
Gameplay as Exercise

Designing an Engaging Multiplayer Biking Exergame

Kristoffer Hagen

Norwegian University of Science
and Technology
Trondheim, Norway
kristoffer.hagen@idi.ntnu.no

Letizia Jaccheri

Norwegian University of Science
and Technology
Trondheim, Norway
letizia.jaccheri@idi.ntnu.no

Konstantinos Chorianopoulos

Norwegian University of Science
and Technology
Trondheim, Norway
choko@acm.org

Stian Weie

Norwegian University of Science
and Technology
Trondheim, Norway
stianwe@gmail.com

Alf Inge Wang

Norwegian University of Science
and Technology
Trondheim, Norway
alfw@idi.ntnu.no

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CHI'16 Extended Abstracts, May 07-12, 2016, San Jose, CA, USA
ACM 978-1-4503-4082-3/16/05.

<http://dx.doi.org/10.1145/2851581.2892515>

Abstract

We designed and evaluated an exertion video game in order to overcome two challenges that are preventing exergames from becoming a viable sustained exercise alternative; insufficient physical exertion and player retention. This was achieved by implementing common features shared by the most popular video games and seamlessly merging them with the exertion found in exergames. A user study was performed where the exergame was played 132 times over three days by 8 participants. Compared to the control condition, a moderately paced walk, the exergame scored better on both subjective enjoyment and degree of physical activity. Further research could consider alternative versions of exergames, as well as different user groups.

Author Keywords

Exergame; exertion game; computer game; sedentary lifestyle; competitive multiplayer; physical activity

ACM Classification Keywords

K.8.0 Personal Computing: General: Games; H.5.2 User Interfaces: Prototyping; J.3 Life and Medical Sciences: Health

Introduction

Computer games are becoming a larger and larger part of everyday life for youths and adults alike. More time is being spent on television, computer and other gaming devices than any other activity apart from sleeping [15]. In the last five years alone, average

computer use by youths has increased by 40 minutes per day [14]. This lifestyle, characterized by increased time spent in front of a screen and decreased physical activity, has been shown to increase the risk of both physical as well as psychological illness [9, 10]. These developments motivated us to investigate the potential of promoting physical exercise in tandem with providing gaming entertainment. If such an alternative existed, wherein people could exercise and be active while also engaging in a favored recreational activity, a significant contribution could be made to deter the impending sedentary lifestyle epidemic.

The goal is to develop a video game that can provide motivation to exercise. The positive relationship between video game usage and weight status has been shown in several studies [17], led to our proposal being aimed primarily at people already familiar with, and avid users of computer games. This exergame could also have applications for people who have yet to venture into the video game domain, but still have difficulty motivating themselves to go to the gym, exercise, move regularly, and stay in shape. It presents the opportunity to achieve an appropriate level of physical fitness while doing something enjoyable. This led us to develop and evaluate the team-based multiplayer exergame Pedal Tanks.

Exergames is a field of research that has seen significant growth in recent years. Recently much research and experimentation have gone into creating different exergames [3, 7, 11, 12, 13, 19], however, many of them has remained experimental prototypes and has not been employed by actual users to evaluate their efficacy. There are also several commercially available exergames, typically cycle simulators where the user ride a stationary bike and the game displays a cyclist who moves accordingly [1, 5]. The goal is to race and try to beat other cyclists. While these kind of games may be motivating for people who enjoy bicycling, they do not convince people reluctant to exercise to play them.

In their systematic review Biddiss and Irwin [2] state that many exergames do not reach the intensity required to replace traditional physical activity. If we want exergames to become a viable exercise alternative, they need to reach a higher intensity level than they currently do. Additionally, in order for an exergame to be sustainable and viable over time, we must assure that both the attractiveness of the gameplay as well as the effectiveness of the exercise complement the user throughout the lifespan of the game [16]. To achieve this, the game must provide a suitable challenge at first play, then provide an appropriate progression both in terms of gameplay and exertion, as the user becomes more familiar and adept at the game [16].

Exergame Design

Although it might seem natural to simply connect an exercise interface to popular games already in existence, the actual implementation is more complicated. In many computer games, the best course of action is to behave reactively, e.g., to respond to an event initiated by someone, or something, else. This can result in low activity gameplay, where standing still, or moving very slowly is the best tactic for large proportions of the game. Conversely, other games require persistent rapid movement, such as in a racing game or similar genres in which the best action is always to move as fast as possible. This translates poorly into the exergame domain, which requires a balanced and healthy approach between activity and rest. Existing games are simply not designed to be used in conjunction with exercise.

On the other hand, the benefit of transferring and adapting gameplay mechanics from contemporary video games for the design of our exergame is two-fold. Firstly, we are leveraging tried and tested video game concepts from the industry, and then at the same time we are ensuring that the game feels intuitive and familiar for the target audience. Using elements from contemporary popular computer games and combining

them in a cohesive way yields an exergame that is both familiar and engaging. We based the design on the prevalent team-based shooter games while also borrowing many features from the Multiplayer Online Battle Arena (MOBA) games which is a very popular video game genre [6]. These cooperative games are characterized by small teams of 4 to 5 players, each controlling an in-game avatar through a third-person isometric view. With this avatar, players must complete various objectives to achieve victory over the opposing team of players. These games are fast paced, extraordinarily competitive, and reward good team dynamics. They are also easy to learn, hard to master, and deliver a strategic depth that enhances the replay value of the game.

The Gameplay of Pedal Tanks

The exergame we have created is an online multiplayer "capture the flag" arena game, created in Unity3D. Each player drives a tank in a 3rd person view throughout the game. The tanks are controlled by the pedals of the bike and six buttons installed on the handlebar, two for turning and four for firing the cannon and performing additional actions and abilities. A tank is selected from a wide selection of vehicles at the start of the game. Certain tanks are slow, powerful and defensive, others are fast, fragile and superior at capturing the flag. The players must effectively utilize the strengths of the tank they chose in order to gain advantage over the opposing team. Each game consists of a preselected number of rounds that end once one team manages to capture the flag, or the two minute timer runs out.

At the end of every game the players are rewarded with experience points based on their performance, and new types of tanks become available as the players advance in level. This aspect of persistence not only

heightens the players' investment in the game, but also enables us to control the learning curve and complexity of the game, allowing players to start out with simple classes of tanks and unlock more complex ones as they grow accustomed to the game. With two games very seldom having the same combination of tanks, the players can keep discovering new interactions and strategies, and the game continues to feel "fresh" even after many hours of play.



Figure 1. Screenshot taken from within the exergame

Movement in the game is encouraged through various objectives; guarding your flag from opponents and capturing their flag back to your base, and through gameplay mechanics such as the ability to regenerate ammunition based on the distance moved within the game. The best strategy is not always to go as fast as possible, sometimes it is better to sneak into the opponents' base, or simply wait for them to make a tactical mistake and exploit it. On the other hand, when in possession of the opponents' flag, it is usually best to return to base to capture the flag as fast as possible and win the round. After a player has been eliminated there is a short break in which the player can rest and catch his/her breath before reinitiating play, this also applies to all players in between rounds.

The gameplay has been designed for an immersive and natural-feeling experience. The players are in full control of their avatar. Being fit is an advantage but not a requirement; a tactical mind is equally important. This lets players of different fitness levels and with different levels of computer game experience both feel a sense of mastery and enjoy the game.

Evaluation

Eight people participated in the study (all male university students, between the age of 23 and 25). The subjects were recruited primarily via word of mouth, the criteria for participation was at a moderate to high familiarity of computer games, which we defined as a minimum 5-10 hours a week of playing games, and no medical conditions that prohibited physical exertion.

Procedure and Pre-experiment

We conducted an eight-person within-subjects lab study in order to examine the viability of using exergames to cover the recommended amount of daily physical activity. Before the experiment started the participants were asked to read and sign an informed consent form and introduced to the study, equipment, and measuring devices used. They were then asked to play the exergame for 15 minutes to remove some of the initial novelty factor from the study.

WALKING

The baseline activity was set to be a (minimum) 15 minute moderately paced walk, which is slightly below the recommended amount of daily physical activity for adults [18]. For both the baseline activity and the exergame activity the subjects were asked to walk or play for a minimum of 15 minutes, but to continue for

as long as they wanted past that. Should any activity reach a 60 minutes duration, the subjects would be asked to stop. To minimize the difference between the two conditions, the participants were asked to walk together to enable the same amount of social interaction that was present when playing the exergame.

PLAYING

Each round in Pedal Tanks lasts for 2 minutes, or until a player manages to capture the flag. During the evaluation the game was played in a "best-of-5" which means that the game is played until one team wins for the third time. After each "best-of-5", the players were given a three minute break before the next one started. As with the walking activity, the participants were asked to play for a minimum of 15 minutes, and for as long as they wanted past that.



Figure 2. Participants during a playing session

Result summary	Walk	Play
Enjoyment	17%	84%
Intensity	39%	87%
Duration (min)	17 min	44 min
Heartrate (BPM)	111	143

Table 1. Summary of results

The two activities would both be performed on the same day with a brief pause in between. To reduce order effects, the initial activity was selected randomly and then alternated the following days. This would be repeated again for two more days for a total of three sessions of each activity.

Data Collection

During the activity the subjects were equipped with both a heart-rate monitor (Polar A300), and an energy expenditure armband (BodyMedia SenseWear System) measuring energy usage. Immediately after each activity the subjects were asked about the perceived exertion and enjoyment of the current activity, and asked to mark it on a visual analogue scale (VAS). After each session the subjects were given a questionnaire to answer and a brief interview was performed.

Results

All the reported results are calculated with a significance value of $p = .05$ (or a 95% confidence interval).

Enjoyment

When asked to subjectively rate their enjoyment the participants preferred the exergame activity over the baseline walking activity. Over the three sessions, the exergame got an average score of 87.5 out of 100 (84.3-90.6), whereas the walking condition received a rating of 38.9 of 100 (30.9-46.9). The duration of each activity was another dependent variable that was measured. Walking was performed, on average, for 17 minutes (14.9-19.1), while the exergame was played for 44.3 minutes (36.2-52.5).

Sessions	1	2	3
Walking:			
Enjoyment	34%	37%	45%
Duration (min)	19	17	15
Playing:			
Enjoyment	91%	85%	89%
Duration (min)	39	43	51

Table 2. Development during the study

Physical Exertion

Average heartrate during the control condition was 111 (104.6 – 117.4) beats per minute (BPM). For the exergame we have two values for the heartrate, one with the breaks in between the games included, 142.6 BPM (133.8-151.4), and one without the breaks included, 162 BPM (153.2-170.7). The maximum heartrate achieved was measured to be 128 BPM (122-134) for walking and 177 BPM (169-185) for playing.

Retention

Neither the subjective enjoyment, nor the playing duration decreased significantly over the three sessions for the playing condition. Enjoyment went from 87.5 out of 100 (80.8-94.1) in session 1, to 85.1 (79.4-90.8) in session 2, and finally to 89.8 (83.3-96.2) in session 3. The average duration of play increased from 39 minutes, to 43 minutes, and finally 51 minutes.

Qualitative Feedback

While playing the exergames, and in the breaks between games, the participants frequently compared it to traditional video games they were familiar with; "The Destroyer tank (a selectable vehicle in Pedal Tanks) is just like Clockwerk (a playable character from the game DotA)", and "The Medium Tank needs a nerf (made less effective), it is way too good in close combat, it cannot be beaten". After playing, when asked to rate their subjective enjoyment and physical intensity the feedback was extremely positive, one participant stated "This is some of the most fun I've ever had" and "If this was available I would play it all the time and be in really good shape". Several mentioned that it felt much more like playing a fun game and not very much like exercising; "I don't think about the exercise before I step off the bike, then I realize how tired I am".

Limitations of the study:

We acknowledge that several subjects had prior social relationships, and that this will affect their experience of the exergame. We attempted to minimize this by regularly changing players between the teams.

While the results are promising, three sessions are not enough to make any conclusion about the ability for this exergame to retain its users. A much longer study must be conducted in order to discover this.

The maximum heart rate of the participants have been estimated by the formula $(220 - \text{age})$ and have not been accurately measured.

No females meeting the desired participation criteria applied to the study, this, together with the age range of the participants, limits the generalizability of the results found.

Discussion and Further Research

Our results show that Pedal Tanks is a highly enjoyable activity that showed no signs of decreasing user interest during the study. Many experimental exergames are lacking formal evaluations [4], in comparison to exergames that have published results, Pedal Tanks compares favorably. In Astrojumper [7, 13] the participants played for 15 minutes with a mean heart rate of 56.3% (+/- 8%). The results from the study of GrabApple [8], that performed a similar within-subject study, shows the participants playing for 10 minutes with an average heart rate of 72% (+/- 12%). In their systematic review Biddiss and Irwin [2] found the average heart rate during exergame play to be 61%. We achieved a mean heart rate of 73% (+/- 4%) over a 44 minute duration, with an average heart rate of 90% (+/- 4%) during active play. Based on the feedback and what we observed during the study, the high intensity is seems to be correlated with the level of immersion and competition in the game. One participant said "My legs were tired, but I really wanted the last point needed to win the game, so I gave it all I had". The competitive setting and high level of immersion made the players forget the exertion and just focus on the gameplay.

The walking control condition received a lower score for both enjoyment and physical exertion, and failed to keep the participants interested for very long (17 minutes on average). The control condition was chosen as it is the most common way of defining the recommended daily activity, in future research the exergame will be compared to more similar activities such as commercial exergames or other experimental prototypes. For the users of the study, the exergame did not only cover the daily recommended physical activity, but would also put them well within the "additional health benefit" category (150mins of vigorous-intensity physical activity a week) if the exergame was to be played for four days a week [18]. Future studies will compare different features of the

exergame to find more information about how exergames work and which features are vital for the efficacy of the game.

A biking exergame design requires a precise balance between interaction design and exercise physiology in order to be both engaging and beneficial to the health of the user. An issue that often seems to be forgotten in current exergame design is that, according to the dual flow theory [16], the gameplay itself must continue to challenge the players as they grow more familiar with the game. The exergame needs a certain amount of depth and complexity in order to be continuously interesting. As players grow more familiar with the basic concepts of an exergame they start looking for new challenges within the game, if they find none this can quickly lead to a lack of interest in the game. The participants of this study did on several occasions compare the exergame to different computer games they were playing in their spare time, using the same jargon and expressing it with similar emotions. When the participants discovered new strategies and got access to new vehicles they discussed with excitement their new options and appeared reinvigorated. Making novel exergames using new technology can lead to interesting results in the lab, but their efficacy with respect to increasing exercise motivation has yet to be demonstrated. Ideally, future projects will focus on real-world applications of exergames and consider different user groups and provide methodologically solid evaluations.

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