Measuring immersion and fun in a game controlled by gaze and head movements

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Abstract

Tracking the human body with cameras such as the Microsoft Kinect has been a successful way to provide players with new input mechanisms in gaming. At present e.g. Tobii Technologies is attempting to offer users affordable eye tracking systems to popularize use of the devices in the game industry.

The main purpose of this work is to discover if playing a First-person shooter (FPS) game with an eye tracker is more fun or immersive than playing it with more traditional input mechanisms, in this case the mouse and keyboard and the Xbox360 gamepad.

A two session experiment with different input devices was conducted in this study. The first session was held during the period from January 25th to February 1st, 2016. The second session was held during the period from February 9th to February 11th, 2016.

Experiment participants played an FPS game with three input mechanisms: an eye tracker, a mouse and keyboard and an Xbox360 gamepad. When using the eye tracker to play the game, the participant controlled the character with gaze and head movements. The experiment included six participants; five of them were male and one female. All the participants were between 21 and 30 years old.

The results of the experiment indicated that using an eye tracker as an input device was more fun than using the other input devices. Nevertheless, there was no clear implication of the fact that the eye tracker would increase immersion compared to the other input devices.

Key words and terms: M.Sc. thesis, eye tracking, experiment, FPS.

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1. Introduction

Over the past decade, eye tracking has been used for example in usability evaluation [Atterer 2006], human behavior research [Senju & Csibra 2008], as an equipment for disabled persons [Kocejko 2009], and in psychological research [Wieser 2009]. Currently, it is used more and more in games. Eye tracking devices have become more available for consumers since the cost of the devices has lowered and they are easier to use without expertise on eye tracking systems [van Gog & Jarodzka 2013].

Eye tracking companies, such as Tobii Technology and SteelSeries, are trying to establish their place among the gamers [Eadacicco 2014 & Moore 2015]. Tobii is the current global leader in the development of eye tracker technology [Online Gaming Alliance 2016] and their products are accessible for a casual gamer. The company's most affordable eye tracker costs approximately 100 $ [Tobii 2016a]. Another eye tracker company, The Eye Tribe, has also introduced their affordable Eye Tribe Tracker Pro which costs approximately 200 $ [Biggs 2016]. Both Tobii's and The Eye Tribe's trackers are independent, separate devices and are meant to be placed in front of the computer screen.

In addition to separate eye trackers, there are integrated devices: MSI, a laptop manufacturer that focuses on computers for gaming, launched the first consumer notebook with an integrated eye tracker in January 2016 [Tobii Tech 2016]. The laptop uses a Tobii eye tracker and the gamers can e.g. zoom with eye gaze, pause the game when not looking at the screen, select objects by looking at them, and switch targets in a game by eye gaze [Carey 2016].

While the eye tracker industry is growing [Li *et al.* 2014], whether an eye tracker has an advantage over other input devices, is still to be determined. A few studies have already indicated that in some cases participants, who took part in experiments, preferred using an eye tracker as an input device over other input devices [Vickers *et al.* 2010; Jönsson 2005]. There could be various reasons for preferring some input device over others but one of them could be that using an eye tracker is simply fun.

On top of the possibility that playing with an eye tracker could be more fun, it could also be an easier way to play. Using a mouse and keyboard or a gamepad may not be an option, e.g. for disabled persons. Eye tracker could provide disabled individuals a potential way to play.

The main motivation for this study is to explore the possibilities with eye trackers in first-person shooter (FPS) gaming since there has not been a lot of research done on the subject. Especially, there are very few studies made that use only an eye tracker and no other input devices to play a game. The focus of the study is in fun and immersion. The first hypothesis of this study is: playing an FPS game with an eye tracker is more immersive than playing it with more traditional input devices, such as the standard mouse and keyboard or an Xbox360 gamepad. The second hypothesis of this study is: playing with an eye tracker is more fun than playing it with other input devices. When planning the pilot experiment, the third and the final hypothesis was formed. That is that the results between the two sessions differ.

In this study, an eye tracker setup which could be used as an interaction technique to play a first-person shooter game is presented. The setup includes a Tobii T60 eye tracker, a standard computer setup and a modified version of an FPS game developed by Isokoski & Martin [2007] and Isokoski *et al.* [2007].

A two session long experiment was conducted within which six participants played the particularly modified game with different input devices. The input devices were mouse and keyboard, an Xbox360 gamepad and a Tobii T60 eye tracker. The participants filled out questionnaires that laid out their thoughts of the input devices.

2. Previous work

2.1. First-person shooters and eye tracking

The term first-person shooter (FPS) refers to a video game genre. The genre's main characteristic is that it is played from the first-person perspective. Shooting is the most important action of the game in the majority of FPS games. Typically the player maneuvers the game character in a two- or three-dimensional world and sees the game world through his/her virtual character's eyes. [Bartholl 2006]

When playing an FPS game, the player has many input devices to choose from. The input device can be for example a gamepad (e.g. a Nintendo Wii controller, a PlayStation controller or an Xbox controller), a mouse and keyboard, a touchpad or an eye tracker. Each of these input devices have different methods for aiming, e.g. when using a mouse and keyboard the aiming is generally done via mouse controlled cursor.

When the player chooses an eye tracker to play an FPS game, eye movement can e.g. control the cursor that is used for aiming. The eye tracker tracks eye movement in order to gather data and calculate the point where the cursor should be. One of the most commonly employed methods in calculating eye movement is a pupil and corneal reflection. In the method the eye tracker tracks the user's pupils in relation to the eyes' corneal reflection. Method uses infrared light which centers to user's eye and brings on a reflection of the cornea. Infrared-sensitive camera records the reflection. [van Gog & Jarodzka 2013]

The Tobii T60 eye tracker used in this study applies the pupil center corneal reflection eye tracking, which utilizes the pupil center and the corneal reflection of an infrared light source, and accompanies it with both dark and bright pupil tracking method (Figure 1) [Tobii 2016b]. Using the dark pupil tracking, the pupil can be seen and detected as a black spot in the captured eye image. On the contrast, when using the bright pupil tracking, the pupil can be seen as a bright white or light spot in the eye image [Al-Rahayfeh & Faezipour 2013]. A combination of both pupil tracking methods provides a more accurate way to track the user's eye movement than using only one of the methods [Tobii 2016b].

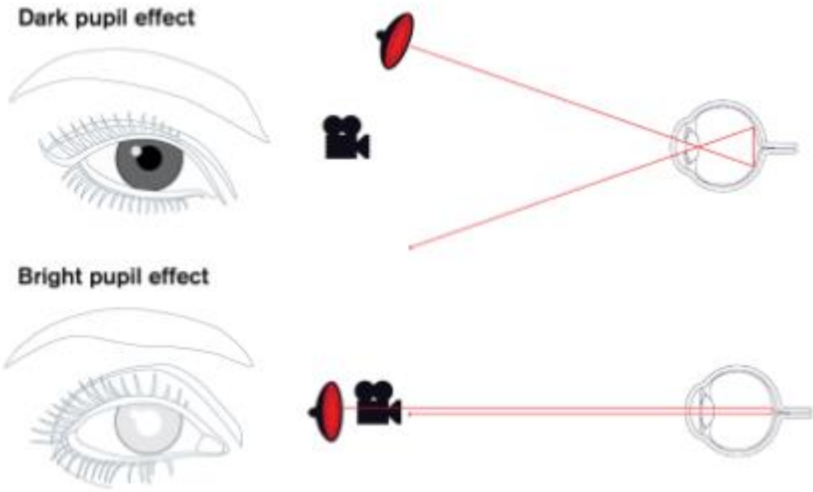

Figure 1 - Dark and bright pupil tracking (Tobii.com)

In FPS games, it is a necessity to be able to aim as precisely as possible in order to shoot the target from a long distance [Isokoski 2009]. Human eyes are constantly shifting and the most common way for them to move is a fast motion called a saccade [Salvucci & Goldberg 2000]. The saccade is typically followed by a fixation which is a period of stability [Jacob 1991]. During the fixation an object can be viewed [Jacob 1991]. The normal time for fixations range from 200 milliseconds to 400 milliseconds being seldom less than 100 milliseconds [Salvucci & Goldberg 2000]. Over fixation eyes do not stay perfectly still but make a constant small movement, generally covering less than one degree [Jacob 1991]. A player may believe he/she is steadily looking at an object but in reality his/her eyes are constantly jittering [Jacob 1991].

Even though a saccade is the most common way for eyes to move [Salvucci & Goldberg 2000], it is not the only way [Vidal *et al.* 2013]. The eyes can also move in a way that is called a smooth pursuit [Vidal *et al.* 2013]. Smooth pursuit eye movements occur when our eyes are closely following a moving object, e.g. a target in a game [Vidal *et al.* 2013].

A precise and accurately calibrated eye tracker system is able to provide valid data because it can genuinely determine where on the screen the user's gaze is located [Tobii 2016c]. The desired accuracy for eye tracking systems should be extremely accurate when playing an FPS game [Leyba & Malcolm 2004].

Few studies of playing first-person shooter games using eye trackers have been conducted within the past years. Jönsson [2005] conducted a study within which she ran a usability experiment to test eye tracking systems. The games played were Sacrifice, which is a real time strategy video game, and Half Life, which is an FPS game. Jönsson compared the eye-tracking systems to a standard mouse and keyboard setup. She discovered via usability study that participants found playing Sacrifice more fun and committing when playing the game with eyes. The majority of the participants rated also playing Half Life (Figure 2) with an eye tracker to be more fun than playing it with the standard setup.

Figure 2 – Changing the view in Half Life with eyes. (Source: Jönsson 2005)

Isokoski and Martin [2006] carried out a similar study as Jönsson. They designed a game especially for playing with an eye tracker. In the study, they compared the effectiveness between different input devices. The compared input devices were a standard keyboard and mouse, an Xbox360 gamepad and a Tobii 1750 eye tracker. They discovered that using an eye tracker support did not always improve player's performance in FPS games. Nevertheless the study suggested that an eye tracker input could improve performance in input device configurations other than the keyboard and mouse combination.

Isokoski *et al.* [2009] compiled a review of past work with playing video games with eye trackers and charted future possibilities with them. Part of the reviewed past work covered first-person shooter games that were played with eye trackers. One of the characteristics of FPS games is that they are often played more or less competitively in the Internet. In the competitive FPS games, the player generally has an advantage when he/she can aim accurately and fast in far distances. Therefore, the competitive FPS players, who appreciate aiming accuracy, ordinarily choose a mouse as an aiming device since eye trackers are not yet competitive enough against the mouse's accuracy. Problems with an eye tracker include inaccuracy in fast eye movements, tracker inaccuracies, tracker noise, and not hitting small targets efficiently. In online games that demand continuous attention and are played competitively against others, the other players' input devices (e.g. standard mouse and keyboard) define the game's difficulty level – which creates a serious challenge for an eye tracker input.

Isokoski *et al.* [2009] concluded that when using well designed interfaces, novice eye tracker users may consider a tracker as an easy input device. However, it is a possibility that the interpretation of the eye tracker's easiness can mislead the participants from seriously estimating their performance with the device. In short-term studies the results can be affected by the feeling of easiness but in potential longer studies, the original interest towards eye trackers may decrease.

The conclusion of the review of Isokoski *et al.* [2009] motivated to include a second session of experiments to this study in order to discover if there are significant differences between the two sessions.

2.2. Eye tracking and immersion

Immersion level is a term used to describe the degree of gamer's involvement in a game. Brown and Cairns [2004] discovered three levels of involvement: engagement, engrossment and total immersion. Engagement is the lowest level of immersion when playing a game and it always occurs before any other immersion level. Engagement requires time, effort and attention from a player. The second level is called engrossment which can happen when player's emotions are directly affected by the game features. Total immersion is the final level, and Brown and Cairns [2004] describe it as "presence" and as if the gamer was "being cut off from reality and detachment to such an extent that the game was all that mattered".

When studying the use of eye trackers in gaming, immersion can be measured subjectively, i.e. through questionnaires, and objectively [Jennett *et al.* 2008]. Objective measuring methods can consist of e.g. measuring task completion time or comparison of eye movements [Jennett *et al*. 2008]. A real world task can be slower to complete if a participant is asked to do it right after an immersive gameplay experience, which gives information of the participant's immersion level [Jennett *et al*. 2008]. Measuring eye movements can be profitable because e.g. in an immersive game a participant's eye movements can decline as his/her focus becomes more concentrated on visual parts relevant to the game [Jennett *et al.* 2008]. For the player to feel immersed, he/she generally needs to feel that the game played creates a good game play experience [Brown & Cairns 2004].

A good game play experience is created when gamer's input and output devices provide good audio and visual feedback, gamer's cognitive processes are challenged, and the gamer feels that he/she is in control of the game, and it is fun to play. While playing a game, it is necessary for the player to turn into an active participant in order to have a strong gameplay experience. [Ermi & Mäyrä 2005]

In this study, there are similarities to various studies on eye trackers and immersion that have been conducted over the past few years. Smith and Graham [2006] performed an experiment where they used the Tobii1750 eye tracker and compared it to the mouse (and keyboard) setup. During the experiment participants played and tested three different games from different genres. The first tested game was an open-source Java port version adaptation of a first-person shooter game named Quake 2 that was called Jake2. The participants played the game both with the traditional mouse and keyboard setup and with the eye tracker control. With the eye tracker control participants looked at an object on the screen to rotate the camera angle.

The second game used in the experiment was a role-playing game called Neverwinter Nights. Moving the character was done simply by pointing and clicking with mouse control. While using an eye tracker setup the participants interacted with the game character by means of eye-based pointing. The participants gazed over a desired point, e.g. a treasure chest or a location on a map, to steer the cursor in the right place, and clicked the left mouse button to confirm the action, e. g. move the character or open the treasure chest. The third game, which was part of the study, was an action/arcade game called Lunar Command (Figure 3). In Lunar Command, eye tracking was used the same way as in Neverwinter Nights, in other words, eye-gaze was used for pointing a desired location on the screen, which was followed by the participant clicking the left mouse button to confirm an action. [Smith and Graham 2006]

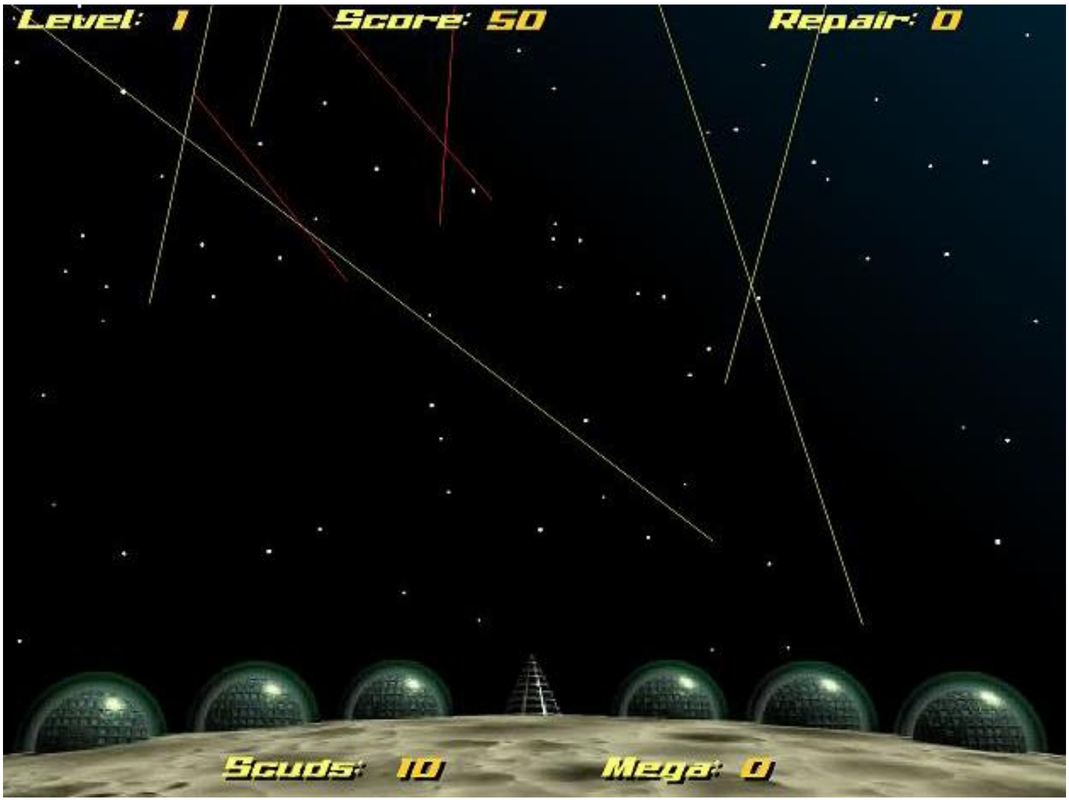

Figure 3 - Players fired at missiles descending from the top of the screen by looking at them at them and pressing a button. (Source: Smith and Graham 2006)

A sample population of 12 persons participated in the Smith and Graham's [2006] study; five of the participants had their vision corrected with glasses but no calibration problems were detected with the eye tracker. After the game had been played with both input devices, the eye tracker and the mouse and keyboard, users filled up a questionnaire (Table 1). Smith and Graham [2006] detected that using an eye tracker did not improve performance compared to the mouse. On the other hand, one of the conclusions was that an eye tracker can have a positive effect on the immersion level of the game.

Question	Quake2		Neverwinter Nights		Lunar Command	
	Eyes (%)	Mouse (%)	Eyes (%)	Mouse (%)	Eyes (%)	Mouse (%)
Which did you enjoy playing with more?	42	58	83	17	42	58
Which was easier to learn?	33	67	67	33	33	67
Which was easier to use?	8	92	50	50	8	92
With which did you feel more immersed in the gaming world?	83	17	83	17	92	8
For which did the controls feel more natural?	25	75	67	33	42	58
Which would you prefer to use in the future?	33	67	67	33	42	58

Table 1 - Analysis of subjective measures (Smith and Graham 2006)

2.3. Eye tracking with different inputs

In gaming, eye trackers can be used integrated with various other input devices. One input device can e.g. perform the aiming and the other carry out the character movement. This chapter concentrates on studies and experiments presenting games that somehow utilize eye tracking. Most of the games presented are FPS games but the rest of the games represent different genres. One of the games utilizes only an eye tracker as an input device but the majority of the games combines at least two input devices, eye tracker being one of them.

Isokoski and Martin [2006] used Tobii 1750 eye tracker with mouse and keyboard to control the character of the game. Eye tracker was used for aiming and it controlled the red reticle (Figure 4). Mouse controlled the white reticle and the camera angle (Figure 4). When eye tracker was disabled the white reticle was used for shooting (Figure 4). Shooting was performed by clicking the mouse buttons – left one for the mouse controlled reticle and right one for the gaze-controlled reticle. Keyboard was used to move the character.

Figure 4 - Screenshot from penguin hunting game. (Source: Isokoski & Martin 2006)

Nacke *et al.* [2010] integrated Tobii T120 eye tracker with mouse and keyboard to play a modified game level which was designed with Half Life 2 Source SDK platform. The player’s goal was to maneuver successfully on a catwalk. Obstacles were placed on the player's way and as a result, there was a possibility to fall off from the catwalk. The eye tracker controlled the first-person camera view and the keyboard was used for character movement. The mouse was given as an option to control the first-person camera view.

Špakov and Miniotas [2005] developed a software to play chess endgames using only an eye tracker. The software was named EyeChess. In the study conducted to trial EyeChess, Špakov and Miniotas [2005] ran an experiment within which the participants played through 20 different endgames. Playing the endgames, the chess pieces were selected by looking at them. If a user wanted to make a move he/she looked to a desired piece. The system detected which piece the user was gazing at and gave the options in which squares the piece can be moved to. Green highlighted square meant a possible move and red highlighted square meant an impossible one. There were three different methods to select the pieces in the software: dwell time, blink and an eye gesture. Špakov and Miniotas [2005] found out that the dwell time was the preferred method, other methods being considered quite eye fatiguing. Figure 5 shows a screenshot from EyeChess.

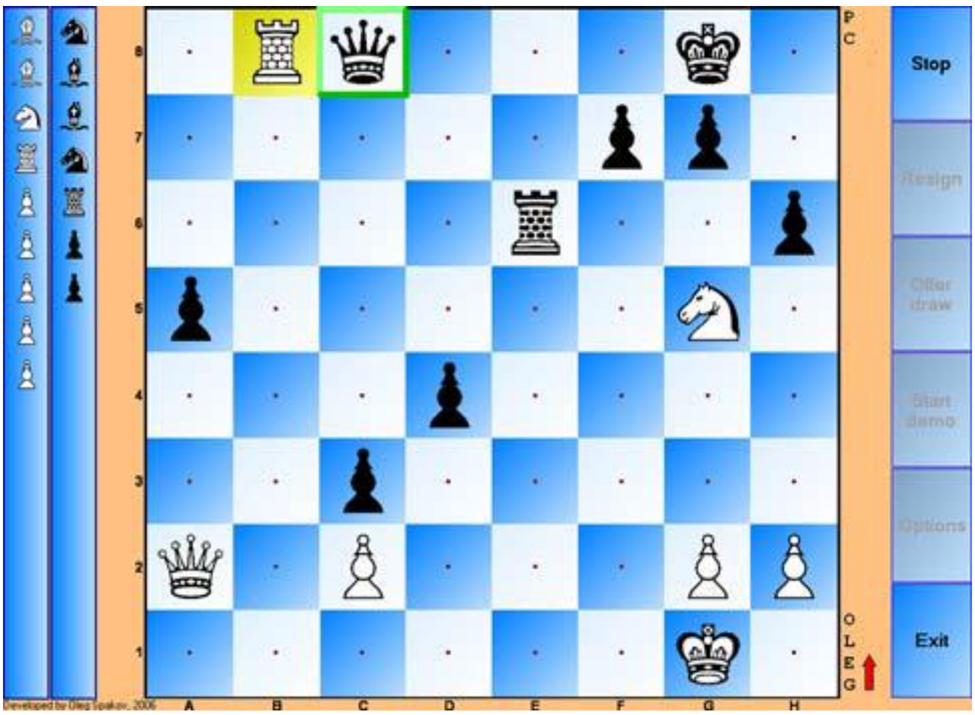

Figure 5 - EyeChess playing window. The square of the selected piece is highlighted, and the square that the user is looking at is shown with the green border. (Source: Isokoski *et al*. 2009)

Eye tracking system can be applied in different surfaces besides a standard tabletop computer or a laptop, e.g. in touch screen. Yamamoto *et al.* [2010] developed a prototype game for an eye tracking tabletop interface (ETTI) which was named "Hyakunin-Eyesshu". With the prototype the users could play a traditional Japanese card game called "Hyakunin-Isshu" against a computer opponent. The computed character was modeled as a cat figure. The input methods used in the interface were gaze and touch (Figure 6). In Hyakunin-Isshu, two players competed in finding cards that matched a poem which was read aloud within the game. Both players held cards with lines from various poems. The player who got the most cards right won the game. The ETTI could analyze the user's gaze point and the moment when the user's hand was going for the matching card. It allowed the computer character to predict the moment when user was trying to take a card. Computer could exploit the user's gaze point and hand movement to grab the card the user was going for before him/her.

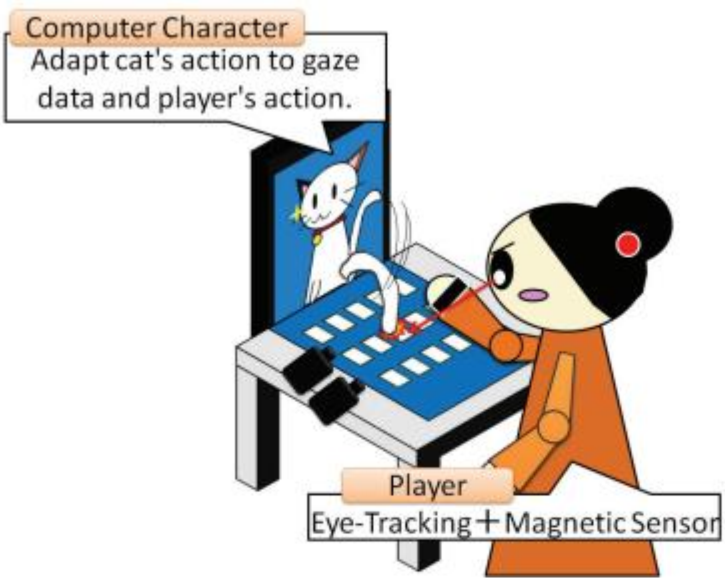

Figure 6 – Concept of Hyakunin-Eyesshu (Source: Yamamoto 2010)

Hyakunin-Eyesshu was publicly demonstrated on October 23rd–24th, 2010, at an Entertainment Computing 2010 held at the Kyoto Institute of Technology. Before every use, the system was calibrated and introduced to the people that experimented with it. A total of 350 participants took part in the experiment. After the gaming session participants were asked to fill out a questionnaire which consisted of four statements that were rated on a five-grade bipolar rating system. The statements were the following: "I enjoyed the game," "I want to play again," "I became interested in Hyakunin-Isshu," and "The eye tracking was precise." 56% of the participants felt like the eye tracking was precise, and the researchers came to a conclusion that the more precisely the gaze was detected, the higher the game was rated.

2.4. Eye tracking for disabled persons

An eye tracker may be an option for disabled persons to play games. Eye trackers basically need only the user's eyes to be functional. Several studies of the subject have been carried out and the results have been promising.

Istance *et al.* [2009] conducted a study within which they developed a software to play a massively multiplayer online role-playing game (MMORPG) with eye gaze, in this case the World of Warcraft. In the study, they wanted to learn if disabled people could play MMORPG's without using a keyboard and mouse or a gamepad. The input for the game was designed as shown in Figure 7 and Figure 8. The heat map (Figure 7) shows how the movement with eye tracker was implemented, e.g. when user wants to move forward he/she gazes in the middle area of the screen.

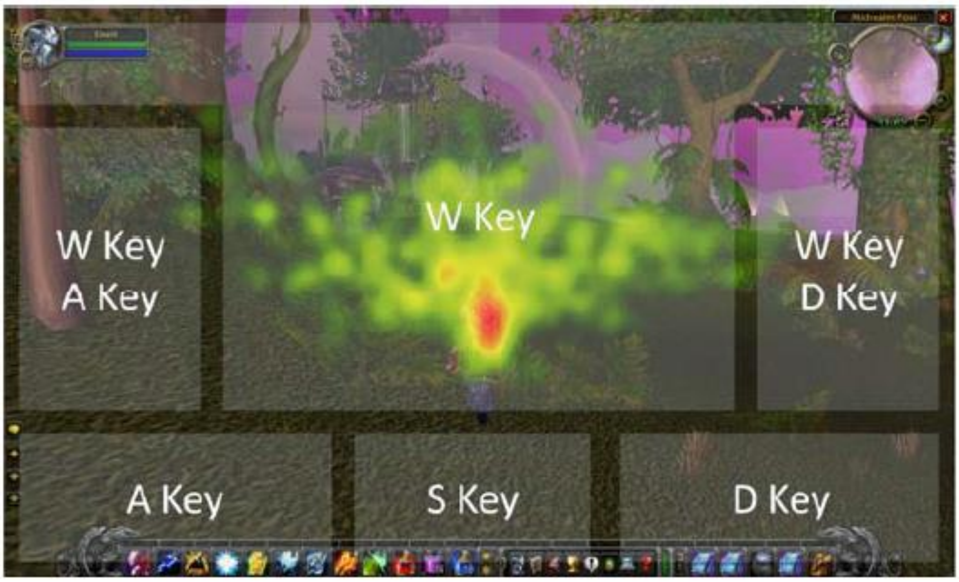

Figure 7 - Heat map in World of Warcraft (Source: Istance *et al.* 2009)

When the user gazes at the icons located at the bottom of the screen, a magnifier glass (Figure 8) pops up to help the user to select a desired icon. Istance *et al.* [2009] found out that by using only eye gaze, it was possible to complete novice skill level tasks of the game. However, they did not have actual disabled persons in the study to test the setup.

Figure 8 - Magnifier class to help selecting from the icons (Source: Istance *et al.* 2009)

Vickers *et al.* [2013] studied how to make gaming more available for people with different kinds of disabilities. They developed a software framework to help the dynamic adaptation of computer games to different levels of physical and cognitive abilities. The framework was called Game Accessibility Development Framework (Figure 9). It controls additional interface components which are laid on top of the game's normal interface.

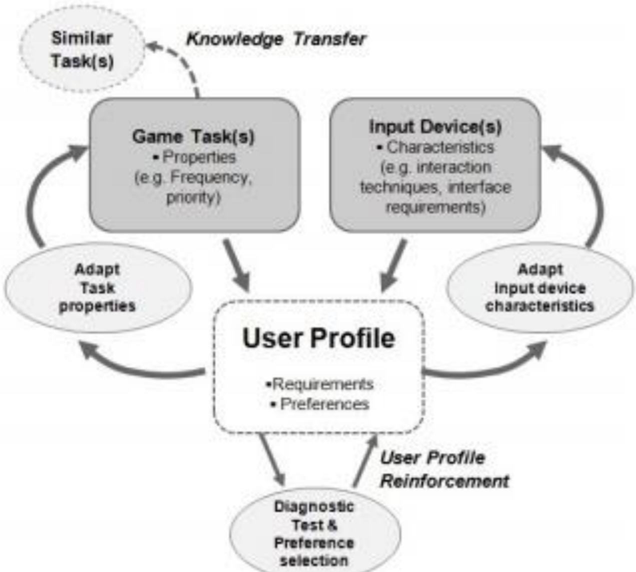

Figure 9 - Game Accessibility Development Framework (Source: Vickers *et al*. 2013)

The interaction technique that abled performing movements and actions using only eye control was developed as an after-effect of working with physically disabled students. The framework was based on a task analysis. It defines the automatic modification of input device configuration, game tasks and interaction technique according to a profile of the user’s abilities. [Vickers *et al.* 2013]

Vickers’ *et al.* [2013] study motivated this study to implement an option to play a game solely with an eye tracker input.

3. Method

In this section the experiment is explained. At first, an analysis of the participants who took part in the experiment is introduced. Secondly, the experiment’s apparatus and procedure are explained. At the end of this section the design of this experiment is presented.

3.1. Participants

A total of six participants took part in the experiments. Counterbalancing the conditions was easy with this amount of participants and the study resources limited the total amount of participants. All the participants were between 21 and 30 years old. Five of the participants were men and one of them was a female. One of the participants had vision corrected with contact lenses and one of them with laser surgery. Every participant had previously played FPS games with either a computer or a console. Two of the participants had come across eye tracking when shuffling through YouTube but they were not aware of the focus point of the experiment. Figure 10 shows a participant playing the game with the eye tracker input.

Three of the participants stated that they play video games (with either PC or console) daily. Two of the participants stated that they play video games sometimes and one of the participants answered that he/she does not play video games.

Figure 10 – A participant playing the game with the eye tracker input.

3.2. Apparatus

A Toshiba Satellite P870-11M laptop, Tobii T60 eye tracker with a 17 inch LCD display (1280x1024 resolution), a mouse and keyboard, and an Xbox360 gamepad were used in this study. The same game software that Isokoski *et al.* [2007; 2006] used in their study was applied also in this study. Slight modifications were made to the game. The source code of the game was modified in such way that it was possible to play using the eye tracker by itself. The game was compiled through Visual Studio 2015 and libraries, such as Boost, were employed. Oleg Špakov's (University of Tampere) ETU-Driver Service was used to calibrate the eye tracker for different participants. TraQuMe software was applied to evaluate gaze data quality [see: Akkil *et al.* 2014]. The mouse and keyboard, the Xbox360 gamepad and the eye tracker were the input devices of the game and each of them was rated separately.

The Game world's terrain was 1000x1000 units and its height profile was random. Trees blocked the player's movement and were impenetrable but targets could freely move through them. The targets were designed as penguin logos and there were constantly ten targets in the game. Whenever a target was shot down another appeared somewhere in the game area. The player had unlimited ammunition and there was no requirement to reload. Each gaming session's maximum length was 5 minutes. Figure 11 shows a view of the Game world.

Figure 11 - The Game world

The Logitech Optical mouse was employed in the mouse and keyboard configuration. Xbox360 gamepad was set to angular velocity of maximum 270 degrees per second in rotations. The displacement-velocity transfer curve was cubed as suggested in the Xbox360 gamepad programming manual. The angular velocity in rotations with the eye tracker was set to maximum of 270 degrees per second, the same as in Xbox360 gamepad.

Eye tracker detected how participant's eyes were located in relation to the tracker. With the help of the information of the distance between participant's eyes and the eye tracker, the leaning technique which enabled the character to move, was implemented [see: Špakov and Majaranta 2012]. An area where the game's character stayed still, a dead spot, enabled the use of the leaning technique. When participant leaned his/hers head away from the dead spot the character moved accordingly. The character stayed still when the length of the alignment from the participant's eyes to the eye tracker was at 65 to 70 cm. The width of the dead spot was 2 centimeters.

Leaning forward resulted in a forward movement with accelerated velocity, the maximum being equivalent of the keyboard speed "3". Leaning backwards produced a backward movement with the same velocity. This was implemented to imitate the common "W" and "S" keys in FPS games that make the character to move forward or backward. Leaning head left or right resulted in strafing in right or left being equivalent of the keyboard speed "1". This was implemented to imitate the common "A" and "D" keys in FPS games that make the character to strafe sideways to avoid obstacles – in this case for the user to more easily dodge trees.

Shooting with eyes was implemented because one of the study's goals was to make it possible to play the game solely with the eye tracker. Eye movements controlled the reticle which was used for aiming, and shooting the target was implemented with blinking one of the eyes or shutting the eyes. A shot was taken when the eye tracker received low quality data from the user – e.g. when the user closed an eye or both eyes. The eye tracker divided the gaze data to different quality categories e.g. to high quality gaze data and to low quality gaze data. With the help of the categorization it was possible to detect when the participant closed eyes.

A loop was created to the game in which a shot was triggered only when the player was gazing at a target immediately before the low quality gaze data, indicating an eye blink was detected. The loop was added because otherwise uncontrolled shooting could have occurred. Unnecessary shooting could have happened when e.g. eyes got tired and participant had to blink even though he/she did not intend to trigger a shot. Eye tracking data could also have been of low quality for some other reason than shutting eyes. The user had an option to trigger the shot with the Xbox360 gamepad if he/she preferred it over shooting by shutting an eye or both eyes. Table 2 describes the different input mechanisms' configurations.

Configuration	Left hand	Right hand	Eye tracking
Mouse and Keyboard	**Keyboard** *moving*: arrow keys	**Mouse** *aiming*: mouse, *trigger*: left button	
Xbox360	**Left stick** *moving:* stick (velocity) *trigger:* shoulder button	**Right stick** *aiming:* stick (angular velocity), *trigger:* shoulder button	
Tobii T60 (+ Xbox360)	*trigger*: shoulder button (optional)	*trigger*: shoulder button (optional)	Moving: Leaning towards: forward movement Leaning backwards: backward movement Leaning head left: strafing left Leaning head right: strafing right trigger: blinking/closing eyes Aiming: eye gaze

Table 2 - The input device configurations

3.3. Procedure

When arriving, the experiment participant was greeted and guided into an isolated laboratory room, where the experiment station was placed. The elements of the experiment were:

1. Information about the outline of the experiment was handed out to the participant and he/she read it.
2. The questionnaire about participant's background was handed out and he/she filled it out.

3. A brief demonstration of eye-tracking and leaning technique was performed by experimenter.
4. The participant sat down at the experiment station and the eye tracker was calibrated.
5. The quality of gaze data was measured with TraQuMe software.
6. The first input device was tested. Participant was instructed to apply the thinking aloud method during every input device experiment. The maximum gaming time for each input device was 5 minutes but the participant could choose to play less.
7. The participant filled out the post-test questionnaire regarding the first input device. The experimenter explained the grading scale (see: chapter 4.4) to the participant in each question.
8. The second input device was tested.
9. The participant filled out the post-test questionnaire regarding the second input device.
10. The third input device was tested.
11. The participant filled out the post-test questionnaire regarding the third input device.
12. The participant conducted the second round of testing input devices. (Steps 6, 8 and 10 repeated.)
13. The participant filled out the post-test questionnaire regarding all three input devices.
14. A concluding interview was held with the participant.
15. The second session of experiments was scheduled with the participant and after he/she agreed to the date, he/she left the laboratory room.
16. The participant returned to the laboratory room at the scheduled date and the second experiment session was conducted (Steps 4–14 repeated).

The procedure above is presented as if the eye tracker was the first input device tested. In reality, the order of the input devices was counterbalanced and the first input device could have been any of the three. The eye tracker was calibrated right before testing it.

When conducting the experiment, participants were asked to play the game while continuously thinking out aloud, which meant that the participants verbalized their thoughts during the gaming session [see: Nielsen 2012].

In the first round of input device experiments, the questionnaire was filled out right after playing with every input device. The approach was chosen to get the immediate reaction of a specific input device. In the second round, the questionnaire was filled out after the participant had played with all the input devices. The approach was chosen to see if the participants' opinions had changed between the two rounds.

The experiment's second session was included to evaluate if the first and second session results would differ, when approximately two weeks passed between the sessions. The approach was chosen to see if the participants' opinions had changed during that time. Both of the sessions were held in a laboratory room of University of Tampere.

3.4. Design

The purpose of the experiment was to gather qualitative data that would indicate how the participants felt using an eye tracker as an input device when playing an FPS game. Additionally, the experiment was conducted to determine the following: if there was a significant difference between the input devices, if one of the input devices was more fun than the others, if the participants lost track of time more easily using one particular input device, and also to discover with which input device the participants would like to play the game the most.

When designing the experiment, the order in which the input devices were used were counterbalanced in order to minimize learning effects. The order of the input device experiments were counterbalanced the following way:

Participant #01:	Participant #02:	Participant #03:
Device 1 – M+KB	Device 1 – Xbox	Device 1 – Xbox
Device 2 – Xbox	Device 2 – M+KB	Device 2 – Eyes
Device 3 – Eyes	Device 3 – Eyes	Device 3 – M+KB
Participant #04:	Participant #05:	Participant #06:
Device 1 – M+KB	Device 1 – Eyes	Device 1 – Eyes
Device 2 – Eyes	Device 2 – M+KB	Device 2 – Xbox
Device 3 – Xbox	Device 3 – Xbox	Device 3 – M+KB

In the second round of experiments the order of devices tested were counterbalanced.

4. Results

In this chapter the experiment results are presented. The results are categorized under the study's first and second hypotheses and they are covered individually. The third hypothesis, which argues that the results from the two session differ, is connected to all of the results presented. The main focus of the chapter is in the evaluation of the hypotheses. Nevertheless, other significant results are presented as well since they can further broaden and explain the results that are connected to the hypotheses. Part of the results are combined in this chapter to describe and explain the conditions in which the experiment was carried out. The information collected with the thinking aloud method is covered in this chapter as well. The majority of the participants (4 of 6) utilized the possibility to write additional comments. Both the information collected with thinking aloud method and the participants' comments are presented separately in the first session section and the second session section. At the end of this chapter a brief summary of concluding interviews is given.

4.1. Procedural outcomes

As mentioned earlier in the chapter 3.2., when playing with the eye tracker input device, participants had the possibility to finalize a shot with the Xbox360 gamepad if they preferred it over shooting with eye control. Nevertheless, none of the six participants chose to shoot with the gamepad.

The eye tracker had to be re-calibrated in 2 of the 12 eye tracker experiments. Both times the reason for re-calibration was that the shooting mechanism did not work properly. After re-calibrating, the shooting mechanism began to work normally in both cases. One of the two participants, who had problems with the shooting mechanism, informed the experimenter that he/she had not been sleeping well the previous nights and that he/she had trouble keeping his/her eyes open, which could have contributed to the problem.

Every participant finished both sessions and no question in the questionnaires were left unanswered. The shortest single input device game session lasted for ten seconds because the participant did not want to play the game with the Xbox360 gamepad any longer. Most of the participants wanted to play the maximum amount (5 minutes/per single input device).

Few days after the pilot experiment, the participant of the pilot experiment informed the experimenter that he/she had experienced headache the day the pilot experiment was conducted. None of the other participants informed having headache after the actual experiments.

4.2. Tracker performance

TraQuMe software was used to measure the quality of eye tracking data during the experiment. Data was gathered in every session. Since all the participants attended two sessions and data was gathered during each session, a total of 12 TraQuMe measurements were gathered. The distance between the screen and the participant was approximately 70 cm which was measured in the beginning of every data gathering. The reported TraQuMe results were from the middle collection point.

The middle collection point was chosen because the reticle followed the participant's eye gaze and the field of view adjusted according to it. E. g. when aiming, the field of view adjusted to present the target in the middle of the screen. Therefore, the shooting being the main action of the game, the middle collection point provides the most valid data.

The accuracy of eye tracking varied between participants and the accuracy being good or bad could have affected the participants' gameplay experience. That is why, it was relevant to know how good the eye-tracking data was.

TraQuMe gathered data samples when a participant was gazing at a data collection point. The normal gathered amount during a 1,5 second period of data gathering was 90 samples. If the number was lower than 90, it could have been e. g. on account of the participant blinking during the sample gathering.

The average amount of samples gathered from one collection session was 86,2. Figure 12 shows the results of offset from every session (12 single sessions in total).

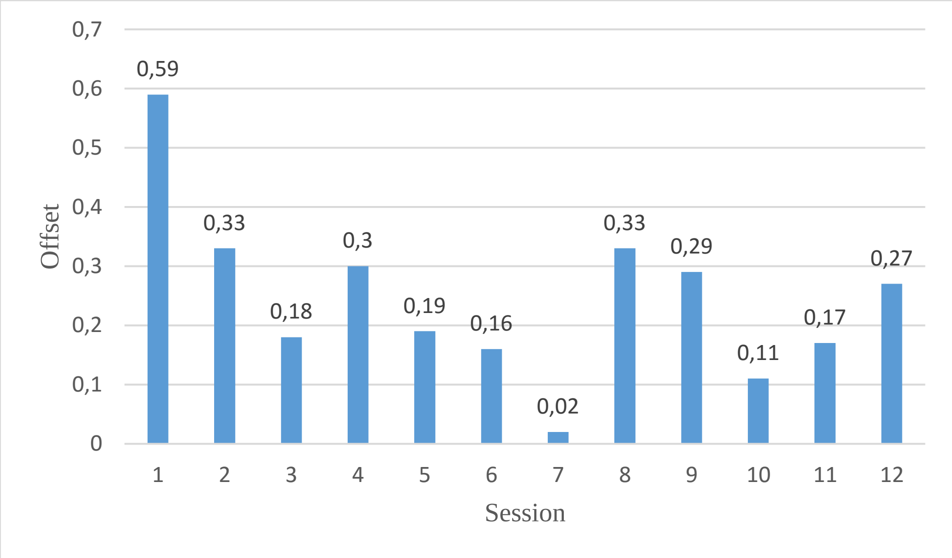

Figure 12 - Offset results from every session.

The offset average was low, only 0,24 degrees. That means the eye tracker was considerably accurate. The standard deviation of offset was 0,5. Dispersion average was 0,15 and the standard deviation was 0,06 in degrees.

4.3. Performance measures

While modifying the game to suit this study and mapping out the hypotheses, the first aim was to calculate participants' hits and misses when playing the game. Once the focus of the study shifted to explore immersion and fun in gaming with an eye tracker, counting hits and misses was no longer that relevant. The idea was dropped because it was made possible to use an eye tracker by itself for gaming and the option of shooting with blinking was introduced.

Participants self-measured how they performed in the game with each different input mechanism. Afterwards, the participants compared the different input mechanisms themselves. The experimenter kept track of the target shooting high score for each input device and updated the score every time when a new high was reached. The score was tracked because some of the participants wanted to know it, and knowing it apparently motivated them to concentrate more in the game session. The current high score was told to the participant if he/she asked for it before the input device tests.

4.4. Qualitative measures

The purpose of the post-test questionnaire was to measure participants' different feelings on the game. The participants answered the questions by choosing a grade that best described their opinion. The grades were scaled from 1 to 7, the grade 1 meaning, for example in question number 1, not difficult at all and the grade 7 meaning very difficult. The post-test questionnaire can be found as an appendix E. The questions were the following:

1. How difficult was it to control with (input device)?
2. How natural it felt to change the field of view when you controlled view with (input device)?
3. How engaged to the game you felt when you controlled with (input device)?
4. How precise you felt when you were controlling with (input device)?
5. How challenging, compared to your best level, was it to control with?
6. How fun was it to control with?
7. How much in control you felt when you controlled with?
8. How irritating it was to control with?
9. Did you feel consciously aware of being in the real world whilst playing the game?
10. To what extent did you lose track of time?
11. To what extent were you aware of your surroundings?
12. How natural it felt to control with?
13. How much would you like to play the game again with?

Figures 13 and 14 show the averages of post-test questionnaire results. The results are explained in the following sections.

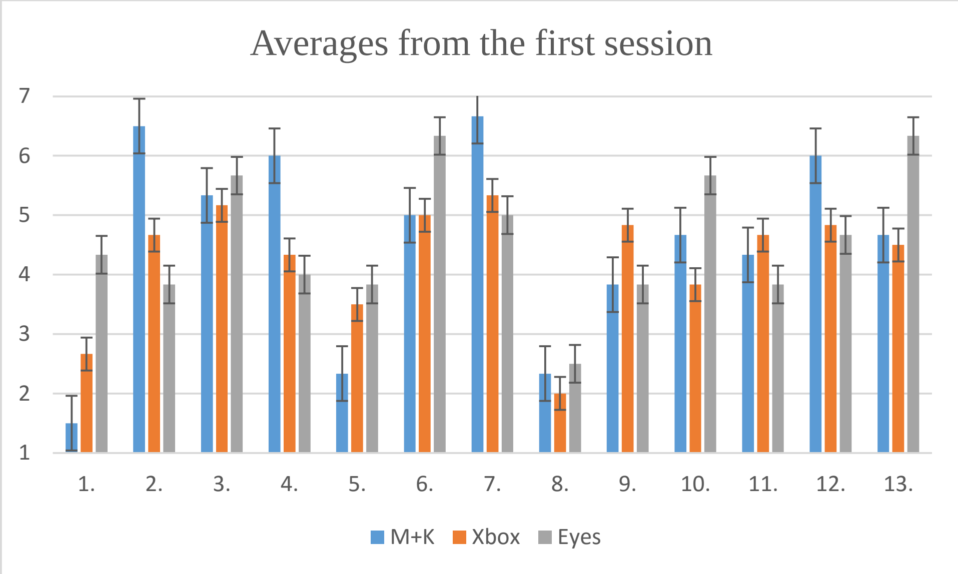

Figure 13 – All questions' averages from the first session.

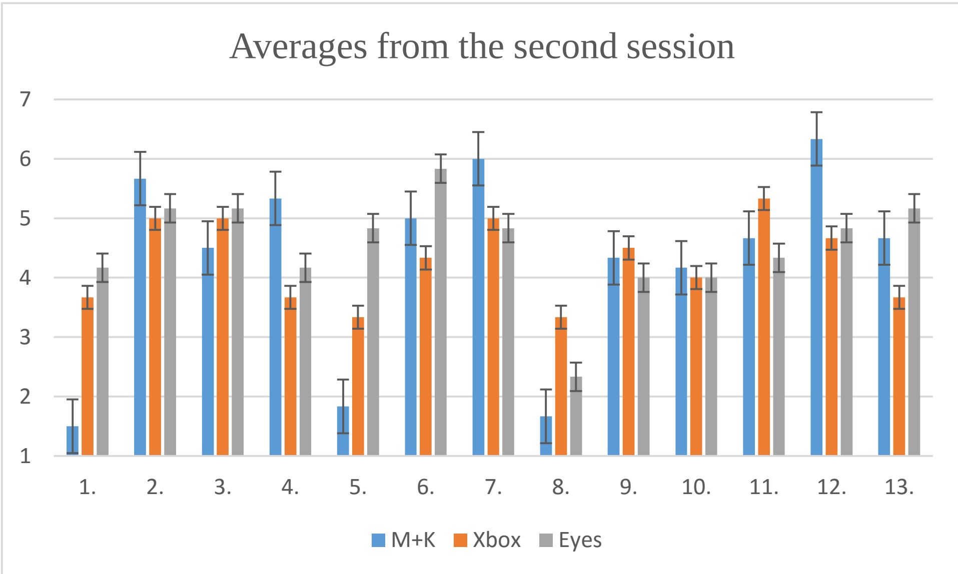

Figure 14 – All questions' averages from the second session.

4.5. Results on immersion

The post-test questionnaire´s questions 3, 9, 10 and 11 concentrated on immersion.

The following results were drawn from the question 3 "how engaged you felt to the game". In both sessions, the participants considered the eye tracker input to be the most engaging way to play the game. In the first session, the mouse and keyboard was rated more engaging than the Xbox360 gamepad but in the second session, the roles reversed. Figure 15 presents the averages of question 3 "how engaged you felt to the game".

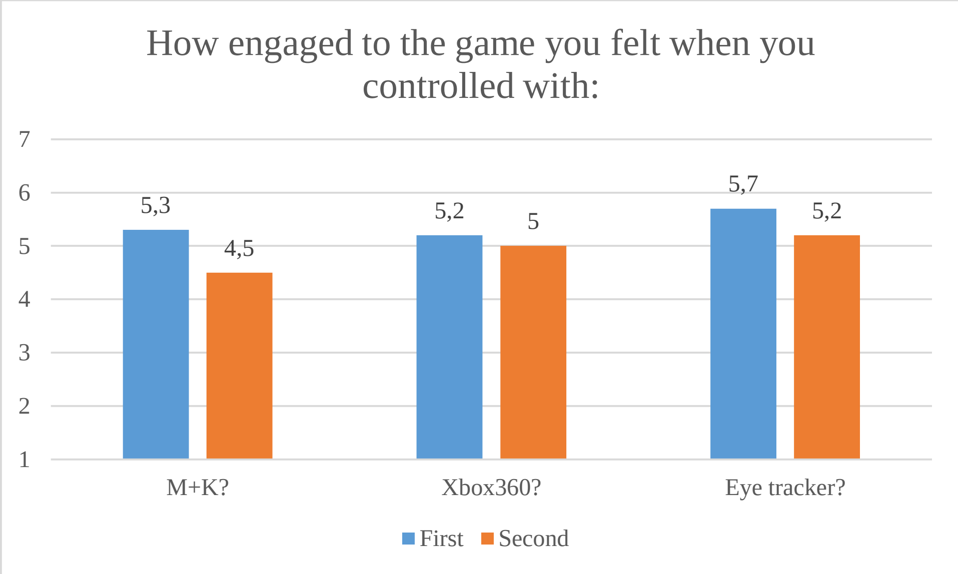

Figure 15 – The participants' engagement to the game.

Question 9 measured participants' "awareness of real world". When comparing the average of results between the eye tracker and the mouse and keyboard, it was quite similar. In the first session, participants felt more immersed when playing with the mouse and keyboard (M=3,8) than with the Xbox360 gamepad (M=4,8). Statistically significant difference between the devices was found (t(5)=2,21; p=0,04). In the second session, the eye tracker was rated to be slightly more immersive than the other input devices. Figure 16 shows the averages of question 9 "awareness of real world".

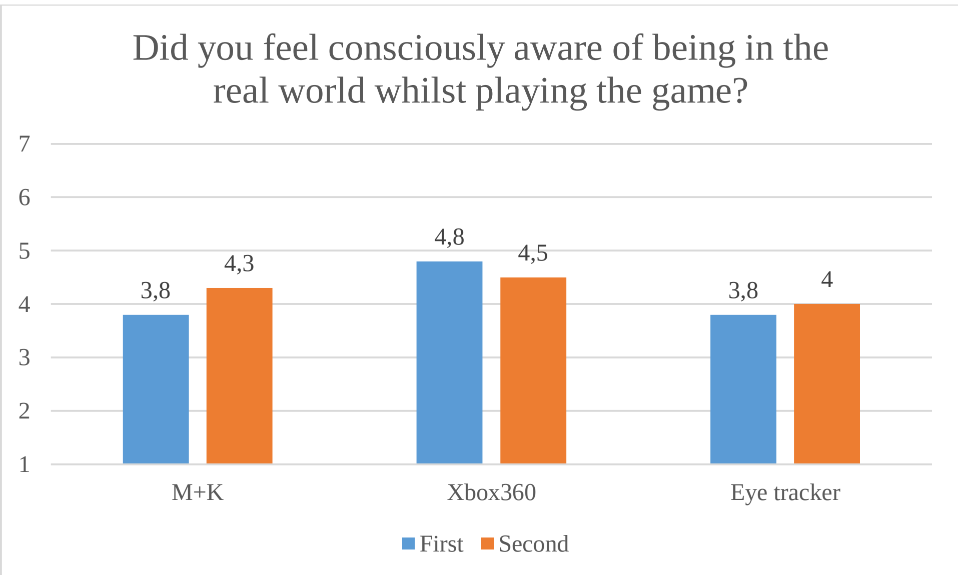

Figure 16 - Question 9 averages from both sessions.

In the question 10 "losing track of time" the eye tracker input results differed the most compared to the other input device results. The eye tracker was rated the highest in the first session but in the second session, it was rated as immersive as the Xbox360 gamepad. No statistically significant difference was discovered between the input devices. Figure 17 presents the averages of the results of question 10 “losing the track of time”.

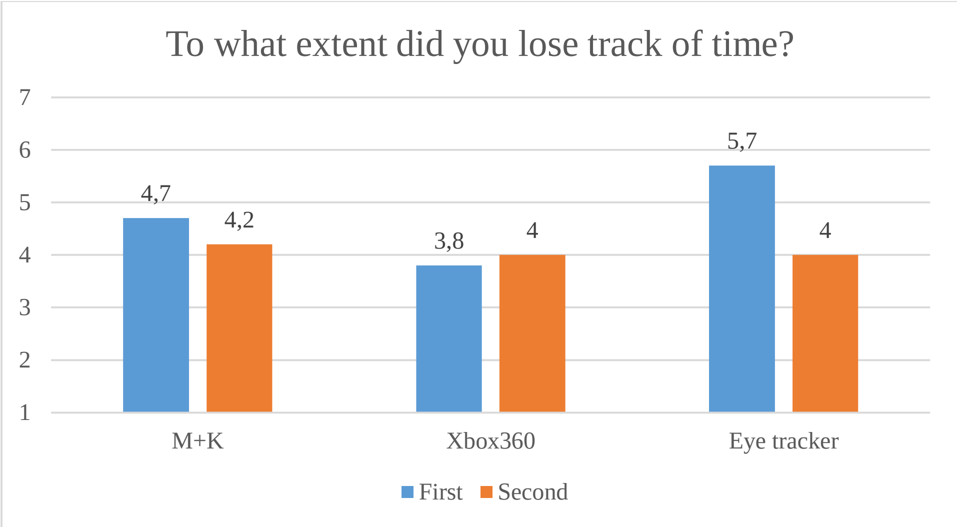

Figure 17 – Question 10 averages from both sessions.

When comparing the averages of the results of question 11 “awareness of surroundings" (Figure 18), the eye tracker was considered to be the most immersive input device. Nevertheless, no statistically significant difference was found between the input devices in either of the sessions. In the first session, the immersion level was higher with every device compared to the second session.

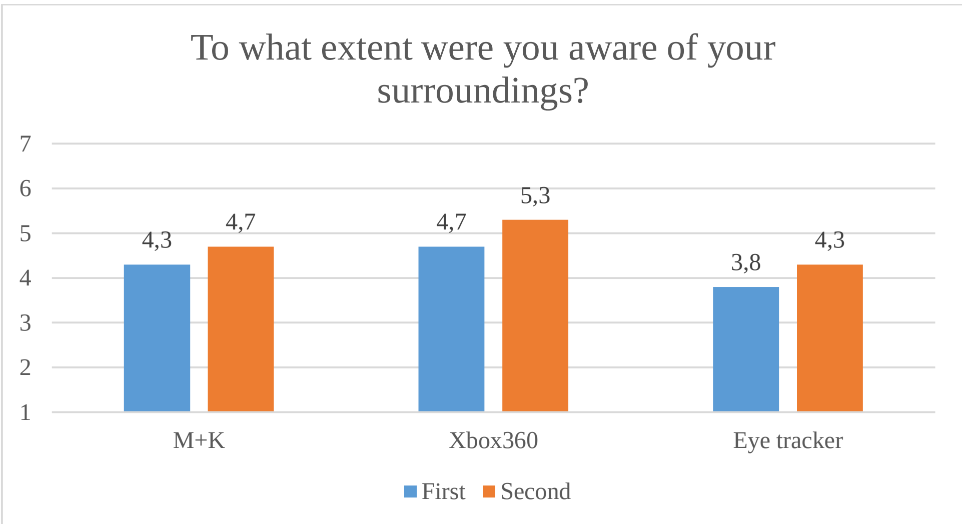

Figure 18 – Question 11 averages from both sessions.

4.6. Results on fun and playing again

Question 6 measured how fun the participants rated playing the game with each of the input devices.

In the first session, five of the six participants considered playing the game with the eye tracker to be more fun than playing it with the mouse and keyboard or with the Xbox360 gamepad. The sixth participant evaluated playing with the eye tracker to be as fun as playing with the mouse and keyboard. A paired samples t-tests indicate that the difference between the mouse and keyboard (M=5,0) and the eye tracker (M=6,3) was statistically significant (t(5)=1,76; p=0,025), as well as the difference between the Xbox360 gamepad (M=5,0) and the eye tracker (t(5)=1,8; p=0,01).

In the second session, there was a statistically significant difference between the eye tracker (M=5,8) and the Xbox360 gamepad (M=4,3), (t(5)=1,81; p=0,04). The mouse and keyboard was rated 5 but the differences between the device and the other devices were not statistically significant.

In the second session, a difference in fun level could be observed when playing with the Xbox360 gamepad or the eye tracker. The mouse and keyboard's fun level remained the same during both sessions. Figure 19 shows the averages of results from both sessions in question 6 "how fun was it to play the game".

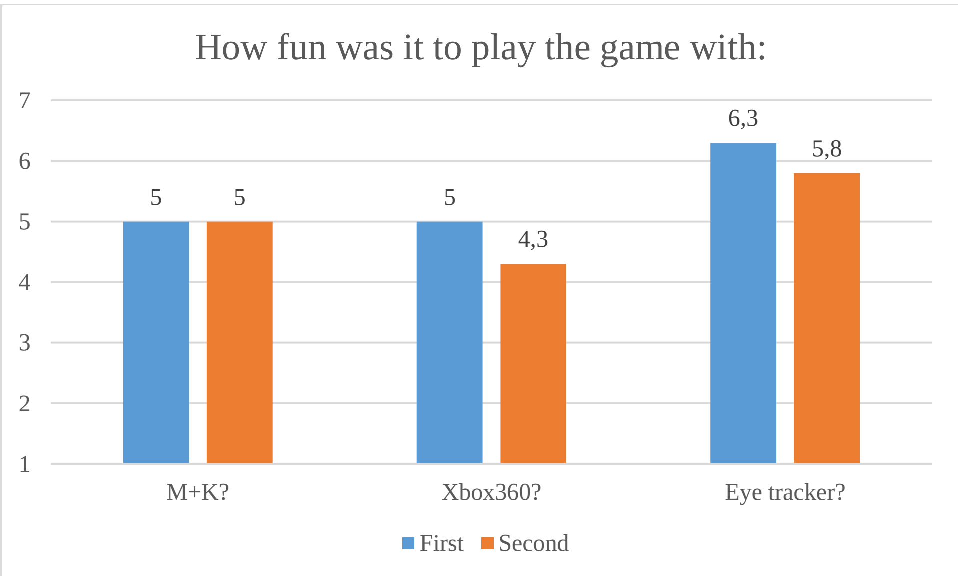

Figure 19 - Question 6 averages from both sessions.

The last question (13) was “How much would you like to play the game again”. In the first session, the eye tracker was rated the highest (M=6,3) – however, there was no statistically significant difference between the input devices.

In the second session, the eye tracker (M=5,2) was also rated the most desired way to play the game again with. The difference between the Xbox360 gamepad (M=3,7) and the eye tracker was statistically significant (t(5)=1,7; p=0,04). The mouse and keyboard was rated at 4,7. The differences between the mouse and keyboard and the other devices were not statistically significant. Figure 20 shows the averages of results in question 13 “playing the game again” from both sessions.

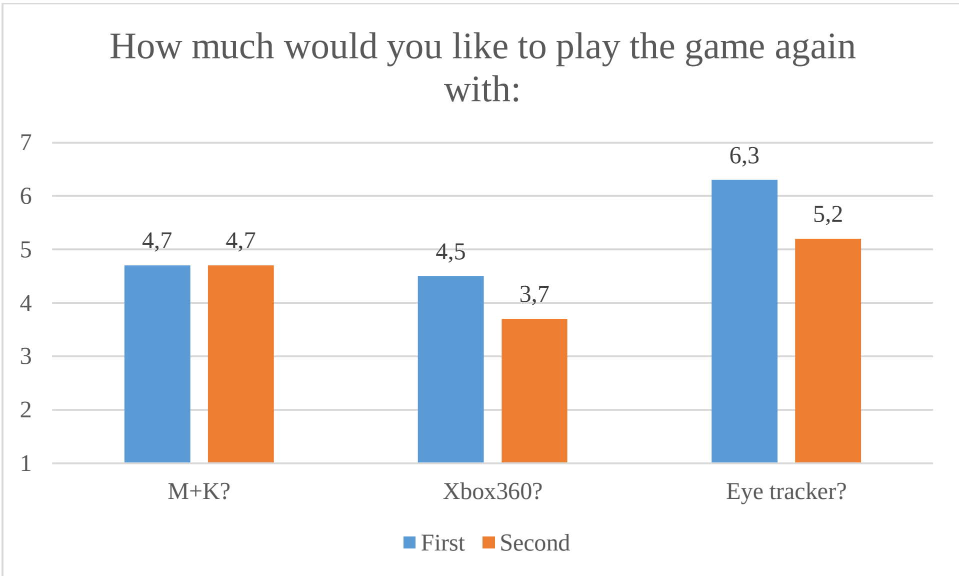

Figure 20 - Question 13 averages from both sessions.

4.7. Other significant results

In this chapter, the results of the rest of the questions are presented. They were not as interesting as the previously covered results given the study’s hypotheses. However, the results on questions 1, 5 and 12 included a statistically significant difference between the input devices.

Question 1 was “How difficult it was to control”. Participants felt that the most easy to use input device on both session was the mouse and keyboard. The eye tracker was rated the hardest in both sessions and the Xbox360 gamepad was rated in between.

A statistically significant difference between the mouse and keyboard (M=1,5 & 1,5) and the eye tracker (M=4,3 & 4,2) was discovered in the first session (t(5)=1,89, p=0,005) and in the second session (t(5)=1,59; p=0,00005). In the second session, the difference between the mouse and keyboard and the Xbox360 gamepad (M=3,7) was statistically significant (t(5)=1,6; p=0,015). Figure 21 displays the averages of results of question 1 “control difficulty”.

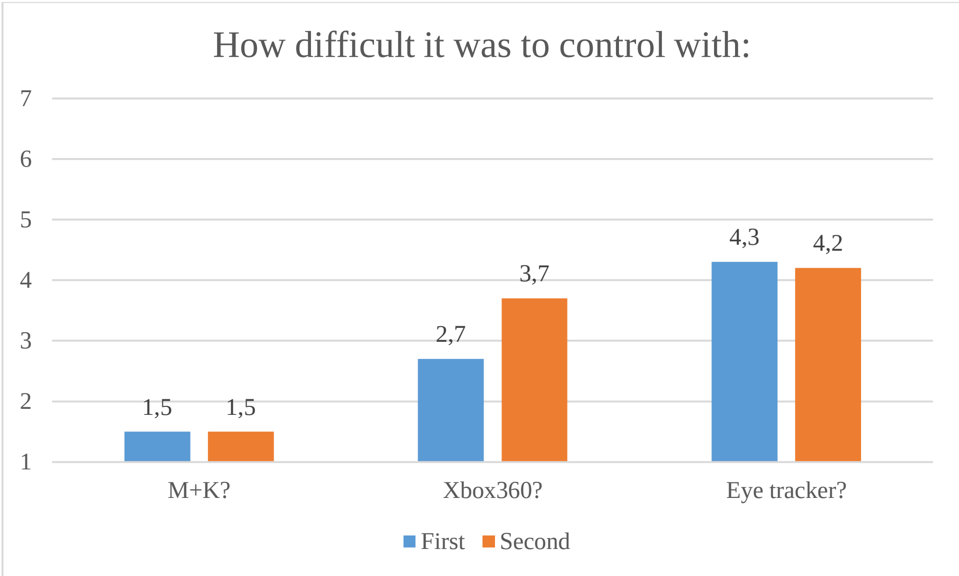

Figure 21 - Question 1 averages from both sessions.

Question 5 measured how hard the participants felt the game was to control with the input devices, comparing to their best level. In the second session, the difference between the mouse and keyboard (M=1,8) and the eye tracker (M=4,8) was statistically significant (t(5)=1,77; p=0,0001), as well as the difference between the Xbox360 gamepad (M=3,3) and the eye tracker (t(5)=1,47; p=0,017). Figure 22 shows the averages of results of question 5 “challenge of control” from both sessions.

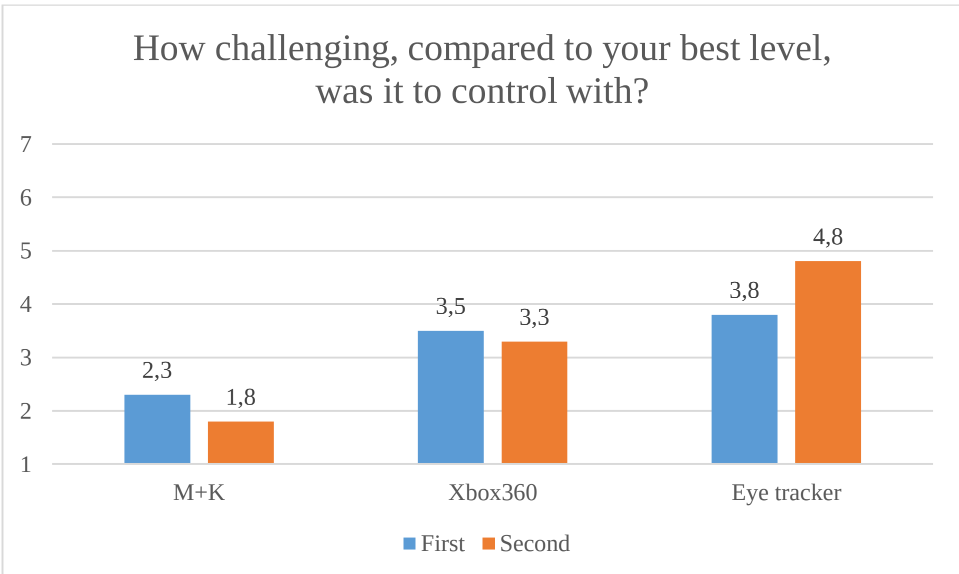

Figure 22 - Question 5 averages from both sessions.

The results of question 12 show that the participants felt the most natural way to play was to play with the mouse and keyboard. In first session, the difference between the mouse and keyboard (M=6,0 & M=6,3) and the eye tracker (M=4,7 & M=4,8) was statistically significant (t(5)=1,85; p=0,025), as well as in the second session (t(5)=1,04; p=0,007). In the second session, the difference between the mouse and keyboard and the Xbox360 gamepad (M=4,7) was statistically significant as well (t(5)=1,86; p=0,03). Figure 23 shows the averages of results of question 12 ”how natural to control” from both sessions.

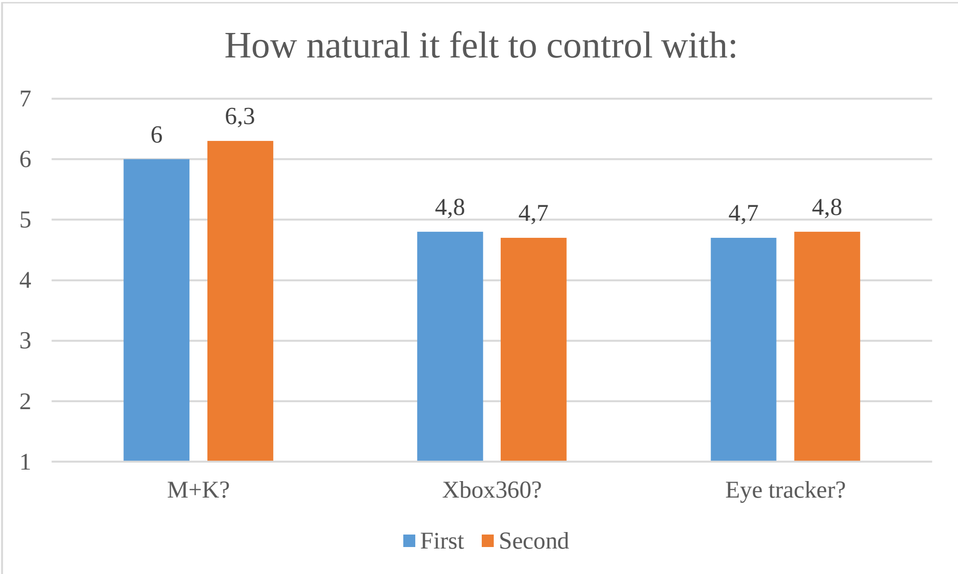

Figure 23 - Question 12 averages from both sessions.

4.8. First session’s thinking aloud

When using the thinking aloud method there were signs that participants had the same type of difficulties with eye tracker game controls. Two of the six participants had problems with shooting the targets from afar and only one person said it was easy. The following comments were given: “I feel like I can’t hit any of the more distant targets”, “Shooting from a distance is difficult.” The majority of the participants gave positive comments about changing the field of view with eye gaze.

The strafing mechanism was also mentioned difficult to use and two participants would have liked the strafing to be as fast as moving forward or backwards. Only one participant said that he/she liked the strafing mechanism, “it’s easier to avoid getting stuck on trees”.

Two participants mentioned that moving forward or backwards was difficult. The following comments were made: ”The character moves too fast when I lean my head forward” and “It feels like the character moves too fast”.

Half of the participants would have liked a bigger “dead spot” – the spot where character stays still without moving.

4.9. Second session thinking aloud

During the second session, it appeared that the participants had caught on how to better use the controls while playing with the eye tracker. For example the following comments were given: “This is much easier than the first time I played it”, “I got a hang on shooting” and “I feel like the character moves better this time.” No changes were made to the game’s code or to the experiment’s setup. The better feeling in controls and movements was most likely result from the participants being more familiar with the game and the inputs.

4.10. Comments from the first session

In this chapter and in the following chapter 4.11., the comments that participants gave are presented. The comments have been collected from the concluding interviews and from the post-test questionnaire’s Comments-fields (see: Appendix D&E). The concluding interview was verbal and the experimenter wrote down the comments. The interview included a few open-ended questions, e.g. “What is your overall feeling after the experiment?” After asking one or two questions, the conversation was no longer bounded by them and it turned into a more casual talk.

Five of the six participants felt like the eye tracker experiment went fast. Three of the six participants commented that it was difficult to move the character around with the eye tracker input. All six participants commented that shooting was as easy as or easier than moving the character. Five of the six participants commented that it was hard to shoot a faraway target.

All six participants commented that using the eye tracker input got easier in the second session. One of the six participants would have liked the possibility to invert his/her Xbox360 gamepad and mouse. One of the participants stated that he/she felt there were too many input commands for eyes to handle and a fewer amount would have been sufficient.

4.11. Comments from the second session

One of the participants mentioned that it was not that important to move accurately in the game area since the targets appeared randomly – therefore only aiming requested accuracy. Two of the participants mentioned that shooting made their eyes tired and that a five minute session was already enough time to make the eyes tired.

One of the participants felt like the sideways movement was too slow. Another participant mentioned a similar issue: he/she felt moving his/her head was difficult to combine with moving his/her eyes at the same time since the character moved due to both head and eye movements and sometimes made unwanted moves.

5. Discussion

The experiment results show that playing with an eye tracker may increase immersion in some levels. However, there was no clear sign whether an eye tracker was a more immersive input mechanism than the other inputs.

It has to be taken into account that using the leaning technique and the thinking aloud method may have effected participants' gameplay experiences. Previous studies, e.g. the ones presented in this study, have not used the same particular technique and method combined.

In the first session, all the participants used the eye tracker for the first time and most of them were excited. In the second session, the devolution of excitement showed in the results. It can be seen especially within the results of question 10, which was: "To what extend did you lose track of time?" In the first session, participants felt that they lost track of time most when they were playing with the eye tracker and the average of the results for the eye tracker was 5,7 on the 1 to 7 scale. In the second session, the average of results for the eye tracker was only 4 and for example, the mouse and keyboard input had a higher average, 4,2.

Some similarities, regarding the immersion results discovered in the study, can be found when compared with Smith and Graham's [2006] results. Smith and Graham [2006] found out via questionnaire that most of the participants felt more immersed in the game's virtual environment when using the eye tracker than using the mouse and keyboard (see: Table 1). However, their questionnaire was used to indicate preference of which input device, the eye tracker or the mouse was preferred over the other, when in this study, a scale from 1 to 7 was used.

When contemplating the results from question 6, it can be seen that the eye tracker input was rated the most fun way to play and the results resemble Jönsson's [2005] study. Jönsson [2005] discovered through a questionnaire (scale ranging from 1 to 7) that all of the participants regarded playing Sacrifice with the eye tracker to be more fun (M=5,9) when compared to the mouse (M=2,5) and five of eight participants rated playing Half Life with the eye tracker (M=5,1) to be more fun than with the mouse (M=4,1).

The results on fun could also relate to the novelty factor since none of the participants had previously played video games with an eye tracker. There was a slight decrease in the results in the second session, from 6,3 (the first session average) to 5,8 (the second session average).

When studying the comments and the findings of the thinking aloud method, there was an implication that in the second session, couple of the participants thought that playing with the eye tracker was not as fun as it was in the first session. Additionally, some of the participants mentioned that they were immersed more easily and some participants did not feel immersed at all with any of the input devices. Some of the participants said that changing the field of view with an eye tracker resulted in them to be more immersed when playing the game. It could have resulted from the feeling that the participant felt actually being in the game world – since the view changed the same way as in real world.

