University of Bergen

Faculty of Social Sciences

Department of Information Science and Media Studies

Master Thesis

Use of Eye Tracking for eSports Analytics in a MOBA Game

Author: Gry Leirgulen Nagel
Supervisor: Barbara Wasson

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Abstract

Eye tracking refers to using the movement of the eye to determine where the user is looking (Zhang, 2008). This thesis will look at the use of eye tracking within a Multiplayer Online Battle Arena game (MOBA) and investigate its utility in analyzing gameplay. An application has been developed to gather eye tracking data, and by employing data source triangulation this data is used together with replays and statistics to understand gameplay. Findings reveal that eye tracking can add value, but it is time consuming to use a manual triangulation method of analysis, in particular using the video replay. Furthermore, while the research finds that the data from the eye tracking application is interesting and potentially useful, it is necessary to carry out more experiments with more players and more games to find its full potential.

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Gry Leirgulen Nagel

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Glossary

Eye tracking: using the movement of the eye to determine where the user is looking (Zhang, 2008).

eSports: refers to "situations where computer games are played competitively" (Schubert, Drachen, & Mahlmann, 2016).

MOBA: Multiplayer online battle arena (MOBA) is a game genre in which two teams compete against each other on a single battleground (Niedhardt, Huang, & Contractor, 2015).

Battleground: the environment (map) that a game takes place

Lane: a lane is one of the main paths on the battleground. