate exercise for extended periods can be difficult many users find motivation hard. PE Interactive [7] is a system designed for use in hospitals to encourage young patients to exercise while there. The system introduces many different elements to provide motivation to users. These include interactive gameplay which are metaphorically linked to real world benefits gained from exercise. This is achieved in out system using areas which are difficult to reach. As the user progresses with their fitness they are able to access these area's giving them a sense of achievement and progress. An intrinsic element of gaming, exercise and exergaming is competition. Competition is a driving factor to adherence and motivation to users [8]. Song et al, studied the effects and differences between competition and non competition in exergaming and found users performed a greater amount of activity with the competition element even if they were non-competitive by nature.

C. Immersion and Gameplay

The main determining factor in adherence, motivation and use of a system is the gameplay itself. Fitness computer game [9] integrated user activity with visual stimuli to create an immersive simulation of cycling through a course. In contrast to this a series of exergames were developed where user activity is completely detached from the gameplay itself [10]. For example a tug of war game where the pulling strength of the avatar is controlled by the user performing squats. Each of these has drawbacks, simulation can often cause frustration when users are familiar with the simulated activity and complete detachment can cause confusion when users cannot perceive links between their activity and gameplay. Speed-based exergaming controllers [11] offer a good balance between the two ideologies. The users activities are still linked to the gameplay in a meaningful way, yet detached enough that users will not experience it as a simulation. We extend the work done with speed-based controllers by adding a secondary controller (a joystick) so that this control method can be used in a virtual three-dimensional space.

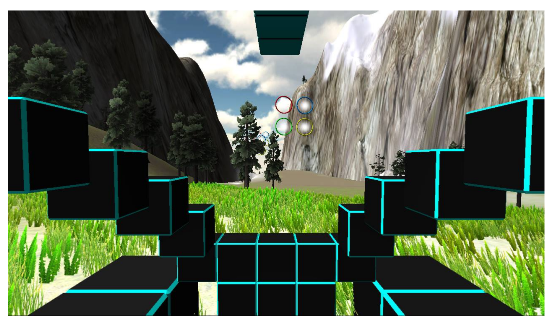

Fig. 1. View from the cockpit

III. Design

HELI: Exergaming Linked Immersion (HELI) is deigned to bring together exercising and gaming components to create an immersive and motivating experience to help users achieve recommended amounts of physical activities. In the exergame users pilot a vehicle through a series of gates around a course with the aim to complete the course in the shortest amount of time. There are two course types used in our experiments. One course incorporates a cognitive tasks which influences the path taken while the other users can simply choose which path to take. Using these variants we are able to measure the effect of cognitive tasks on user performance and motivation when using an exergaming system.

A. Exercise

Many people hold negative connotations towards exercise for to a number of reasons, though mostly due to the strenuous nature and physical pain experienced. Regular physical exercise however is part of a healthy lifestyle and brings about many benefits. To overcome these negative connotations and promote physical exercise we believe gameplay should be detached from physical activities users would participate in.

These were the motivating factors which influenced our choice to use a helicopter as the vehicle in the game. Other exergames using exercycle hardware have users controlling bicycles, however this may cause problems for some users due to the direct link between the in game activity and the exercise. Exergames in which the activity is completely unrelated to the exercise performed also causes problems, as users become confused as to the purpose of their actions causing discomfort. In order to eliminate these problems the activity should not carry any direct links to cycling, yet still has enough of a link that users would not become confused. Linking rotor speed of a helicopter to the pedal speed of the exercycle satisfies both these requirements, while also allowing movement through a third dimension not possible with ground based vehicles. Use of a joystick is a natural choice for helicopter control as they are used in actual helicopters. Joysticks have higher precision than other computer input hardware, and have freedom of movement in three dimensions.

B. Environment

We have designed our test course with three main key considerations (immersion, motivation and amount of physical activity). Courses should be designed to be immersive so that users enjoy using them which also improves their motivation to use the system. Care must also be take to ensure users achieve the recommended amount of physical activity; something which commercial exergaming systems fail to do.

Initial designs of simple courses with high walls and grid like textures were found to cause disorientation and discomfort this lead us to use a more natural design. With a natural design, a lot of care was taken to fill the environment with realistic looking scenery, including trees, rocks, paths and lakes. Without this scenery the course would look bland and unrealistic breaking immersion and reducing enjoyment. The length of the course was also made so that it would take users about 5-6 minutes to complete a lap, as if the course was shorter users may not achieve the recommended amount of activity, however too long and users may lose motivation.

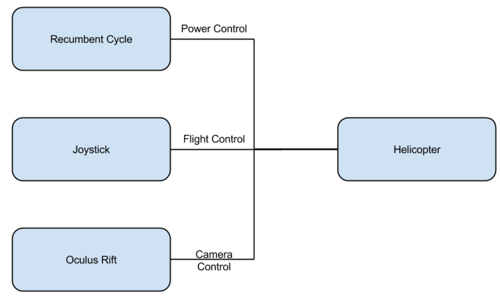

Fig. 2. Inputs

C. Cognitive Task

Introducing a cognitive task into gameplay engages more of the users brain, helping take attention from the physical activity. This hopefully will improve user immersion and motivation in the system. Cognitive tasks should be difficult enough to be engaging, yet not too difficult so that the flow of gameplay is negatively affected due to users giving them more attention than the main task. These tasks should also be integrated into the gameplay so the immersion is not broken.

With these requirements in mind we chose a ”Simon Says” type task. In this task users are shown a sequence represented spatially, aurally and chromatically which they then have to repeat. After each successful repetition the sequence grows by one element. If the user makes a mistake the sequence is reset to being one element long.

IV. Implementation

The HELI system was developed in the Unity 3D Pro engine[1], and uses three main hardware components: joystick, exercycle and oculus rift[2]. The majority of assets were built using blender software[3] and the sripting language of choice was C#.

There are three hardware components used to control the helicopter as shown in figure 2. Power controls change the speed of the rotor blades which in turn affects

[1]http://unity3d.com/
[2]http://www.oculus.com/
[3]http://www.blender.org/

the lift of the helicopter. Flight controls are used to adjust the roll, pitch and yaw. Camera controls adjust the orientation and therefore the view of the camera in game.

A. Inputs

Lift is controlled by pedaling with the exercycle. We have mapped movement in the x direction (left to right) to roll, y direction (forward and back) to pitch and rotation about the z axis (twisting) to yaw of the helicopter. To further improve user immersion and comfort the exercycle has been converted into a recumbent system. Where instead of the seat being above the pedals it is behind them. Cycling from this position does not effect the exertion of the user, however it offers more back support and is more comfortable for most users. In addition to this, the joystick can be easily mounted in front of the seat making the setup similar to a cockpit of a helicopter.

V. Evaluation

A. Methodology

The experiment was performed using an additional cognitive task as the independent variable with physical exertion as the dependent variable. In addition to this users are given questionnaires to assess motivation and satisfaction with the system. Physical exertion is measured using a heart rate monitor.

Before beginning the experiment participants are given a preliminary questionnaire V which provides Participants perform the same navigation task, in which they pilot a helicopter through a course with the aim to pass through as many checkpoint rings as possible in six minutes. The virtual helicopter is directly powered by users pedaling on an exercycle, while flight is controlled by joystick input. In the alternative case a meta task is introduced in which users are shown a sequence represented spatially, aurally and chromatically which they then have to repeat. To repeat the sequence users are required to navigate through the ring corresponding to the current element at the next checkpoint. After each repetition the sequence grows by one element. If a mistake is made the sequence is reset. Users spend 2-5 minutes in each case to familiarise themselves with the system before measurements are taken. The participants were randomly split into two groups. Each group completed the alternatives in different orders to mitigate order bias and training effects. After completing each alternative participants are given a post case questionnaire VI and at the end of the experiment a summary questionnaire VII

B. Results

We conducted user experiments on 10 participants aged from 18-24. Due to technical difficulties we were unable to record participants heart-rates during the study. The test group was predominantly male (80%) and the majority had not used an oculus VR headset or joystick controller before. Half the participants cycle (either on a stationary bike or bicycle) on at least a monthly basis, while 90% of particpants regularly exercise. All participants play video games on at least a monthly basis while two participants described themselves as hardcore gamers.

Most participants considered themselves physically fit, and all but one felt either physically normal or well. The majority of particpants enjoy physical exercise to some degree, while all enjoy playing video games.

Overall participants found both tasks to be neither very challenging or not at all challenging, however the majority found the experience to be somewhat challenging. Only a small number of participants were uncomfortable when performing the cognitive task while almost half were uncomfortable during the non-cognitive task. Often when using VR technology such as the oculus headset users experience some forms of motion sickness, however only one of our participants experienced motion sickness which was reported as being ”very mild” [sic]. The majority of participants found both tasks to be cognitively challenging, however those who had found the non-cognitive task un-challenging found the cognitive task to be more challenging, while those who found the non-cognitive task to be challenging felt either the same level or less of challenge. All users found the exergame to be fun and immersive. Without the measured heart-rates the borg-scale question in invalid. The majority of users would prefer to use our system as a means of exercise than traditional methods. Also most found the addition of the cognitive task to be more motivating. In the open comments the most requested feature was the addition of guns followed by more flight displays including horizon lines and altimeters.

C. Discussion

Due to different constraints our sample size was small and uniform, with all participants being mostly students between the ages of 18-24 and 80% being male. With this lack of diversity we cannot conclude any strong points about the general population, however this study does give insight to male students between the ages of 18-24. A large threat to validity of our study is the lack of objective measures. With entirely subjective data it is hard to accurately portray information we need to validate the success of our system. Results show that subjectively the system has performed well and the introduction of the cognitive task has improved motivation in the average case. However without heart-rate and other measures for example distance cycled we cannot conclude that participants had higher levels of exertion during the cognitive task.

VI. Conclusion

We have created a system that combined exercise and gaming in a VR environment. Through user testing we have provided qualitative evidence that the addition of a cognitive task to gameplay has improved motivation and perceived performance in the physical exercise aspect of the system. However due experimental errors we cannot support these claims with quantitative evidence. In our future work we aim to collect more quantitative data, as well as broadening our testing demographic.

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Age:	18-24				
Gender:		Male: 8		Female: 2	
Occupation:		Student: 9		Marketing: 1	
	Daily	Two-Three times a week	Weekly	Monthly	Never
Have you used an Oculus Rift/VR headset before?				1	9
Have you used a joystick before?				1	9
How often do you use an exercycle/bicycle before?	1	1		3	5
How often do you exercise?	3	2	4		1
How often do you play video games?	3	3	1	3	
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I consider myself physically fit		1	2	4	3
I feel physically fit today.	1		4	4	1
I enjoy exercising.	1		2	6	1
I enjoy playing video games.				4	6

TABLE I
PRE-QUESTIONNAIRE RESULTS

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I found the experience physically challenging.		3	1	6	
I felt comfortable while using the system.		4	1	4	1
I experienced motion sickness while playing the game.	3	4	2	1	
I felt physically challenged while using the system.		3	3	4	
I felt cognitively challenged while using the system.	1	2	2	3	2
Playing the exergame was enjoyable overall.			2	6	2
The exergame was immersive.			2	8	
On a scale of 6-20, what number best describes your level of exertion?		Mean: 12.2		Median: 12	

TABLE II
NON-COGNITIVE QUESTIONNAIRE RESULTS

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I found the experience physically challenging.		2	3	5	
I felt comfortable while using the system.		2	2	4	2
I experienced motion sickness while playing the game.	2	5	2	1	
I felt physically challenged while using the system.		2	5	3	
I felt cognitively challenged while using the system.		1	3	5	1
Playing the exergame was enjoyable overall.				8	2
The exergame was immersive.			3	6	1
On a scale of 6-20, what number best describes your level of exertion?		Mean: 11.8		Median: 12	

TABLE III
COGNITIVE QUESTIONNAIRE RESULTS

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I enjoyed playing the exergame.			2	6	1
I would prefer to exercise using this exergame rather than through traditional means.		3	2	3	1
I found the game with the cognitive exercises more motivating.		1	2	4	2

TABLE IV
POST-QUESTIONNAIRE RESULTS

Age:	12-17	18-24	25-34	35-44	45+
Gender:		male		female	
Occupation:					
	Daily	Two-Three Times a week	Weekly	Monthly	Never
Have you used an Oculus Rift/VR headset before?	1	2	3	4	5
Have you used an exercycle/bicycle before?	1	2	3	4	5
How often do you exercise?	1	2	3	4	5
How often do you play video games?	1	2	3	4	5
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I consider myself physically fit	1	2	3	4	5
I feel physically fit today.	1	2	3	4	5
I enjoy exercising.	1	2	3	4	5
I enjoy gaming.	1	2	3	4	5

TABLE V
PRE TRIAL QUESTIONNAIRE

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I found the experience physically challenging.	1	2	3	4	5
I felt comfortable while using the system.	1	2	3	4	5
I experienced motion sickness while playing the game.	1	2	3	4	5
I felt challenged physically while using the system.	1	2	3	4	5
I felt challenged mentally while using the system.	1	2	3	4	5
Playing the exergame was enjoyable overall.	1	2	3	4	5
The exergame was immersive.	1	2	3	4	5

TABLE VI
POST CASE QUESTIONNAIRE

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I enjoyed playing the exergame.	1	2	3	4	5
I would prefer to exercise using this exergame rather than through traditional means.	1	2	3	4	5
I found the game with the cognitive exercises more motivating.	1	2	3	4	5
How do you think the additional task affected your performance?					
Which of the modes of play would you prefer to use as a form of entertainment?					
Which of the modes of play would you prefer to use as a form of exercise?					
Comments and Suggestions?					

TABLE VII
SUMMARY QUESTIONNAIRE