The Impact of Controller Design on the Player Experience

Dominic Talbot

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Project submitted to University of Suffolk in partial fulfilment of the requirements of the degree of BSc (Hons) Computer Game Technologies 2019.

DECLARACTION

I hereby certify that the whole of the work being submitted by me in partial fulfilment of the degree BSc (Hons) Computer Game Technologies complies with the Academic Regulations of University of Suffolk is the result of my own investigation and study.

Signed:

Date:

ABSTRACT

Introduction: Gaming controllers are an integral part to gaming. It has been suggested that innovated controller designs could have an impact on factors such as player comfort, reaction time, and play time in the game. **Method:** The current study was comprised of 10 gamers, each testing three controllers to all three games. The participants' level of experience ranged from experienced to professional. Three game controller designs were tested (Xbox One Controller, Adaptive Controller, and Keyboard). A webcam was positioned in front of the player, and a heat beat monitor was collecting information about the participant's heart rhythm during the games. **Results:** There were differences in the participants heart beat between controllers. For example, on 'Dom's Racer' the participant's mean max heart rate for the Adaptive controller shows a 1.1± second increase to the keyboard. **Discussion:** The results of the study could have implications for gamer performance, reaction speed, and enjoyment. **Conclusion:** Controller design has an impact of the enjoyment of the gamer. Future research should focus on players who are not so experienced and female participants (none were available to take part in the study). More effort should be made to create a controller which everyone can enjoy across all platforms, which ultimately enhances their experience.

Keywords: Game Controller, Heart Beat, Performance, Enjoyment

ACKNOWLEDGEMENTS

Firstly I would like to thank David Gee and Raymond Oliver for their assistance and guidance throughout the dissertation process. I would also like to appreciate the participants who were involved in the study for giving their valuable time, and my friends for helping setting up the equipment. Finally I would like to thank my family for their continued love and support.

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1. Introduction

In this project, the aim is to measure the impact of a variety of game controllers to examine how they correlate to the player experience. Video game controllers are an integral part of the gaming experience. The main purpose of a gaming controller is to retain comfort and accessibility so the user have a smooth and comfortable experience while playing. An important aspect for a controller to possess is called the Body-thing Dialogue, this is a concept that was described by Larssen *et al* (2010). The physical properties of the controller give it the shape and mass, which effects how the user will control that controller. "In the process of incorporating things into our bodily space, there is a dialogue between our perception and the thing, which is enacted as a change in our potential for action." Larssen *et al* (2010). This explains how different masses and styles of controllers can lead to different experiences and uses. Different input controls have an effect on the player experience, this all depends on how the input device suits the game mechanics. Personal experience is also a factor while engaging in video games: if the player has had a substantial amount of time player on a specific controller in their gaming experience, it will tie them towards their preferred hardware interface. There is a debate about whether keyboard and mouse is better than other handheld controllers. Nevertheless, according to the Entertainment Software Association (ESA) Michaela D. Gallagher, President and CEO stated that there are 2.6 billion gamers who enjoy using all different varieties of controllers for their games.

1.1. Project Aim

The purpose of this study is to investigate the effect of a new controller design with a gamer, in particular their enjoyment levels and overall experience. The study also aims to gain an understanding of whether controller design could impact the reaction time of the video gamer. Overall, the study aims to arrive at an understanding of any significant impacts on the performance of gamers when they are faced with a new design of controller.

1.2. Objectives

1. To collect information on which what controllers are best suited for which game.
2. To record the gamers reactions, heart rhythm and enjoyment while playing a video game with different types of controllers. This will be recorded with a face camera, heartbeat monitors and video game data.
3. To record the participant's opinion on the comfort and enjoyment of each controller design.
4. To analyse the video recordings and heartbeat monitors to compare the reactions of excitement.
5. To make recommendations on how controller design can affect the gamers experience on different games, and whether this could improve the gamers performance.
6. To create video games with Unity to compare each controller to that experience.

1.3. Research Questions

Does the controller design have an effect of the players experience while playing video games?

1.4. Hypotheses

H_1 –

Using an unfamiliar controller will affect the performance and heart rate of the player.

H_0 –

Using an unfamiliar controller will not affect the performance and heart rate of the player.

H_2 –

Using the adaptive controller will increase the reaction time of the player.

H_0 –

Using the adaptive controller will not increase the reaction time of the player.

2.0. Literature Review

2.1. Gaming

To first establish how controllers can increase enjoyment, we must first investigate the cognitive effects of gaming and why gamers find it enjoyable. Many news articles suggest that gaming promotes laziness and is intellectually draining, nevertheless gaming promotes a wide range of skills to work towards goals and challenging tasks. The urge to progress and achieve the feeling of success creates a willingness to continue, by that the player has an enjoyable experience. "When they reach the goals after overcoming obstacles, positive feelings and a sense of competence emerge" - Poels *et al.* (2010). The gameplay experience also comes down to the game mechanics and how the game is challenging for the player. When it comes to the overall effects of gaming, there are a number of emotional outcomes (e.g., enjoyment, boredom). To find the right balance of challenge and skill in games, the four-channel flow model helps to manage the gameplay. The flow-channel models share the idea that there are certain cognitions that are followed by emotions. "In an ideal situation where skills and challenges are high and in balance, an optimal state of flow occurs". Poels *et al.* (2010, p.31)

The paper Gerling, K *et al.* (2011) used psychophysiological methods to provide covert and reliable affective measurements of user experience. They used Electrooculography (EOG) and EEG psychophysiological measurement apparatus to collect brain activity while playing a video game. The results showed that more experienced players had an increase of delta activity, the function in the brain which correlates to a sense of being drowsy of tired. This ultimately suggests that experienced players didn't need to concentrate when playing the game to progress. Players who showed increasing signs of

beta power were the ones who were unfamiliar to the controls and gameplay. This links towards alert and attentive brain power while undergoing decision making.

2.2. Gaming Controllers

Controllers have come a long way and have adapted to create a more immersive feeling for the player. The evolution of game controllers correlates to the increasing complexity of environments and tasks in-game. Joysticks, for example Atari and Commodore, only handled up-down-left-right and fire, suite to 2D environments and simple game mechanics - Mechanics Park, J. (2018). In the 8bit era, paddles from the NES and Master System made a second task button common and introduced the basic handheld layout common to all modern controllers - Nintendo of America (1987). In the 16bit era, paddles from SNES introduced additional face-buttons and shoulder buttons, tripling the number of inputs for more demanding games. Introduction of motion controls (Wii) tried to break away from an increasing number of controller buttons, which alienate non-gamers, in favour of intuitive motions. For instance, Wii Tennis, which requires one button press in the entire game). This greatly widened the target demographic of video games, something that Nintendo confirmed was their ultimate - Anthony, S. (2008). For instance, early first-person shooters like Wolfenstein 3D and Doom only offered horizontal orientation due to the lack of real 3D environments (Gerling, K *et al.* 2011). It could be argued that there is more interaction in the current video game market than there was in the 1990's, bearing in mind that there are more input variables than before. Adaptive controllers are now introduced to enable gamers with a disability to continue gaming - Takahashi, D. (2018).

Console controller designs have improved with the introduction of smoother and technological design that changed the way players experience their games. In order for controllers to be improved, the design of input devices requires critical discussion and improvement from the last model. Compared to the 1995 PlayStation 1 controller which offered only a D-pad with four shapes and four shoulder buttons, there is a now an extensive amount of features that the new generation of controllers possess - Mustaquim, M. (2014). The Xbox One controller altered the way people feel connected to the game by introducing trigger rumble motors. This effect was to create an illusion that the player could feel the vibration of the gun being fired, or changing gear in a racing game. The PlayStation 4 controller has the touchpad on the front which allows new and creative ways to interact with games. These new generation controllers are heavily modified to have faster response times and comfort so the player can have a satisfying experience. Body movement seems to be an important factor when playing a video game. This is why arcades can be so fun, because everything is interactive and there are different ways to play each game. A study from Lindley *et al.* (2008) showed that a more active controller led to more engagement from the players. The tests showed that the level of interactivity from the '*Donkey Konga'* bongos increased enjoyment and spatial presence.

2.3. Conclusion

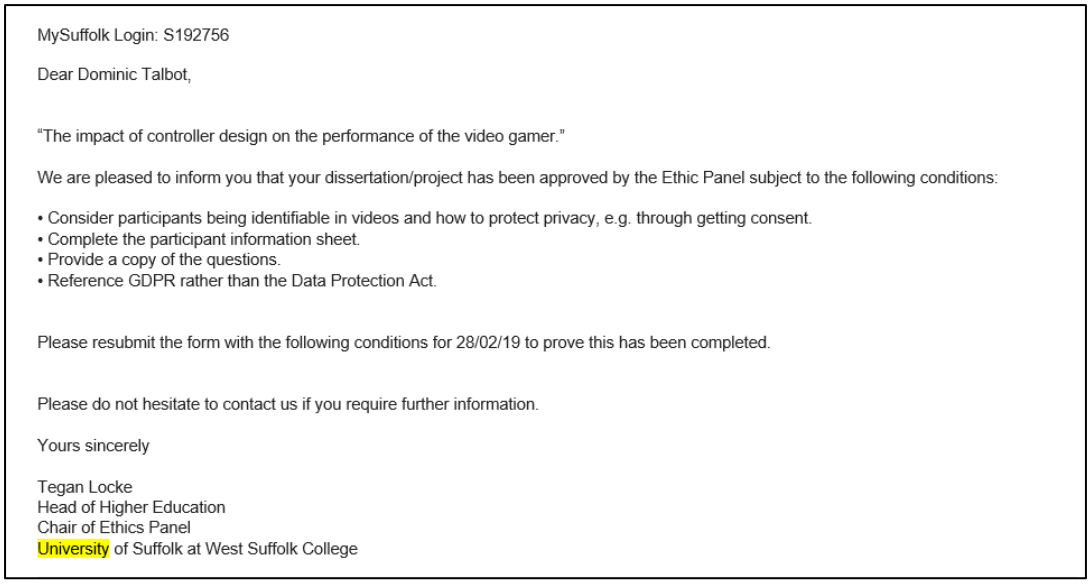
Overall, the gaming controller is an important area of research because it affects multiple factors such as the performance of the player and reaction speed. It is also important for player comfort, stability and accessibility. Now that processing power has reached a point where almost any game mechanic and environment is possible, companies play a balancing act between oversimplifying controls and alienating hard-core gamers, and providing hard-core controls and limiting their appeal. In this paradigm, some games deliberately confuse the gamer with complex controls as part of the core game mechanic (such as Manual Samuel). There have been studies relating to controller usability on the player with regards to enjoyment. However, the research is specifically on which controller is better than the other. Further research should be conducted to test the effect of controllers on the player's gaming experience, in particular excitement and enjoyment assessment through the measurement of heart beat monitors and cameras. Furthermore, standardised definitions of the players level of experience does not exist. Therefore it is difficult to objectively quantify the player's ability within the game and their reactions to situations. Further research needs to be conducted to objectively quantify these variables.

3.0. Methodology

The process of this study is to

1. Collect information on which are the most popular controller designs according to the general gamer population via a questionnaire
2. To measure the player's heart beat and reactions when playing in varying controller designs with different game types
3. To analyse the video recordings using Logitech C920 HD Pro.
4. Analysis of the data collected using Microsoft Office excel 2016.

3.1. Ethics Process



MySuffolk Login: S192756

Dear Dominic Talbot,

"The impact of controller design on the performance of the video gamer."

We are pleased to inform you that your dissertation/project has been approved by the Ethic Panel subject to the following conditions:

- Consider participants being identifiable in videos and how to protect privacy, e.g. through getting consent.
- Complete the participant information sheet.
- Provide a copy of the questions.
- Reference GDPR rather than the Data Protection Act.

Please resubmit the form with the following conditions for 28/02/19 to prove this has been completed.

Please do not hesitate to contact us if you require further information.

Yours sincerely

Tegan Locke
Head of Higher Education
Chair of Ethics Panel
University of Suffolk at West Suffolk College

Figure 1. Ethics approval

3.2. Questionnaire

A questionnaire was used to highlight the most popular controller designs in the gaming population. There will be a questionnaire before and after the controller test. The results of the first questionnaire will determine which controller designs will be used to test the hypotheses. The questionnaire will be composed of multiple choice questions. This will be aimed at gamers only, and only respondents aged 18 years old and over could answer the questionnaire. In accordance with the General Data Protection Regulation 2016 the information provided by resonance will be kept safe and secure. The respondents will be made aware of this before completing the questionnaire. The data collected will be only used for the purposes of this study. Once the work is completed, it will not be kept for longer than necessary. Overall a questionnaire will help to avoid bias and avoid conflict of interests. The results of this questionnaire will give an insight on what designs of controller should be used for this study.

3.3. Pilot Study

A pilot study was performed over the course of one day using the controllers and the 3 games that were created. This was to test the feasibility and repeatability of the methods and procedure which was utilized in the full scale study. The overall aim of the pilot study was to identify any problems with the proposed methods. In accordance with the General Data Protection Regulation 2016 the subjects name alongside personal information was not published in this study. The use of the different controllers was useful because the main focus of the current study was to demonstrate how controller design has an effect of the players experience while playing video games. The three controllers were also tested, the same controllers were used for each game. The video camera and heat beat monitor equipment was tested in this pilot study to ensure that all of the devices were in working condition for the actual study.

3.3.1. Strengths and Limitations of Pilot Study

The completion of this pilot study highlighted some significant strengths with the study design, as well as some limitations. It was made aware from the video analysis that the players needed to be a lot closer to the screen to allow accurate and repeatable video analysis of the players faces. Some players didn't mind, but a few felt uncomfortable with the short distance between the screen and their eyes.

3.3.2. Pilot Study Participants

This pilot study was compromised of eight gamers (one female and seven males; mean age ± S.D., 20.3 ± 0.9). These participants were chosen using a method of opportunity sampling. This is obtained by asking members of the population of interest if they would take part in the research. The participants chosen were from the University to ensure that they were of age and were capable of getting to the study without a long travel. The subjects' level of experience of gaming were ranged from intermediate to advanced, to reduce variables.

3.4. Materials

Figure 2 highlights the 3 commercially available controllers which were used in this study. These controllers were chosen based on the results from the questionnaire (figure *32*). The full list of equipment needed for this study is outlined in Appendix IV. The materials in this study will include two of the chosen controller designs picked from the questionnaire, and the Adaptive Xbox controller. There will be ready-made Unity games for the gamer to play. This game will include a wide range of challenges for the player, this includes quick time events, races and shooter game events. To record the data in the test there will be a heart monitor, a camera to record facial expressions and reactions to gameplay, and the game will collect information on the player's reaction time to events and how quickly the player completed the game. This information will be provided at the end of the game, this data will be recorded.

Controllers	Name	Information
	Xbox Adaptive Controller	Video game controller designed for people with disabilities to help make user input for games more accessible - Armstrong, S. (2018).
	Xbox One Controller	Primary controller for the Xbox One - Xbox. (2019).
	Keyboard	The keyboard is the piece of computer hardware used to input commands into the PC - Fisher, T. (2019).

Figure 2 - List of controllers

Recording Devices	Name	Information
	Polar Heart Rate Monitor FS3C	The long device goes round the user's waist to record the heart rate. The watch connects to the device to show the information - Polar Electro Oy. (2006).
	Logitech C920 HD Pro	Full HD video webcam which records a 1080p - Ansaldo, M. (2017).

Figure 3 - List of recording devices

3.5. Procedure

For this dissertation, ten random subjects were chosen to take a short questionnaire on their preferred controller design. From this questionnaire, two of the controller designs will be chosen to take part in the project (alongside the Adaptive Xbox Controller). When this information is finalised, the ten subjects now take part in the controller testing phase. The player will be recorded using the webcam, the gameplay can also be captured alongside the footage of the player. The participants were required to make sure their whole face was in view of the camera. The camera will be set up facing the subject, and the heart beat monitor will be gathering information on the subject's heart rhythm. Before each game commenced each subject was allowed to take a small break if they felt dizzy or hungry/thirsty. The participants will play through each game using all three controllers, they had to finish the games to advance to the next controller. All of the findings will be gathered for further research. When the work is completed, all of the recordings will be destroyed in accordance with the General Data Protection Regulation 2016. The subjects then filled out a final questionnaire on how they enjoyed playing on each of the controllers and what were the positives and negatives from their experience.

3.5.1 Time Implications

The Gantt chart illustrates the length of the time taken to complete the study (Figure….). Overall, it took just over two weeks to complete the pilot study and analyse the findings. After this long period, I was then able to complete the full scale study less than 2 weeks.

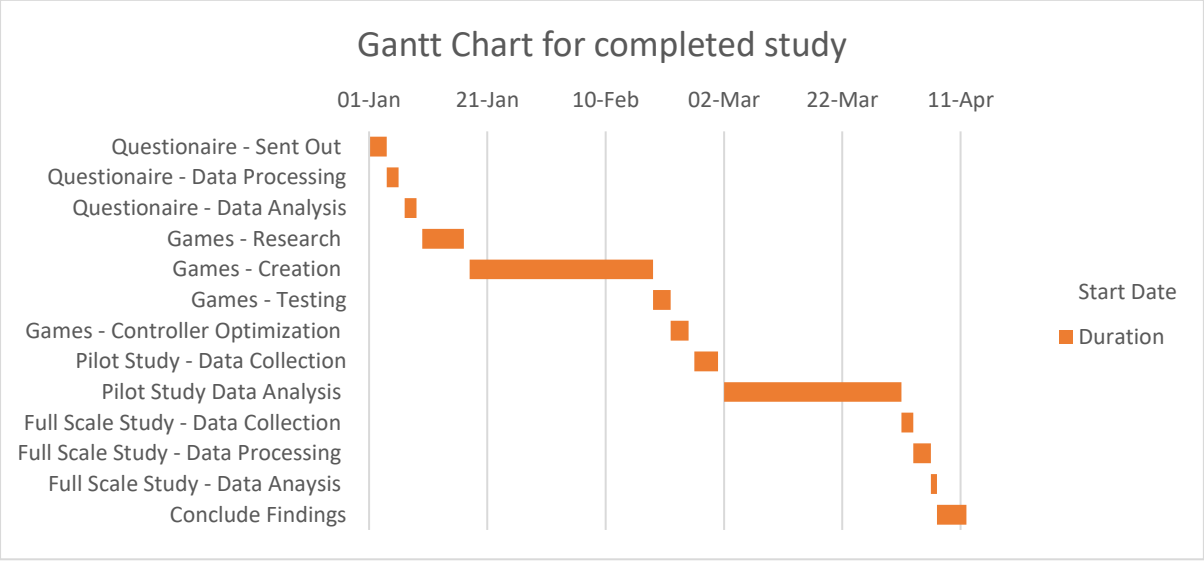


Figure 4 - Gantt chart for completed study

3.6. Data Analysis

The Video recordings collected were analysed in Open Broadcaster Software. The videos were paused when the gamer was making an excited or alarmed expression on their face. The heartbeat was recorded with Polar Heart Rate Monitor FS3C. The heartbeat monitor was attached to the player throughout the entire experience. This was to ensure that spikes of their heartbeat during gameplay could be recorded.

When the testing was completed, the information for each subject was also put into the Microsoft Office Excel 2016 spreadsheet to match the video recordings. Firstly, each raw data set was analysed using descriptive statistics to provide a general understanding of the selected dependent values. This was in order to determine whether the data was either parametric or non-parametric, as this would affect the statistical tests that needed to be used.

3.7. Ethics and Risks

3.7.1. Ethical Considerations

A detailed outline of the proposed methodology of the study, including the details regarding the justification for the study, questionnaire and pilot study, was submitted to University of Suffolk Board to be authorized. In accordance with the General Data Protection Regulation 2016 the participants' names were not published alongside personal information. This was done for the whole study. Furthermore, the data collected was for the purpose of the study only, and was stored safely and securely. Once the study was complete the data was destroyed.

3.7.2. Risks

Health and safety was considered before commencing the study. Control measures were put in place to reduce any potential risks. For example, the area which was used to test was an open location where the participant could leave without obstruction. Also, regular breaks were permitted to the tester if needed. If the testers were to be in any pain, the university would provide first aid if needed. The participants were made aware of the procedures and the potential risks. Prior to taking part in the study each participant signed an informed consent form. For the main study the participant's level of gaming was taken into account, and they could stop the tests if they so wished at any time.

4.0. Development

Dom's Racer was the only game which was developed in this experiment. This was to examine how the participants would react to different genres and game quality. The games found were from YouTube tutorials such as the Dodge the Blocks game Brackeys. (2016), and the Infinity Runner game made by Calice, N. (2018).

4.1. Creating Dom's Racer

The first section of the game process was to set up the physical objects and assets that were necessary in the racing game. These include the player and the enemy cars, the racing track, scripts, and other files. The project started with downloading the pre-made assets and creating a Unity project with C#.

The car and tree assets which are visible in the game are from the *Standard Assets* files in the Asset Store. To create the illusion of the sky, a skybox was also downloaded from the store called *Classic Skybox*. When these files were unzipped and imported to the project, the game was ready to start development.

4.2. Creating the terrain

Unity has a useful terrain tool which can be used to create many different scenes and environments. By initiating the terrain tool in Unity, it automatically places a surface plane in the scene to work from. By using the *Raise/Lower Terrain* tool, it structured the plane to the correct environment, also using the *Paint Height* tool to fix the consistency of the height on the plane. When the environment was modelled correctly, the next stage was to introduce the textures to the map.

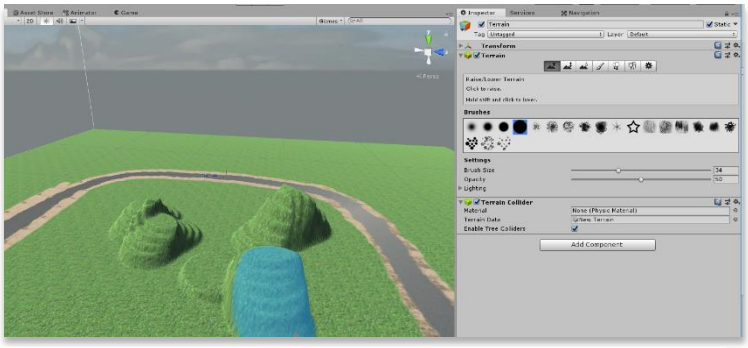


Figure 5 - Screenshot of terrain tool

To include textures into the project, the user has to drag and drop the image into the assets folder. The user can use the terrain tool again to brush over the canvas with the texture using the *Paint Texture* tool. Before adding the texture to the terrain tool, to create a more realistic and 3D effect to it must come with a Normal Map version. To do this, copy and paste the texture and set its *Texture Type* settings to Normal Map. When this is completed, the user can now upload the files to the *Paint Texture* tool and start making the plane more realistic.

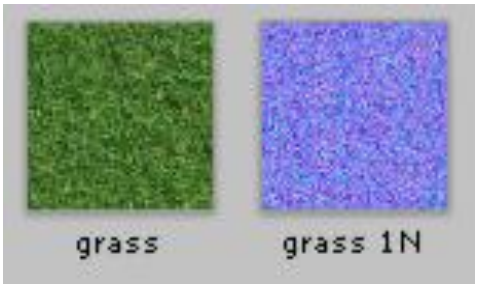


Figure 6 - Screenshot of grass and grass normal map

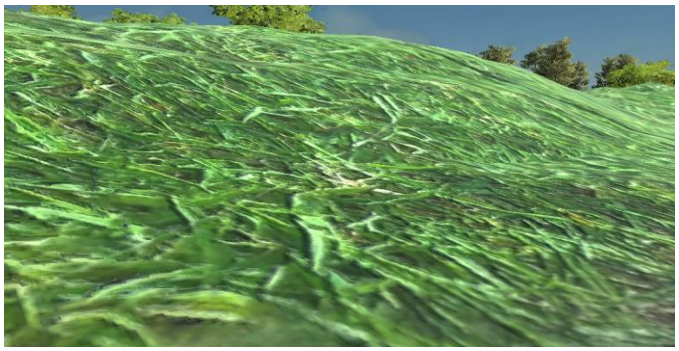


Figure 7 - Screenshot of normal map applied to paint texture tool

The trees were also included in the *Standard Assets* files and can be used to spread across the map using the *Paint Trees* tool.

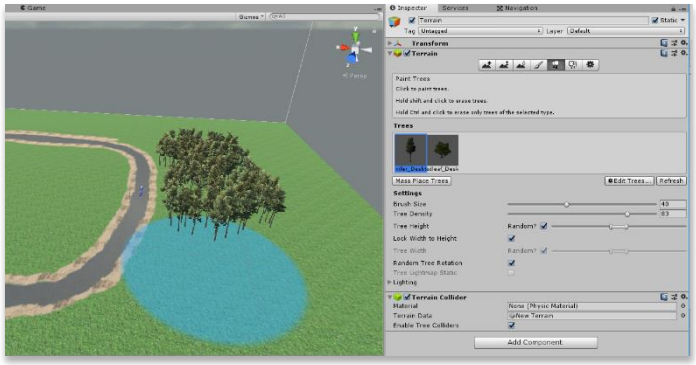


Figure 8 - Screenshot of Paint Trees tool

To add the skybox to the map, go into the Windows tab and select Rendering – Light settings. The skybox can now be dragged into the correct box to upload it into the scene.

4.3. Controlling the players car

As the car was already coded with the driving script, no further scripts were added to influence the movement of the cars. However, there were some aspects of the camera which needed to be improved. To introduce camera stabilization to the car, there must be a hidden game object connected to the car to act as the filmed object. When the camera is locked onto the hidden game object instead, the car is able to flip and turn without the camera moving with it.

```
public GameObject TheCar;
	public float carX;
	public float carY;
	public float carZ;

	//Create these variables equal to a number - this is for the camera to lock on
to
	void Update () {
		carX = TheCar.transform.rotation.eulerAngles.x;
		carY = TheCar.transform.rotation.eulerAngles.y;
		carZ = TheCar.transform.rotation.eulerAngles.z;
		//eulerAngles is similar to using a gameobjects rotation variables


		transform.eulerAngles = new Vector3 (carX - carX, carY, carZ - carZ);
		//This is to rotate the object away from the cars rotation - this is by
subtracting the X and Y variables

	}
}
```

Figure 9 - Code that stabilizes the cars camera while driving

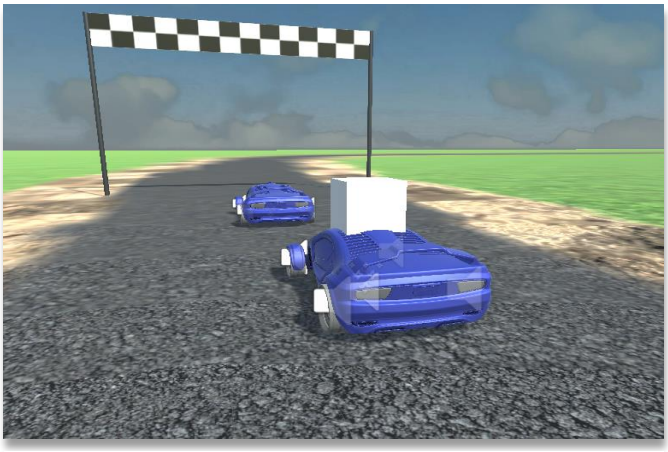


Figure 10 - Screenshot showing the cube that the camera is focused on

4.4. A.I

Now the car was working properly and there was a map introduced, all that was left to do is to introduce the enemy cars, UI, and the lap function.

When including waypoint cars to the map, there is a singular way point assigned to the vehicle that it will travel to when the game is played. To get the car to travel around the track, more waypoints are required. By placing empty objects around the map and connected them to the waypoint script in order will make them continuously travel in that motion. The environment on the map made the cars find it difficult to keep to its initial trajectory around the lap. To overcome this, the cars settings needed to be adjusted so the cars would react correctly for the scene around them.

Figure 11 - Screenshot showing the car A.I's path. The line represents the connection of waypoints (which are invisible game objects)

To create the lap, there needs to be two triggers to let the game know when the car has made it half way round the map, and when it has crossed the finish line.

```
public class HalfPointTrigger : MonoBehaviour {

	public GameObject LapCompleteTrig;
	public GameObject HalfLapTrig;

	void OnTriggerEnter  () {
		LapCompleteTrig.SetActive (true);
		HalfLapTrig.SetActive (false);
		//This code will de/activate invisible game objects in the map that act as check points for
the racer
	}
}
```

Figure 12 - Code for activating certain triggers on the map to compete lap

```
	void Update (){
		if (LapsDone == 2) {
			RaceFinish.SetActive (true); //if the car goes past the finish line twice, the
ending music and spinning camera will play
		}
	}
```

Figure 13 - Code for final lap of the race

4.5. Timer

```
//Estsablishing what Time.deltaTime is + the counts
	void Update () {
		MilCount += Time.deltaTime * 10;//x10 because Time.deltaTime records in game seconds. This
will make the seconds into milli seconds
		RawTime += Time.deltaTime;
		MilliDisplay = MilCount.ToString ("F0");//This converts MilCount to a string to display
correctly
		MilliBox.GetComponent<Text> ().text = "" + MilliDisplay;//This put this information in the
timer box in the game

		if (MilCount >= 10) {
			MilCount = 0;
			SecondCount += 1;
			//if the millisconds gets to ten, it will then revert it back to zero
		}

		if (SecondCount <= 9) {
			SecondBox.GetComponent<Text> ().text = "0" + SecondCount + ".";
		} else {
			SecondBox.GetComponent<Text> ().text = "" + SecondCount + ".";
		}
		//if SecondCount number is less than 9, this code will make sure that there is a zero infront

		if (SecondCount >= 60) {
			SecondCount = 0;
			MinuteCount += 1;
		}
		//if SecondCount goes over 60, this code will revert back to zero and add a minute onto the
counter

		if (MinuteCount <= 9) {
			MinuteBox.GetComponent<Text> ().text = "0" + MinuteCount + ":";
		} else {
			MinuteBox.GetComponent<Text> ().text = "" + MinuteCount + ":";
		}

	}
}
```

Figure 14 - Code for Timer. This establishes how the milliseconds turn into seconds, then minutes

Figure 15 - Screenshot of Dom's Racer in action

5.0. Results

5.1. Questionnaire

In total the questionnaire received all of the 10 responses. Of these respondents, all of them where gamers and owned a console/gaming PC (n=10, 100%). The largest proportion of the respondents were ages 18-24 (n=8, 80%), and 25-34 years old (n=2, 20%). In addition, no females were involved in this study making males to total amount of respondents (n=10, 100%). The largest percentage of the respondents classes themselves as being at an advanced level of gaming (n=5, 50%). The most preferred gaming system was the PC at a (n=9, 90%).

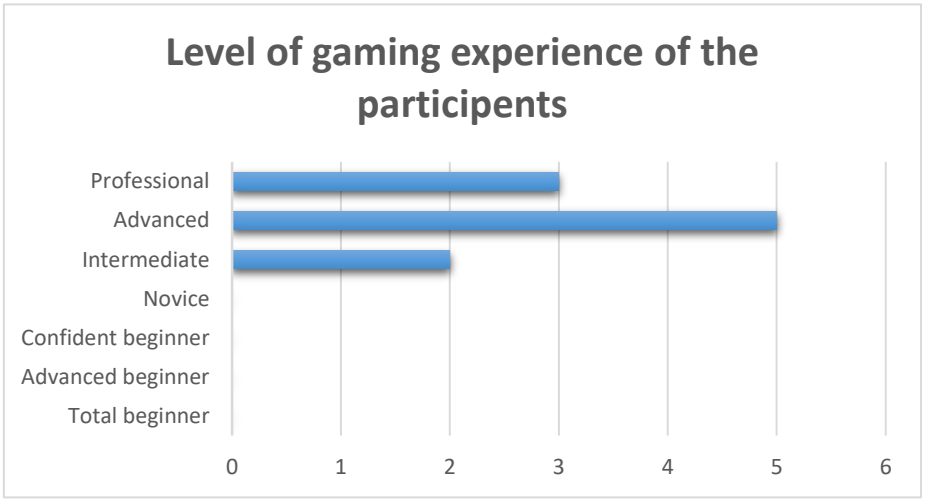


Figure 16 - Clustered bar graph showing the level of gaming experience of the participants

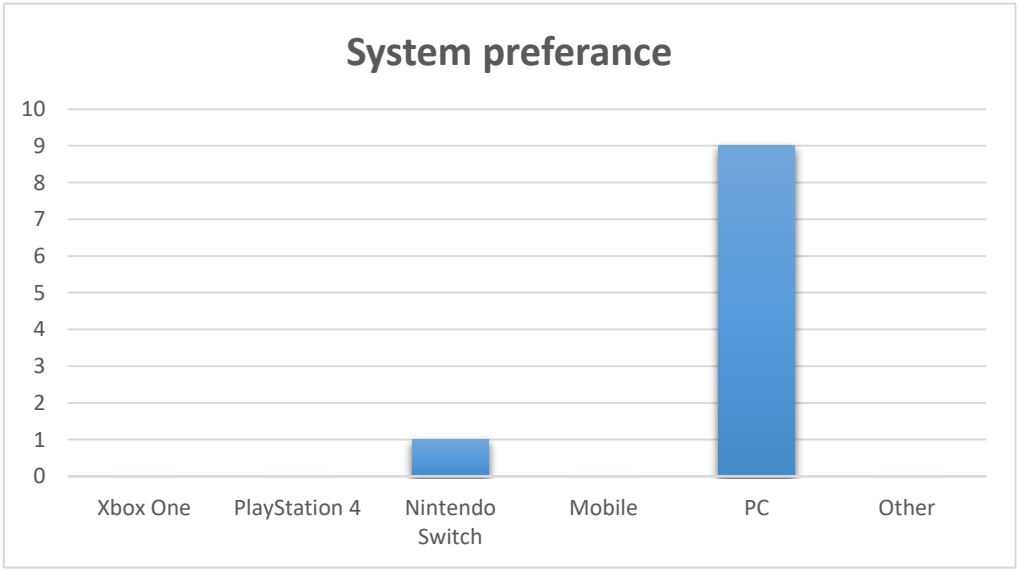


Figure 17 - Clustered column graph showing the participant's system preference

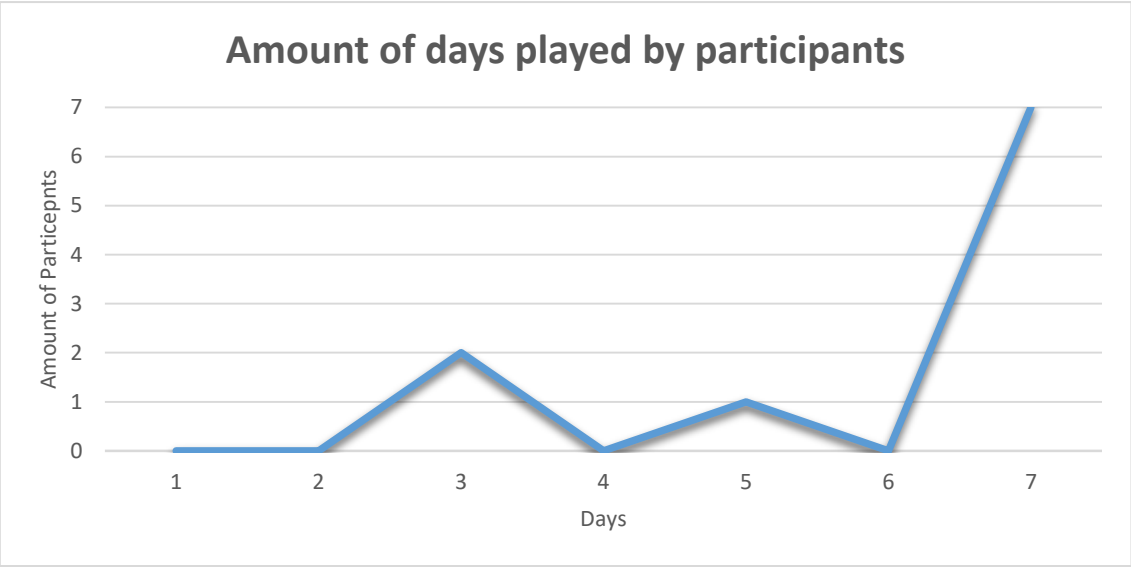


Figure 18 - Line graph showing the participant's amount of days played

5.2. Heart beat readings

The mean data was collected for all ten of the participant's heart rate during their experience. This data is compared to the British Heart Foundation to find significant changes in the participant's heart rhythm. The BHF suggests that a normal heart rate is between 60 and 100 beats. To find the maximum heart beat rhythm, the participant should subtract their age from 220bmp.

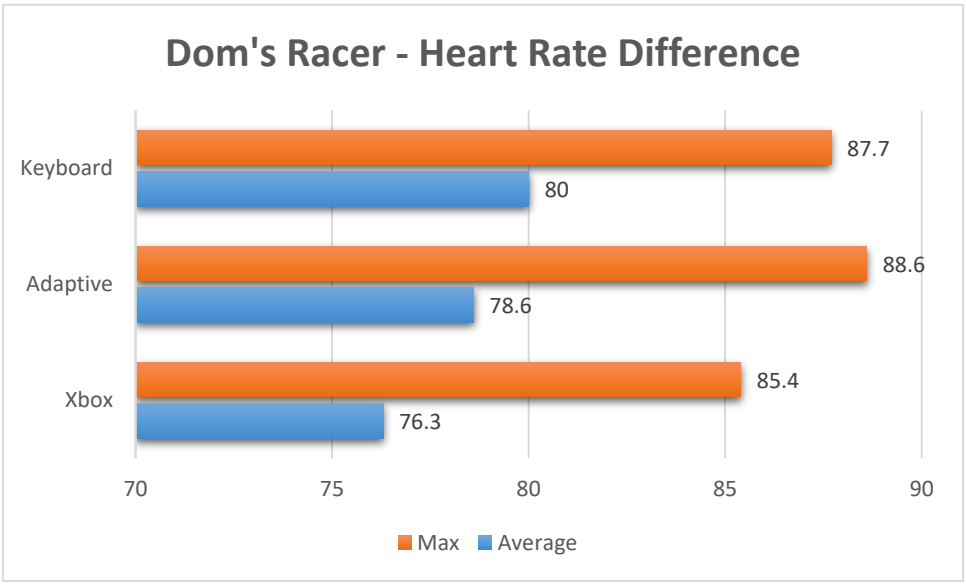


Figure 19 - Clustered bar graph showing the heart rate of participants during Dom's Racer

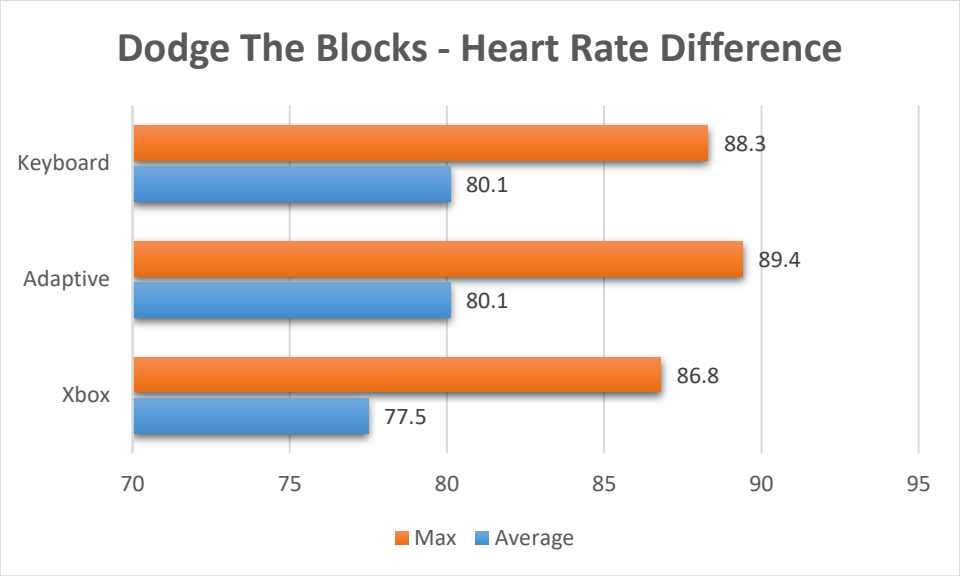


Figure 20 - Clustered bar graph showing the heart rate of participants during Dodge the Blocks

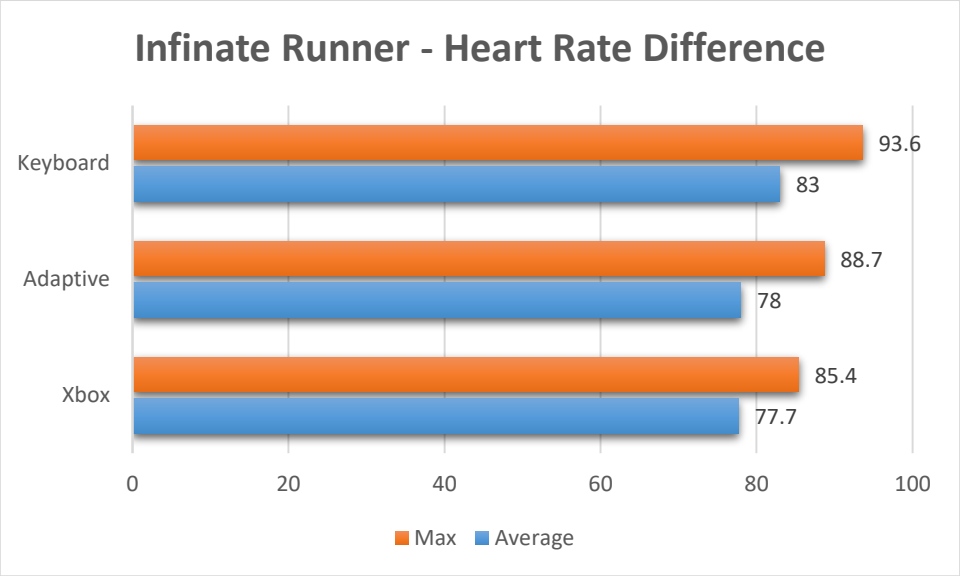


Figure 21 - Clustered bar graph showing the heart rate of participants during Infinite Runner

In Dom's Racer there were no significant differences found between the three controllers. The highest mean average heart rhythm of the participants while using the keyboard was (p=±80bpm), which is the highest of all three controllers. Students from the test revealed that their gaming experience during Dom's Racer was intense and thrilling, this proves that their adrenaline was higher than other games shown. The Adaptive controller shows the highest mean max bpm (p=±88.6bpm), participants mentioned that the controller was new to them and felt more exciting to press down on the large buttons to accelerate the car.

In Infinite Runner there were no significant differences found between the three controllers. The highest mean average heart rhythm of the participants while using the keyboard was (p=±83bpm), which is the highest of all three controllers. Students from the test reviled that their gaming experience during the Infinite Runner was fast and needed quick time reactions, this proves that their adrenaline was higher than other games shown. The keyboard also shows the highest mean max bpm (p=±93.6.6bpm), which is the highest mean recording in the results. Participants mentioned that the keyboard helped them react faster to the incoming obstacles, allowing them to progress further. The more that the participant scored, the more that their heart rate would increase.

In Dodge the Blocks there were no significant differences found between the three controllers. The highest mean average heart rhythm of the participants while using the keyboard and Adaptive Controller was (p=±80.1bpm). Students from the test revealed that their gaming experience with these controllers was difficult as the block would carry on sliding as the player stopped moving. This design flaw increased the player's aggravation as they would collide with the incoming blocks without them meaning to. The Adaptive controller shows the highest mean max bpm (p=±89.4bpm), participants mentioned that the two big buttons on the controller were satisfying to press, and it was easy to know which button to use. Nevertheless, the increase in heart rate could also be from the aggravation from the amount of deaths from the design flaw.

5.3. Games scores

The Likert scale scores were collected for each subject for Dom's Racer, Infinite Runner, and Dodge the Blocks. This is displayed on Figure 22-24. It is clear that the Infinite runner was the most enjoyable game as it has a clear advantage over the other titles.

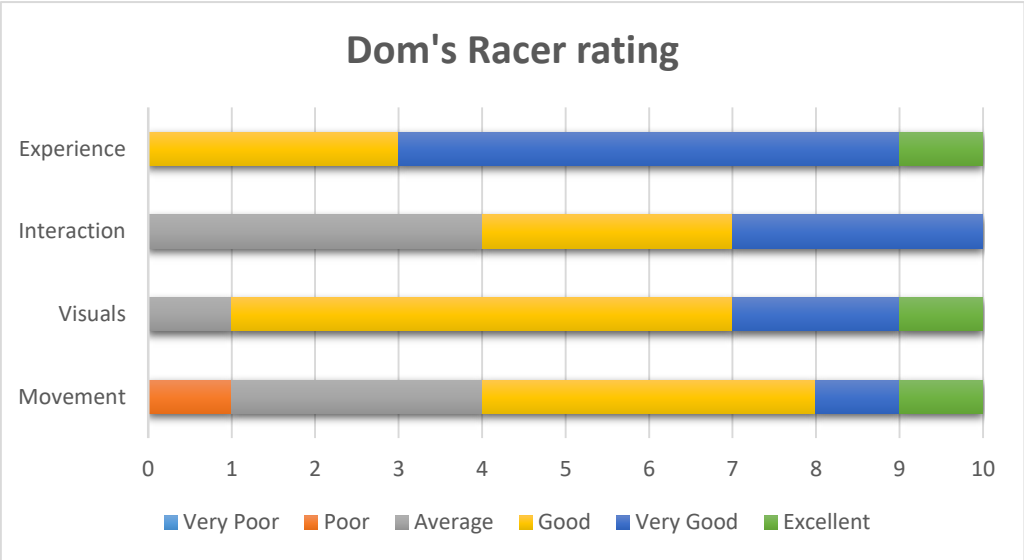


Figure 22 - Results for Dom's Racer rating

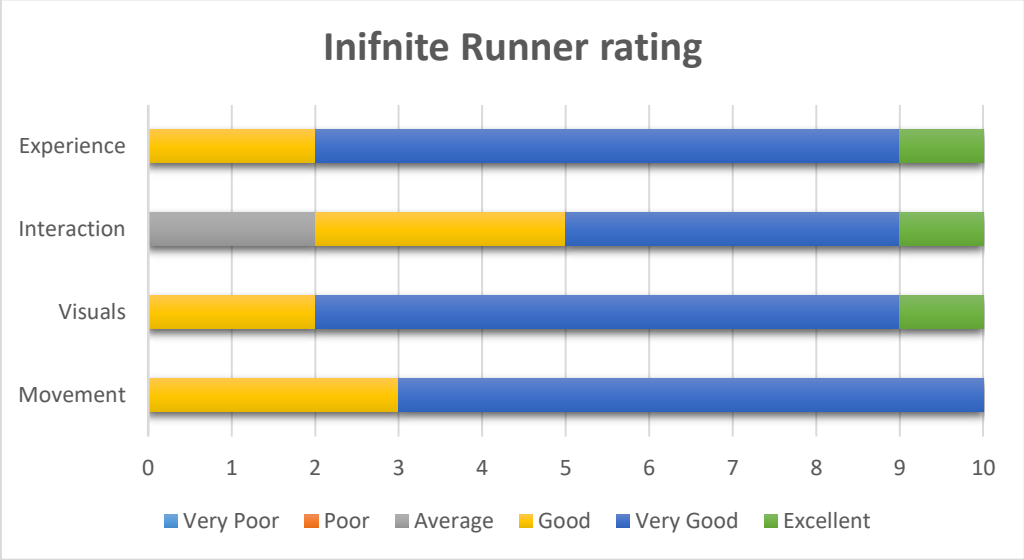


Figure 24 - Results for Infinite Runner rating

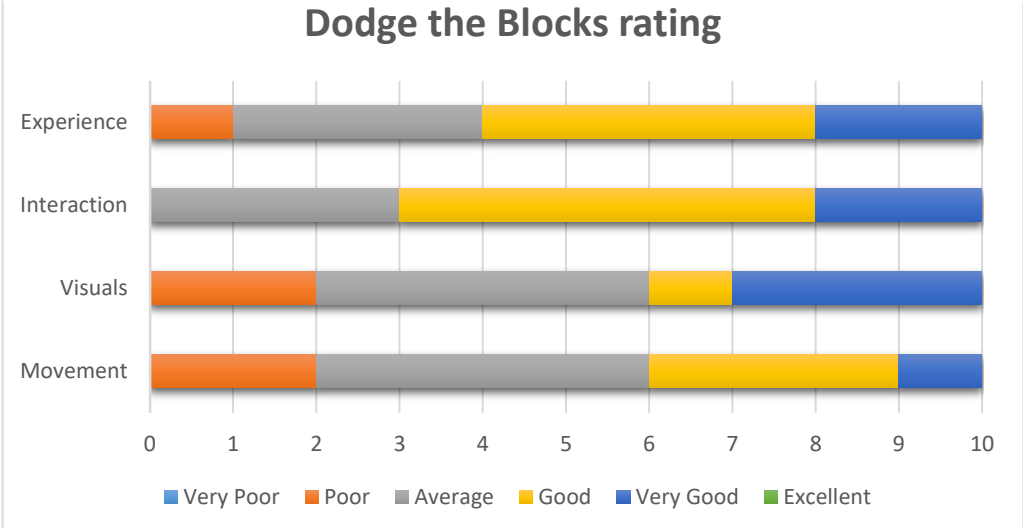


Figure 23 - Results for Dodge the Blocks rating

5.4. Controller Scores

The Likert scale scores were collected for each subject for controller. This is displayed Figure 25-27. When the data is shown on these table it shows a variety of diverse scores for the controllers. The participants mentioned that the games were suited towards a certain controller, some of which didn't suit a particular game at all. For example, the majority of the participants marked the Xbox One (n=4, 40%)/Adaptive Controller (n=6, 60%) a 3/7 while playing Dodge the Blocks.

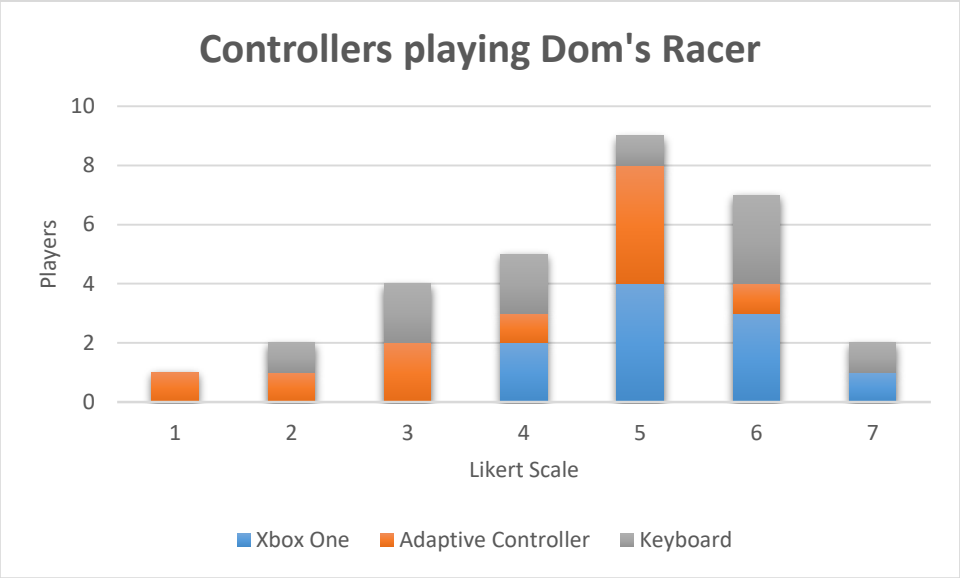


Figure 25 - Results for Likert Scale questions for Dom's Racer

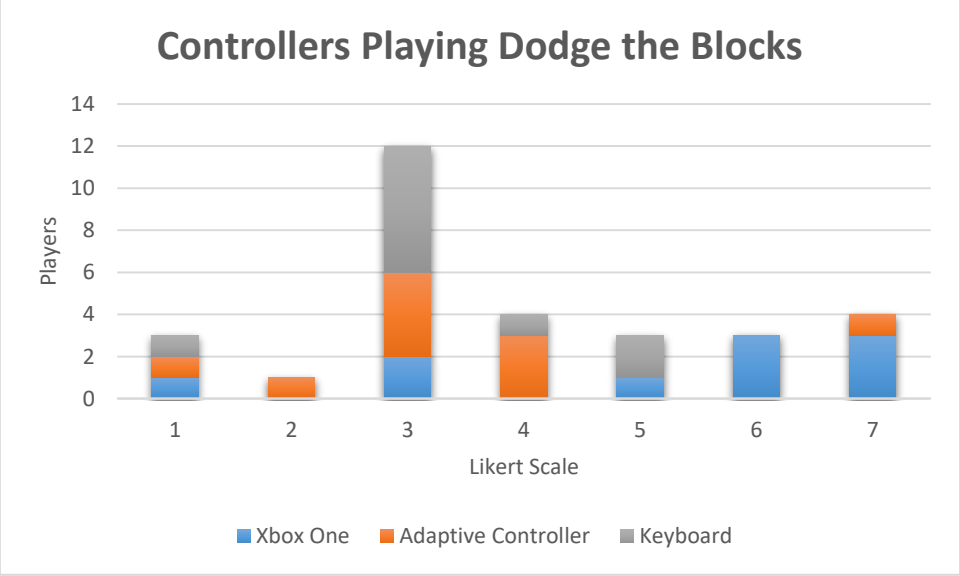


Figure 26 - Results for Likert Scale questions for Dodge the Blocks

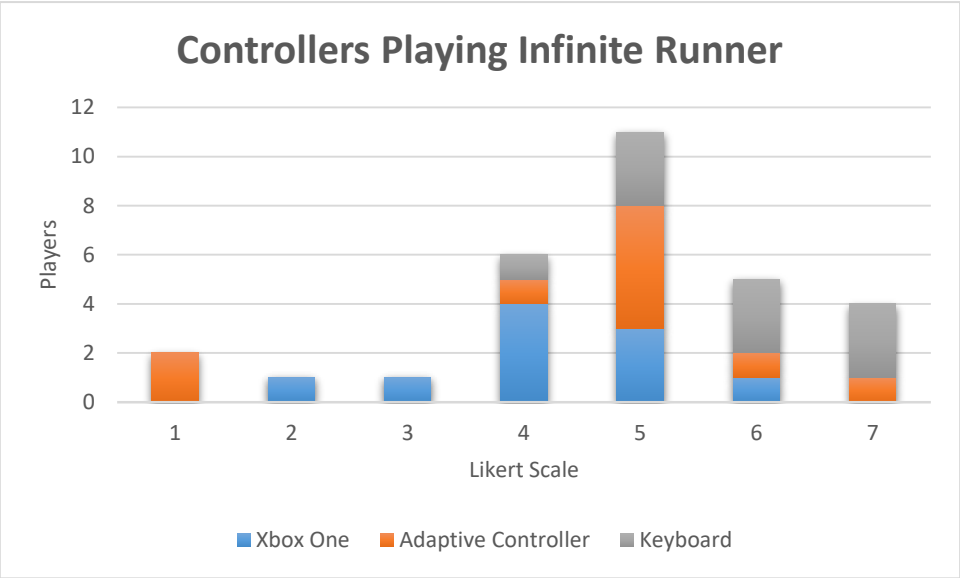


Figure 27 - Results for Likert Scale questions for Infinite Runner

6.0. Discussion

6.1. Overview

The gaming controllers are a fundamental factor when it comes down to player enjoyment and performance of a video game. This is an area of research which has been previously overlooked. However, it is now a growing subject of investigations in game research labs and the industry, with a focus on human computer interaction (HCI) (Nacke, L *et al.* 2010). There are a number of extrinsic and intrinsic factors which can affect the gamer's interaction. In particular for the player, different input controls may affect player experience, comfort, and reaction speed Gerling, K *et al.* (2011).

The aim of the current study was to establish whether controller design had a significant effect on the enjoyment of the gamer. The experimental hypothesis was that using a different kind of controller will affect the performance and heartbeat of the player, this is because the gamer is not familiar with the design and pattern of the controller. Statistical analysis allowed the acceptance of the hypothesis that controller designs will significantly influence the increase of heart rate of the gamer with controllers that they haven't used/preferred to their preference. There was a significant difference of the max heart beat between the Adaptive Controller and the keyboard. On 'Dom's Racer', the participant's mean max heart rate for the Adaptive controller shows a 1.1± second increase to the keyboard. This can also be said for 'Dodge the Blocks' for there is a 0.9± second mean difference. However, the 'Infinite Runner' showed that the majority of player's heat beat increase while playing on keyboard, showing a 4.9± second increase compared to playing on the adaptive controller. The justification of this study is that although there has been research into the player's preference of controller, there has been little to no research into the effect

of innovative controller designs. This is important as the number of video gamers is increasing and they are influenced by the media to choose a controller which is suited to someone else.

The findings from the current study indicate that different controller designs significantly influence the player's reaction time. For example, the Xbox One controller significantly increased the players run time during the 'Dodge the Blocks game'. The participants mentioned in the questionnaire that this controller provided more control over the movement, and the sticks made the gameplay more enjoyable. This was proved when analysing the total enjoyment of the controllers on the questionnaire, the controller scored a 30% on 6 and 30% on 7 using the 7 point Likert scale with 'Dodge the Blocks'. The results from this study also suggest that varying controller designs can affect the comfort and enjoyment of the player. Overall these findings support the claims of certain innovative controller designs such as the Adaptive and Xbox One Controllers.

6.2. Comparison of Controller Design

The current study was one of the first studies to investigate the effect of three different controllers on the gamer. However, based on comparable areas of the manufacturers and areas of research, it was expected that the innovative controller designs would significantly influence enjoyment over specific game genres. The majority of the participants who took part in this experiment mentioned that the controller felt more comfortable on different games. This shows that depending on the game, the controller design needs to be innovative for that type of genre. This is why a lot of the participants (n=6, 60%) rated the keyboard a 3/7 for the 'Dodge the Blocks', as it wasn't designed for that type of game.

In addition, it was expected that the keyboard was going to show better results as the majority of the players used PC to play their games. According to Gerling, K *et al.* (2011) their study found that the participants who did not use their habitual input device felt more challenged. However, in this test it showed that the participants were comfortable using the controllers for different games.

The important aspects of controller design to consider are the size of the buttons, size of the controller itself, button layout, rumble effect, and material.

6.3. Questionnaire

Many innovative controller designs, such as the Xbox Elite Controller, have been marketed to suggest that they can improve the performance of the gamer. Results from the participant's questionnaires found that the main factors that influenced the respondent's choice of the controllers was the type of game, comfort and price. According to the results of this study the keyboard was the most comfortable out of the three controllers tested. The results of this questionnaire could be explained by the preference of

gaming device and skill level of the participants, in comparison to the general population. On the other hand, the average age of the respondents was 18-24 (n=8, 80%), this indicates that they are likely to be students with a lower income. This is an important factor because it could be beneficial for future study, to include questions that ask the player whether they chose their controller for comfort or price.

A limitation of the questionnaire is that it is unclear what aspect of cost the respondents thought was important. However, sometimes the higher cost of the controller is a sign of higher quality. Bearing this in mind, the Adaptive controller costs twice the amount of both of the other two controllers, yet it feels and looks cheap in the eyes of the player. The only reason that the Adaptive controller is at a higher price range is because it is able to be combined with multiple controllers and devices to create a custom set up for the gamer.

6.4. Limitations and Recommendations

There is limited research when it comes to the effect of the controller design on the gamer's enjoyment. Consequently, it is not possible to compare the results from this test to previous ones. However, the importance of controller design is a growing area of research from the amount of new consoles coming out each year. For example, Google have recently announced named 'Google Stadia' which is reportedly going to be the Netflix to video games. It allows gamers to play their games on any screen, regardless of what physical hardware they have. Their controller is made as sleek and comfortable as possible, but what makes this Google Stadia special is that the player can use any controller that they already have. This lets players pick and choose their most desired controller for the system, allowing the gamer to experience more than just a single piece of hardware that the gamer will have to get used to. Overall, this is the reason why the keyboard showed more practical results. It was because they were all PC gamers who were used to a keyboard and mouse.

However, this study analysed the player's facial expressions, heartbeat, and gaming performance during the tests. Future research should incorporate the addition of more questioned asked about the controllers, and would have included a very challenging game that walks the user through each control step by step. Manual Samuel is a perfect challenge for a future study.

As previously mentioned, the test needed a 'triple A' title to show a bigger difference in the players results. The games that were set in front of them were all made from Unity Project, and had many problems even though they were the final builds of the games. For future study, there needs be a wider variety of testers that included both 'habitual' gamers and non-gamers.

6.4.1. Potential improvements

Dom's Racer

Lap counter difficulties – To record a lap, there was a halfway trigger that would open the finish line trigger that would complete the lap. This worked, but the other cars in the map could activate this trigger also. During the tests, if the player drove through the half way trigger the other cars could drive through the finish and complete the circuit. This was an issue for the players as they would be half way through the race and the game would finish.

A.I cars weren't challenging enough – As it was difficult to calculate a balance between speed and accuracy of the enemy cars, it was hard to make the cars have a quick acceleration. The players during the test said that it was easy to pass them, they were more of an obstacle than a challenging opponent.

Name of game - it was a mistake to name the game that you built 'Dom's Racer' as this will have influenced the player's perception of enjoyment – *need to expand, for example, following feedback from the test subjects they advised that knowing the game who the game was made by affected their perception before even playing the game.*

Dodge the Blocks

Score – The players wanted to see a visual goal for the player to pass and succeed with.

"Slidey controls" – For the Adaptive controller and the keyboard, when the player moved the block it would finish the movement with a quick slide effect. This would carry the player over the side of the falling block and they would fail. This was not planned, but it was good for the results.

Endless Runner

Score – The score would keep rising even though the character was dead.

It is important to mention the quality of the video footage that recorded the player as well as the game. The data for this study was recorded with a 1080 web cam which took up a lot of space after the test was complete. This made it very difficult to transfer the files and analyse the footage. Instead, there could have been a cheaper and less high quality camera which could have done the same job but with less memory space on the memory stick. The gamer's levels of experience was mostly at an experienced and professional level. This meant that they had all played the types of games that were shown to them in the test. The majority of them showed the same facial expression for the games, which was predicted from the start. For future tests there should be a larger variety of genres.

For each of the tests, the subjects were allowed to take breaks if they wanted to. Most of the testers stated that they didn't want to take a break and carried on with the experiment. One subject, took a 2 minute break in the middle of the testing. As the gamers were constantly playing the games, their heart rhythm

didn't have a chance to go back to a normal state. This could have affected the results of the test. For a future study, breaks will be made between each game to relax their heart beat for accurate results.
The sample size was very small as there was only 10 participants. Also, the diversity of the testers were not varied. From this acknowledgment, the results could have been different if there was more variety. Further studies should try to reach more demographics, particularly older people, and also a variety of genders.

7.0. Conclusion

The current study has investigated the impact of gaming controllers on the experience of the player. This can be an important area of study for future consoles and services which require and new and improved innovative controller. The results of the current study found that varying controller designs caused differences in the heart beat, reaction time, and facial expression of the video gamer. The findings of this study indicate that the players preferred using a certain type of controller for each genre. Consequently this suggests that the controllers were good in some places, but significantly worse in others. Not one controller achieved a good rating for all three of the games, yet when they had the right set up there was a positive spike in the results found to indicate that the controller does matter to enhance their experience. Future research should focus on players who are not so experienced and female participants. More effort should be made to create a controller which everyone can enjoy across all platforms, which ultimately enhances their experience.

Word Count - 6359

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Appendices

Appendix I Questionnaire 1

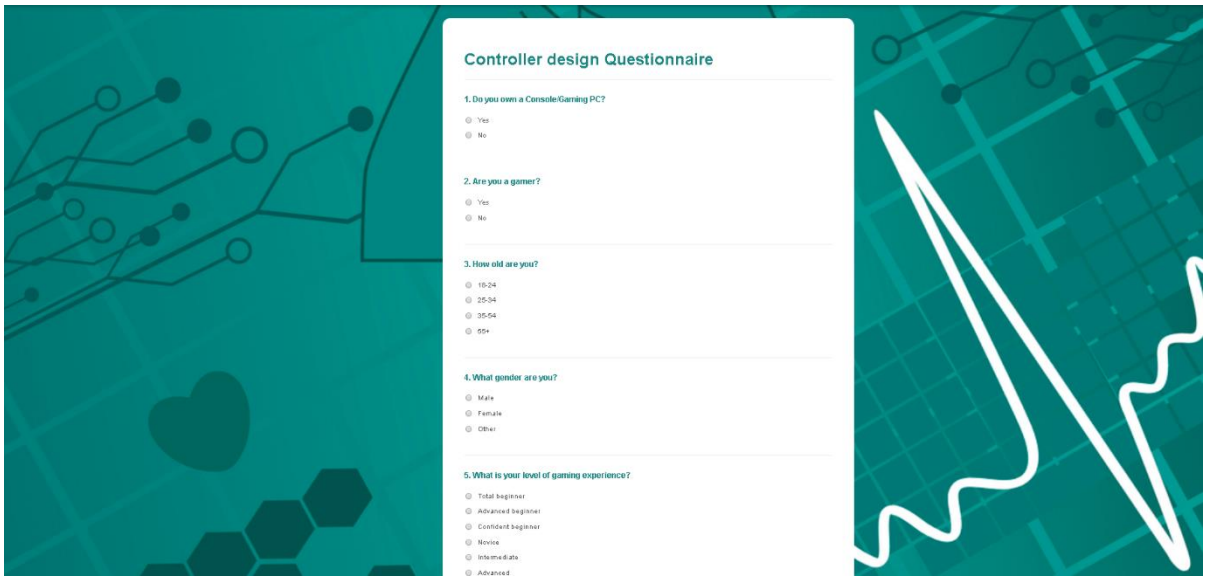


Figure 28 - Questionnaire 1 on Smart Survey

Q1. Do you own a Console/Gaming PC?

Yes/No

Q2. Are you a gamer?

Yes/Sometimes/No

Q3. How old are you?

18-21, 22-25, 26-29, 30-33, 34-37, 38-41, 42-45, 46-49, 50-51

Q4. What gender are you?

Male/Female/Prefer not to say

Q5. What is your level of gaming experience?

Total beginner, advanced beginner, Confident beginner, Novice, Intermediate, Advanced, Professional

Q6. How many days a week do you play video games?

1,2,3,4,5,6,7

Q7. What system do you play on?

Xbox one/Xbox 360/PlayStation 3/PlayStation 4/ Nintendo Switch/ Mobile/PC

Q8. Are you happy with the systems controller?

Yes/No

Q9. Which would be your preferred choice of controller?

Xbox one/Xbox 360/PlayStation 3/PlayStation 4/ Nintendo Switch/ Mobile/PC

Appendix II - Questionnaire 2

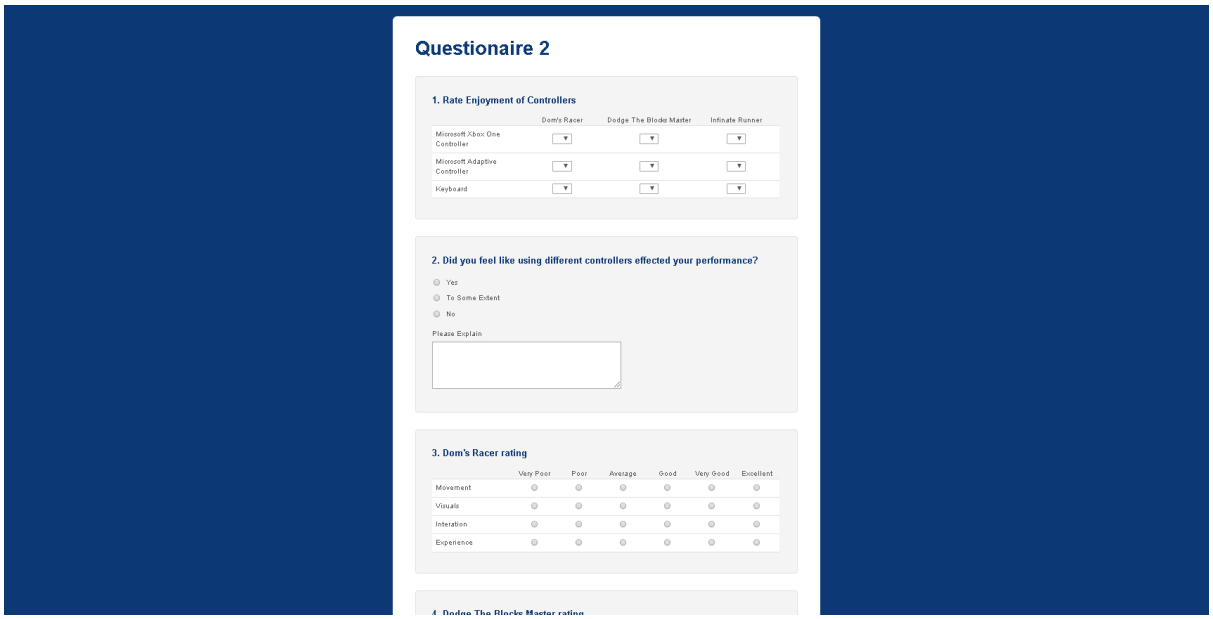


Figure 29 - Questionnaire 2 on Smart Survey

Q1. Rate enjoyment of first controller for each game

Game 1 –

1, 2, 3, 4, 5, 6, 7

Game 2 -

1, 2, 3, 4, 5, 6, 7

Game 3 -

1, 2, 3, 4, 5, 6, 7

Q2. Did you feel like using different controllers effected your performance?

Yes/To some extent/No

Please Explain

Q3. Dom's Racer Rating

Very poor/Poor/Average/Good/Very good/Excellent

Q4. Dodge the Blocks Rating

Very poor/Poor/Average/Good/Very good/Excellent

Q5. Infinite Runner Rating

Very poor/Poor/Average/Good/Very good/Excellent

Q6. Would you consider changing your controller preference after this experience?

Yes/No

Appendix III - Participation sheet and Informed Consent Form

P A R T I C I P A T I O N S H E E T

Study Title: The Impact of Controller Design on the Player Experience

Main Investigator: Dominic Talbot
Academic Supervisor (for Student research): David Gee

You are invited to take part in a study on the impact of controller design on the player experience. This Participant Information Sheet will help you decide if you would like to take part. It sets out why we are doing the study, what your participation would involve, what the benefits and risks to you might be, and what would happen after the study ends. We will go through this information with you and answer any questions you may have. You do not have to decide today whether or not you will participate in this study. If you agree to take part in this study, you will be asked to sign the Informed Consent Form. You will be given a copy of both the Participant Information Sheet and the Informed Consent Form to keep. Please make sure you have read and understood all the pages of the Participant Information Form.

What is the purpose of this study?
The purpose of this study is to (1) collect information on which are **the most popular controller designs** according to the general gaming population via a questionnaire, (2) to **measure the reaction time** and completion of the games while experimenting with different designs of controller, (3) to analyse the gameplay data and the players **overall experience** with the controller.

What will my participation in the study involve?
Your participation will involve the **testing of controllers on three different games** created on Unity Project. A **webcam** will be set up facing the subject, and a **heartbeat monitor** will be gathering information on the subject's heart rhythm. The subject will play through the games with all three controllers and the findings will be gathered for further research.

What are the possible benefits and risks of this study?

We cannot promise the study will help you but the information we get from the study will help to increase the understanding of The Impact of Controller Design on the Player Experience.

What happens if I change my mind?

If you withdraw from the study all the information and data collected from you, to date, will be destroyed and you name removed from all the study files.

Who do I contact for more information if I have concerns?

The Academic Supervisor (for Student research): David Gee.

How will my data be stored and for how long?

All information you provide will be strictly confidential and only used for the purposes of this data collection only. After submission to this project, all information and data collected from you will be destroyed.

What if I don't want to answer a question being asked of me?

The patient is in their right no not answer any question which they are uncomfortable to answer. You are free to withdraw at any time.

Informed Consent Form

The University of Suffolk expects all research to be carried out in accordance with the following principles:

- The emotional well-being, physical well-being, rights, dignity and personal values of research participants should be secured.
- Research participants and contributors should be fully informed regarding the purpose, methods and end use of the research. They should be clear on what their participation involves and any risks that are associated with the process. These risks should be clearly articulated and if possible quantified.
- Research participants must participate in a voluntary way, free from coercion. Participants have the right to withdraw at any time.

This research has been approved by the University of Suffolk Ethics Panel. Should you have any concerns about the Ethics of this research, please feel free to contact the Chair of the Ethics Panel,

Professor Emma Bond e.bond@uos.ac.uk (01473 338564) or the Research Development Manager, Andreea Tocca a.tocca@uos.ac.uk (01473 338656).

Study Title: Impact of controller design on the player experience

Main Investigator: Dominic Talbot

Academic Supervisor (for Student Research): David Gee

Please initial the boxes below.

I confirm that I have read and understand the information sheet/letter (delete as applicable) dated *[insert date]* explaining the above research project and I have had the opportunity to ask questions about the project.	☐
I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason and without there being any negative consequences.	☐
I understand that my responses will be anonymised and any personal or identifying information removed from published materials	☐
I give permission for members of the research team to have access to my anonymised responses.	☐

I understand that my name will not be linked with the research materials, and I will not be identified or identifiable in the report or reports that result from the research.	
I understand that the data I provide will be used solely for the purposes of the research study outlined and will not be used for any other purpose. I also understand how long my data will be stored for.	☐
I agree to take part in the above research project.	☐

_____	_____	_____
Name of Participant (*or legal representative*)	Date	Signature
_____	_____	_____
Name of person taking consent* (**if different from lead researcher*)	Date	Signature

To be signed and dated in presence of the participant

_____	_____	_____

Researcher*	Date	Signature

To be signed and dated in presence of the participant

**Delete as appropriate*

Copies:

Once this form has been signed by all parties the participant should receive a copy of the signed and dated participant consent form, the letter/information sheet and any other written information provided to the participants.

A scanned copy of the signed and dated consent form should be placed in the project's main record by the student/researcher/PI. This must be kept in a secure location.

Appendix IV - Equipment

Computer

Mouse

Keyboard

Logitech C920 HD Pro

Polar Heart Rate Monitor FS3C

Xbox Adaptive Controller

Xbox One Controller

Smart Phone

Appendix V - Example of Heart Rate Analysis

Figure 31 - Picture of time playing the game

Figure 30 - Picture of average heart beat

Figure 32 - Picture of maximum heart beat

Appendix VI - Participants Heart Beat Results

Xbox Controller	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Participant 6	Participant 7	Participant 8	Participant 9	Participant 10	Mean
Time	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9	Test 10	
Doms Racer	3:16	2:51	2:50	3:03	4:05	2:56	3:03	3:02	3:42	3:05	3:11
Infinate Runner	1:57	1:43	1:17	2:04	2:19	2:47	1:59	1:59	1:23	1:56	1:56
Dodge The Blocks	2:21	1:50	2:26	2:11	1:46	2:19	1:40	1:36	1:24	1:14	1:52
Average	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9	Test 10	
Doms Racer	70	70	79	61	70	95	66	85	73	94	76.3
Infinate Runner	72	72	76	71	74	87	65	89	75	96	77.7
Dodge The Blocks	71	79	81	63	72	83	65	89	76	96	77.5
Max	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9	Test 10	
Doms Racer	81	76	88	67	77	117	70	92	80	106	85.4
Infinate Runner	79	83	81	83	77	97	72	95	78	109	85.4
Dodge The Blocks	83	97	96	66	81	91	68	96	88	102	86.8

Figure 33 - Heart beat ratings for the Xbox One Controller

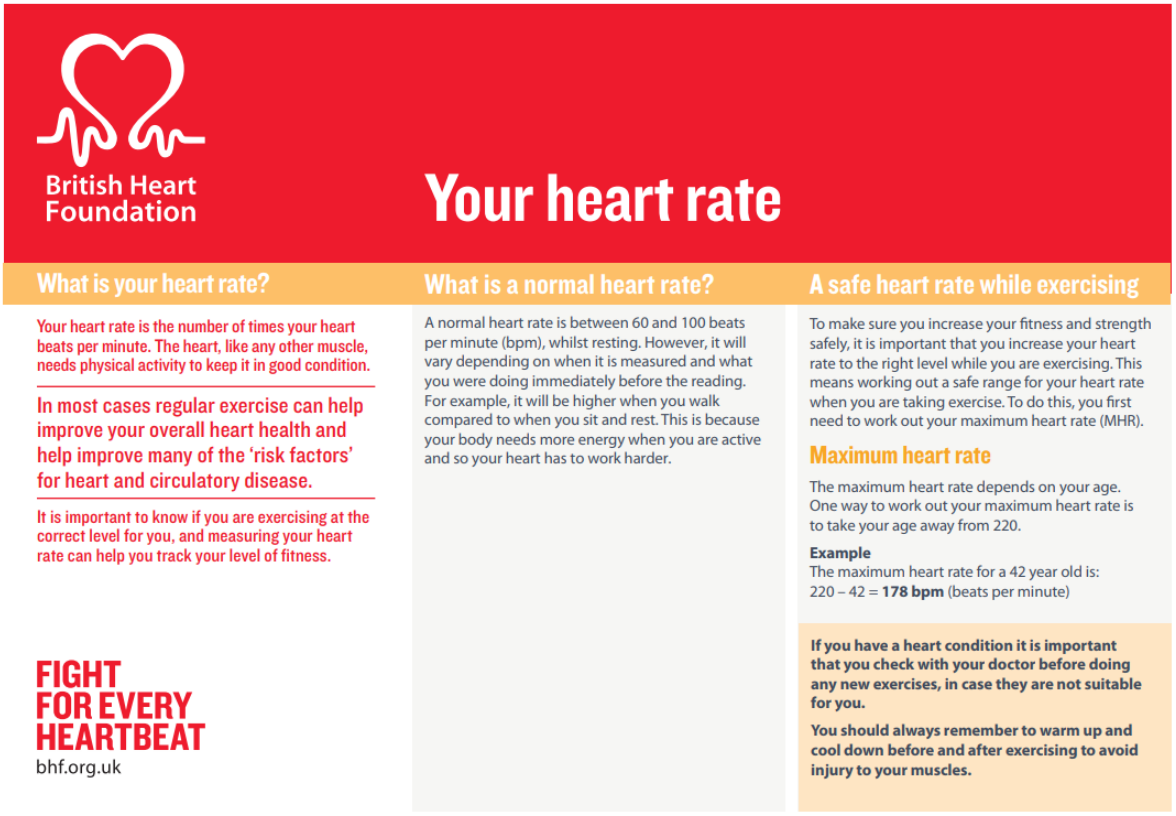
Adaptive Controller	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Participant 6	Participant 7	Participant 8	Participant 9	Participant 10	
Time	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9	Test 10	
Doms Racer	3:36	3:25	3:24	3:42	2:07	2:37	2:44	2:52	2:37	2:55	2:59
Infinate Runner	1:58	2:34	1:45	2:37	2:33	3:43	1:15	1:36	1:24	2:06	2:09
Dodge The Blocks	2:03	1:19	2:33	1:45	1:34	2:39	1:45	1:20	1:21	1:33	1:47
Average	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9	Test 10	
Doms Racer	71	76	78	63	74	87	68	91	80	98	78.6
Infinate Runner	70	78	75	62	75	85	69	92	78	96	78
Dodge The Blocks	69	87	83	66	72	104	66	91	72	91	80.1
Max	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9	Test 10	
Doms Racer	78	89	93	68	84	96	73	101	88	116	88.6
Infinate Runner	82	91	80	70	86	100	71	105	87	115	88.7
Dodge The Blocks	91	96	93	69	78	111	72	104	79	101	89.4

Figure 34 - Heart beat ratings for the Adaptive Controller

Keyboard	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Participant 6	Participant 7	Participant 8	Participant 9	Participant 10	
Time	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9	Test 10	
Doms Racer	3:32	3:20	3:07	2:47	2:04	3:17	2:15	2:55	3:00	1:38	2:47
Infinate Runner	2:19	1:51	1:34	1:56	2:11	3:56	1:15	2:13	1:18	1:07	1:58
Dodge The Blocks	2:37	2:49	1:40	2:29	1:44	2:36	2:10	1:21	1:00	1:38	2:00
Average	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9	Test 10	
Doms Racer	70	73	80	66	78	87	67	87	75	117	80
Infinate Runner	72	73	84	71	79	101	69	100	79	108	83.6
Dodge The Blocks	74	75	78	69	75	91	69	83	70	117	80.1
Max	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9	Test 10	
Doms Racer	75	80	93	72	85	99	73	96	80	124	87.7
Infinate Runner	85	82	93	87	92	106	74	114	84	119	93.6
Dodge The Blocks	77	88	93	85	80	102	75	86	70	127	88.3

Figure 35 - Heart beat ratings for the Keyboard

Appendix VI - Example of normal heat rate rhythm



British Heart Foundation

Your heart rate

What is your heart rate?

Your heart rate is the number of times your heart beats per minute. The heart, like any other muscle, needs physical activity to keep it in good condition.

In most cases regular exercise can help improve your overall heart health and help improve many of the 'risk factors' for heart and circulatory disease.

It is important to know if you are exercising at the correct level for you, and measuring your heart rate can help you track your level of fitness.

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What is a normal heart rate?

A normal heart rate is between 60 and 100 beats per minute (bpm), whilst resting. However, it will vary depending on when it is measured and what you were doing immediately before the reading. For example, it will be higher when you walk compared to when you sit and rest. This is because your body needs more energy when you are active and so your heart has to work harder.

A safe heart rate while exercising

To make sure you increase your fitness and strength safely, it is important that you increase your heart rate to the right level while you are exercising. This means working out a safe range for your heart rate when you are taking exercise. To do this, you first need to work out your maximum heart rate (MHR).

Maximum heart rate

The maximum heart rate depends on your age. One way to work out your maximum heart rate is to take your age away from 220.

Example
The maximum heart rate for a 42 year old is:
220 – 42 = **178 bpm** (beats per minute)

If you have a heart condition it is important that you check with your doctor before doing any new exercises, in case they are not suitable for you.

You should always remember to warm up and cool down before and after exercising to avoid injury to your muscles.

Figure 36 - British Heart Foundation information page