Isokoski *et al.* [2009] reflected that over time novice players' opinions and skills may shift when playing with an eye tracker. This study suggests that it may be so. All of the participants of this study were first time users of an eye tracker. The immersion results of the experiment were lower in all questions (3, 9, 10, and 11) in the second session when comparing both sessions. The participants felt that they performed better in the second session when playing with the eye tracker. During the second session, the participants were of the opinion that it was easier to control with the eye tracker (question 1) and that they were more precise (question 4) than in the first session.

When comparing the results from question 5 "challenge of controlling" between the two sessions, the results indicated that the participants may have realized that controlling the character with the eye tracker was actually more challenging than they initially thought. In the second session, the participants evaluated the eye tracker to be more challenging, when comparing it to their best level performance. The foregoing also supports the thought Isokoski *et al.* [2009] had.

In this study, the mouse and keyboard as an input device was considered more easy to use than the eye tracker or the Xbox360 gamepad. Smith and Graham [2006] discovered also in their study that participants felt that mouse (and keyboard) was easier to use than the eye tracker. It may be, as all of the participants were familiar with the mouse and keyboard as an input device and all of them were first time eye tracker users.

The participants would have preferred to play the game again with the eye tracker (question 13). It may be because the eye tracker as an input device was something new to them.

When studying the comments and the findings of the thinking aloud method, there was an implication that some of the participants would have liked faster or slower character movement speed when playing with the eye tracker. The preferred movement speed differed among the participants. A possible solution could be that the participant would be able to adjust the movement speed to the speed which he/she preferred.

Limitations

It has to be taken into account that the sample size was small and quite homogenous – every participant was considerably young and had previously played FPS games. Therefore, further testing with bigger sample size with a more variable age and gender distribution could result in different results on immersion. Further testing could also help to determine whether there were too many commands for eyes or was the amount of commands reasonable.

6. Conclusions

The research in question shows that using an eye tracker input to play an FPS game could be more fun than using more traditional input devices, in this case mouse and keyboard and an Xbox360 gamepad.

There was no clear indication that applying the eye tracker input would make participants more immersed than using other input devices.

There was some indication of the fact that participant would prefer playing again with the eye tracker input rather than other input devices.

Similar study, which would contain a longer-lasting experiment featuring more than two sessions, could be conducted to see if the participants loose interest or not with the eye tracker input.

Future work

Conclusion is that to draw conclusions further testing with more participants would be required. Further testing could conclusively determine whether playing with the eye tracker input is more fun, more immersive, and whether users would prefer to play again with it instead of the more traditional inputs.

This study aligned with the previous studies conducted on eye tracking and immersion, e. g. with the study carried out by Smith and Graham [2006]. It indicated that using an eye tracker was more fun than using the more conventional input devices, which could give a reason to explore further possibilities with eye tracking in games. This study's results suggest that it could be meaningful to develop a more refined and targeted version of a setup to play FPS games.

The setup, the characteristics of which would be drawn from the results of this study, could utilize an eye tracker input to control e.g. the actions that do not require sub-pixel accuracy. The participants of the study's experiment liked e. g. the option to change the field of view with the eye tracker and also, considered the eye tracker to be the most fun way to play the game. Therefore, the eye tracker could be in charge of changing the field of view in the future setup. The setup would preferably also integrate other input devices, e.g. the mouse and keyboard, to control actions that require more accurate control and as a result, are difficult to control with the eye tracker. The setup that combines the good qualities of different input devices, could be immersive and still as easy to control as a singular input device, e.g. the mouse and keyboard input.

Future studies on the topic could incorporate conducting the experiments in different environmental contexts, preferably in participants' homes since laboratory environment could cause the participant to not be as relaxed as he/she would be in his/her normal gaming environment.

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Appendix A

Participant information and consent form
Gaze controlled game, fall 2015

Investigator: Mika Suokas (mika.suokas87@gmail.com)

Introduction

You have been invited to participate in an experiment on gaze control. It is your choice whether to participate in this study or not. This form explains what participating entails so that you can make an informed decision.

Purpose of the study

I want to know whether gaze control in First Person Shooter (FPS) game is more fun or immersive than the mouse and keyboard combination or an Xbox360 controller. To accomplish this participant is to play the same game with these three input devices.

Who can participate?

The participants' skill in English language must be sufficient enough to answer questionnaires in the English language. Some eye glasses or contact lenses may make it difficult for the eye tracker to see where the eyes are pointing.

Procedure

After arriving at the laboratory, the participants will be asked to fill in this form and a background information questionnaire. The eye tracker will be calibrated, and the calibration quality will be measured. After that the participant will play an FPS game with three different setups. At the end there will be another questionnaire about the game controls.

Data handling

Only the experimenter will know the identity of the participants. All data will be stored separately from the participant names using anonymous codes to identify individuals. The research will be reported in Master's thesis without identifying the participants. If other researchers request to see the data to verify the results, only anonymous data will be delivered.

Risks and benefits for a participant

The experiment will be as safe as any other instance of using a desktop computer for gaming. No unusual risks are involved. The eye tracker uses infrared light that is invisible to the human eye to illuminate the eyes while tracking. In comparison to the infrared radiation from the sun on a sunny day, for example the intensity of the used light is very low and poses no risk for safety. For individuals with tendency for epileptic seizures due to game graphics or to simulator sickness (nausea or head ache similar to motion sickness) participation is not recommended. All participants are free to stop participating in the experiment at any time for any reason.

Further information

The experimenter will be happy to answer questions regarding the experiment.

Consent to participate

I have read and understood this document and decided to participate in this experiment.

Date: ________________________

Name (print): ________________________

Signature: ________________________

Appendix B

Welcome!

This experiment is anonymous and you can quit at any point if you want. In some cases playing games might cause light-headiness so please let the experimenter to know if you are not feeling well.

Experiment

1. Pretest questionnaire
2. Demonstration of eye-tracking
3. Calibration
4. Calibration quality measurement
5. Device 1
6. Device 2
7. Device 3
8. Post-test questionnaire
9. Interview, discussion

Thank you for your participation!
Mika Suokas

Appendix C

Pretest Questionnaire

Fill in questionnaire and give it to experimenter when you are ready.

Gender

[ ] Male [ ] Female

Age:____

How often do you use a computer?

[ ] I don’t use computers [ ] Sometimes [ ] Daily

How often do you play video games?

[ ] I don’t play video games [ ] Sometimes [ ] Daily

Which platform(s) do you use for playing games?

[ ] PC/Mac [ ] Console e.g. Playstation [ ] Something else [ ] I don’t play video games

Have you heard about gaze controlled interaction?

[ ] Yes [ ] No

If yes, how and have you used it in some way?

Appendix D

Post-test Questionnaire

Questions in this questionnaire about your experiences in the PenguinHunt. Control with eyes, mouse and keyboard and an Xbox360 controller are separated. The scale is 1-7 where 1 = little and 7 = a lot. Fill the questionnaire and give it to experimenter after finishing.

1. How difficult it was to control with:

   Eyes?
   Not at all 1 2 3 4 5 6 7 Very
   Comments:

2. How natural it felt to change the field of view when you controlled view with:
   Eyes?
   Not at all 1 2 3 4 5 6 7 Very
   Comments:

3. How engaged to the game you felt when you controlled with:

   Eyes?
   Not at all 1 2 3 4 5 6 7 Very
   Comments:

4. How precise you felt when you were controlling with:

   Eyes?
   Not at all 1 2 3 4 5 6 7 Very
   Comments:

5. How challenging, compared to your best level, was it to control with:

   Eyes?
   Not at all 1 2 3 4 5 6 7 Very
   Comments:

6. How fun it was to control with:

   Eyes?
   Not fun 1 2 3 4 5 6 7 Very
   Comments:

7. How much in control you felt when you controlled with:

   Eyes?
   Not at all 1 2 3 4 5 6 7 Very
   Comments:

8. How irritating it was to control with:

   Eyes?
   Not at all 1 2 3 4 5 6 7 Very
   Comments:

9. Did you feel consciously aware of being in the real world whilst playing the game?

   Not at all 1 2 3 4 5 6 7 Very much so
   Comments:

10. To what extent did you lose track of time?

    Not at all 1 2 3 4 5 6 7 A lot
    Comments:

11. To what extent were you aware of your surroundings?

    Not at all 1 2 3 4 5 6 7 Very much so
    Comments:

12. How natural it felt to control with:

    Eyes?

Not at all 1 2 3 4 5 6 7 Very
Comments:

13. How much would you like to play the game again with:

Eyes?
Don’t want to 1 2 3 4 5 6 7 Very
Comments:

Appendix E

Post-test Questionnaire

Questions in this questionnaire about your experiences in the PenguinHunt. Control with with eyes, mouse and keyboard and an Xbox360 controller are separated. The scale is 1-7 where 1 = little and 7 = a lot. Fill the questionnaire and give it to experimenter after finishing.

1. How difficult it was to control with:

Eyes?	Mouse keyboard?	Xbox?
1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7

Comments:

2. How natural it felt to change the field of view when you controlled view with:

Eyes?	Mouse keyboard?	Xbox?
1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7

Comments:

3. How engaged to the game you felt when you controlled with:

Eyes?	Mouse keyboard?	Xbox?
1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7

Comments:

4. How precise you felt when you were controlling with:

Eyes?	Mouse keyboard?	Xbox?
1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7

Comments:

5. How challenging, compared to your best level, was it to control with:

Eyes?	Mouse keyboard?	Xbox?
1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7

Comments:

6. How fun it was to control with:

Eyes?	Mouse keyboard?	Xbox?
1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7

Comments:

7. How much in control you felt when you controlled with:

Eyes?	Mouse keyboard?	Xbox?
1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7

Comments:

8. How irritating it was to control with:

Eyes?	Mouse keyboard?	Xbox?
1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7

Comments:

9. Did you feel consciously aware of being in the real world whilst playing the game?

   Eyes
   Not at all 1 2 3 4 5 6 7 Very much so
   Mouse and keyboard
   Not at all 1 2 3 4 5 6 7 Very much so
   Xbox?
   Not at all 1 2 3 4 5 6 7 Very much so
   Comments:

10. To what extent did you lose track of time?

    Eyes
    Not at all 1 2 3 4 5 6 7 A lot
    Mouse and keyboard
    Not at all 1 2 3 4 5 6 7 A lot
    Xbox
    Not at all 1 2 3 4 5 6 7 A lot
    Comments:

11. To what extent were you aware of your surroundings?

Eyes

Not at all 1 2 3 4 5 6 7 Very much so

Mouse and keyboard

Not at all 1 2 3 4 5 6 7 Very much so

Xbox

Not at all 1 2 3 4 5 6 7 Very much so

Comments:

12. How natural it felt to control with:

Eyes?	Mouse keyboard?	Xbox?
1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7

Comments:

13. How much would you like to play again with:

Eyes?	Mouse keyboard?	Xbox?
1 2 3 4 5 6 7	1 2 3 4 5 6 7	1 2 3 4 5 6 7

Comments: