Evaluating Player Experience in Cycling Exergames

By

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Thesis Submitted to the
Faculty of Graduate and Postdoctoral Studies
In partial fulfillment of the requirements
For the degree of

Master of Science in E-Business Technologies

School of Electrical Engineering and Computer Science

University of Ottawa

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Abstract

Obesity has become a worldwide problem that most countries are trying to fight. It affects many people, irrespective of age, race, gender, or religion; anyone can suffer from obesity, which leads to serious problems, both for individuals and for society as a whole. In this study we have selected two groups of people: the basic people who do not exercise on a weekly basis, and the average people who exercise regularly, every week. We have explored the attitude of the two groups in regards to mixing exercises with games, in order to motivate the people with basic activity levels to exercise more frequently. We have used a qualitative standard online questionnaire from AttrakDiff, which evaluates user experience through four important aspects: a) quality; b) subjective understanding of quality and subjective evaluation of quality; c) pragmatic and hedonic features; and d) emotional and behavioural effects. We also did a qualitative study and a quantitative study of some of the important factors present during exercise. The results of the qualitative and quantitative studies were very encouraging as they revealed that mixing games with exercise can transform boring exercises into entertaining ones. It can also motivate players to continue and repeat the exercises. The ANOVA test was applied and it shows that combining games with a stationary bike has a significant effect on the speed and the average rotation per minute of the participants.

Acknowledgments

First and above all, I thank God for granting me the capability to proceed successfully during this educational journey. It is also a pleasure to thank those who made this thesis possible:

I would like to thank my supervisor, Professor Abdolmotaleb Elsaddik, for his knowledge, support, comments and advice.

I gratefully acknowledge the Saudi Arabian Cultural Bureau and the Ministry of Higher Education in Saudi Arabia for giving me the opportunity to accomplish this degree.

I am deeply grateful and will forever be thankful to my parents who have been my biggest supporters through it all, especially my mother, who is my guardian, my soul mate, Mom, I never could have achieved this without you.

I am also grateful to my treasure and my everything, my son Khalid, who is my source of happiness and my continuous motivation and inspiration to be a better person. Also to my siblings Omar, Reem, Alyaa, Lamya and Noran for their unconditional love, continuous care and constant support in every aspect of my life. They have always encouraged me to reach for excellence, and there are no words to express my thanks for everything that they have done for me.

I am also thankful to my friends at the MCR lab for making my journey so enjoyable; I have shared with them great times, many talks and a lot of laughter. A special thanks to my dear friends Bahar, Valeh, and Mohammad Huda.

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Chapter 1: Introduction

1.1 Overview of the Issue

Obesity has become a worldwide phenomenon that, if left unaddressed, will have severe effects on society's health, productivity, and economic well-being. It is considered a risk factor that can lead to diabetes, cardiovascular disease, high blood pressure, osteoarthritis, cancer, and gallbladder disease. The main two reasons for the rise in obesity are unhealthy eating habits and a lack of sufficient physical activities (Wang & Lobstein, 2006). Obesity is among the top health risk factors for the American and Canadian populations, including children of all ages, men, women and various ethnic groups.

The prevalence of obesity has increased in Canada over recent years; there was approximately a 14% increase from 1972 to 2005 among Canadian adults. In adults, obesity can be defined as a body mass index (BMI) higher than 30 kg/m^2, where weight (kg) is divided by height (m^2). It is crucial that research be conducted to help overcome problems caused by obesity for the obese patients involved, their families, their social surrounding, and the society and economy in general. Today, the primary methods used to counter obesity rehabilitation are dieting and physical exercise. Evidence suggests that nutritional adequacy, physical activity and nutritional education are the key components needed to combat these diseases (Kelleher, 2009). Evaluation of weight gain prevention programs have identified four necessary interventions, which are:

> (a) multi-focus cardiovascular disease prevention programs that targeted obesity along with other risk factors for cardiovascular disease (e.g.: hypertension and smoking), (b) prevention programs that focused solely on the prevention of obesity or weight gain, (c) interventions designed to solely increase physical activity, and (d) eating disorder prevention programs that promote use of healthy weight management skills. (Stice et al. 2006; p. 668)

While these methods are effective, they are clearly not stopping the adverse trend (reported above), and so more work needs to be done to control this dangerous phenomenon.

One of the most effective physical activities to fight obesity and stay in good shape is cycling, as it is a highly popular form of exercise and a great way to lose weight or maintain a healthy figure. It is one of the best low impact calorie burning cardio exercises, which means it is gentle on the joints and bones; the result is less injuries and more calories being burnt. This is why cycling is often considered a favourite exercise, whether outdoor or at the gym. It is clear that this generation, specifically children and youth, are facing greater exposure to technology, new devices, and various kinds of video games that can have both negative and positive effects. But if addressed well and with the right content, these types of media can be used as tools to influence and encourage people to lead a healthy, active lifestyle. As an example, scientists have been trying to develop video games with the purpose of encouraging movement and exercise in order to fight obesity. This can also improve the boring nature of exercising, making it much more fun and enjoyable. This naturally leads to more interest and participation in physical activities. These games are referred to as “exergames”, derived from the term “exergaming”, a portmanteau of "exercise" and "gaming" which is a term used for videogames that are also a form of exercise.

However, one of the key success factors for games, and for exergames in particular, is the user experience. In this thesis, the term “player experience” is used synonymously with the term “user experience”. In games, the player experience is focused on delivering a better and more immersive gaming experience, with fewer unnecessary interruptions or challenges that were not designed by the developers. There are many reasons why delivering a high quality experience is important in games. For one, playing games is voluntary. If the player has to struggle with problems that make playing less fun than doing something else, then there is nothing to stop the player from switching off the console. This is a serious risk, as user acceptance is very sensitive to user experience problems, and fun and encouragement are considered the most important aspects of the player experience. Another reason why the user’s experience is important in games is the fierce competition in the gaming market. The player can choose which games to buy from a wide variety of titles; if the experience is not pleasant, there are many more titles left from which to choose. Also, another highly influential aspect of the player experience is the context of use in which the game is played. This matter for the quality of the player experience, and any slight change in the context could affect the reaction and naturally the experience itself.

1.2 Objectives and Research Purpose

The following are the objectives linked to the purpose of this study.

1: To evaluate the player experience in cycling exergames. By conducting an experimental evaluation, the extent to which such games encourage physical activity will be assessed.

2: To know to which extent the player experience depends on context of use, namely the setting in which the game is played, including anything that could affect the experience.

3: To know to what extent the activity level of the participants (either average or basic) affects their experience.

To achieve this purpose, a research investigation will be created. The evaluation results could help the design of such games from an experience point of view and make them more engaging, attractive, and most importantly more fun for the users.

1.3 Research Hypotheses

The following hypotheses will be investigated. These hypotheses will be measured in terms of average activity time, average speed, and average distance cycled by the test groups, comparing the results of cycling "with" and "without" the game.

$H1_a$: The ExerBike game encourages physical activity.

$H2_a$: For people with an average activity level, the game does not encourage the user to cycle more than when watching TV while cycling.

$H3_a$: For people with a basic activity level, the game encourages the user to cycle more than when watching TV while cycling.

$H4_a$: If the context of use changes, the effect of the game on the user’s motivation to cycle changes.

1.4 Research Contribution

1. I will provide empirical studies describing the relation of context, activity level, and player experience in exergames, in order to prove that if player experience improves we will achieve healthier life-style and eventually prevent obesity.

2. I will provide an evaluation framework for the exerbike game in terms of the 4 hypothese which would help improve the user experience.

3. This knowledge would help researchers and companies to tailor their games and products for a specific user group.

1.5 Organization of the Thesis

This thesis is organized into six chapters. Chapter 1 introduces the objectives and purpose of this research, and the hypotheses being tested. Chapter 2 presents a literature analysis of the background of the field of exergaming, presenting the related work. This includes an overview of the recent exergames and the latest research efforts in this area and presents background information that introduces the content of the research, a brief description of the system being evaluated, and the major concepts underlying the research. Chapter 3 introduces the research methodology, including the research goals and method, as well as the recruiting process, including sampling and data collection, and the analysis process.. Chapter 4 presents the results of the evaluation, including a descriptive and statistical data studies. Finally, Chapter 5 is the conclusion of the project, presenting a summary, some study limitations, a discussion, and some recommendations for future work.

Chapter 2: Literature Review

2.1 Overview of the Literature

The literature reviewed in this chapter will focus on the ways in which the benefits of exergaming, as well as its challenges, have come to light through evidence-based research. A number of gaming platforms examined in academic literature will be assessed, and findings will be presented. The literature review is broken up into subsections that address different aspects of exergaming and its impact on motivation. Where possible, images from the games in question are presented as exhibits.

2.2 Health and Benefits of Sport

Physical activity is an important aspect of health, as "regular physical activity reduces the risk of heart disease, diabetes, obesity, and other chronic diseases" (Kandula et al., 2004, p. 360). Being overweight can lead to problems with respect to diabetes, cardiovascular disorders, and other serious illnesses including the early onset of cancer (McLaughlin & Wittert, 2009). McGarvey et al. (2006) note a number of physical conditions directly caused by overeating and lack of exercise. Many of these problems were formerly only considered adult conditions, but have now spread to young people with the advancement of childhood obesity. Hypertension, also known as high blood pressure, is nearly nine times more evident in obese children than in those of normal weight. Cardiovascular disease can also occur, and children have had heart attacks as young as seven years old (McGarvey et al., 2006). Sleep apnea, which is characterized by a difficulty breathing or the cessation of breathing during sleep, also rises significantly for obese youth. Many obese children are also at risk of developing asthma due to a lack of pulmonary exercise, as well as prolonged exposure to dust mites and other household allergens from leading a sedentary lifestyle. Physical challenges associated with extra weight or obesity can also include orthopedic issues. The cartilage in children's lower limbs and joints is in the process of development. When cartilage is forced to bear more than average weight, it can be damaged and even permanently malformed (McGarvey et al., 2006).

There are, therefore, interconnected social, psychological, and medical reasons for which people become overweight, and different reasons that cause those same people to remain overweight over a number of years. There is therefore a need for a physical activity intervention. In the Canadian culture, as in many countries around the world, sport is celebrated as a significant achievement and different sports are enjoyed by many people. The most popular sports in Canada are "golf, ice hockey, swimming, soccer, basketball, baseball, volleyball, skiing and cycling" (Ifedi, 2005, p. 11). Despite the popularity of these sports, over the last few years, the national sport participation rate has been dropping in Canada (Ifedi, 2005). As a whole, "participation in sport declined from 45% in 1992 to 28% in 2005 in Canada" (Ifedi, 2005, p. 9). There is a concern about this trend at the highest levels of the government, because of the fact that a lack of participation in sport can lead to health problems in the population. The federal government is trying to take steps to make sure that more people participate in sport in Canada (Bloom, Grant, & Watt, 2005; Canadian Heritage, 1998).

The primary benefit of sport is that of fitness and relaxation (Bloom, Grant, & Watt, 2005). As noted by Heritage Canada (1998), those who are active in sport state that the reason they take part is to make sure they stay fit, but also to relax. Over 70% of Canadians who are active in sport report that they are in "excellent" health (Heritage Canada, 1998, p. 4). On the opposite end of the spectrum, "in 2004, nearly 60 per cent of Canadian adults faced health risks due to excess body weight" (Bloom, Grant, & Watt, 2005, p. 2). What this means is that with fewer people involved in sport, there is a greater chance that they will become ill. This will cause problems in our health care system, and it will mean that more people are taking time off from work as a result of illness.

Another benefit of sport is that of social development (Bloom, Grant, & Watt, 2005). People who participate in sport are more likely to spend time with other people (Heritage Canada, 1998). This is a trend that can start in childhood, where most people gain an interest in sport. Cerin et al. (2009) refer to differences in physical activities as related to their domains, namely the kinds of physical activities connected to leisure, household work, occupational work, and human transportation, which have a positive effect on quality of life. In other words, people may perceive the value of physical activities differently as they are connected with different social meanings. Cerin et al. (2009) suggest that most research linking mental health and physical activities has been connected to the leisure domain, whereas doing housework, for example, has been shown to lead to increased stress and a negative quality of life, even though it may have the same physical effects on the body. In a linear regression analysis of two surveys on the different domains of physical activities, Cerin et al. (2009) found that there was an indication that the levels of discretion in activity and of activity preference could have an effect on mental well-being. What this means is that if an individual chooses to exercise, no matter in which domain that activity takes place, then there is a potential positive effect.

2.3 Benefits of Cardiovascular Exercise and Cycling

Hamer and Stamatakis (2010) contend that, more specifically, cardiorespiratory fitness and health have been shown to be connected to the quality of one's life in terms of physical and mental success. As noted by Ortega et al. (2010), for example, the results of their 15-year longitudinal study have shown that both men and women who have a high level of cardiovascular fitness are likely to extend their lives. Similar results were found by Sui et al. (2009) in a 25-year longitudinal study, wherein in the long term, a higher rate of physical activity was specifically associated with lower cardiomyopathy.

For adults, Sizer (2011) writes that not only does exercise help to achieve and maintain a healthy body weight, it also helps the body's tissues to become more responsive to the flow of insulin, which will decrease the chance of diabetes. This will also have an effect on preventing heart and pulmonary diseases, which are a major cause of difficulty later in life. This can be accomplished through the addition of 20 to 30 minutes a day of vigorous, continuous, and rhythmic aerobic exercise (Grosvenor & Smolin, 2006). This helps with heart health, stamina, flexibility, muscular strength, and improves body tone. At the same time, as noted by Sizer (2011), exercise should also include weight training. The rationale for this is that weight training is not only good for the bones, but it increases muscle mass so that the body processes all carbohydrates better.

According to the literature (Oja et al., 2011; Panis, 2011), cycling in particular presents high cardiovascular exercise benefits. As a whole, cycling presents significant benefits over other forms of cardiovascular exercise with respect to extended life expectancy, even when the majority of cycling takes place outside and exposure to pollution occurs (Panis, 2011). This is likely due to the fact that this form of exercise has fewer strains on the body than other forms of cardiovascular exercise such as running or aerobic dance. In a review of 16 cycling-specific studies, Oja et al. (2011) found that all recent results pointed to the increased benefits of cycling over other forms of cardiovascular exercise. While Oja et al. (2011) found that commuter cycling of a few kilometres substantially improved the cardio respiratory performance of low-fitness adults; there was also evidence that whether the cycling took place indoors or outdoors, cycling up to 3.5 hours per week reduces the risk of cardiovascular disease by about 20 per cent. Over 3.5 hours per week of combined cycling and sport reduces the risk by almost 40 per cent.

	Traditional		Video	
Variable	Pre	Post	Pre	Post
Age (y)	22±2	—	23±5	—
Height (cm)	176±10	—	177±6	—
Weight (kg)	85±18	85±18	84±13	82±14
Body mass index (kg·m^{-2})	28±6	27±6	27±6	27±6
Fat mass (kg)	17±8	17±9	18±9	17±10
Lean body mass (kg)	68±11	68±12	66±5	66±5
Maximal respiratory exchange ratio	1.20±0.06	1.25±0.09	1.21±0.05	1.19±0.06
Maximal heart rate (beats·min^{-1})	189±9	185±11	194±12	183±12*
Maximal power output (W)	307±43	296±9	272±36	307±43*
Maximal oxygen pulse (mL·beat^{-1})	19±4	20±4	17±3	20±3*
Grip strength (kg)	98±15	102±20	101±15	103±10
Flexibility (cm)	27±7	29±9	29±8	31±8
Leg power (W)	5089±801	5132±946	4858±724	5237±652*
Vertical jump (cm)	54±8	55±8	52±5	58±6*
Resting systolic blood pressure (mmHg)	131±7	128±8	131±7	123±6*
Resting diastolic blood pressure (mmHg)	68±5	67±9	69±7	67±6

Table 1 Fitness Measures Before and After a Video Game Cycling Program, *Source:* Warburton et al., 2007, p. 657

Video components of cycling exercises can lead to better cardiovascular results. In particular, Warburton et al. (2007) found that cycling indoors in combination with video games can have a positive impact on health over other forms of cycling. The Warburton et al. (2007) study discovered that a training program that links interactive video games to cycle exercises can make a difference in terms of improvements in health-related physical fitness in comparison with traditional cycle exercise training, as illustrated in the table below.

Warburton et al. (2007) found that indoor, video-game based cycling resulted in greater attendance, as illustrated in the figure below, and thus a higher volume of physical activity, and therefore a more substantial increase in physical fitness.

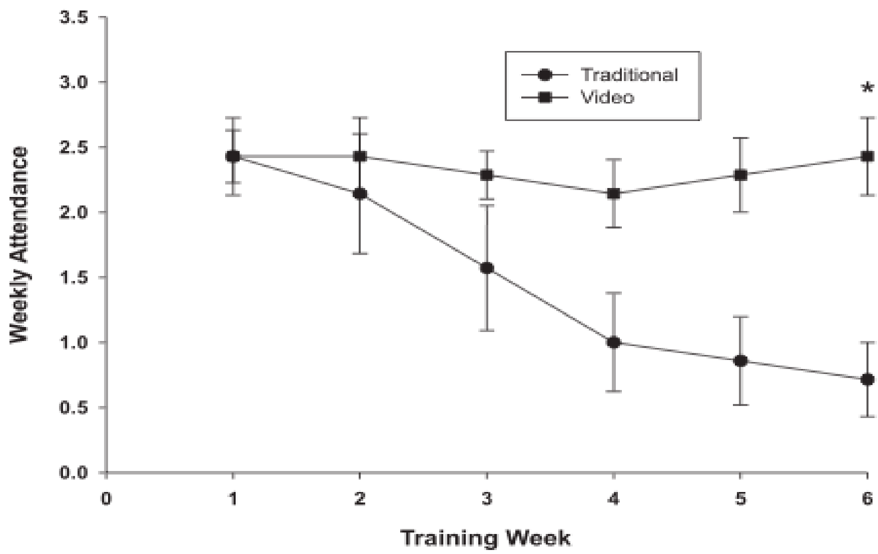


Figure 1 Attendance Comparing Traditional Cycling to Video Game Cycling, *Source:* Warburton et al., 2007, p. 659

What these examples demonstrate is that cycling presents significant benefits over other forms of cardiovascular exercise, and that indoor, video-game based cycling can present significant benefits over other forms of cycling.

2.4 Virtual Reality and Exergaming

Mestre et al. (2011) investigated the general assumption that virtual reality can enhance the experience of exercising. This was done by analyzing the effect of sensory input, in terms of music and video feedback, on performance, enjoyment, and focus, while cycling on an ergometer. The video feedback was related to the course that a participant needed to finish. The results showed that the positive effect related to repeated reminders about the participants' performance was only present when the video feedback was associated to music. According to Mestre et al. (2011), adding music to video feedback appears to be necessary to maintain the participants' commitment to the task over the long term.

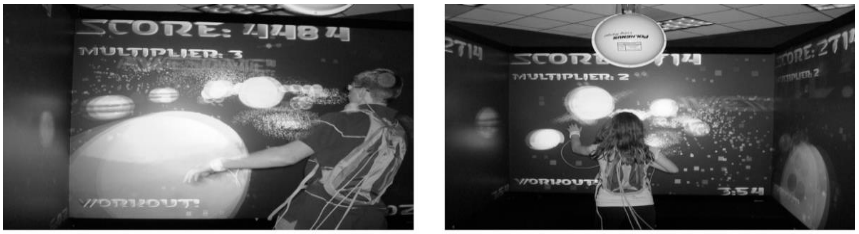
Ahn et al. (2009) discuss the design and implementation of a game that can mimic the act of running on a treadmill. The development of their Swan Game exists as a platform for high value games that are popular among the gamers and that use the Interactive Treadmill hardware. The literature review will analyse how the game is evaluated.

With the introduction of the PSP 4 in the present technological world, the importance of games shifted from a source of entertainment only to a way of exercising to lose weight and have a healthy lifestyle, while having fun. This is possible as children, or adults, involved in the process are constantly moving. Running on a treadmill becomes a general practice in the fitness laboratories as they also serve as clinics where most people are trying to lose weight or gain muscle power. Thus, games have replaced fitness centers for the tedious aerobic exercises (Ahn et al., 2009). The difference between the treadmills and games that have an aerobic element is that the former are monotonous and involve repetitive work, whereas the latter are more enjoyable. The Swan Boat became a popular multiplayer racing game, as illustrated in Image 1, which motivates the audience. The purpose of the Swan Boat is to make the interaction process between games and sport more entertaining, involving the whole body during these exercises

Image 1 Swan Boat screen and play, *Source:* Ahn et al., 2009

When the game was tested on eleven university students and six professors, most of them concluded that Swan Boat is more than just a sport exercise, since the time goes by very fast when involved in the game. One student commented that the fitness center became more enjoyable for him because of the opportunity to play the Swan Boat game. The typical likeable features included the arm gestures, which included the punching and hindering of the opponent to prevent him from winning, and running faster than usual on the treadmill in order to win. These activities prevented the users from being bored or exhausted, as the thrilling effects forced them to forget about fatigue and their lack of desire to continue (Ahn et al., 2009). The arm gestures feature of the game made it more interactive. According to the students participating in the survey, the replacement of arm gestures by buttons would make the game less interactive and therefore less interesting. Most importantly, the game motivated the students to run more enthusiastically during the game compared to their regular training (Ahn et al., 2009).

Finkelstein et al. (2011) present the design and evaluation of Astrojumper, a "stereo-scopic virtual reality exergame" which is an exergame aimed at physical simulation. When playing the game, virtual game objects fly forward toward the young players who must avoid collision using their own physical movements. The user needs to dodge planets that are speeding toward him or her. Scores increase by tapping gold suns that appear periodically.



(a) (b)

Image 2 Astrojumper screen and play, *Source:* Finkelstein et al., 2011

The study examined the experience of people between the ages of 6 and 50, all of whom were involved in the testing of the game for a period of 15 minutes. The virtual reality of the game positively influenced the participants regardless of their age, gender, and level of activity. The video game caused most of the participants to experience a high heart rate during the gaming process. The level of motivation was high during the workout, and results of the testing proved an influence on motivation for both children and adults. Finkelstein et al. (2011) concluded that gaming exercise, with the help of virtual reality technology, fosters the motivation of participants because of the interactive design and engagement processes.

2.5 Social Contexts and Exergaming

Gustafsson and Bang (2008) presented a pervasive game that was designed to encourage teenagers to reduce energy consumption at home. The idea of the game was to use an agent on a mobile phone that provides hands-on experience with electricity usage and promotes engagement. The results proved the game concept was motivating and engaging. Players and their families showed changes in their daily energy consumption patterns. Gustafsson and Bang further argued that pervasive games are effective for behavioural change and learning, and may also be appropriate to address lifestyle-induced health problems.

In another study, Ijsselsteijn et al (2005) investigated how media technology factors "may help users of exercise equipment to stay motivated to do regular workouts" (p. 688). They evaluated how immersion and coaching by a virtual agent affects the intrinsic motivation of users exercising on a stationary ergometer. Their results clearly showed that immersion positively affects both motivation and presence. The presence of the virtual coach also reduced the negative effects associated with VEs, such as feeling dizzy or nauseated.

2.6 Exergaming and Addressing Specific Health Issues

The literature also demonstrates the ways in which exergaming can be used to motivate people to address specific health issues. In a study testing a game (SilverBalance, on the Nintendo Wii Balance Board) for the elderly, Gerling, Schild, and Masuch (2010) found that physically engaging games may reduce the risk of depression among senior citizens, but it will also allow them to develop the motor skills they need to avoid some of the side effects of aging. In their study, Gerling et al. (2010) designed SilverBalance to support navigation in two positions: (1) sitting in an upright position with the player's feet placed on the board; and (2) standing on the board, as required for most commercial Balance Board games. This adaptation made it possible for the frail elderly, who need to sit rather than stand, to still participate in the game and to develop a desire to exercise. The physical and virtual designs were both simple in nature, in order to allow the participants to focus on the task and easily meet their physical and mental capacities. Motivation was also tied to the social aspect of working with the game in a group, in that "the group quickly engaged in competitive play by comparing and commenting on other player's results despite the simplistic graphical design and game mechanics of the prototype” (Gerling et al., 2010, p. 68). This approach seemed to increase motivation as well as the commitment to play the game again in the future.

In a similar research and game design approach, Morelli et al. (2010) created VI Tennis, which was a modified version of a popular motion sensing exergame that explored the use of vibrotactile and audio cues, but that was designed for visually impaired individuals. The game was tested among 13 blind children who experienced moderate to vigorous levels of physical activity while playing it. Morelli et al. (2010) found that using this game, as opposed to a non-virtual exercise activity, helped significantly increase motivation among these children. Although the physical output associated with the regular game and VI Tennis was similar, Morelli et al. (2010) discovered that the children “enjoyed playing this version more, which emphasizes the potential of tactile/audio feedback to engage players for longer periods of time” (p. 147). In other words, there was a greater positive association with the exergame than with standard exercise, which means it would likely produce longer-term positive benefits for participants.

2.7 Personalization of Exergames and Motivation

When they are personalized to the physical and mental needs of users, exergames can become even more effective. In a study by Gobel et al. (2010), three such games were tested and compared in terms of their effects on motivation. The games included a) ErgoActive, which was a set of mini games for sports and health that incorporated an ergometer and the vital parameters of a player into gameplay, illustrated in Image 3; b) SunSportsGo, which used accelerometers to recognize the player’s movement categories and intensity; and c) Y- Move, which used video recognition to track player movements which were directly injected into the game to control the direction of a car, illustrated in Image 4.

Image 3 ErgoActive, *Source:* Gobel et al., 2010

Findings from the study indicated that the recognition of the player's physical activities, movements, and vital status can add value to the game, not only in terms of game adaptability to their physical needs, but also to their motivation. The more the game was able to match the players' needs, the more likely they were to continue playing over a longer term.

Image 4 Y-Move, *Source:* Gobel et al., 201

2.8 Background Information

For the purpose of this study, we used an ExerBike developed at MCRLab/DiscoverLab. The ExerBike is an off-the-shelf stationary training bike (ErgoMeter) that is coupled with a virtual reality game that my colleague developed. The player controls the game with his/her cycling speed in RPM (revolutions per minute), and must aim and shoot at virtual flying ducks. The user needs to cycle with a certain speed in order to constantly point the gun towards the sky, where the ducks are flying. The cycling conditions are constant throughout the experiment, namely the virtual route, the elevation and the required average/maximum power (BPM). Since there was only one bike, all participants used the same bike. The game is based on a typical target-shooting scenario. The user interface shows a 3D Island Environment where the camera viewport has a first person shooter perspective, showing the direction where the player is looking. The player's character is standing on a platform facing a field, and in his/her line of vision there are three targets located at different distances. The player must knock down these targets by throwing coconuts at them. The player sits on a stationary bicycle, which acts as the input controller for the game, with a computer screen positioned in front of them and at eye level, as observed in Image 5.

Image 5 the 3D Island Environment, *Source:* MCRLab /DiscoverLab

The game engine manages the framework of the game as follows. In order to gain points, the player must hit all three targets within a ten-second time frame. Once ten seconds have passed, the targets reset and the game begins again. The player receives feedback about his/her ability to hit the targets with the use of crosshairs, as illustrated in Image 6. The player does not control the crosshairs, as they shift horizontally on their own. They move left and right at a constant speed, and can have an impact on the direction of the throw on the x axis. The vertical movements of the crosshairs, on the other hand, are controlled by the stationary bicycle. The

RPM reading from the stationary bike pedals connects with the y axis coordinates of the crosshairs, which has an effect on the direction and distance (depth) to which a coconut may be thrown by the player. As the RPM goes up, the player is able to improve the direction and increase the distance of their throw. In order to play effectively, the player must therefore moderate the speed of his/her exercise in order to match the targets. A button adapted to the handles of the bike is used to execute the throws.

Image 6 Screenshot of the game showing coconuts being thrown at targets, *Source:* MCRLab/DiscoverLab

What this approach means is that while the coconuts thrown are on a parabolic path matched to the crosshairs, these crosshairs do not work in the same way as other, more traditional sniper games. It is therefore not possible to train the crosshairs exactly on the intended target. This approach increases the challenge level of the game, and also ensures that the participant is focused on the necessity of increasing their physical output in order to make their marks more successful. At the end of the game, which continues for a fixed amount of time, the total score is calculated. However, the game can also be reset and started anew, depending on the needs and interests of the participant or on the needs and interests of those managing the participant’s exercise program.

2.9 Major Concepts

The major concepts underlying this thesis are evaluation, exergaming, and player experience.

2.9.1 Evaluation

According to Patton (1997), evaluation is the systematic collection of information about a program in order to enable stakeholders to better understand the program, to improve the program’s effectiveness, and/or to make decisions about future programming. There are three types of evaluation. The most common forms of assessment include pre-assessment, formative evaluation, and summative evaluation (Oliva, 2005). Pre-assessment measures skills which are necessary for a student to begin instruction (Oliva, 2005). Formative evaluation is used during instruction to diagnose progress or a need for remediation (Oliva, 2005). Summative evaluation reveals whether or not an individual has met the objectives of a program or course (Oliva, 2005). Evaluation can be thought of as a general process or appraisal and method of data collection that measures participants’ success in meeting goals, but also as a means of evaluating the overarching program and its efficiency.

2.9.2 Exergaming

The underlying theory of exergaming is connected to Ulbrich’s (1999) Exercise as Self Care Theory, which is a middle-range theory which demonstrates that there is a connection between the motivation to care for oneself and the practice of exercise. The development of this theory was connected to the idea that people need to be responsible for their own care over the long term in order to prevent disease and that for self-care to occur, people have to be aware of the ways in which they can take part in their own health development. To this end, as noted by Ulbrich (1999), motivation is a necessary precursor to exercise, and can be connected back to the transtheoretical model of nursing, which has denoted that there are “five stages of change, which are precontemplation, contemplation, preparation, action and maintenance” (Plonczynski, 2000, p. 698). An individual needs to be able to go through each of these stages in order to develop a strong foundation of self-care linked to exercise. For these reasons, Ulbrich’s (1999) Exercise as Self Care Theory requires the acknowledgment that there is a triangular relationship between self-care, motivation, and the specific needs of individuals with medical issues.

Taking into account research in exergaming, as determined by Gerling et al. (2010) and Sinclair et al. (2007), Ulbrich’s (1999) Exercise as Self Care Theory demonstrates that models for study may need to take into account broader, integrated factors that have an impact on health and self-care in connection with motivation. For example, as noted by Plonczynski (2000), behaviour is an incomplete measurement of motivation, and yet it is still used as a means by which evidence is collected from research subjects. Plonczynski (2000) argues that Ulbrich’s (1999) theory has proven that there is a need to look more deeply into the contributing factors preventing individuals from exercising, which may have nothing to do with their level of motivation but might be related to particular health issues, emotional factors, social factors, or environmental challenges. Any of these issues might affect an individual’s motivation in an exercise setting, for example when using exergames (Sinclair et al., 2007). Plonczynski (2000) suggests, for example, that Ulbrich’s (1999) theory has revealed the absence of comprehensive theories that include the most explanatory components of cognitive approaches to self-care.

Predicting and explaining optimal forms of exercise behaviour, as noted by Gerling et al. (2010), has been severely limited by research focused on behaviour rather than the causes of behaviour.

2.9.3 Player Experience

The theory of player experience (Bellotti et al., 2009) deals with the affective impacts of gaming. It is evident that player experience is related to the acceptance of such games and to the repeated or regular use of the same game (Desurvire et al., 2004). While many researchers link player experience with the fun factor, in fact it represents more than engagement and enjoyment. In particular, it allows the analysis of a player's cognition, emotions, and physical activity while playing a game or after playing a game. According to the theory of player experience, the variables that influence the intensity of emotions are: sense of reality, proximity, unexpectedness (wow-effect), and arousal. Costello and Edmonds (2009) have presented different categories for player experience. They listed thirteen different emotions felt while playing or after playing a game.

Category	**Description**
Captivation	Experience of forgetting one’s surroundings
Challenge	Experience of having to develop and exercise skills in a challenging situation
Competition	Experience of victory-oriented competition against oneself, opponent, or system
Completion	Experience of completion, finishing and closure, in relation to an earlier task or tension
Control	Experience of power, mastery, control or virtuosity

Discovery	Experience of discovering a new solution, place or property
Eroticism	Experience of sexual pleasure or arousal
Exploration	Experience of exploring or investigating a world, affordance, puzzle or situation
Expression	Experience of creating something or expressing oneself in a creative fashion
Fantasy	Experience of make-believe involving fantastical narratives, worlds or characters
Fellowship	Experience of friendship, fellowship, communality or intimacy
Nurture	Experience of nurturing, grooming or caretaking
Relaxation	Experience of unwinding, relaxation or stress relief. Calmness during play
Sadism	Experience of destruction and exerting power over others
Sensation	Meaningful sensory experience
Simulation	Experience of perceiving a representation of everyday life
Subversion	Experience of breaking social roles, rules and norms
Suffering	Experience of frustration, anger, boredom and disappointment typical to playing
Sympathy	Experience of sharing emotional feelings
Thrill	Experience of thrill derived from an actual or perceived danger or risk

Table 2 Categories for player experience, *Source:* Costello & Edmonds, 2009

Ijisselsteijn et al (2005) investigated how media technology factors “may help users of exercise equipment to stay motivated to do regular workouts” (p. 688). They have evaluated how immersion and coaching by a virtual agent affects the intrinsic motivation of users exercising on a stationary ergometer. Their results clearly showed that immersion positively affects both motivation and presence. The presence of the virtual coach also reduced negative effects associated with VEs, such as feeling dizzy or nauseated.

One way in which the game can satisfy players' needs is through a carefully rendered design process, as noted by Sinclair, Hingston, and Masek (2007). As they write, it is important for game designers to boost player motivation through an increase in the need to concentrate. This can be achieved by directing a player's narrow field of attention to the device or to the game itself. For example, Sinclair et al. (2007) suggest that Dance Dance Revolution requires the player to focus on the device, rather than on the game, whereas other games, such as those found on the Nintendo Wii, are more likely to require that the player focus on the game that is on the screen. A game designed to require that the player focus on the screen and on the device at the same time would likely be the most successful at user engagement. As noted by Sinclair et al. (2007), the player experience is tied to nine key factors, which are:

1. Balance between perceived skills and perceived challenge (the activity is neither too easy nor too difficult).
2. The merging of action and awareness.
3. Clear goals (expectations and rules are discernible and goals are attainable and align appropriately with one's skill set and abilities).
4. Unambiguous feedback (successes and failures in the course of the activity are apparent, so that behavior can be adjusted as needed).
5. Concentrating and focusing, a high degree of concentration on a limited field of attention (a person engaged in the activity will have the opportunity to focus and to delve deeply into it).

6. A sense of personal control over the situation or activity.
7. A loss of the feeling of self-consciousness (no feelings of self-doubt or self-concern).
8. Transformation of time (one's subjective experience of time is altered).
9. Autotelic experience (the activity is intrinsically rewarding - it is undertaken for its own sake). (Sinclair et al., 2007, p. 292).

In order to facilitate the most authentic and motivational player experience, these factors must be taken into consideration.

While exergames and their effects on some aspects of player experience have been studied by other researchers, to the best of my knowledge no other work has analyzed the extent to which the player experience in cycling exergames depends on the context of use and on the personal activity level of users.

Chapter 3: Research Methodology

3.1 Research Goals and Rationale

The scientific research goals of this study are to explain the effect of combining virtual reality games with physical exercise, and how this impacts the motivation levels of the participants. This study will allow physical activity researchers to understand to which extent games can encourage physical activity, specifically within the context of ExerBike activities. This study will analyze if the effect is constant for users of different ExerBike activity levels. Understanding the findings could help researchers and companies tailor their games and products for a specific user group. In addition to a user's personal activity level (fitness), another important factor for player experience is the context of use. To the best of my knowledge, this factor has been neglected in the evaluation of games that encourage physical activity. To this end, this study places a focus on the gain associated with the introduction of cycling games compared to simply watching TV while cycling.

The social research goals of this study are to create the means by which society may benefit from a more physically active population and economically stronger companies. The results of this study may help sport or fitness clubs, trainers, physical therapists, and product developers to better understand potential customers, and can lead to better product design and more customized games. Sport clubs and producers of exercise devices will benefit from results illustrating the effects on motivation, fun, and enjoyment for different user groups. This can help companies and medical personnel improve their services and products for people in need of fitness options. It can help motivate more users to cycle and increase customer satisfaction, therefore increasing use and profit. Users will benefit from improved services and product quality. Moreover, encouraging physical activity will improve the health of users in general. In this case, increased physical activity would imply more deployment and therefore the purchase of more exercise devices.

3.2 Research Method

The study employed a basic 2x5 mixed experimental design, whereby participants were presented with a cycling exercise system that divided the users based on two different activity levels (basic versus average) and five different settings (plain bike, bike + game, bike+ game+ movie, bike +game+ TV, bike+ TV). The causal nature of the research questions, as related to motivation, is best served by an experimental approach, which seems to hold the greatest promise in providing a direct and credible set of answers. Experimental design is regarded as the most appropriate route to examine a causal relationship between two variables, especially when evaluating the direct impact of one variable on another. "Experimental design is appropriate when one wishes to discover whether certain variables produce effects in other variables". Experimentation provides the most powerful support possible for a hypothesis of causation (Cooper & Schindler, 2010, p. 136).

An experimental design is appropriate for this study. Patten (2012) suggests that, "In experiments, researchers give treatment and observe to see if they cause changes in behaviour" (p. 5). In studying cause and effect relationships, the experimental approach is almost always preferred over non-experimental (Cooper & Schindler, 2010). The definition of an experiment involves research in which there is "at least one independent variable and one dependent variable". The purpose of the experiment is to estimate the extent to which independent variables cause changes in the dependent variables (Patten, 2012). Based on the above information, this study will follow an experimental approach which will be designed to examine the effect, magnitude of effect, and direct vs. indirect effect of activity levels and settings when using exergames. The experimental format is proper because it allows us to test for causation directly and to eliminate variables that might intervene in non-controlled circumstances.

3.3 Variables

In this study, the variables are defined as follows. There are two independent variables. The first independent variable is the context in which bicycle riding occurs. These contexts include: the "plain bike" context, which refers to the setting where participants only exercise on the ergometer without playing the game; the "game" setting, which refers to the case where subjects play the ExerBike game; the "only TV" setting which refers to the case where subjects cycle while watching TV only; the "game-cinema" context of use, which refers to a situation where participants watch an exciting movie of their choice on a high quality screen with an appropriate sound system while they are exercising; and the "game-TV" context of use which refers to a situation where participants watched a randomly-chosen Canadian TV channel. The second set of independent variables is the physical factors, which include average speed and heart rate, distance, and duration. The dependent variable is the participant's level of motivation.

3.4 Population, Sample, and Rationale

The sample was derived from a population with the following demographic, geographic, and psychographic characteristics. The population includes people living in the Capital Region, as subjects needed to take part in the tests in person at 800 King Edward, Discover Lab, University of Ottawa. The population included male and female persons between the ages of 18 and 36.

Subjects needed to meet the following criteria in order to be eligible for the sample, and were invited to the study lab for inclusion or exclusion purposes. Sample subjects needed to have a basic knowledge of virtual reality games, as well as general experience in cycling, but could not be recreational or competitive cyclists. Sample subjects could not present any medical condition which was contraindicated for athletic participation, according to their answers on the Physical Activity Readiness Questionnaire (PAR-Q). People with diabetes, heart disease, or any other chronic diseases were not recruited, in order to avoid complications. Should any participant have answered “Yes” to one or more of the questions on the questionnaire, they would have been asked to see a family doctor or a physician and be excluded from the research. Sample subjects had to present a basic or average activity level. Basic activity subjects are those who are willing to be physically active but whose activities do not go beyond walking or taking the stairs instead of the elevator. Average activity subjects are those who do sports two or three times a week, or who have a job that is physically demanding. Such people train more than 60min - 120min a week (jogging, swimming, or other aerobic activity). The activity levels refer to the last three months.

Body mass index, or BMI, is the individual's body weight divided by the square of his or her height (Center for Disease Control, 2011). This measure is used to define whether or not an individual is overweight or obese. Obesity is defined in relation to a historical normal group, but can loosely be defined as a BMI greater than the 95th percentile (Center for Disease Control, 2011). Sample subjects had to have a normal weight of 18.5 to 24.9 kg/m^2, according to the international body mass index (BMI) standard, and a waist-to-hip ratio in the normal range of <0.85 for women and <0.95 for men. To obtain the BMI, the formula BMI (kg/m^2) = weight (kg)/ (height (m)) ^2 was used. Subjects with BMIs outside of the standard range were excluded.

Participants were randomly chosen, independent of each other, and with no relation to the experimenter, within a framework of first-come, first-accepted. Participants were recruited using e-mail lists using a snow-ball sampling effect through personal networks. While the researcher's social network was used to recruit participants, members of this social network were not asked to participate in the study. Once the ideal number of participants was reached, no more participants were accepted. The study participants included two groups of ten people; one for the basic activity level (five males, five females) and another group for the average activity level (six males, four females). Each group was evaluated in each of the settings listed as independent variables on five different days within a span of three weeks. Since only one prototype of the game was available, it was not possible to run parallel sessions. Participants were not aware of other participants' activities.

The number of participants was limited, but this was necessary due to organizational reasons (because of limited access to the game prototype) and justified by the research literature. For evaluating the usability of interactive applications, the use of five to seven participants have been reported to be enough to detect major usability problems (Nielsen & Landauer, 1993; Turner et al., 2006). Although there are limited empirical studies or analytical work on the minimum sample size for player experience research, the community continues to use five to seven participants for player experience evaluations (e.g., Mestre et al., 2011). To this end, the number chosen was higher than average and therefore appropriate. Since this experimental research design required two groups (basic versus average activity levels), five to ten subjects for each group was thought to be appropriate.

Due to the aspect of regular training within this experiment, it was expected that the personal fitness and performance of subjects would increase, which could become a source of bias. To this end, subjects of each group were randomly assigned to one of the five settings in order to counterbalance the possibility of bias over time.

3.5 Confidentiality

No personal information such as names, birthdates, addresses or social insurance numbers were collected. Each participant received a unique participant number, a Globally Unique ID (GUID). The GUID is computer generated and looks like the following example 936DA01F-9ABD-4D9D-80C7-02AF85C822A8. If a user wanted to be excluded from the study for any reason he or she would have needed to provide the researcher his GUID, and this person's data would have been excluded from further use in the study. Only the researcher had access to the GUIDs, but there was no link between GUIDs and a person's real identity. Once potential participants responded, the research objective was explained, and confirmation of volunteer status was obtained. There was no payment or reward for participating.

Participants were informed that no personal data would be collected and all collected data would be anonymous and protected by means of modern security mechanisms. The consent form was sent via e-mail before the first session. This was done after potential participants had responded to the recruiting e-mail. If a participant disagreed, no participation took place and no data was collected. There was also the chance to read the form at the lab where the experiments took place. In any case, the first time subjects entered our lab the experiment was explained to them, and they were asked to read and sign the consent form.

3.6 Instrumentation

There were a number of different instruments used to measure the variables in the user experience. The physical factors (weight, BMI, average speed, distance, duration, and average heart rate) were measured using standard metrics. The ExerBike uses an off-the-shelf ErgoMeter that allows it to measure all the above mentioned variables as well as cycling power (RPM). Activity Readiness was assessed using the Physical Activity Readiness Questionnaire (PAR-Q-Test). The Activity level of the participants was captured using the general Practice Physical Activity Level Questionnaire. The heart rate and speed was measured three times in each session: at the first minute, at the fifth, and at the tenth minute. The heart rate was taken by an earlobe heart rate monitor that is connected to the bike and gives continuous readings. The average round per minute RPM was measured right before the end of the 10^{th} minute.

For the purpose of evaluating the player experience in the cycling exergame, namely the level of motivation and the dependent variable, the standard online questionnaire from AttrakDiff was used. Data collected using AttrakDiff gave an idea of the attractiveness of an exercise and how it is experienced including usability and appearance of the product, which is the bike (ergometer) by itself or with the different contexts of use. In this questionnaire, participants were presented two opposite adjectives regarding their experience and had to choose which extreme best matched their response to the experience. They had the freedom to choose the intensity of their feelings about the experience. Results should show these four important aspects: a) quality of the exergame; b) subjective understanding of quality and subjective evaluation of quality; c) pragmatic and hedonic features of the exerbike; and d) emotional and behavioural effects.

3.7 Data Collection

Meeting times were set with each participant according to their preference over a period of six weeks. Every week, between 8 am and 6 pm, five participants were asked to attend the sessions at a rate of two per weekday, until all participants had completed five sessions each. While contexts varied, as noted above, every participant had to do the cycling in the five contexts of use, but in a random order in order to decrease bias.

The participants received a basic demo of the Exerbike and the ergometer itself before the experiment began. The experiment and data collection were conducted at 800 King Edward, 5th Floor, Discover Lab, Ottawa, ON, Canada. Each session took between 30 and 45 minutes. The first 10 minutes were mainly an explanation of the task and preparation of the game. If users were expected to watch a movie of their choice, this choice was made from the Internet (Video-On-Demand) and was purchased by the researcher.

In each session, the physical activity readiness questionnaire PAR-Q test was conducted. Once the ergometer, the game, the TV/Movie was set up, the user started cycling. This part took 10 to 20 minutes. The participant had the choice to stop even earlier, if needed. They were not asked to continue or not to interrupt the session. After the session, notes of the training results and the performance data presented by the ergometer were taken. This included speed [km/h], distance [m], time [h: m: s], heart rate [1/min]; the data collection took about 5-10 minutes. While the data was being entered, the participants could relax. Finally, the participants responded to the questionnaire that has been designed to test user experience. The questionnaire was posted online using Google Forms. The participants needed to log into Google using their own data (e-mail address, password) in order to complete the form. Using Google Forms, participants were sent an invitation email that contained a link to the questionnaire. The participants completed the questionnaires in the lab. Participants used one of the computers that are present in the Discover Lab or MCRLab. Both labs are collocated. Within the lab, people had access to soft drinks and water. Participants had the freedom to continue watching the movie or TV channel, but could not use the ergometer for more than 20 minutes.

3.8 Data Analysis

Data entry was done online using Google Forms. It is a very reliable and secure means of data storage. Data communication between the Google server and the researcher's computer were encrypted using SSL. The researcher was the only person to have access to the data, and it was protected with a very strong password.

After having collected the data, statistical hypothesis testing was conducted in order to answer the hypotheses of this work. The ultimate goal was to see if the game encourages physical activity, in terms of increasing motivation and fun. The next goal was to analyze this effect under different contexts of use and for users of different activity levels. First the data from both the questionnaires and the objective measures such as average speed, average heart rate and average (RPM), was sorted. Next, the data was analyzed to see if introducing the virtual reality game significantly enhanced the cycling experience. The possible positive influence on the perceived player experience was tested and objective measures that are indicators of higher motivation (e.g. average speed, average RPM and average heart rate) were evaluated. Data was analyzed to see if the differences between the groups were significant. Finally, the results were compared between different user groups (basic and average activity levels). Statistical data analysis methods were applied to verify if the hypotheses were supported or rejected. Statistical data analysis methods were applied to analyze the validity and reliability of the measures. Results and findings were compared to those from the existing literature.

Chapter 4: Results

Within a month of sending the recruiting emails, the researcher received 38 responses from people willing to participate in the study, most of them university students. An apologetic refusal email was sent to two of them because they were under 18, and the others were asked to come to the lab so that additional information could be gathered. Once at the lab, their measurements were taken using an off the shelf scale, and they were asked to complete a hard copy of the PAR-Q test so that the researcher could choose the ones with normal BMI's and with no issues performing this sort of exercise. Only 20 participants were needed for the whole experiment, 10 with an average activity level and 10 with a basic activity level. To determine who fit into what group, they were also asked to complete the general Practice Physical Activity Level questionnaire, in hard copy, in order to measure their activity level.

Out of the group, one individual was excluded because of a low BMI, two were excluded because of a higher than normal BMI, and three were excluded because they answered yes to some questions in the PAR-Q, which indicated that they were not qualified to participate.

Finally, the researcher had to apologize to the rest of the group because the total number of participants needed were found; a total of 20 participants, 10 with an average activity level (6 male and 4 females), 10 with a basic activity level (5 males and 5 females), all between the ages of 20-36, all with normal BMI's and absolutely no health issues or concerns related to any physical activity. The meeting times were set according to their preferences. For a period of 6 weeks, every week 5 participants were asked to attend the sessions. There were 2 sessions per day, and only on weekdays.

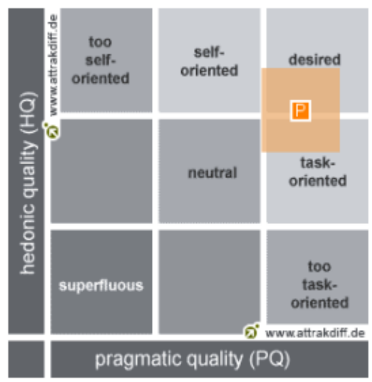
4.1 Qualitative Analysis (Attrakdiff)

The Attrakdiff questionnaire provided the 4 sets of data collected. The first set is to indicate the pragmatic qualities (PQ) of the bike and describes its usability and indicates if the users could achieve their goals using it. The next set is to provide the hedonic qualities of the bike with a focus on the stimulation (HQ-S) to determine to which extent this product can support the need to develop and move forward, which is part of human's nature. The third set provides the hedonic qualities with a focus on the identity (HQ-I), which means to which extent the bike allows the users to identify with it. The last set is to determine how attractive the product (ATT) is, in order to get an idea of how the users are valuing it based on the quality of their perception. All these work together equally to determine the user experience. After collecting the data from participants and using Attrakdiff, the following are the results regarding the experience of participants in both activity levels, including both genders using the bike in the 5 different contexts of use. Attrakdiff provided us with three different diagrams giving distinct dimensions to evaluate the user experience. The 1st diagram is mainly a portfolio of average values of the PQ (pragmatic quality), HQ (hedonic quality), and confidence level. The values of the hedonic quality are represented on the vertical axis (bottom = low value) the horizontal axis represent the pragmatic quality (left = low value), so depending on the values, the product or context of use will lie in one or more character regions. The small orange rectangle is where the rating sits exactly; the big faded rectangle is the confidence rectangle. It shows if the users agreed in their evaluation. The bigger the confidence rectangle, the less sure one can be as to which region it belongs; a smaller confidence rectangle is an advantage because it indicates results that are reliable and less coincidental.

4.1.1 Attrakdiff Results for Basic Activity Level Participants:

In figure 2, the diagrams show the results of the rating of participants with a basic activity level, in order from best to least favourite according to their personal exercise experience.

2a) Bike + Game



2b) Bike + Game+ TV

2c) Bike + TV

2d) Bike+ Game + Movie

2e) Bike Alone

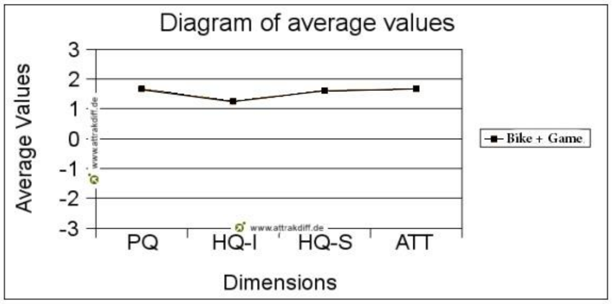
Figure 2 Portfolio with average values of the dimensions PQ and HQ and the confidence rectangle in the five different contexts of use for basic activity users

In Figure 2a) in the context of use, cycling while playing the duck shooting game got the highest rating amongst participants with a basic activity level. It is rated as desired and very pragmatic and assists the users optimally. However, according to the hedonic qualities it is only average, which means there is still room for future improvements. In Figure 2b) when the participants tried playing the game while a TV was also on, there was a slight difference in their experience and the evaluation moved the rating more towards considering it task oriented, but it was still very pragmatic and desired overall.

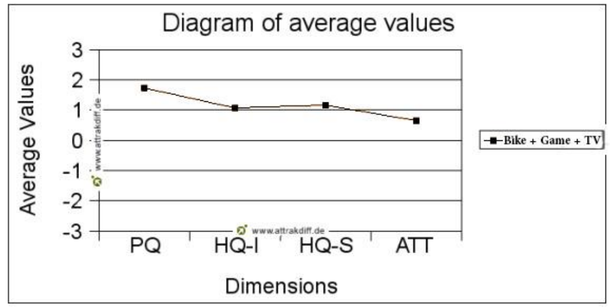
However, as seen in Figure 2c), when they tried cycling while watching TV only, results came up as neutral, which means the pragmatic and hedonic qualities are average, leaving room for improvement in terms of usability and stimulation.

When participants tried cycling, playing the game, and also watching a movie of their choice, the results shown in Figure 2d) show a rating of practice oriented, which means it is pragmatic and somehow it stimulates the users. Then, when they tried the bike only, the evaluation decreased to rate it as superfluous, according to the hedonic qualities. It is not stimulating and users do not identify easily with it. In terms of pragmatic qualities it is rated as average, as seen in Figure 2e).

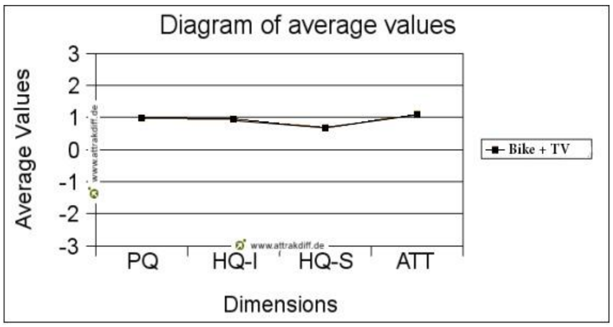
The 2nd Attrakdiff diagram is the average values of the four dimensions (Pragmatic, Hedonic-Identity, Hedonic-Stimulation and Attractiveness).



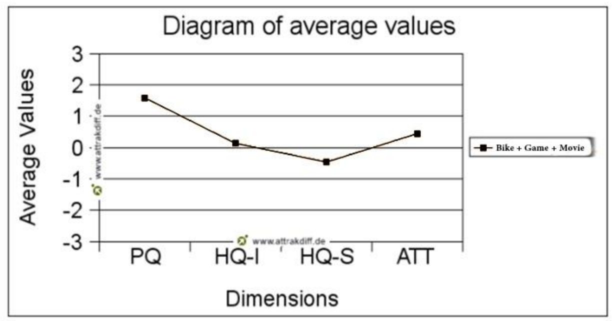
3a) Bike + Game



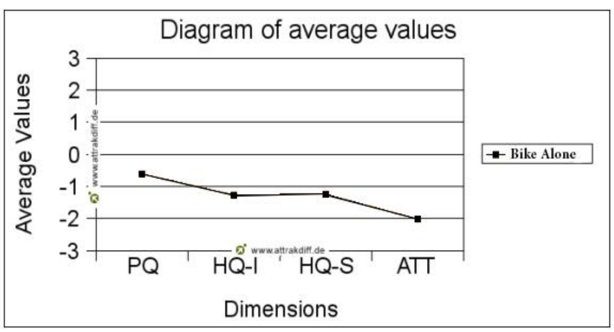
3b) Bike + Game+ TV



3c) Bike + TV



3d) Bike + Game + Movie



3e) Bike alone

Figure 3 Mean values of the four Attrakdif dimensions for the five contexts of use for the basic activity users

In Figure 3a), with regard to the hedonic-identity quality, biking while playing the game is rated above average, which means it provides the participants with identification while also meeting ordinary standards. With regards to the hedonic-stimulation quality it is also rated above average, which means cycling with the game stimulates the participants, awakes their curiosity, and motivates them. Attractiveness is rated higher than average, which indicates that the overall impression of it is very attractive.

However, as seen in Figure 3b) and 3d) ,when they played the game while TV was also running and when they tried playing the game while watching a movie of their choice, the experience rating dropped. In this case, with regards to hedonic (identity-stimulation) and attractiveness qualities, it was only rated average, which means it only meets ordinary standards and is considered moderately attractive. As for the biking while only watching TV context of use, Figure 3c), the experience was also rated as average for the hedonic (identity-stimulation) qualities, but the attractiveness rating increased to above average.

Finally, as seen in Figure 3e), the plain bike context evaluation rating decreased below average in the hedonic (identity-stimulation) and attractiveness qualities, which indicates how users could not engage or bond with it. The participants' lack of motivation caused them to rate it as simply unattractive.

Figure 4 shows the description of the word-pairs used in the questionnaires. It describes in detail the basis of the 2nd diagram (previously discussed) including the 4 dimensions of the Attrakdiff user experience: the pragmatic quality, the hedonic (identity-stimulation) qualities, and the attractiveness of the exerbike, in the five contexts of use.

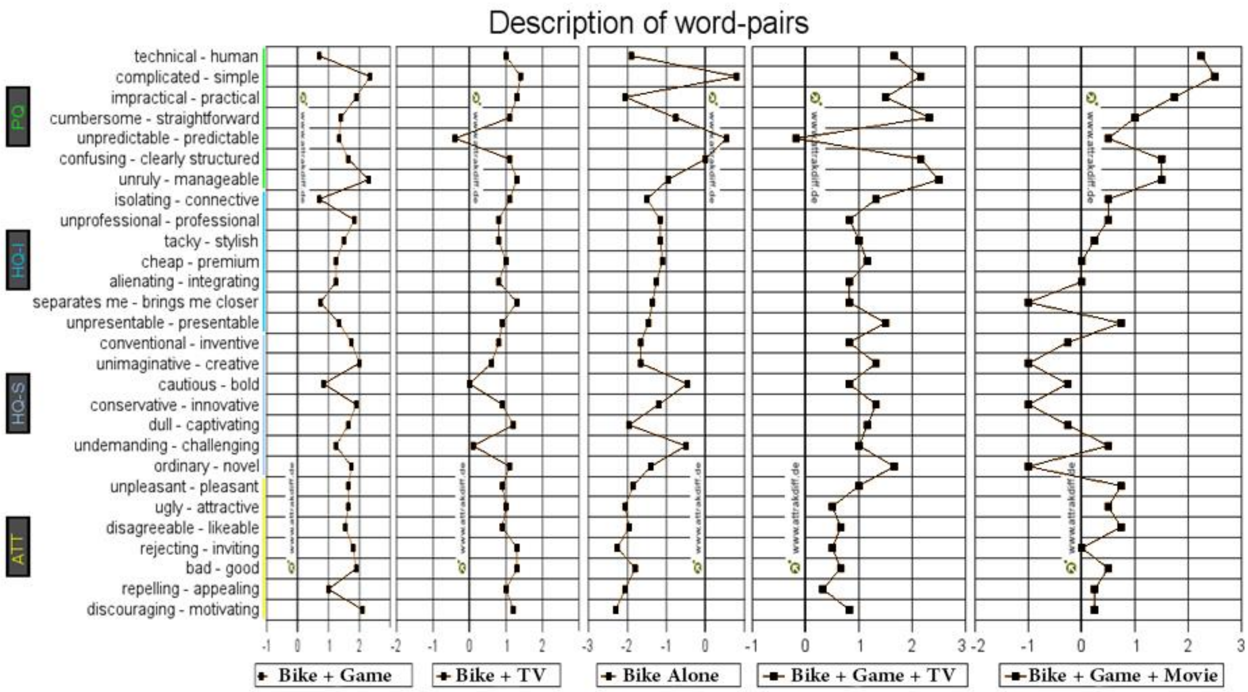
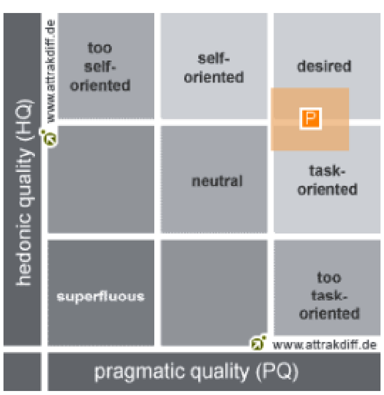


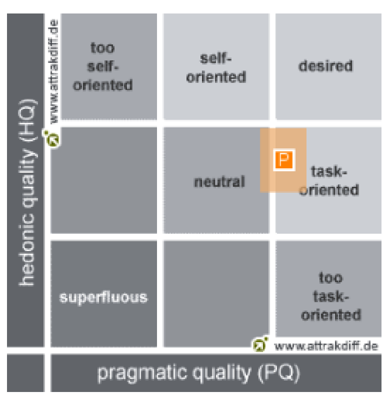
Figure 4 Mean values of the Attrakdiff word pairs for biking in the five different contexts of use for basic activity level participants

4.1.2 Attrakdiff Results for Average Activity Level Participants:

As seen in figure 5, the diagrams show the results of the ratings for participants with an average activity level, in order from best to least favourite, according to their personal exercise experience.



5a) Bike + TV



5b) Bike + Game

5c) Bike alone

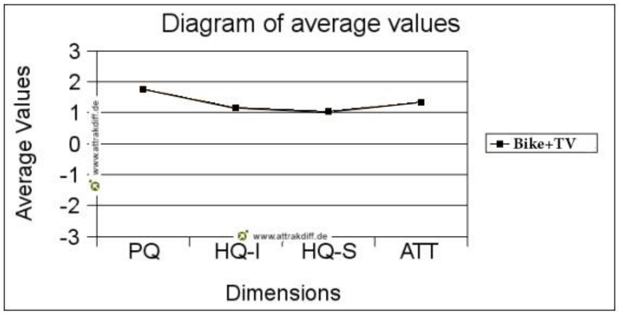
5d) Bike +Game +TV

5e) Bike +Game +Movie

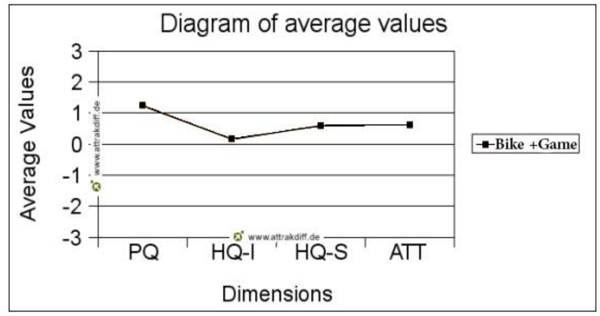
Figure 5 Portfolio with average values of the dimensions PQ and HQ and the confidence rectangle in the five different contexts of use for average activity users

In Figure 5a), participants with an average activity level tried biking while watching TV only. Their experience rating is closer to desired, and it was their favourite amongst the other contexts of use. Results show that it is very pragmatic, but according to the hedonic quality, it is average. When these participants played the duck shooting game while cycling, their experience changed and they rated it more as fairly practice-oriented, with average pragmatic and hedonic qualities, as can be seen in Figure 5b). Figure 5c) shows that their experience response towards the plain bike was also rated as practice oriented with average hedonic and pragmatic qualities. In Figure 5d), when the context changed to biking while playing the game and watching TV, results showed how it is also practice-oriented but very pragmatic, with just average hedonic qualities. Finally, as seen in Figure 5e), the results for biking and playing the game while also watching a movie of their choice were neutral, with only average pragmatic and hedonic qualities.

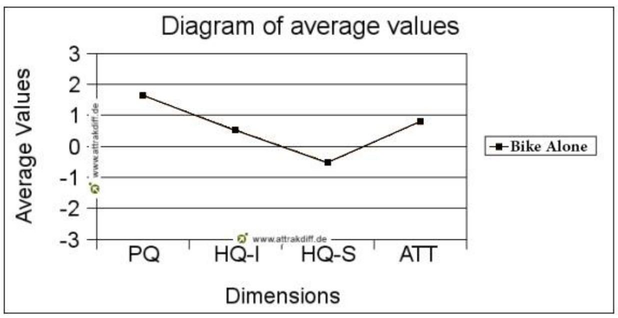
Figure 6 shows the results of the mean values for the four Attrakdiff qualities, in the five contexts of use, for participants with an average activity level.



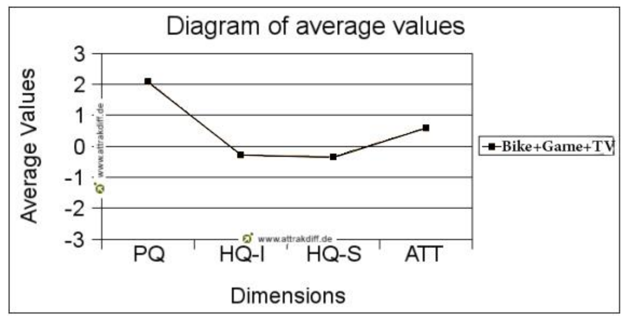
6a) Bike +TV



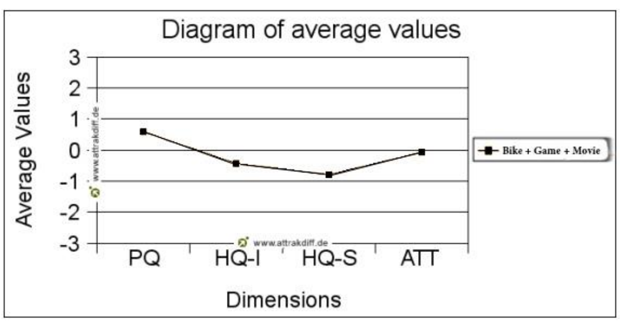
6b) Bike +Game



6c) Bike alone



6d) Bike+ Game+ TV



6e) Bike+ Game+ Movie

Figure 6 Mean values of the four Attrakdif dimensions for the five contexts of use for the average activity users

As can be seen in Figure 6a), when participants were cycling while watching tv, with regard to the hedonic (identity-stimulation) qualities and attractiveness, this context of use provided users with identification as well as stimulation and motivation. The overall impression is that it is attractive. As shown in the diagram, all values are located above the average. However, for biking while playing the game, biking alone, biking while playing the game and watching TV or a movie of their choice, the ratings dropped to average, which means it only meets the ordinary standards with regard to the hedonic qualities but is above the average for pragmatic. It is also considered moderately attractive, as seen in Figures 6b) 6c) 6D) and 6e).

Figure 7 shows the detailed description of the word pairs used in the questionnaires, for participants with an average activity level, in the five different contexts of use.

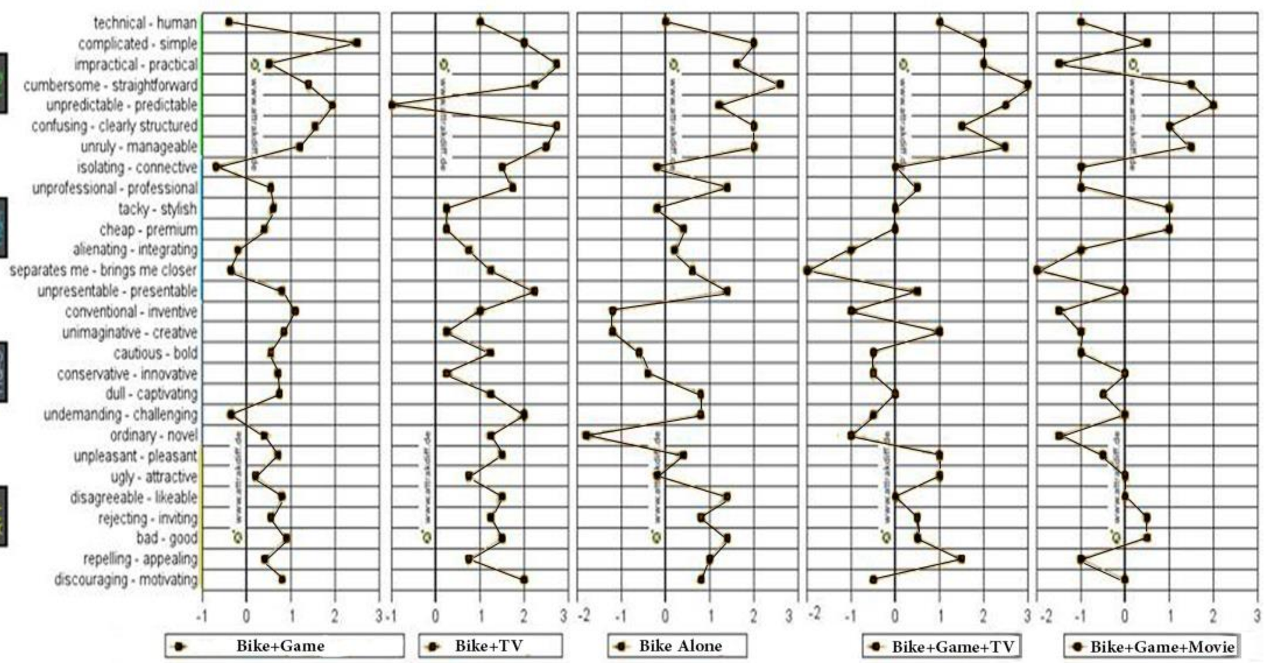


Figure 7 Mean values of the Attrakdiff word pairs for biking in the five different contexts of use for average activity level participants

4.2 Statistical Analysis

4.2.1 Evaluated Parameters

Heart rate (HR) is the average number of heart beats per minute. It is recommended that individuals monitor their heart rates during exercise in order to stay within a safe range. Heart rate levels differ between men and women, and between youth and adults (see equations 1.1, and 1.2).

$$Women: 226 - age = age - adjusted\ Max\ HR \tag{1.1}$$

$$Men: 220 - age = age - adjusted\ Max\ HR \tag{1.2}$$

It has a maximum and a minimum value (Table 3), which can be used to measure the intensity of the exercises. A heart rate above maximum value is unsafe, while a heart rate below minimum value indicates that the exercise is not effective.

Target Heart Rate During Exercise	
Age	**Min-Max Heart Rate (BPM)**
15	123 – 164
20	120 – 160
25	117 – 156
30	114 – 152
35	111 – 148
40	108 – 144
45	105 – 140
50	102 – 136
55	99 – 132

60	96 – 128
65	90 – 120
70	90 – 120
75	87 - 116

Table 3 Minimum and Maximum Target heart rate with respect to the age during exercises

In this study, in order to ensure the effectiveness of the exercise and the safety of the participants during the training session and to prove that the exergame does not affect the heart rate, readings of the heart rate were taken at the first, fifth, and tenth minutes.

The heart rate level depends on the intensity of the exercise. In this case, the biking speed is the main factor that determines the intensity level. For this reason, the speed of all participants was recorded at the first, fifth, and tenth minutes, in addition to the average rounds per minute for the cycling.

4.2.2 Statistical Results and Discussion for Average Activity Level Participants

As we can see in Figure 8, results depict the heart rates of the average activity participants at different time points in the context of (a) Bike + Game, (b) Bike + TV, (c) Bike + Game + TV, (d) Bike + Game + Movie, and (e) Bike alone. The x-axis shows the number of participants, in this case ten, and the y-axis shows the recorded heart rate value in beats per minute. Each of the curves corresponds to the heart rate at a different time (diamond symbol and blue curve for the first minute; square symbol and red curve for the fifth minute; triangle symbol and green curve for the tenth minute). Although there are natural differences between one participant and another in terms of heart rate at each time level, all the values of their heart rates are located within the safe range. Moreover, for all the participants and in all the contexts, the heart rates increase with time.

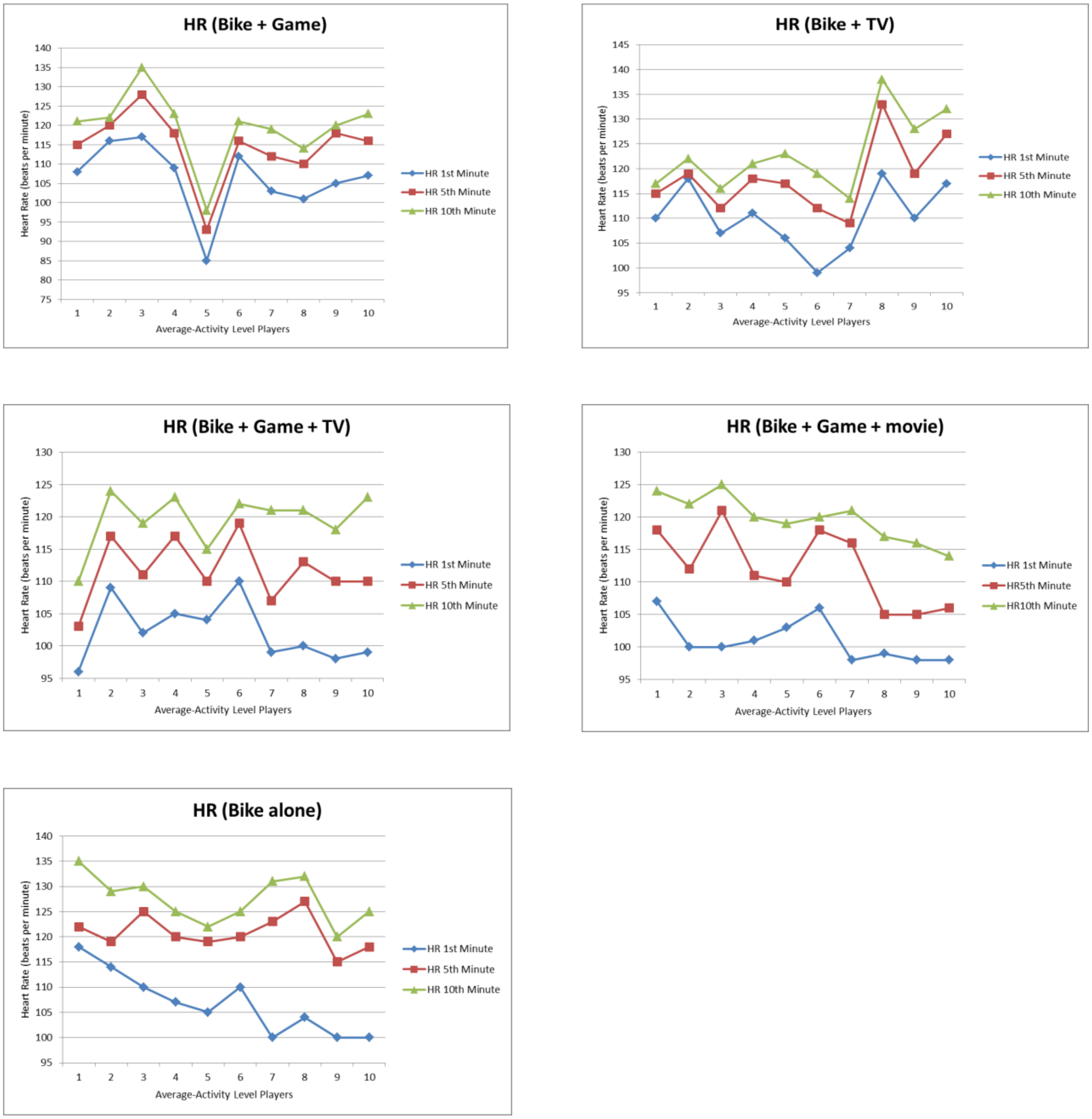


Figure 8 Heart Rate of the average activity participants at the first, fifth, and tenth minutes

The maximum value of the heart rate (138 bps) is reached by participant eight in the Bike + TV context. Since the same participants performed the exercises, we cannot claim that the differences in the heart rates between the different settings are due to the fitness level of the participants, it is mainly because of the environment itself; the average participants are more used to cycling while watching TV.

In order to support our claim, we conducted the ANOVA test and it was determined that there is a significance on the rounds per minute when we are in the Bike + TV context and in the Bike + Game context, $F(1,18) = 11.84$, with $p < 0.003$. The significance of the Bike + TV and Bike alone on the rounds per minute is relatively smaller than that of the Bike + TV and Bike + Game, $F(1,18) = 4.85$, $p < 0.04$ and $F_{critical} = 4.41$. The Bike + Game context had no significant effect on the rounds per minute when the recorded values were compared to those recorded in the Bike alone context, $F(1, 18) = 0.86$, $p < 0.36$.

The speed and the average (mean) rounds per minute recordings of the different sessions are shown in Figure 9 and Figure 10 respectively, and they are, to a certain extent, consistent with the heart rate of the participants. The maximum speeds (32.9 km/hr, 33.8 km/hr, 34.2 km/hr) are also reached in the Bike + TV context during the first, fifth, and tenth minutes respectively. In the Bike + Game context, the average speed of the participants is less than that of the Bike + TV and the Bike alone contexts. The maximum value (90.8 rpm) of the average rounds per minute is also recorded in the Bike + TV context. Again, this is also consistent with the qualitative results we obtained from the participants after each training session; combining games with the bike does not have that much of an effect on the motivation of the average activity level participants.

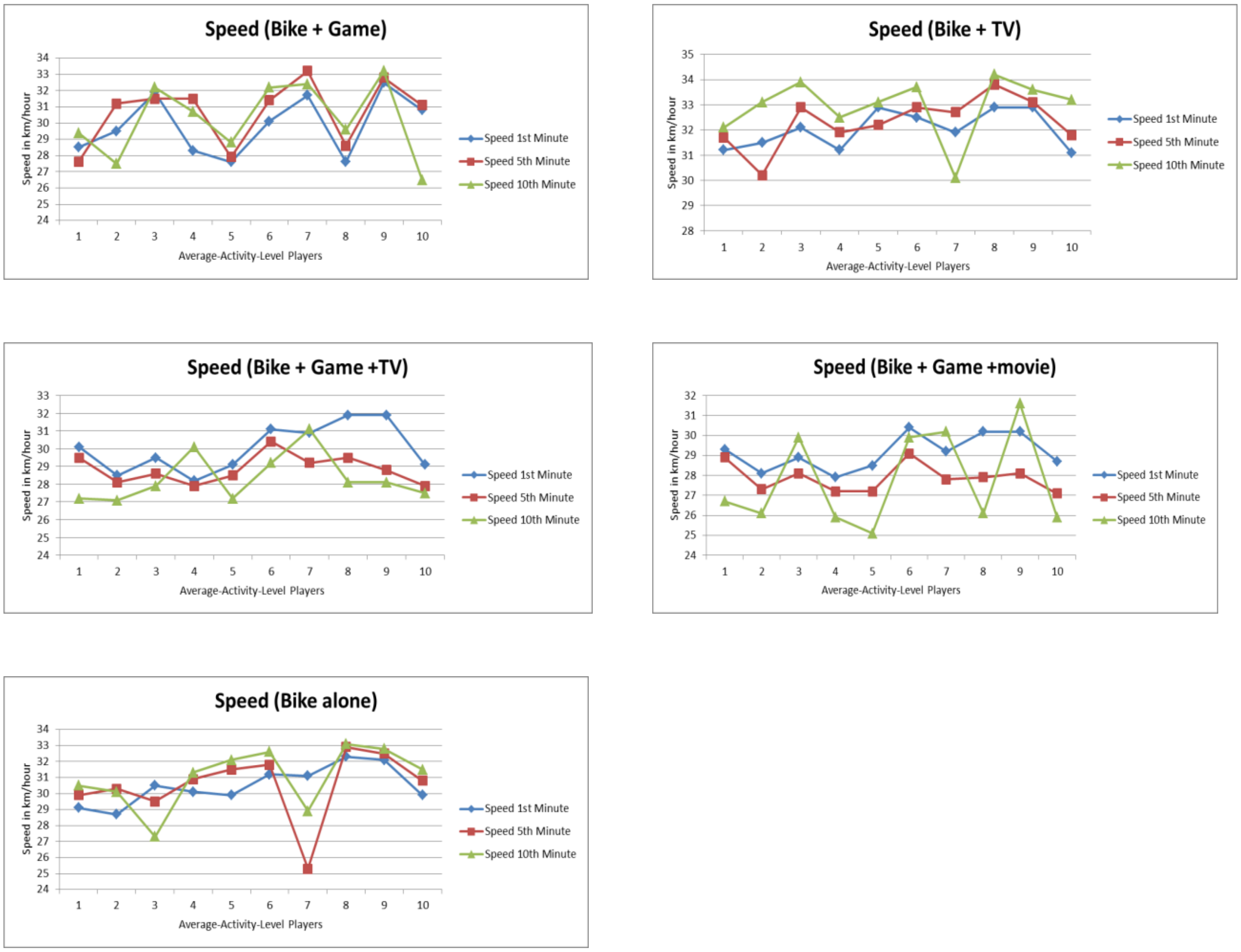


Figure 9 Speed of the average activity participants at the first, fifth, and tenth minutes

The average, the standard deviation, the maximum and the minimum values of the age in years, the height in centimeters, the weight in kilograms, the average rounds per minute (RPM) during the exercise, the heart rate (HR) in beats per minute at the first, fifth, and tenth minutes, and the speed in kilometers per hour at the first, fifth, and tenth minutes of all the participants were calculated and are shown in Table 4.

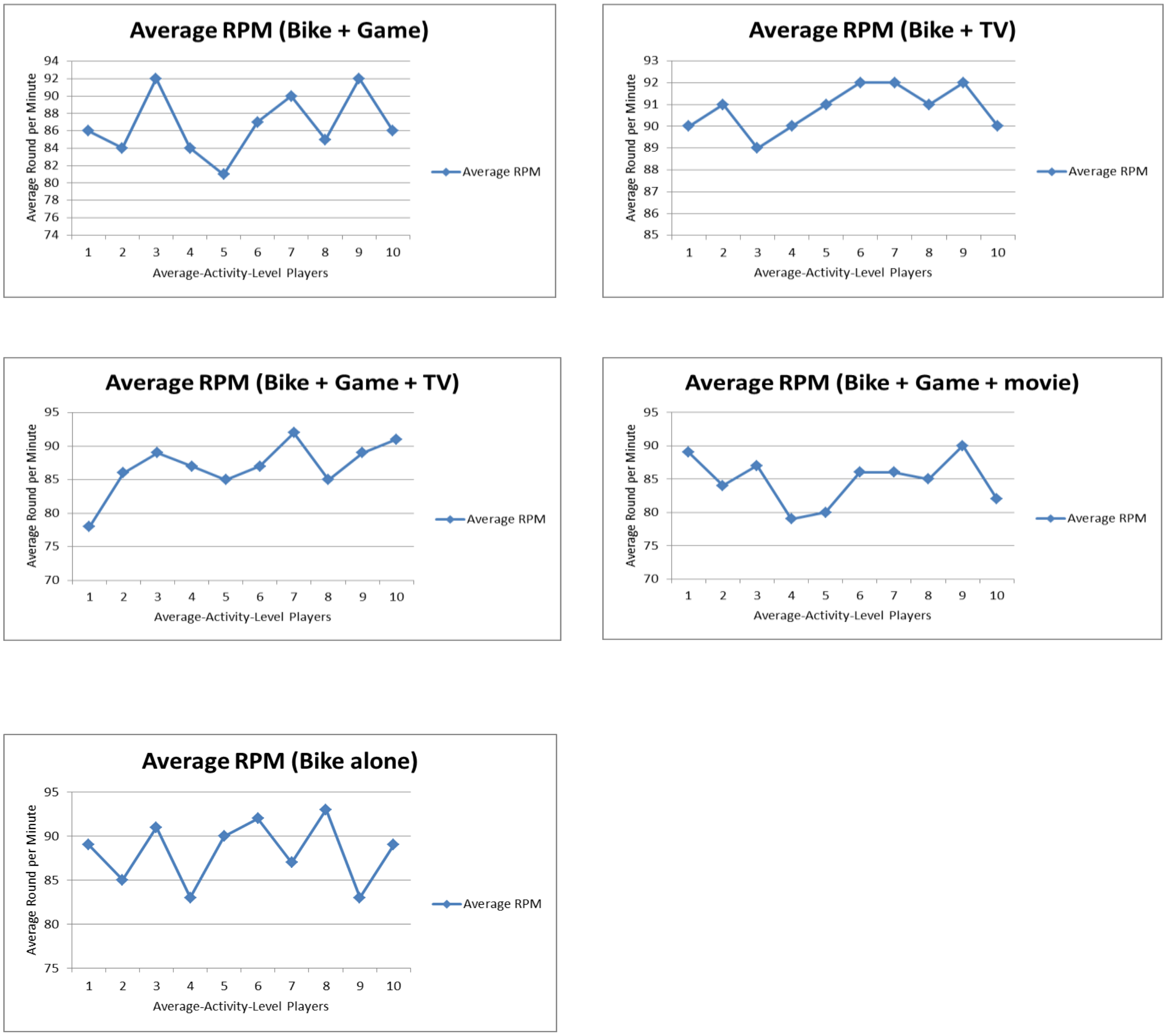


Figure 10 Average rounds per minute for the average activity level participants

When looking into these numbers, it was noticed that the Bike + TV context is the favorable exercise environment for the average activity level participants. The Bike + Game setting was third on the list of favourite contexts, which means that for the average participants, adding the duck shooting game to the bike does not seem to motivate them to achieve their exercise goal.

Average activity participants found it almost ideal to be able to watch their favourite shows on TV. Being able to change the channel at any time is the best context in which to exercise on the bike, since it is familiar and convenient.

Results also showed that these participants believe that in order to burn more calories and get a good workout, it is better to be focused on the exercise and not be distracted by any means, whether it be TV or a game. Moreover, changing the context of biking and playing the game to add watching TV or a movie was too distracting and resulted in a less effective workout.

	Bike + Game (Average)				Bike + TV (Average)				Bike + Game + TV (Average)			
	Average	StDev	Max	Min	Average	StDev	Max	Min	Average	StDev	Max	Min
Age	26.3	4.76	35	20	26.3	4.76	35	20	26.3	4.76	35	20
Height	175.3	6.11	183	162	175.3	6.11	183	162	175.3	6.11	183	162
Weight	68.8	6.28	78	55	68.8	6.28	78	55	68.8	6.28	78	55
Average RPM	86.7	3.62246	92	81	90.8	1.032796	92	89	86.9	3.928528	92	78
HR 1st min	106.3	9.10494	117	85	110.1	6.471304	119	99	102.2	4.709329	110	96
HR 5th min	114.6	9.00864	128	93	118.1	7.23341	133	109	111.7	4.922736	119	103
HR 10th min	119.6	9.24001	135	98	123	7.586538	138	114	119.6	4.325634	124	110
Speed 1st min	29.85	1.82833	32.5	27.6	32.02	0.748034	32.9	31.1	30.03	1.358144	31.9	28.2
Speed 5th min	30.68	1.96344	33.2	27.6	32.32	0.997553	33.8	30.2	28.84	0.811309	30.4	27.9
Speed 10th min	30.25	2.2609	33.2	26.5	32.95	1.183451	34.2	30.1	28.35	1.358308	31.1	27.1

	Bike + Game + Movie (Average)				Bike alone (Average)			
	Average	StDev	Max	Min	Average	StDev	Max	Min
Age	26.3	4.76	35	20	26.3	4.76	35	20
Height	175.3	6.11	183	162	175.3	6.11	183	162
Weight	68.8	6.28	78	55	68.8	6.28	78	55
Average RPM	84.8	3.61478	90	79	88.2	3.583915	93	83
HR 1st min	101	3.29983	107	98	106.8	6.214678	118	100
HR 5th min	112.2	5.84618	121	105	120.8	3.521363	127	115
HR 10th min	119.8	3.45768	125	114	127.4	4.742245	135	120
Speed 1st min	29.14	0.89094	30.4	27.9	30.49	1.189257	32.3	28.7
Speed 5th min	27.87	0.70719	29.1	27.1	30.54	2.1376	32.9	25.3
Speed 10th min	27.74	2.3684	31.6	25.1	31.02	1.853405	33.1	27.3

Table 4 The average, the standard deviation (StDev), the maximum (Max), and the minimum (Min) values of the age in years, the height in centimeters, the weight in kilograms, the rounds per minute (Average RPM), the heart rate (HR) in the first, fifth, and tenth minutes, and the speed in the first, fifth, and tenth minutes of all average activity level participants

4.2.3 Statistical Results and Discussion for Basic Activity Level Participants

The parameters and the statistical tests that were used to analyze the data of the average activity level participants were also used for the data obtained from basic activity level participants.

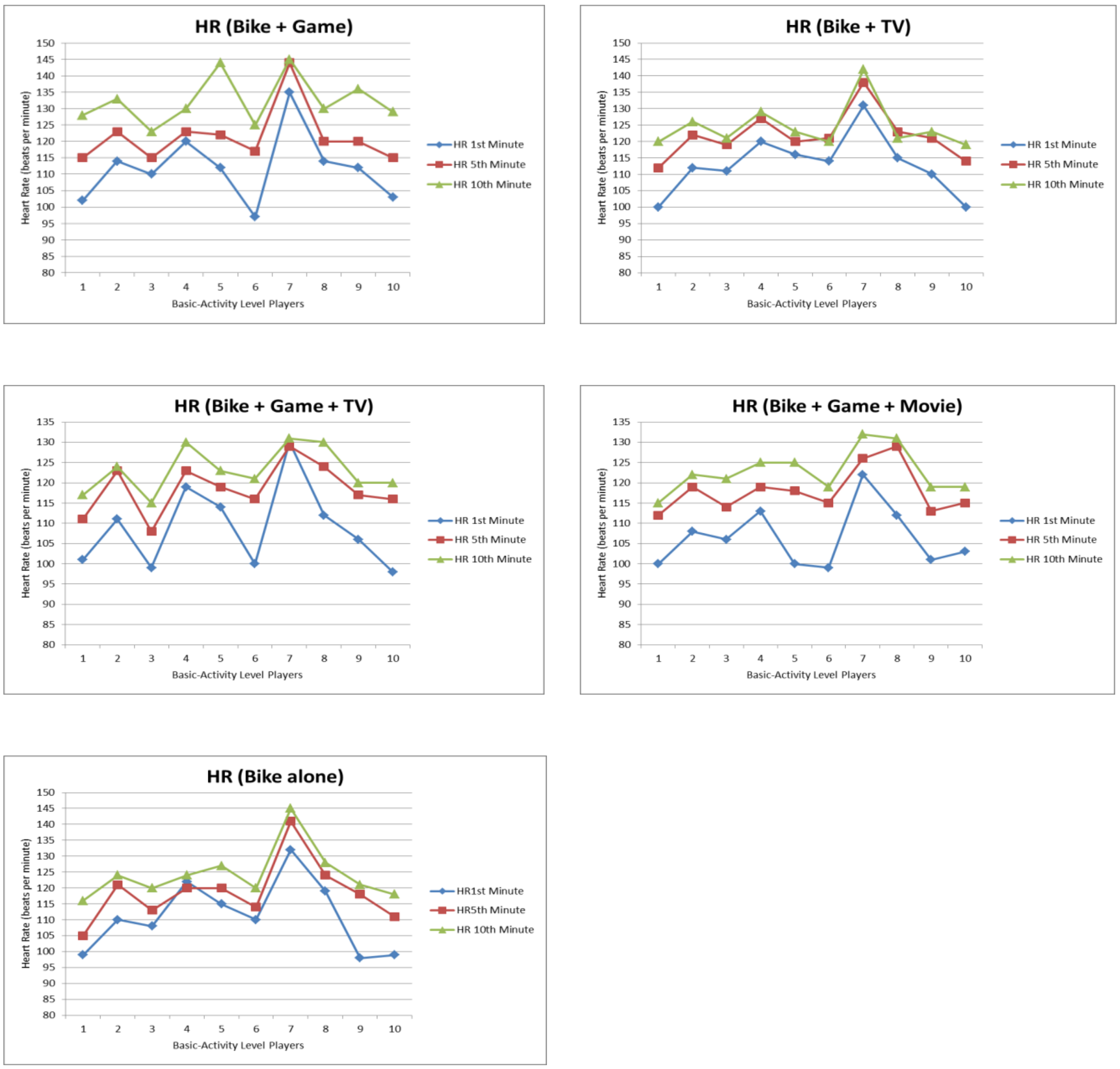


Figure 11 Heart Rate of the basic activity participants at the first, fifth, and tenth minutes

Figure 11 shows the heart rate of the basic activity participants in the five contexts of use at the first, the fifth, and the tenth minutes. Again, all the heart rates are located within the safe range and increase with time. The maximum heart rate (145 bpm) was obtained in two contexts, the Bike + Game context and the Bike alone context.

The standard deviation of the heart rate in the Bike + Game context is smaller than the one in the Bike alone, which means that adding a game to the bike made the exercises more challenging and raised the heart rate of the participants.

Since analyzing the maximum heart rate and the standard deviation of the heart rate is not enough to support our conclusion, we have conducted the ANOVA test for the records obtained in different contexts at the first, fifth, and tenth minutes. In the first minute, there was no significant effect of the game on the heart rate in any of the contexts; $F(1,18) = 0.051$, 0.385, 0.021, and 1.803, $p < 0.1$ for the heart rates in the Bike + TV, Bike + Game + TV, Bike alone, and Bike + Game + Movie respectively. The same observation was detected at the fifth minute, where the significant effect on heart rate of combining the bike to the game or combining the bike to another medium on is almost negligible; $F(1, 18) = 0.007$, 0.688, 0.437, and 1.101, $p < 0.1$ for the heart rates in the Bike + TV, Bike + Game + TV, Bike alone, and Bike + Game + Movie respectively. However, at the tenth minute, a significant effect of the game on the heart rate was detected; $F(1, 18) = 6.102$, 9.803, 5.245, and 10.663, $p < 0.02$ for the heart rates in the Bike + TV, Bike + Game + TV, Bike alone, and Bike + Game + Movie respectively.

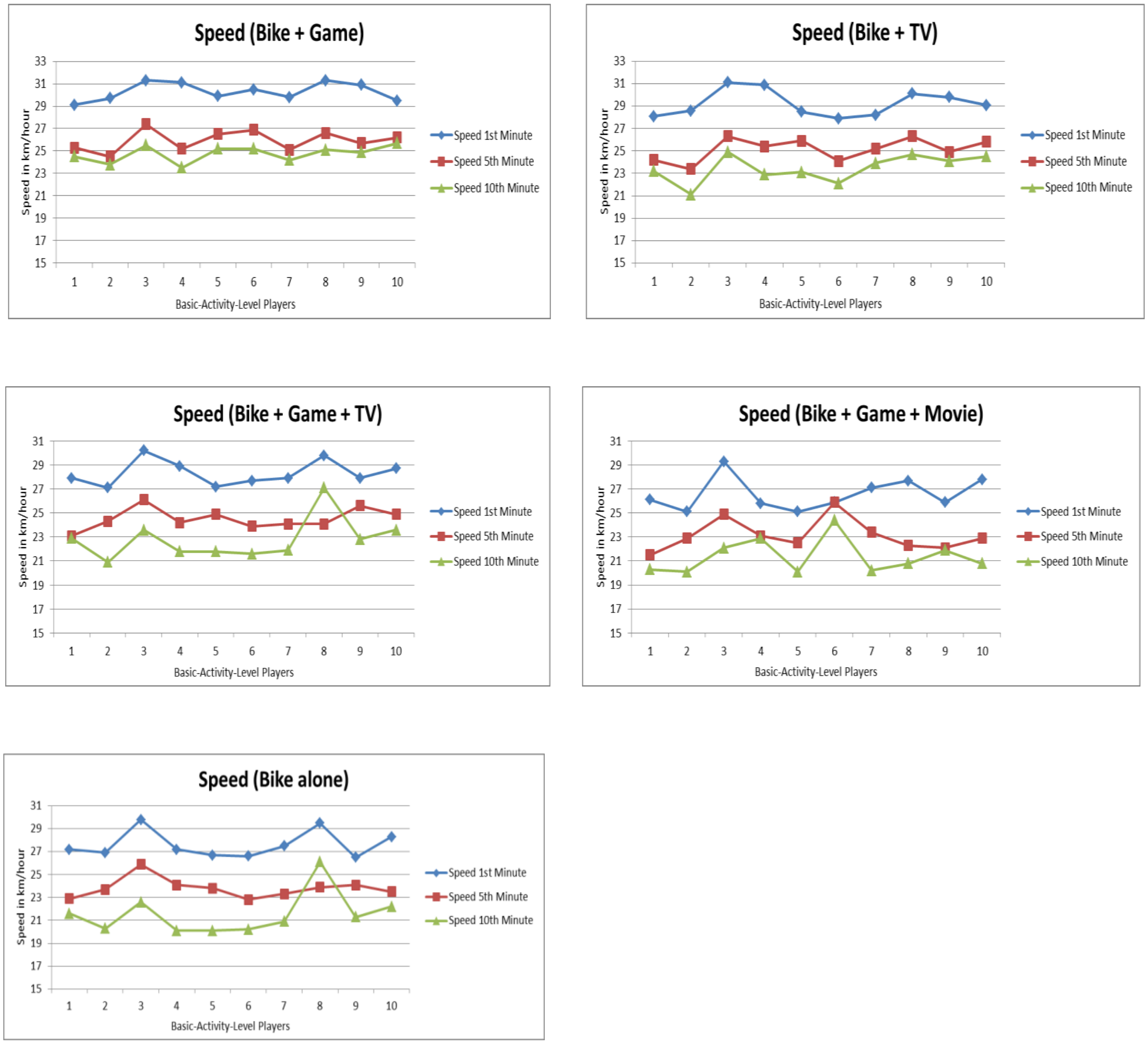


Figure 12 Speed of the basic activity participants at the first, fifth, and tenth minutes

As noticed, the speeds of most participants dropped with time, as shown in Figure 12. In the Bike + Game context, the maximum speeds were recorded at the first and fifth minutes, with standard deviations lower than in most contexts of use. Although the maximum speed at the tenth minute did not record in the Bike + Game context, the standard deviation was much smaller than in other contexts. Moreover, the largest minimum value of the speeds was also recorded in the Bike + Game context (Table 5).

Figure 13 shows the average rounds per minute of the participants, in all contexts of use. The maximum value was recorded when the bike was combined with the game, while the minimum value was recorded when the bike was combined with the game and the movie (Table 5). Although the standard deviation of the average rounds per minute within all contexts of use was significant enough (StDev = 7.734) to have an indication about the effectiveness of the game when combined with the bike, a more in depth statistical analysis is needed to draw the above conclusion.

The ANOVA test was used as a statistical analysis tool to further study the effect of adding a game to the bike, on the participants’ performance. At first, the significance of combining the bike with a game versus combining the bike with a TV was studied. With $F(1,18) = 5.733$, and $p < 0.027$, there was a significance difference on the speed at the first minute between the two settings. Moreover, the difference increased when the speed at the first minute in the bike plus game context was compared to the speed at the same minute in the bike alone context; $F(1,18) = 34.89$. In addition, the effect on the speed at the first minute of combining the game with the bike in comparison to other contexts of use is significant; $F(1,18) = 22.4$, and 55.7 when comparing the Bike + Game context to the Bike + Game + TV and the Bike + Game + Movie respectively.

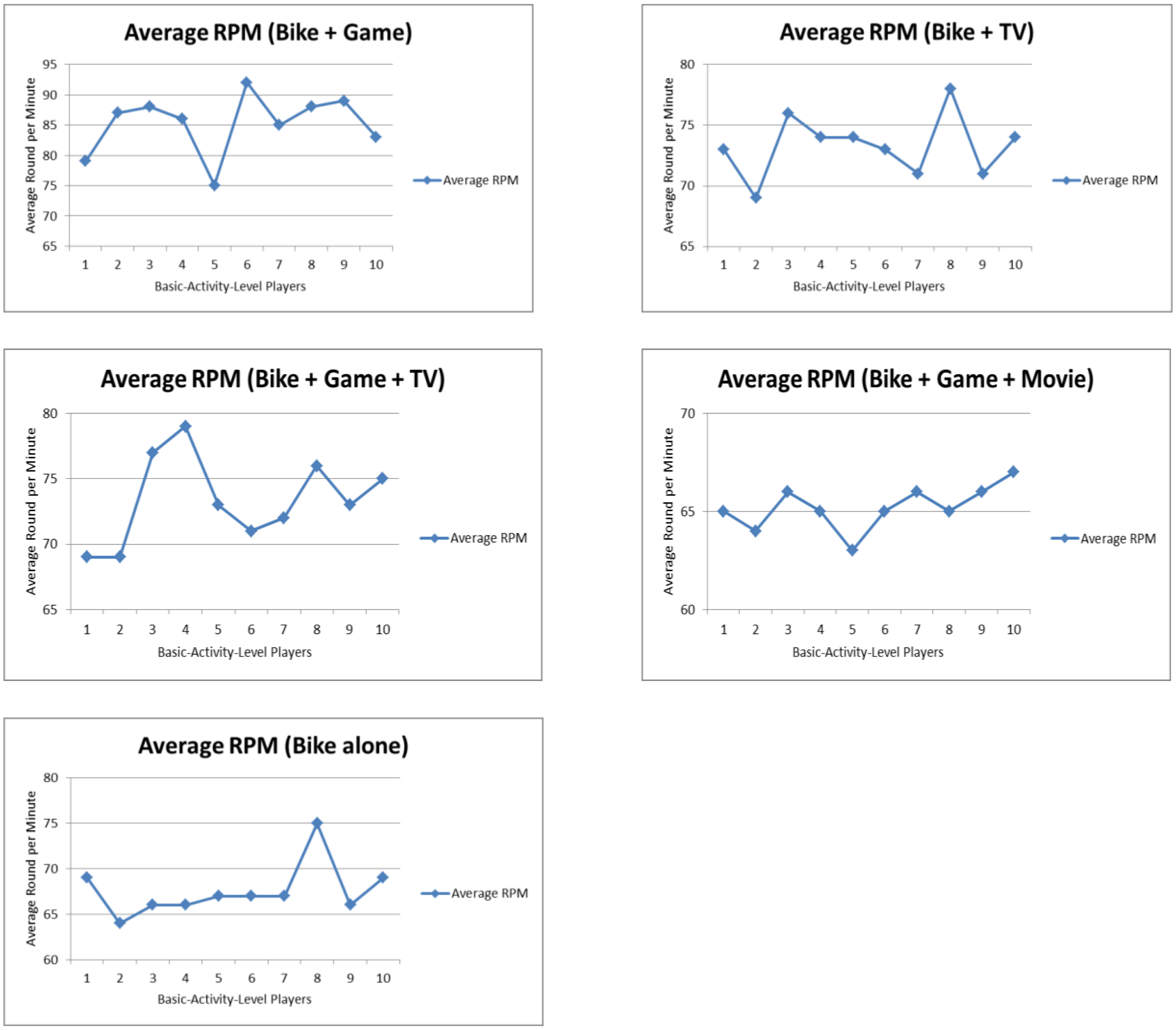


Figure 13 Average rounds per minute for the basic activity participants

At the fifth minute, there was no significant difference between combining the bike with the game and combining the bike with the TV on the speed of the participants. Indeed, for the previously mentioned settings, F(1,18) = 3.4, with $p < 0.08$ with Fcritical = 4.41. However, at the fifth minute, the effect of combining the bike with the game was significant on the speed of the participants in comparison to the rest of the contexts; F (1,18) = 12.45, 28.57, and 29.87 within the Bike + Game and the Bike + Game + TV group, and the Bike + Game and the Bike alone group, and the Bike + Game and the Bike + Game + Movie group respectively. At the fifth minute, the effect on the speed of combining the bike with the game was significant in comparison with the the other contexts of use. The ANOVA test has shown the following results: F(1, 18) = 8.54, 10.64, 26.54, and 44.14 in the Bike + TV, Bike + Game + TV, Bike alone, and Bike + Game + Movie environments respectively, when compared to the Bike + Game environment. Moreover, the effect on rounds per minute was significant when comparing the

	Bike + Game (Basic)				Bike + TV (Basic)				Bike + Game + TV			
	Average	**StDev**	**Max**	**Min**	**Average**	**StDev**	**Max**	**Min**	**Average**	**StDev**	**Max**	**Min**
Age	28.8	5.63323	37	20	28.8	5.633235	37	20	28.8	5.633235	37	20
Height	173.7	9.73025	195	161	173.7	9.730251	195	161	173.7	9.730251	195	161
Weight	70.55556	8.23273	80	57	70.55556	8.232726	80	57	70.55556	8.232726	80	57
Average RPM	85.2	5.02881	92	75	73.3	2.58414	78	69	73.4	3.339993	79	69
HR 1st min	111.9	10.5982	135	97	112.9	9.060905	131	100	109	10.29563	130	98
HR 5th min	121.4	8.57904	144	115	121.7	7.149981	138	112	118.6	6.345602	129	108
HR 10th min	132.3	7.39444	145	123	124.4	6.899275	142	119	123.1	5.626327	131	115
Speed 1st min	30.31	0.80891	31.3	29.1	29.23	1.174781	31.1	27.9	28.33	1.046741	30.2	27.1
Speed 5th min	25.94	0.9228	27.4	24.5	25.15	0.99023	26.3	23.4	24.52	0.872799	26.1	23.1
Speed 10th min	24.76	0.73364	25.7	23.5	23.45	1.212206	24.9	21.1	22.8	1.752459	27.1	20.9

	Bike alone (Basic)				Bike + Game + Movie (Basic)			
	Average	**StDev**	**Max**	**Min**	**Average**	**StDev**	**Max**	**Min**
Age	28.8	5.63323	37	20	28.8	5.633235	37	20
Height	173.7	9.73025	195	161	173.7	9.730251	195	161
Weight	70.55556	8.23273	80	57	70.55556	8.232726	80	57
Average RPM	67.6	2.98887	75	64	65.2	1.135292	67	63
HR 1st min	111.2	11.1036	132	98	106.4	7.441625	122	99
HR 5th min	118.7	9.63846	141	105	118	5.597619	129	112
HR 10th min	124.3	8.20637	145	116	122.8	5.473167	132	115
Speed 1st min	27.62	1.19145	29.8	26.5	26.58	1.356302	29.3	25.1
Speed 5th min	23.8	0.86667	25.9	22.8	23.15	1.324345	25.9	21.5
Speed 10th min	21.54	1.83497	26.1	20.1	21.36	1.442375	24.4	20.1

Table 5 The average, the standard deviation (StDev), the maximum (Max), and the minimum (Min) values of the age in years, the height in centimeters, the weight in kilograms, the rounds per minute (Average RPM), the heart rate (HR) in the first, fifth, and tenth minutes, and the speed in the first, fifth, and tenth minutes of all basic activity level participants

values of RPM obtained from the Bike + Game context and other contexts. For instance, F(1,18) = 44.29, 38.20, 90.51, and 150.5 in the Bike + TV, Bike + Game + TV, Bike alone, and Bike + Game + Movie environments respectively.

Chapter 5: Conclusion and Future Work

In this thesis we have explored the acceptance rates of participants when combining exercise with games in order to motivate people with basic activity levels to exercise more frequently. The qualitative and quantitative results led to the same conclusion: exergames are more entertaining and more encouraging compared to cycling only, for people with basic activity level. The maximum values, the minimum values, the average, and the standard deviation of the most important parameters that were taken into consideration have been calculated, along with the ANOVA test, and they show that combining games with cycling has a significant effect on the speed, the heart rate, and the average rotations per minute of the participants. Our research hypotheses which are" $H1_a$: The ExerBike game encourages physical activity, $H2_a$: For people with an average activity level, the game does not encourage the user to cycle more than when watching TV while cycling, $H3_a$: For people with a basic activity level, the game encourages the user to cycle more than when watching TV while cycling and $H4_a$: If the context of use changes, the effect of the game on the user's motivation to cycle changes." Were totally supported and proven.

As for limitations of this work, we were not able to evaluate the player experience for a bigger sample size in order to expand the research. Also, only one exergame was available for this study so as for recommendation for future work, same research method can be used but with more than one exergame in order to add variety and compare results with respect to what game users have used and how their experience was affected. Also, the presented evaluation framework can be done but for only obese participants in order to evaluate their experience and whether exergames have an effect on their exercise performance or not.

References

Ahn, M., Kwon, S., Park, B., Cho, K., Choe, S. P., Hwang, I., ... & Song, J. (2009, October). Running or gaming. In *Proceedings of the International Conference on Advances in Computer Enterntainment Technology* (pp. 345-348). ACM.

Alan S.Go, Mozaffarian D et al (2013), American Heart Association Statistics Committee and Stroke Statistics Subcommittee. *Heart disease and stroke statistics*–2013 update: a report from the American Heart Association. Circulation; 127:e6–e245.

Bellotti, F., Berta, R., De Gloria, A., & Primavera, L. (2009). Player Experience Evaluation: An Approach Based on the Personal Construct Theory. In*Entertainment Computing–ICEC 2009* (pp. 120-131). Springer Berlin Heidelberg.

Bloom, M. Grant, M. & Watt, D. (2005). *Strengthening Canada: The Socio-economic Benefits of Sport Participation in Canada*. Ottawa: The Conference Board of Canada.

Canadian Heritage. (1998). *Sport Participation in Canada*. Ottawa: Canadian Heritage.

Cerin, E., Leslie, E., Sugiyama, T. & Owen, N. (2009). Associations of multiple physical activity domains with mental well-being. *Mental Health and Physical Activity, 2*, 55–64.

Cooper, P. & Schindler P. (2010). *Business Research Methods* (9th ed.). New York, NY, McGraw-Hill.

Desurvire, H., Caplan, M., & Toth, J. A. (2004, April). Using heuristics to evaluate the playability of games. In *CHI'04 extended abstracts on Human factors in computing systems* (pp. 1509-1512). ACM.

Finkelstein, S., Nickel, A., Lipps, Z., Barnes, T., Wartell, Z., & Suma, E. A. (2011). Astrojumper: Motivating exercise with an immersive virtual reality exergame. *Presence: Teleoperators and Virtual Environments, 20*(1), 78-92.

Gerling, K. M., Schild, J., & Masuch, M. (2010, November). Exergame design for elderly users: the case study of SilverBalance. In *Proceedings of the 7th International Conference on Advances in Computer Entertainment Technology* (pp. 66-69). ACM.

Göbel, S., Hardy, S., Wendel, V., Mehm, F., & Steinmetz, R. (2010, October). Serious games for health: personalized exergames. In *Proceedings of the international conference on Multimedia* (pp. 1663-1666). ACM.

Grosvenor, M. B. & Smolin, L. A. (2006). *Nutrition: Everyday Choices*. New Jersey: John Wiley & Sons, Inc.

Hamer, M. & Stamatakis, E. (2010). Objectively assessed physical activity, fitness and subjective wellbeing. *Mental Health and Physical Activity, 3*, 67-71.

Ifedi, F. (2005). *Sport Participation in Canada.* Ottawa: Statistics Canada.

Ijsselsteijn, W. A., Kort, Y. D., Westerink, J. H. D. M., Jager, M. D., & Bonants, R. (2006). Virtual fitness: stimulating exercise behavior through media technology. *Presence: Teleoperators and Virtual Environments, 15*(6), 688-698.

Juan M. Silva, and Abdulmotaleb El Saddik, "Exertion Interfaces for Computer Videogames Using Smartphones as Input Controllers", *Springer Multimedia Systems*, DOI: 10.1007/s00530-012-0268-y, 2012

Kandula, N.R., Kersey, M., & Lurie, N., (2004). Assuring the health of immigrants: what the leading health indicators tell us. *Annual Review of Public Health, 25*(3), 357-376.

Kelleher, J. (2009). School Lunch Report. *Parenting School Years*, *23*(4), 62.

McGarvey, E., Collie, K., Fraser, G., Shufflebarger, C., Lloyd, B., Oliver, M. (2006). Using Focus Group Results to Inform Preschool Childhood Obesity Prevention Programming. *Ethnicity and Health*, *11*(3), 265 – 285.

McLaughlin, R. & Wittert, G. (2009). The obesity epidemic: implications for recruitment and retention of defence force personnel. *Obesity Reviews*, *10*, 693–699.

Mestre, D. R., Maïano, C., Dagonneau, V., & Mercier, C. S. (2011). Does virtual reality enhance exercise performance, enjoyment, and dissociation? an exploratory study on a stationary bike apparatus. *Presence: Teleoperators and Virtual Environments*, *20*(1), 1-14.

Morelli, T., Foley, J., Columna, L., Lieberman, L., & Folmer, E. (2010, June). VI-Tennis: a vibrotactile/audio exergame for players who are visually impaired. In *Proceedings of the Fifth International Conference on the Foundations of Digital Games* (pp. 147-154). ACM.

Nasser H. Dardas . Juan M. Silva . Abdulmotaleb El Saddik, "Target-Shooting Exergame with a Hand Gesture Control", *Springer Multimedia Tools and Applications*, (accepted)

Oja, P., Titze, S., Bauman, A., De Geus, B., Krenn, P., Reger‐Nash, B., & Kohlberger, T. (2011). Health benefits of cycling: a systematic review.*Scandinavian Journal of Medicine & Science in Sports*, *21*(4), 496-509.

Oliva, P. (2005). *Developing the Curriculum*, 6th ed. Boston: Allyn and Bacon.

Ortega et al. (2010). Psychological Well-Being, Cardiorespiratory Fitness, and Long-Term Survival. *American Journal of Preventive Medicine, 39*, 440-448.

Patton, M.Q. (1997). What is evaluation? In *Utilization-Focused Evaluation* (pp. 23–32). Thousand Oaks, CA: Sage.

Patten, M.Q. (2012). *Understanding Research Methods: An Overview of the Essentials*. Pyrzcak Publications.

Plonczynski, D. (2000). Measurement of motivation for exercise. *Health Education Research, 15*(6), 695-705.

Sinclair, J., Hingston, P., & Masek, M. (2007, December). Considerations for the design of exergames. In *Proceedings of the 5th international conference on Computer graphics and interactive techniques in Australia and Southeast Asia*(pp. 289-295). ACM.

Sizer, F. (2011). *Nutrition Concepts and Controversies*. Toronto: Nelson.

Stice, E., Shaw, H., & Marti, C. N. (2007). A meta-analytic review of eating disorder prevention programs: Encouraging findings. *Annual Review of Clinical Psychology, 3,* 233-257.

Sui, X. et al. (2009). Prospective Study of Cardiorespiratory Fitness and Depressive Symptoms in Women and Men. *Journal of Psychiatric Research, 43*(5), 546–552.

Ulbrich, S. (1999). Exercise as self-care. *Journal of Nursing Scholarship, 31*(1), 65-70.

Wang Y, Lobstein T. Worldwide trends in childhood overweight and obesity. Int J Paed Obes 2006;1:11-25.

Warburton, D. E., Bredin, S. S., Horita, L. T., Zbogar, D., Scott, J. M., Esch, B. T., & Rhodes, R. E. (2007). The health benefits of interactive video game exercise. *Applied Physiology, Nutrition, and Metabolism, 32*(4), 655-663.

Appendixes

Appendix 1: Recruiting Email

"Hello, I would like to evaluate an Ergometer that is coupled with a simple 3D computer game, to see if introducing games enhances the cycling experience and if it could encourage physical activity. By participating in this study you will help me to understand the factors that encourage people to do more physical activity and if games would make some significant contribution. The experiment will be done based on 5 sessions within 3 weeks. Every session only takes 30 - 45 minutes of your time. For approximately 10-20 minutes, I will ask you to perform a cycling exercise on a normal Ergometer that is coupled with a computer game. Thank you and have a great day, if you are interested in participating in this study and have any questions you can contact me.

Moreover, the recruitment is being done on behalf of the researcher and not on behalf of the person sending the e-mail".

Appendix 2: Consent Form

Consent Form

Purpose of the Study: The purpose of the study is to evaluate the player experience in pervasive games by conducting an experimental evaluation analyzing to which extent such games encourage physical activity. Also, to know to which extent the player experience depends on the context of use.

Participation: My participation will consist essentially of attending 5 sessions in a 3 week period, each session will take about 30-45 minutes during which I will be given instructions for the first 10 minutes and filling a pre activity questionnaire, and then for 10-20 minutes I will perform a cycling exercise on a normal exercise bike coupled with a game. The sessions have been scheduled for the weekdays between 8.00 a.m. to 6:00 p.m., The experiment will be conducted at 800 King Edward, 5th Floor, Discover Lab, Ottawa, ON, Canada , I will also be asked to fill up a questionnaire regarding my play experience while resting for 10 minutes after the exercise .

Risks: My participation in this study will entail that I do not share or give any personal information that would reveal my identity. The entire data collection will be done anonymously.

Subjects are chosen among those people that have some physical activity such as running or cycling. Therefore, the only risk is tiredness.

There will be no other risk due to the exercises. There will be double check for health condition based on the PAR-Q: “Pre-Exercise” Questions (Physical Activity Readiness Questionnaire).

The exercises include only light cycling activities. The duration will be max. 20 minute. However, I can stop at anytime, e.g. after 5min. In case I get tired.

There is an area within the lab to rest and refresh by having water and other soft drinks, a university clinic is only about 200m away, so in any emergency case a physician can be consulted.

Benefits: My participation in this study will help the researcher to understand the factors that encourage people to do more physical activity and if games would make some significant contribution. Results can help sport clubs and product developers to better understand potential customers, and can lead to better product design and more customized games. This can help fitness clubs to motivate more users for cycling and to increase customer satisfaction, which in turn would increase turnover and profit. More physical activity in this case would imply more deployment and therefore purchasing of exercise devices.

The society will benefit from a more physically active population and economically stronger companies.

Confidentiality and anonymity: I have received assurance from the researcher that I will not be asked for names or any other personal information that could reveal my identity in the research or in any publications. I understand that the contents and data collected will be used only for evaluating the player experience in different contexts of use, and that my confidentiality will be protected.

Conservation of data:

All data will be collected in an electronic form using Google Documents. There will be no hard copies or any other forms of data collection. Data will be kept within Google Documents are encrypted using highest IT security standards. Only the researcher and the supervisor will have access to data.

After that, researcher will destroy the Google documents (the form containing the experiments data and results).

Supervisor will securely delete the e-mail and any copy of the document after the conservation period which is 5 years long.

Voluntary Participation: I am under no obligation to participate and if I choose to participate, I can withdraw from the study at any time and/or refuse to answer any questions, without suffering any negative consequences, if I choose to withdraw, all data gathered until the time of withdrawal will be securely deleted

Acceptance: I agree to participate in the above research study conducted by Rana Alattas of the Department of Electronic Business Technologies, which research is under the supervision of Professor Abdolmotaleb Elsaddik of the department of Electrical engineering and Computer Sceince.

If I have any questions about the study, I may contact the researcher or her supervisor.

If I have any questions regarding the ethical conduct of this study, I may contact the Protocol Officer for Ethics in Research, University of Ottawa

There are two copies of the consent form, one of which is mine to keep.

Appendix 3: The Physical Activity Readiness Level Questionnaire (PAR-Q)

1. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?

2. Do you feel pain in your chest when you do physical activity?

3. In the past month, have you had chest pain when you were not doing physical activity?

4. Do you lose your balance because of dizziness or do you ever lose consciousness?

5. Do you have a bone or joint problem that could be made worse by a change in your physical activity?

6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?

7. Do you know of any other reason why you should not do physical activity?

Appendix 4: The General Practice Activity Level Questionnaire

1. Please tell us the type and amount of physical activity involved in your work. Please tick one box that is closest to your present work from the following five possibilities:

		Please mark one box only
a	I am not in employment (e.g. retired, retired for health reasons, unemployed, full-time carer etc.)	
b	I spend most of my time at work sitting (such as in an office)	
c	I spend most of my time at work standing or walking. However, my work does not require much intense physical effort (e.g. shop assistant, hairdresser, security guard, childminder, etc.)	
d	My work involves definite physical effort including handling of heavy objects and use of tools (e.g. plumber, electrician, carpenter, cleaner, hospital nurse, gardener, postal delivery workers etc.)	
e	My work involves vigorous physical activity including handling of very heavy objects (e.g. scaffolder, construction worker, refuse collector, etc.)	

2. During the *last week*, how many hours did you spend on each of the following activities?

Please mark one box only on each row

		None	**Some but less than 1 hour**	**1 hour but less than 3 hours**	**3 hours or more**
a	Physical exercise such as swimming, jogging, aerobics, football, tennis, gym workout etc.				
b	Cycling, including cycling to work and during leisure time				
c	Walking, including walking to work, shopping, for pleasure etc.				
d	Housework/Childcare				
e	Gardening/DIY				

3. How would you describe your usual walking pace? Please mark one box only.

Slow pace (i.e. less than 3 mph)		Steady average pace	
Brisk pace		Fast pace (i.e. over 4mph)	

Appendix 5: Participants Information Sheet

<u>Participant's information</u>

Age		
Gender		
Height		
Weight		
Employment Status		
Education level		
Familiar with 3D computer games	Yes	No

Appendix 6: The Attrakdiff Evaluation Questionnaire

Questionnaire regarding the quality of Exerbike, with the help of the word-pairs please enter what you consider the most appropriate description for **Exerbike**.

Please check on your choice in every line!

Human	○	○	○	○	○	○	○	technical
isolating	○	○	○	○	○	○	○	connective
pleasant	○	○	○	○	○	○	○	unpleasant
inventive	○	○	○	○	○	○	○	conventional
simple	○	○	○	○	○	○	○	complicated
professional	○	○	○	○	○	○	○	unprofessional
ugly	○	○	○	○	○	○	○	attractive
practical	○	○	○	○	○	○	○	impractical
likeable	○	○	○	○	○	○	○	disagreeable
cumbersome	○	○	○	○	○	○	○	Straightforward
stylish	○	○	○	○	○	○	○	tacky
predictable	○	○	○	○	○	○	○	unpredictable
cheap	○	○	○	○	○	○	○	premium
alienating	○	○	○	○	○	○	○	integrating

brings me closer to people	○	○	○	○	○	○	○	separates me from people
unpresentable	○	○	○	○	○	○	○	presentable
rejecting	○	○	○	○	○	○	○	inviting
unimaginative	○	○	○	○	○	○	○	creative
good	○	○	○	○	○	○	○	bad

confusing	○	○	○	○	○	○	○	clearly structured
repelling	○	○	○	○	○	○	○	appealing
bold	○	○	○	○	○	○	○	cautious
innovative	○	○	○	○	○	○	○	conservative
dull	○	○	○	○	○	○	○	captivating
undemanding	○	○	○	○	○	○	○	challenging
motivating	○	○	○	○	○	○	○	discouraging
novel	○	○	○	○	○	○	○	ordinary
unruly	○	○	○	○	○	○	○	Manageable

Thank you!