Flying for Fitness

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***Abstract*—Exergaming is an activity where users play a virtual game that requires moderate physical exertion. Exergaming systems primarily exist to increase the accessibility of exercise for people lacking the motivation or the means to exercise with conventional methods. Preventing boredom while a system is being used, and creating a motivating force for continued use serve as the main challenges in exergame design.**

We present an exergaming system that utilises performance of a memory task as a key gameplay mechanic in order to divert the players attention from the exercise being performed. Players pilot a pedal-powered helicopter in a virtual world, and are given the task of traversing a race course in a manner dictated by a previously memorised pattern. We conduct a user study comparing the system with a variant where players navigate the track without any memory task. Both the participants' levels of enjoyment and their percieved exertion were used to evaluate the effectiveness of these memory tasks for improving the players experience and motivation. Results of this user study validate our hypothesis that the addition of a cognitive task can lead to increased willingness from users to exercise using a system.

I. Introduction

Regular exercise is fast becoming recognised as one of the largest positive contributors to human health, but many people do not make time to do it. Exergaming is an emerging activity created with the aim of increasing accessibility to exercise, and motivate users who do not usually exercise sufficiently. Exergaming involves playing a game that is controlled through an interface that requires some kind of phyisical exertion.

While there have been many games in the commercial sector that have had great success such as the wii fit, they often only involve light levels of exercise. Exergaming is yet to provide the revolution of health benefits that many think it could create, a shortcoming that may be linked to a lack of more enjoyable physically intensive exergames.

For many individuals, moderate intensity exercise can create great discomfort, which acts as a barrier to continued use. In order to enable more intense forms of exergaming to be successful, the methods of motivation used by designers of physically intensive exergames need to be better refined. We believe that research into individual aspects of player motivation will lead to more motivating games that can create lasting positive changes to users' health.

There are many ways that game design could be used in order to shift a player's attention from the exercise they are performing to other elements of game-play. One way through which this could be achieved is through shifting the focus of games away from completion of automatic or reactive tasks and towards tasks that involve problem solving and more direct attention and reasoning.

We have developed an exergame with the aim of creating a testbed for experiments in motivation in exergames. In our game players pilot a pedal powered helicopter through a series of rings that mark a race track through a virtual world. The aim of gameplay is to navigate the track in as short a time as possible while ensuring that they travel through a rings in a manner dictated to them by a memory task. The player interacts with the game through pedalling on an exercycle in to control the lift of the helicopter.

Following this introduction, we present an analysis of related work in game motivation and exergames before describing our game's design, and the features that make our experiments possible. We then give a comprehensive explanation of our experiment, along with an analysis of the results gathered. Finally, a reflective discussion of the work described, and of the potential of investigating motivation further with expermiments of this kind.

II. Related Work

There are existing studies that have been performed relating game-play features to motivation. J. Reeve and E. Deci [1] published a study in 1996 that explored the interaction between various aspects of competition and their affect on intrinsic motivation. Their findings suggest that perceived competence positively influences motivation, and that this can be increased by feedback about performance while performing a task. In our work, we wish to give a related commentary on the psychological factors that lead to motivation in exergames.

Fitzgerald et al. [2] utilised exergaming as a way to increase intrinsic motivation for participants of physical therapy that need to do exercises with a wobble board. The results of their study showed an increase in interest and enjoyment in subjects using the exergaming system compared to the control group using conventional physical therapy techniques. This is greatly relevant to our work, but does not help towards the design of such exergaming systems. We focus on the inclusion of problem solving tasks as a specific method for increasing intrinsic motivation, with the aim of leading to the development of exergames that make full use of their motivational potential.

In the short paper by Gobel et al. [3], a series of exergaming systems were evaluated that all used some degree of personalisation. The results of the paper simply showed feasibility of this particular mechanic however this type of exploratory

research into particular aspects of exergame design is similar to our own. Our focus is more specific in nature, and we present our research in the more rigorous form of a controlled user study with the hope of finding reproducible result.

An article on exergames unlocked [1] gives an overview of a series of studies comparing competitive exergames to cooperative exergames. Results showed benefits in both techniques, with cooperative play showing larger levels of weight loss over the study period, and the competitive group scoring higher in cognitive assessments. The studies examined do not however analyse which aspects of competitive play are the most motivating, which we believe is important knowledge that could greatly contribute to the design of more motivating exergames.

W. Peng and J. Crouse [4] performed a study on the impact of different multiplayer experiences on motivation in exergames. Single player, cooperative multi-player and competitive multi-player were compared through affected enjoyment and motivation for future play. They found interpersonal multi-player games positively influenced motivation, with competitive play leading to greater physical exertion than cooperative play. Our work focuses more directly on competitive play and the psychological affect of direct parallel competition motivation.

There is an increasing amount of research being done into motivation in exergames, however little work has been done into the impact of specific features of game-play on intrinsic motivation. Of those studies that address similar research questions, to our knowledge none have examined the implications of different forms of cooperative play. Competitive exergames have been shown to be successful at increasing motivation for future play, however without research of the kind we present, we are unable to make informed decisions about the design of competitive exergames.

III. Design

We have designed an exergame with the focus of providing an enjoyable game that if played would contribute to better health through fitness. A core challenge with these systems is capturing the attention of people who already use games as a form of entertainment and are possibly exercise averse. These users have high expectations regarding virtual worlds in games and are used to their experiences being stimulating and engaging. Here we explore our approach to overcoming what we see as some of the core issues preventing exergames from reaching their potential with both the above demographic and wider audiences.

A. Associations with exercise

Many people hold negative connotations with exercise due to a history of unpleasant experiences or due to the initial effort required to begin receiving health benefits. If presented with a game that resembles some real world exercise we believe that users are likely to lose interest, and view the game as a chore.

[1] http://exergamesunlocked.org/2013/05/16/cooperation-versus-competition/

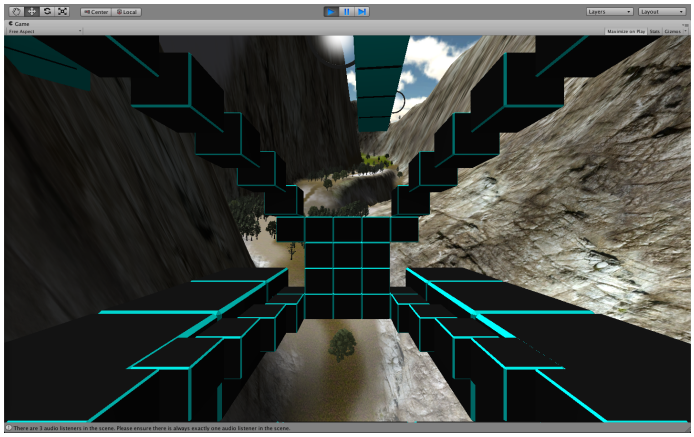

Fig. 1. View from the pedal powered helicopter

A fundamental design principal for this exergame was to have game-play that was detached enough from any known form of exercise that a user would not associate it with the task of exercising. We believe that in doing this users will be able to enjoy themselves more, leading to an increase in personal motivation while still improving their fitness.

To achieve these goals we designed a system where players fly around a track in a one-man pedal powered helicopter. Few people have had an opportunity to pilot a helicopter in real life so game-play still embodies some novelty. By making the helicopter pedal powered, we hope to create a slightly amusing and yet plausible way of integrating exercise into game-play.

Although there exists an obvious link to cycling, we believe the context of the player's interaction through pedalling is sufficiently different that playing the game will not feel like cycling in real life.

B. Engaging Simulation Environments

When trying to detach a game from existing fitness tasks while also ensuring the game will be a source of exercise, game-play can easily begin to feel awkward. We aimed for the world to still be immersive and for the ways in which the player interacts with the system to feel natural and appropriate.

Players interact with our game through an exercycle and joystick. The exercycle is used only to control power to the rotor-blades creating lift. Players can fly higher by pedalling faster and may descend by slowing down. This clear link between the action required to control the game and the game world itself was designed to make the game feel natural and engaging. The joystick is used to control the three axes of rotation in the helicopter. This interface was chosen due to its tactile nature and the links between joystick control and flying in the real world. The joystick can be mounted on the exercycle to make control as easy as possible.

While using a system that involves so much physical control, players may become too aware of their current physical setting and be dissuaded from participating fully in the game. In our design, we mitigate this possibility by using a virtual reality headset to focus the user's perception on the simulated

world. We hope for this to focus the users attention to the tasks presented to them.

C. Cognitive Stimulation

Finally we think that one key to distracting the user from the difficulties of exercise is to stimulate them mentally while they play. Typically in flying games players are either in a race or involved in some form of combat. We did not wish to include combat into our system, but believe that racing alone is not enough to divert a players attention away from their physical performance.

In our game we incorporate a simple memory task into game-play. The task resembles the game 'Simon' where a device flashes a sequence made up of four colors, each with their own audible tone and position on the device. The player then needs to repeat the sequence they were presented with by pressing buttons on the device in the correct order. In our exergame, when the player begins, they are presented with a similar sequence of colours and tones that appear on the periphery of their vision. At each checkpoint along the virtual race track there are four rings with the same colour and relative position as the elements of the sequence the player was shown. The player's task is to travel between checkpoints while passing through the sequence of rings matching the pattern they were presented with.

One potential disadvantage to this technique is that the memory tasks may feel like an unnecessary addition to the player if they are not correctly integrated into the rest of the game's aesthetic. We believe our memory task is fairly well integrated into the system, and that it contributes to the engagement of the user while distracting them from their physical excursion. Due to the scope of this research effort we were unable to pursue more involved forms of stimulation however many other approaches may be used such as competition, story telling, or cooperation with other players.

IV. Implementation

We implemented a prototype of our exergame in the Unity game engine. An exercycle and joystick were used as input devices for the game, both interfaced with the computer through USB. The exercycle was used to control the helicopters lift while the joystick controlled the pitch, roll and yaw of the Helicopter. The game was rendered in 3D and output for the game was presented through an Oculus Rift VR headset. The Rift's head tracking was used to allow the user to look around the Helicopter and the game world independently of steering, helping to increasing immersion.

The main difficulty experienced in implementation of our exergame was in balancing of controls for the Helicopter. Without assistance or heavy practice, users found it difficult to continue controlling the helicopter after it had started to tilt. This lead to players crashing and not experiencing the game as we had intended. To avoid this issue, a self correction system was implemented so that the helicopter would correct its orientation automatically when tilted too far. This auto correction provided the necessary stability for users to be able to participate in the user study.

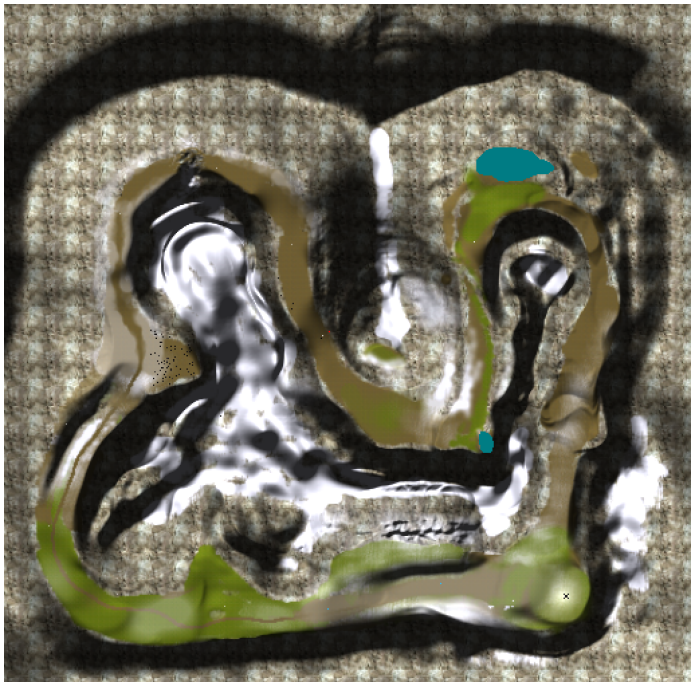

Fig. 2. Top down view of the course

V. Evaluation

A. Methodology

In our study we aimed to evaluate the influence of cognitive stimulation on motivation and physical exertion in exergames. To evaluate this relationship we conducted a user study.

To measure the effect of cognitive stimulation, we created two versions of the our exergame. One version required the completion of the pattern memorisation task described above. The aim these tests was for the subject to navigate the track, passing through the correct ring at each checkpoint to match the sequence they had first been presented with. The other version was more similar to a typical racing game by only involving navigating through the track with a single ring at each checkpoint and no memorisation task.

All subjects played the exergame both with the memory task and without it. In order to mitigate ordering effects, the order in which each subject experienced the test conditions alternated between subjects. Subjects were required to use the exergame for 6 minutes in each condition.

Measurement of users motivation was done through the use of questionnaires. These questionnaire were designed to indirectly evaluate the users enjoyment of the task and the likelihood that they would continue to use the system as a form of exercise or entertainment given the opportunity.

Before using the system, subjects filled out a short questionnaire shown in Table I that explored their past and current habits of exercise as well as their experience with gaming systems and virtual reality.

Once this is complete, a statement about the experiment will be read to the subject detailing both the purpose of the experiment and the aims that the subject should take on while participating in order to create the most useful results. Subjects will be asked to play the game in a competitive manner, trying their best to complete the tasks at hand and navigate the course as quickly as possible.

The subject was then given a 2-5 minute training period where they could practice flying around the course to get used to the controls and feel of the game. After this was completed, they were placed into their first test condition and instructed to begin.

After completing the first test, the next set of questions were given to the subject. These questions may be found in Table II were answered in relation to the system that they just experienced. The second condition was then tested before the same questionnaire was filled out regarding the second game, as well as a summary of the experience overall (Table III).

VI. Evaluation

The data gathered from the multi-choice questions from the questionnaires may be found in tables IV, V, VI and VII.

IV shows a variety of information regarding the demographics of our participants. All of the users that tested our system were between 18 and 24 years old and eight out of the total of ten participants were male with all but one of the participants of the study being students.

In the short answer component of the questionnaire we received a variety of responses. When asked what kind of effect the extra cognitive task had on their performance, Four of the participants outlined that they felt the cognitive task had made the exergame more difficult. Only one user claimed that the extra task improved their performance while the rest stated it made little to no effect.

In regards to relative entertainment value, six of the participants stated that they would prefer to use the memory game version as a form of entertainment. Only one user stated that they would prefer to use the version without the memory task for exercise while the others stated that they would have no preference.

For exercise, once again six of the players stated that they would prefer to use the memory game version while the rest would prefer the non-cognitive version for fitness.

The open comments included both positive comments and suggestions for improvement to design. Similar comments were made by three participants that the system could be made easier to control. One participant suggested that the helicopter design be closer to a real helicopter for greater immersion and one participant also mentioned that multi-player and combat would improve their enjoyment of the game.

VII. Discussion

A variety of constructive results have come out of our study. There was a clear preference of the cognitive task compared to the non cognitive task, however also statements that the inclusion of the cognitive task made the game more challenging. This suggests that inclusion of other game-play elements can improve enjoyment experienced by users, and that this form of the game was more motivating and engaging. However, due to the lack of significant results showing any decrease in perceived exertion when the memory task was included, we could not claim that it successfully distracted users from the task of exercising.

A variety of factors should be highlighted as potential threats to validity. Firstly, the participants of the study mostly belonged to a limited demographic, namely male students between 18 and 24 years of age. This should be taken into consideration when observing the results as the observations made in our study may not be applicable to other demographics.

As the technologies used in our game such as the oculus rift are popular in the technology world but still not available to consumers, our study may have been effected by selection bias. Due to the associations with ordinary video games we also expect that participants are by selection mostly interested in playing video games as a form of entertainment. As one of our aims of this study was to consider factors that contribute to acceptance of exergames by people in these demographics we believe that our results remain useful.

Without measurements of heart-rate or distances travelled, we are unable to make objective statements about the whether the addition of the memory task effected the amount of physical exertion required by the participants. However, cycling is known to be a valid form of moderate intensity exercise and we are confident that overall our game would have the same properties if used with moderate frequency.

VIII. Conclusion

In this paper we have described an exergaming system that was designed with the intention of being engaging and motivating for users regardless or their previous experiences with exercise. The results of our study suggest that overall our attempts were successful, although some of our design decisions did not create the expected effects.

In future work we would like to pursue different methods of cognitive stimulation, including competition, and other problem solving tasks. We believe that different types of gameplay would have different effects on the subjects perceived exertion.

Creating better feedback on performance while the player is using the game would likely create a more enjoyable experience. This could include time splits at each checkpoint, feedback regarding how far the person had travelled or awards for completing laps within certain time limits.

TABLE I
PRE TRIAL QUESTIONNAIRE

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 playing video games.	1	2	3	4	5

TABLE II
POST CONDITION 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 III
SUMMARY 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 IV
PRE-QUESTIONNAIRE RESULTS

Age:	18-24: 10				
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
Have you used 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 V
NON-COGNITIVE 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 VI
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 VII
POST-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

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