

Designing a Fantasy Bike-based Exergame to Foster Physical Activity

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Abstract

Authorities recommend the practice of moderate physical activity to improve health and quality of life. "Play'n Ride" is a bike-based exergame aimed at promoting and controlling physical activity. This paper presents the usefulness of using extrinsic fantasy and a commonplace real bike to address a wide audience. It depicts the interactive universe in which the player pedals a bike equipped with sensors to control the flight altitude of an imaginary character. During a 'Tour de France 2019' stage, one hundred and seventy-eight fan park visitors - from youths to retirees - tested the exergame. Data were collected from an online questionnaire composed of SUS questionnaire items and from a digital tracking system attached to the game-engine in order to assess the usability, the learnability and the acceptability of the system. Analysis shows that using extrinsic fantasy makes exercising fun and it engages people of all ages regardless of their interest in video games or sports.

Keywords: Bike, Exergame, Serious Game, Physical Activity, Game Design, Cycling

1 Introduction

The digital revolution leads people to practice less and less physical activity and to opt for a sedentary lifestyle. In most industrialized countries, authorities recommend the practice of moderate physical activity to improve health and quality of life [1, 2]. Physical inactivity is responsible for 6 per cent of all deaths worldwide [3]. In this paper, the terms 'Physical Activity' (PA) and "Sport" refer to the definition produced by the World Health Organization (WHO) [1].

In recent years, there has been an increasing interest in immersive Virtual Worlds, mobile applications and medical training simulators to foster physical activity. Although many applications are freely available, they mainly address sportsmen and sportswomen. In the case of medical training assisted by a bike-based digital application, most of the applications use a stationary bike. Despite their efficacy, they suffer from several major drawbacks. Firstly,



using a real bike instead of a stationary bike should allow access to a wider audience. Secondly, they mainly failed to consider the importance of fantasy and gaming in encouraging lay people to exercise.

In general, our objective is to design an exergame based on a common road bike. Our research aims to show the usefulness of using extrinsic fantasy to address a wide audience and to engage people in exercising. The paper also presents the main constraints to consider in designing such an interactive environment. It particularly implies precisely controlling the pedals input to make the game easy to use and player-friendly. Moreover, controlling precisely the pedal input ensures the reliability of the physical activity measurements.

The paper is organized as follows: Section 2 introduces the related work, Section 3 depicts the exergame "Play'n Ride" and its game design based on extrinsic fantasy; the Section 4 presents the method used to assess the exergame. We conclude the paper by analyzing some results and discussing future work in Section 5.

2 *Related Work*

The term Exergame defines a serious game which combines digital gaming and physical activity. This term is used to describe a digital game which interprets the player's body movements as inputs to control the onscreen character's movements. A systematic review focusing on older adults, conducted by Kappen et al. [4], classifies the purpose of exergames in three main clusters: "Training", "Rehabilitation" and "Wellness". They identified 9 categories and 19 exergame themes. Exergames represent innovative tools to fight obesity, to rehabilitate patients or to improve health and achieve wellness goals.

Some research showed how gamification [5] can help encourage people to exercise. As an illustration, the Volkswagen Fun Theory website presents an experiment which was carried out in the Stockholm subway. "The Piano Stairs" are stairs made to look like a piano keyboard and engineered to make the sound of each piano key when people step on different steps. It was installed right next to an escalator and effectively changed people's behavior, increasing the use of the staircase by 66 per cent. Fantasy is one lever to attract and motivate people to exercise. The ability of exergames to attract audience have been shown in some studies [6]; however, the point is to maintain mid- and long-term interest. In order to improve the retention rate, some studies use fantasy and combine physical activity with gaming to make physical exercise fun. Two main approaches have been identified in order to develop a successful exergame experience: (1) adapting popular video games and (2) creating original gaming universe. The next sections present various examples of applications designed to encourage or to monitor people while they exercise.

2.1 *Fantasy*

According to Malone, "intrinsic motivation is created by three qualities: challenge, fantasy, and curiosity". Malone [7, 8] defines fantasy as that which evokes mental images of physical or social situations not actually present. They classify the concept of fantasy as intrinsic and extrinsic fantasy. This classification can be explained by the relationship between fantasy and skills in game environments. An intrinsic fantasy is defined as "one in which the skill being learned and fantasy depend on each other" and "there is an integral and continuing relationship between the fantasy context and the instructional content being presented", whereas extrinsic fantasy is defined as "one in which the fantasy depends on the skill being learned but not vice versa" and the relationship is arbitrary and periodic.

To illustrate the intrinsic fantasy concept, let us consider bike-based exergames. In the case of a realistic world, the player pedals on a road, climbs mountains on a bike, or rides next

to beautiful landscapes. As in a real context, the player controls backward to forward movement. Using this kind of fantasy can be well adapted to an audience which wants to improve their physical performance through cycling programs. In case of non-sports enthusiasts this might cause lack of interest.

2.2 *Using Fantasy to Make Physical Exercise Fun*

2.2.1 *Adapting a Popular Video Game to an Exergame*

Some research focuses on adapting popular video games into exergames. Ketcheson et al. [9] studied the conversion of "Half-Life 2" and "The Elder Scrolls V: Skyrim". They placed the players on a recumbent bicycle with a gamepad controller and equipped them with Heart Rate Powers-Ups (a technique that has been shown to increase players' exertion in exergames by rewarding players for maintaining a target heart rate.). The results show that the games include non-controlled activities that make it difficult for players to maintain a high level of cadence. In another study, Kabir et al. [10] converted "Temple Run" and "Flappy Bird" to exergames. Gestures, such as jumping, raising the left hand and raising the right hand, replace the original inputs and control of the avatar and achieve the in-game tasks.

Following the same idea, Stafford et al. convert the popular "Flappy Bird" into a "Flappy Breath" [11]. "Flappy Breath" acts like a personal trainer to exercise to breathing techniques using a Bluetooth belt and a mobile phone microphone. If we redirect the focus on bike-based exergames, Huh et al. [12] use "Minecraft" as a sandbox-genre game and they provide some bike exercises through an exergame platform called "Iexercise" [13]. They translate pedaling movement into forward and backward movement in the virtual world. The player also uses a traditional game controller to enable directional movement and game actions. In the same way, Bolton et al. [14] designed a virtual reality cycling based exergame system inspired by the Arcade video game "Paperboy". They aimed to combine VR headset technology, Microsoft Kinect Technology and novel gaming to increase immersion. They also translate the pedalling movement into forward movement in the virtual universe.

2.2.2 *Creating an Original Game Universe*

Developing an original exergame to support physical education or to help patients to recover motor abilities using gaming is not new [15–18]. Lin et al. [19], inspired by the Tamagotchi virtual-friend concept designed a pervasive game called "Fish'n Steps" to encourage people to walk. People, equipped with a pedometer, take care of a virtual fish whose size and emotion changes according to the covered distance. The daily outcomes of the participants affect the facial expression of the pet. If he reaches the daily goal, the fish is happy. In case of insufficient results, the pet is angry or sad. Another example is "Running Othello" [20] where the players use a smartphone and wear a smart wrist band to compete in a board game enhanced with physical and pedagogical missions.

According to a mechanical monitoring approach based on sensors, Ranky et al. [21, 22] aimed to design a mechatronic rehabilitation system with an interactive virtual environment named "VRACK" (virtual reality augmented cycling kit). This system aims to deepen understanding movement disorders emerging from human motor control of lower extremities. To that end, the system monitors the physiological parameters and the human bio-mechanical interactions while the user rides a bike on a virtual road. The system is composed of two sensorized pedals, two handlebars with hydraulic pressure sensors and a heart rate monitor. It provides visual, auditory and haptic feedback and the pedals are used to move forward.

Another approach consists in using VR technology to enhance the exergaming experience. As an illustration, "VirZoom" is an immersive exergame platform designed to be used with a

stationary bike. You can ride a bike through exotic locations around the world, fight against a tank in a battle, race a F1 car and fly a Pegasus in a horse riding game. You can also ride a horse in the old west or take part in traditional ranch roping. Their game technology is based on VR motion, so their customers are expected to use a VR equipment.

2.3 Using Social Lever to Make Physical Exercise Fun

Combining gaming and social media to make people have fun while exercising becomes quite popular [5]. During the last decade, many running applications have been designed to make running fun, socially exciting, collaborative, lucrative business and even charity. "Charity Miles" [23] proposes converting the distance you run, bike or walk into a donation to charity. "Running Heroes" [24] proposes rewarding the sportsmen or women with exclusive discounts when they go shopping according to the challenge they won. "Nike+ running", "PumaTrac", "Garmin Connect", "Polar Flow", "Runtastic" and "Zombie Run" [25] are some examples of these running applications which allow people to track, share, challenge and interact with friends and other runners across the world. They try to engage people and particularly sportsmen challenging them on their physical performance without using fantasy. This kind of approach consists in turning a solitary physical activity into a social activity. Moreover, research shows that the social presence in a competitive setting influences the participants' behavior and their performance. By focusing on bike-based exergames, Anderson-Handley et al. [26] assessed the effect of virtual social presence on behavior while exercising. They used a system based on a stationary bike interfaced with "Netathlon" riding software. They showed that the presence of competitive avatars in the virtual world significantly increases pedaling intensity.

2.4 Controlling Physical Activity and Assessing Health Benefits

In the healthcare field, researchers have been trying for a long time to assess the benefits of using exergames, virtual worlds, existing video games or academic interactive virtual environments. A systematic review was conducted of exergaming interventions delivered to adults with cancer [6]. According to Tough et al. [6], "the adherence rates and enjoyment appear greater during exergaming compared to standard care, supporting the feasibility and acceptability". Using a bike-based exergame cycling program, Knights et al. [27] carried out an experiment involving children with cerebral palsy and evaluated their effects on quality of life, exercise tolerance, anaerobic power and adiposity. They obtained a similar conclusion: it enhances adherence and fun more than standard care. Other studies focus on the comparison of energy expenditure between exercising with and without using motion-based games [28, 29]. Graham et al. [28] showed that motion-based games can provide physical activity levels similar to that of unstructured activity. Following the same idea, Yao et Kim [30] explored the impact of immersion in virtual reality using a bike-based exergame. They compare two groups, one played on a traditional PC-setup on a flat-screen and another VR-group played the game using a Head-Mounted Display. They showed that the use of full VR exergame increases the user's physical exercising performance.

Studies aim to assess the energy expenditure while playing an exergame [31–33]. One of the most popular mobile application is "Pokemon Go". It aims to encourage walking combining gaming and smartphone technologies such as Global Positioning System (GPS) and step-counter. It is an augmented reality mobile game in which players search real world locations looking for cartoon characters. Once they appear on screen, the objective is to "catch them" using the touchscreen function of the smartphone. Some research [34–37] studied the benefits and risks of "Pokemon Go" to fight against physical inactivity. Leblanc et Chapput [38] highlighted that we need long-term experimental research to understand the underlying physiological responses and the energy expenditure during a gaming session.

2.5 *Synthesis*

Various kinds of mobile applications, video games or exergames already exist to challenge sportsmen and sportswomen to cycle. All the studies reviewed so far, however, suffer from three main weaknesses. Firstly, bike-based exergames designed to be used for rehabilitation purpose use mainly stationary bike which is equipped to report biomechanical or biomedical feedback. However, they fail to consider the importance of fantasy and provide a low level of gaming. Secondly, bike-based exergames resulting from a conversion of popular games provide a high level of gaming; however, they mainly fail to consider physical effort. The only thing that counts is the fun resulting from physical effort. The monitoring system attached to the bike (sensors) is poor or insufficient to precisely indicate the physical performance, the biomedical parameters and address the audience of sportsmen or the clinical staffs. As the consequence, the physical effort does not really affect the gaming performance. Thirdly, all the studies reviewed so far use the pedals input to move forward as in real pedalling contexts while the bike-based exergame "Play'n Ride" is composed of a common road bike and an interactive universe where the pedals input transforms the traditional "move from backward to forward" to "move up and down".

3 *"Play'n Ride"*

To that end, we provide a digital game, in which the player manipulates the main character by using a real bike equipped with a variety of data sensors. Firstly, the use of a common bike should allow the exergame to address a wider audience. Secondly, using fantastic universe and extrinsic fantasy [7] should allow to make physical activity and exercising fun. The innovative idea consists in converting a horizontal movement while pedalling in real-life into a vertical movement in the fantastic universe. Moreover, the exergame should be easy to use accessible to a wide audience, and customizable to adapt the level intensity of a physical activity to the user's physical capabilities or/and to the (para)medical staff's expectation.

3.1 *Background*

Tools are available to simulate the pedalling and control PA. As an illustration, PCGamerBike Mini [39] is a pedalling device which is plugged with a USB connector and simulates key presses when the player pedals. It could be used to control forward movement of an avatar in games. However, it does not allow us to achieve our goals particularly because we want to control the global processing and be able to assess the distance covered.

The main components of "Play'n Ride" are presented on Figure 1:

- an application (software) installed on a computer with a monitor to display the game scene (4),
- a real road bike to interact with the main character on the scene (1),
- an indoor home-trainer to properly prop-up the road bike (1),
- a specific measurement chain based on an Arduino card [40] to count the number of back wheel revolutions. It is composed of: an Arduino card equipped with an infrared sensor (3), a 3D-printed support to maintain the infrared sensor close to the back wheel (2), a set of 3D-printed parts which have been designed to be attached and centered on the back wheel and to pass through the infrared sensor while the back wheel is rotating (2).

When the back wheel turns, the U-notched wheel goes through the infrared gate and the Arduino card sends a binary value to the game engine (each 500 ms). The game engine translates the binary value into a flying height. The U-notched wheel has been designed with 4 U-notches which gives 8 inputs during 1 rotation of the wheel: 4 front edges and 4 back edges.

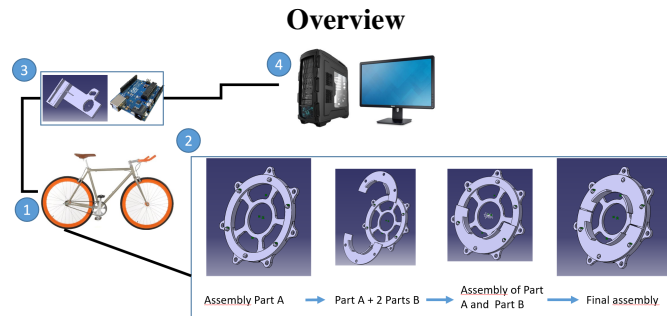


Figure 1: *Components*

1. *The road bike*
2. *The U-notched wheel with 4 notches and its modular support designed to be assembled and attached to the back wheel.*
3. *Arduino card with a sensor and 3D-printed support attached to the back wheel*
4. *The computer with the game engine.*

3.2 *Software Architecture*

The application was developed using the cross-platform game engine Unity which supports the creation of 2D and 3D games. Unity comes with efficient assets for making games and connect them with ANT+ protocol and Arduino card. We followed an oriented-object paradigm and used the extended model-view-controller architectural pattern. The architecture of the game engine is composed of four modules: a game controller module (1), a game logic module (2), an Arduino Connector module (3), and a scenario loader (4). The player chooses a scenario from a list and the game engine loads the parameters attached to the scenario (e.g. universe, scrolling background speed, and physical exercise settings) from JSON files. The Arduino Connector module constantly monitors the Arduino input from the USB serial port. The game engine requires a pedaling input to start the gaming session. The game logic module locates the obstacles on the scene. The game controller checks the collisions between the character and the obstacles from the starting point to the end point.

3.3 *Extrinsic Fantasy*

Peddaling is a routine task that could be more enjoyable if we add some fantasy. Considering fantasy as a key factor to engage the player and to support the physical effort, we chose to use extrinsic fantasy to design "Play'n Ride". The innovative idea consists in transforming the traditional movement from backward to forward attached to pedalling situations into vertical movements (from down to up) in the virtual world. It implies turning the universe of cycling (road, trail...) into a metaphoric and fantastic gaming universe where the player does not drive a vehicle or ride an animal to move ahead.

The game design is extremely simple and has been guided by the game design of the runner game genre. A runner game is essentially a game where a main protagonist runs forward into a scene. In the 90's, the runner games stemmed from 2D platform games. One of the most popular runner is Super Mario Rush where the player must help Mario avoid dangers

along the way. Nowadays, the runner games are popular on mobile devices and involve a main character who constantly runs (or shoots). Players only have one touch control to facilitate the use with one hand (tap to fly, or to boost...). In "Play'n Ride", the player controls a flying character which flies at different heights according to the speed of pedalling (extrinsic fantasy). It is important to highlight that our system does not use musical rhythm i.e. the music does not guide nor encourage the rider to pedal. The speed of the scrolling background is constant and independent from the player's pedaling speed. The main character constantly moves ahead (from left to right on the screen) even when the player does not pedal. As the gravity force is attached to the main character, the rider must pedal continuously to avoid crashing to the ground.

Two fantasy universes have been designed (see Fig. 2). The player can control either a spaceship ("Speedy Rocket" universe) or a crazy bee ("Crazy Maya" universe). The mission entrusted to the player is to get from point A to point B. During the journey, he must avoid a large variety of obstacles such as satellites, wasps, spiders depending on the fictional gaming universe. In the first fictional universe, the player controls the spaceship (at the bottom left on the scene) and must avoid successively spatial top objects (at the top left of the screen) and spatial objects on the ground (at the bottom right of the scene) before reaching the spatial center. In the second fictional universe, the player manipulates a crazy bee and must avoid fantastic obstacles such as garden gnomes and killer spiders to join the hive (see the right part of the Fig. 2). A dozen of scenarios are available and they all can be played with both universes (e. g. "Montagne Russe", "L'Albigeoise", "Challenge").

"Play'n Ride" user interfaces

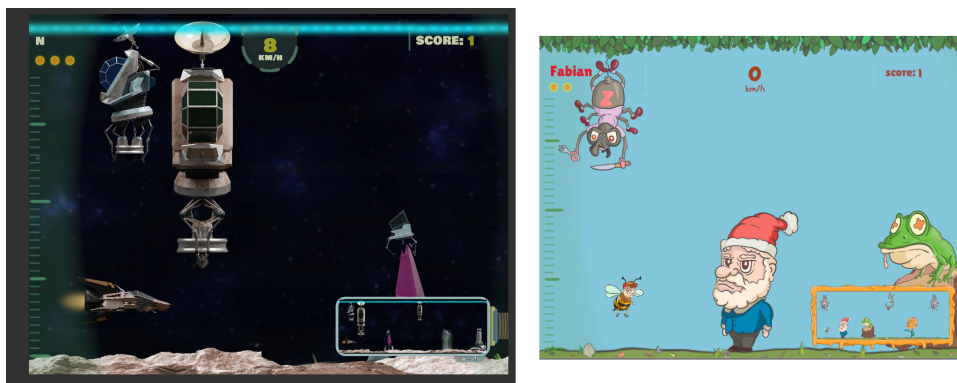


Figure 2: "Play'n Ride" proposes two different universes: the screenshot on the left presents the "space" and on the right the fantastic garden.

4 Method

Our research aims to show the usefulness of extrinsic fantasy to address a wide audience and to engage people in exercising. To that end, we decided to experiment our system in a place where a wide audience is likely to be interested in testing a bike-based exergame. We took the opportunity of the 'Tour de France 2019' to recruit people who are likely to be interested in testing a bike-based exergame.

We automatically log quantitative data thanks to an in-game digital tracker. A database, attached to the exergame, stores indicators related to the gaming sessions: participant's identity and data attached to a gaming session. Qualitative data are collected through a questionnaire and participants were equipped with a connected bracelet to track the heart beat. Participants

were asked to answer to a questionnaire after they played. The questionnaire is composed of demographic items, background items, graphical preferences and 10 items related to SUS questionnaire. To check the usability of the system, we use a standardized questionnaire System Usability Scale (positive version) (SUS) [41]. This questionnaire is widely available, and has been used in many research studies. The figure 3 illustrates the procedure with diagram blocks. The data related to the heart beat is not presented in this paper.

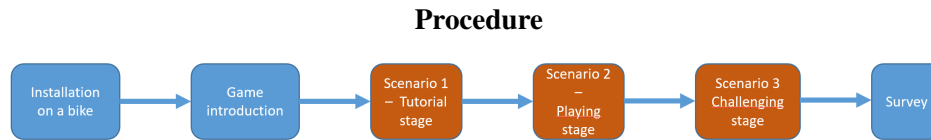


Figure 3: *Test session procedure*

5 Experiment

The user study was conducted in a real context (outside of the laboratory) to explore the participants' experiences which means the physical condition of the subjects was not under control. Both quantitative and qualitative data were collected to assess the usability and the acceptability.

5.1 Setup

In Albi (south of France), 10th stage town of the 'Tour de France 2019' [42], the game was provided in a specific booth (30m²) during three days in the Fan Park. The booth was set and equipped in partnership with the Serious Game Research Lab of Champollion University and the City of Albi. Bikes were fitted on a home trainer in front of a monitor which displayed the game scene. The Figure 4 illustrates the setup. Two independent instances of the game can be launched separately at the same time. Each instance is completely independent. Each bike has its own test leader who hosts and instructs the visitors.

A dedicated booth in the Fan Park of the Tour de France

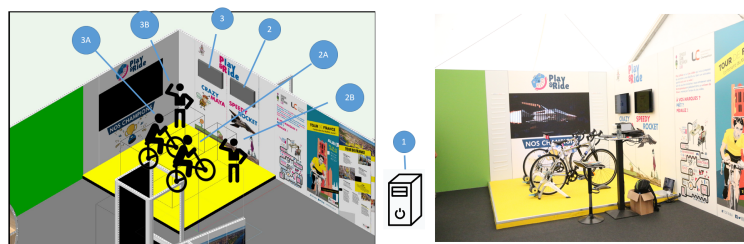


Figure 4: *The evaluation setup took place in a booth. Two players can ride at the same time. The game launched two different instances. (1) computer running, (2) screen for player 1, (2A) player 1, (2B) test leader (3) screen for player 2, (3A) player 2, (3B) test leader*

5.2 Procedure

The participants were recruited among the Fan Park visitors. None of them were selected from personal social network and they all certified not to have a health problem that prohibits

them from practicing sports. When they are visiting the "Play'n'Ride" booth, they asked to participate on the research. If they agreed, the test leader introduced the game and fits the height of the saddle according to the participant's height. Before starting the ride, test leader also fills out the participant's background information. The participant is free to choose in which universe he wants to play the game: either the "space" or "the crazy garden". A participant is supposed to test at least three scenarios. The test is composed of three physical exercises designed to progressively add difficulties and to progressively challenge the player. The participants are told to respect a particular order and they are free to give up if they want to. Firstly, the participant discovers the game environment using a scenario called "Montagne Russe" and the interactions by cycling as a warm up. Secondly, he uses a training scenario called "L'albigeoise" where speed of scrolling, number and positions of barriers have been initialized to challenge the rider on the pedalling cadence. Thirdly, he uses a gaming scenario called "Challenge" where speed of scrolling, the number and the position of barriers have been initialized to challenge the riders on their reactivity, the ability to use successively the pedals and the brakes. At the end, the participant fills out a questionnaire.

6 Results

6.1 Sample of Participants

Over three days, one hundred and seventy-eight participants were involved in the experiment and used the prototype: 67 percent of participants are men (119 males) and 33 percent are women (59 females). The age of participants range from 10 years to 89 years ($M = 25.7$, $SD = 21.33$). The Figure 5 shows the distribution of the participants through their age.

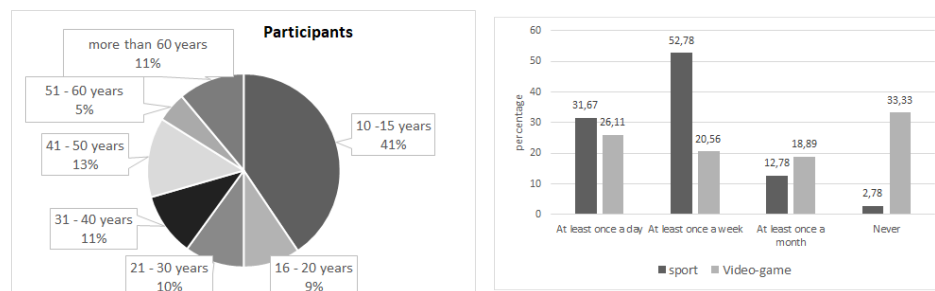


Figure 5: The pie chart shows the age distribution of the participants (left); The Diagram shows how often the participants practice sport and play video-games (right)

Video-game Experience The sample of participants was composed of people who had experience of video-games (at least once a day = 26.11 per cent, once a week = 20.56 per cent, once a month = 18.89 per cent) and people who had never played video-game (never=33.33 per cent). 2 participants did not answer to this question.

Physical Activity Practice The sample of participants was composed of people who declared practicing physical activity (at least once a day = 31.67 per cent, once a week = 52.78 per cent, once a month = 12.78 per cent) and people who never practice sports (2.78 per cent).

6.2 Usability and Learnability

The SUS questionnaire was used. The following items compose the questionnaire and were translated into our native language.

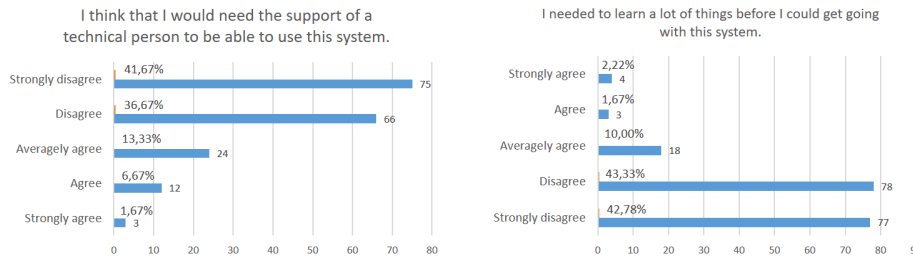


Figure 6: The SUS questionnaire was answered by 178 participants. Item 4 on the left and Item 10 on the right.

- Item 1: "I think that I would like to use this system frequently"
- Item 2: "I found the system unnecessarily complex."
- Item 3: "I thought the system was easy to use."
- Item 4: "I think that I would need the support of a technical person to be able to use this system."
- Item 5: "I found the various functions in this system were well integrated"
- Item 6: I thought there was too much inconsistency in this system.
- Item 7: "I would imagine that most people would learn to use this system very quickly."
- Item 8: "I found the system very cumbersome to use."
- Item 9: "I felt very confident using the system."
- Item 10: "I needed to learn a lot of things before I could get going with this system."

The Table 1 presents the answers collected through the SUS questionnaire.

The answers concerning the Item 1 show the great interest of the participants. 56.67 percent thought that they would like to use this system frequently.

Table 1: SUS questionnaire responses in percent

SUS	1-Totally disagree	2	3	4	5-Totally agree
Item 1	5.56	12.78	25	40	16.67
Item 2	53.89	33.89	8.89	2.78	0.56
Item 3	1.67	5	20.56	41.11	31.67
Item 4	41.67	36.67	13.33	6.67	1.67
Item 5	0.56	0.56	11.11	56.11	31.67
Item 6	37.78	45.56	10.56	3.89	2.22
Item 7	1.11	0.56	12.78	42.22	43.33
Item 8	31.67	48.89	13.89	5.56	0
Item 9	0.56	3.89	6.67	43.33	45.56
Item 10	42.78	43.33	10	1.67	2.22

If we re-orient the focus on learnability (Items 4 and Item 10. See Fig. 6). 78.33 per cent consider that they do not need the support of a technical person to be able to use this system. It means that they feel comfortable with the exergame. 86.11 per cent consider that they do not need to learn a lot of things before they could get going with this system).

6.3 Game achievements

745 gaming sessions were saved during the three days of the experiment. The scenario called "Montagne russe" has to be friendly and has been set with an appropriate scrolling speed to facilitate the initiation. 231 gaming sessions were launched and only 6 sessions were stopped while playing. Among the 6 games stopped while playing, 5 participants played again and only 1 dropped out. This person is no longer taken into account in the following values. 225 games were played by 178 participants, with 165 failures and 60 successes. 83.7 per cent of the participants played just once (149 participants), and 32 per cent played twice (25 participants).

Among the 178 participants, 133 participants lost and 58 participants won.

Failure Among the 133 who lost, 23 of them played a second time and 13 participants won on their second try. 106 who lost dropped out of this scenario but played the other scenarios, 3 participants played 3 times and only 1 played 4 times but they never won.

Success Among the 58 winners, 45 participants won on their first try (25.3 per cent). Among the 45 winners who won on their first try, 43 played only one time and then they played the next scenario. Among the 45 winners who won on their first, only 2 winners played a second time and won again.

To sum up, 106 participants lost and changed to play the next scenario, 43 participants won this scenario and changed to play the next one, i.e. 149 participants played just one time 'Montagne Russe' scenario.

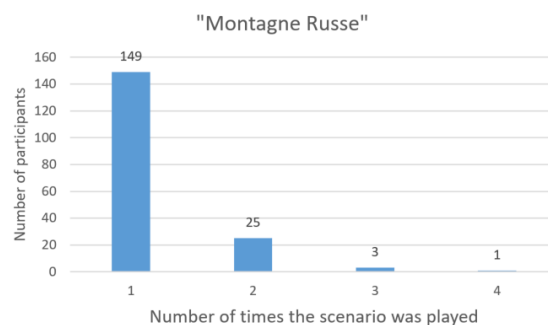


Figure 7: This graphic presents on the horizontal axis the number of times the scenario "Montagne russe" was played and the vertical axis presents how many participants played.

The second scenario called "L'albigeoise" was used 232 times. Participants managed to reach the end point 71 times and failed 161 times (69.4 per cent of games lost against 30.6 per cent of games won).

The third scenario called "Challenge" was used 252 times. Only 3 per cent of participants managed to reach the end point (10 games won sessions against 242 games lost sessions).

6.4 Game Universe

58.33 per cent of participants chose the bee universe "Crazy Maya" while 41.67 per cent used the spatial universe "Speedy rocket". The item "Would you prefer a game universe" proposes three answers: "1-more realistic", "2-as it is", and "3-more fantasy". The questionnaire accepts multiple answers to this question. 49.44 per cent answer "as it is", 26.11 per cent answer "more fantasy" and 25.56 answer "more realistic".

6.5 Acceptability

We propose to measure the acceptability through 5 factors: the number of volunteers at the beginning and at the end of the protocol, gender, age, practice of sports and video game experience. The high number of participants expresses a great interest and highlights the willingness to play. The high number of game achievements especially at the third step of the protocol highlights a high level of interest in playing. The item "I think I would like to use the system frequently" shows that 57 per cent totally agree or agree with this sentence against 18 per cent who totally disagree or disagree; 25 per cent are neutral) Moreover, the answers to the items: "Would you prefer a game universe" and "I think I would like to use the system frequently" clearly indicate that the system is very well accepted by the participants.

Finally, 78 per cent of participants indicate that they sensed practicing a sport and 67.78 per cent indicate that they sensed playing a video-game. The questionnaire asks participants about what they liked in this experience. They could choose between "the graphical universe", "the bike", "the diversity of the scenario" and "the sporting challenge" (multiple answers are possible). They mainly enjoyed the use of the bike (74.44 percent) and then the sport challenging (56.11 percent).

7 Discussion

Previous research [4, 18, 26, 27] has shown that exergames can be used with older adults and young people in the case of medical training. The impact of various factors (such as the presence of competitive avatars or the importance of competitiveness) have been studied with older adults. However, the effects of fantasy on exercise behaviors is still unclear. The aim of this study was to evaluate the impact of fantasy and particularly extrinsic fantasy on behaviors using a bike-based exergame. The results showed that extrinsic fantasy makes physical activity very appealing to a wider audience.

7.1 A Game Dedicated to a Wide Audience

In 2003, the French Ministry of Sports, the French National Institute of Statistics and Economics Studies (INSEE) published a report [43] on physical activities and sports practice in France. This report mentions that 33 percent of people practice at least a physical activity with a cycling during the year. It includes road bike, mountain bikes or a fully packed touring bikes. The cycling activities also include the touring bike as family activity, urban mobility and competition. In this study, 43 percent of people who declare practicing a cycling activity are women; 57 percent are men. 56 percent of people engaged in physical practice through simulators are women.

Genre: Studying the difference between people who practice cycling and the panel of people involved in our study, we can notice that the sample is a bit different. There is 1/3 women and 2/3 of men involved in the experiment. It might highlight that men are more interesting in cycling with this bike-based exergame than women. However, this hypothesis could be invalidated arguing that the experiment was carried out in July; the climate was hot; and women might not wear suitable clothes for cycling (dress, skirt. . .). Finally, this assumption "men are more interested in the bike-based exergame than women" is not adopted.

Age: Considering the age of the participants, the results clearly indicate that this exergame is usable at any age (see Fig. 5): the youngest player is 10, the oldest one is 89. Some younger kids would have appreciated taking part but the bikes were not small enough to allow them to ride. Even if there is a bulk of teenagers, the distribution of players' age is rather balanced

between the other clusters. Actually, this distribution shows that "Play'n Ride" addresses any age category. This bike-based exergame seems to be suitable to exercise at any age. In addition, using extrinsic fantasy attracts people whatever their age and their sex.

Physical activity Enthusiast: We notice that the sample is mainly composed of physical activity enthusiasts: nearly 85 per cent of the players practice a physical activity at least once a week. Considering their attraction for physical activity, enthusiasts of physical activity seems to be more interested in playing with the exergame. Using the extrinsic fantasy does not seem to affect the appeal for people who do not practice physical activity.

Video Game Experience: Considering the video game experience of the participants involved, 47 percent of participants regularly play video-game (at least once a week or once a day) and 53 percent are casual players; The extrinsic fantasy used is attractive both for regular gamers and casual gamers. Consequently, we can conclude that this game is attractive for the bulk of people who played with it, not only for gamers or physical activity enthusiasts.

7.2 Usability and Learnability

The questionnaire shows significant results about usability and learnability. 57 percent of participants declare that they enjoy the game, 80.6 percent consider that the system is user-friendly and 72.78 percent consider that the system is easy to use.

If we consider the number of gaming sessions per participant (see Fig. 7), a huge majority of the participants (83.7 per cent) tried just once the initiation scenario before going forward. If we consider the number of gaming sessions per participant and their outcomes, 133 lost on their first try, 45 won on their first try, 23 participants tried again and 13 won on their second try ($133+45=178$ persons). As a consequence, we notice that 106 participants lost the scenario but they didn't feel the need to play again to understand how it works. Even if the success rate is 25.2 per cent on the first try (45 persons won on the first try), the rate increases to 56.5 per cent on the second try (23 persons played again and 13 succeeded). We notice as well that 2 participants (among the winners on their first try) played again and won again. It means that they did not win by chance. They won because they felt comfortable with the fantasy which converts pedalling into a vertical movement. Considering participants who lost and tried again, the success rate is multiplied by 2 on their second try. It means that the bulk of the participants felt comfortable with the device on their first try.

Considering the third scenario ("Challenge"), the number of lost gaming sessions was not surprising because this scenario was designed to include a tiebreaker for all the participants. We needed a scenario to qualify applicants for a daily contest.

Even if the number of lost gaming sessions seems to be important especially with the first and third scenario, the drop-out rate and the continuation rate during the protocol is significant enough to conclude that using extrinsic fantasy in an exergame is successful in catching attention and motivating a large audience to exercise.

7.3 Acceptability: A game versus a biking application ?

A large majority of participants indicates that they consider "Play'n Ride" as a game and they feel like they are doing sport. They underline that they enjoyed pedaling for fun. This result is not really surprising because the booth was installed during a stage of Tour de France 2019 which attracts many cycling enthusiasts. But we can ask ourselves if this exergame is considered as a biking application by the most physically active participants. In the questionnaire, the participants were asked if they had the feeling of practicing sport. When we correlate the factors "practicing sport at least once a day" and "having the feeling of exercising", we can see that 80 per cent of people who practice sport at least once a day consider that "Play'n Ride" makes them practice sport. If we correlate the factor "practicing sport at least once a

week” and ”having the feeling to exercise”, we find that 81 per cent of participants consider they practice sport when play with this game. Surprisingly, only 60 per cent of participants who do not practice sport very often (once a month) consider they practice sport with ”Play’n Ride”.

In the same way, if we correlate the factor ”having the feeling of using video-game” and the factor ’video game player at least once a day’, we find that 74 per cent of the video game players have the feeling of using a video game. This percentage is nearly the same (75 per cent) if we enlarge to the participants who play at least once a week. These are interesting results because they mean that this game is acceptable by all the users, whether they are gamers or not, physical activity enthusiasts or not.

7.4 *Game Universe and gender*

The study of the questionnaire does not show any particular difference between male and female: we find approximately the same percentage of male as the percentage of female who declare that they would like to play with this game. However, there is a difference in their choice of game universe: 69 percent of males preferred the universe of ”Speedy Rocket” while 62 percent of females preferred the universe of ”Crazy maya”. Obviously, these results just give us a trend. It would be interesting afterwards to see if the graphical universe affects the gaming experience and if it is correlated to gender.

7.5 *Maintained Interest*

The data analysis from the scenario ”Montagne russe” gives some more interesting results about the impact of the fantasy on the maintained interest. This scenario was developed to make the participants discover the system and to make them understand how it works. Firstly, we notice that only one person among one hundred and seventy-eight participants started the game but stopped during playing while all participants are free to stop whenever they want. A global study of the gaming sessions shows that 133 participants lost while 58 participants won. It means that people involved were curious continuing even if they failed.

7.6 *Engagement*

During the experiment the participants were asked to play 3 scenarios (see Fig. 3). They could drop out whenever they wanted or replay a scenario if they wanted to (not as many times as they wanted because of the queue at the entrance of the booth). Only 6 participants (3 per cent) did not play successively the 3 scenarios of the procedure. We notice that 745 gaming sessions were played although 534 gaming sessions (178 participants * 3 scenarios) should have been played during the experiment. It means that players enjoyed playing the game and asked to retry one of several scenarios in order to improve their score. ”Montagne Russe” was the first scenario of the procedure. This scenario aims to make the participant familiar with the system. Even if the participants failed to achieve this first mission at their first try, they played the tutorial scenario just once (75 percent), without repeating it, and 19 percent replayed it. That means that nearly 95 per cent of the players had understood the game mechanisms after playing two times. If we compare this value to the 72.78 per cent of the sample who consider that the system is easy to use, we can consider that they feel easy controlling the character’s altitude through the pedalling cadence. ”Albigeoise” and ”Challenge” are the 2 following scenarios. They are both more challenging. We notice that a lot of players retried many times: ”Albigeoise” was played 262 times (for 178 players) and ”Challenge” was played 252 times. On average these scenarios were played nearly 1.5 times by each participant. This highlights that participants enjoyed playing with this game and their interest remained after their first try.

In fact, many players would have liked to play again to improve their score or to challenge their friends or family. Due to the large number of participants in the queue, it was not possible to allow all the persons to play again.

7.7 *Quality of Life*

Multiple studies show the importance of physical activity for the well being of people. Felce and Perry [44] consider that Physical Activity is one of the 5 dimensions of quality of life. Therefore, it is important to think about how to promote physical activity in populations that are often too sedentary. The fantasy of the game succeeds in making physical exercise fun. This implies that people may change their perception about physical activity. "Play'n Ride" helps to show a more playful idea of exercising. Our study highlights the positive effects of fun and user-friendliness through the use of the extrinsic fantasy. We highlight that the point is not only about promoting physical activity for all, but promoting a variety of scalable exercises to suit to the user's abilities or specific purposes as well. The scenarios must be adjustable according to the age, the pathology, the medical or personal purpose. The settings must take into account the duration, the frequency and intensity of the expected effort. A large library of exercises will be designed under medical supervision with medical experts to improve the quality of life and well-being.

7.8 *Limitations*

The methodology used allows to highlight a trend concerning the influence of extrinsic fantasy universe on people motivation to practice physical activity. Even if the number of participants is quite high in our study, it is composed of a large majority of men (67 percent of participants) and a strong percent of young adults (41 percent) are represented. These gender and age imbalances could have an impact on the results. Extrapolation of the findings can only be done for men and young adults. In addition, it could be interesting to extend the gaming experiment beyond the temporal confines of public events and to pre-select participants according to specific criteria such as genre, age, video game enthusiast, cycling enthusiast and medical or physical criteria to check their influence on the findings. In addition, it could be interesting to collect data in a real world context by offering the opportunity to freely play in public or private places.

Using extrinsic fantasy universe to practice physical activity can be adopted in other situations such as running, tennis or rowing but in each case, it implies a high degree of precision related to the specific measurement chain which is necessary to design physical exercises, to control physical activity, to record data, and to display feedback.

8 *Conclusion*

The aim of this work was to develop a new device to promote and to control physical activity. The innovative road bike exergame called "Play'n Ride" offers a fantasy world based on extrinsic fantasy where the player controls a character's flight altitude by pedalling. "Play'n Ride" was tested in a Fan Park booth during three days in a stage town of Tour de France 2019. One hundred and seventy-eight participants from different age groups used the prototype. The experiment shows that this exergame is easy to use, user friendly and exciting to play. Nearly all the participants tested all the scenarios proposed in the procedure. The findings from this study make several contributions to the current literature. The findings validate that using extrinsic fantasy fosters physical activity. The device developed in this research fulfills the requirements of making physical activity attractive and fun. Future work will focus on the

modelling, controlling and adjusting the scenario settings to the expected the physical activity. It consists in designing customized fitness trails according to particular sport objectives or (para)medical staff's expectations.

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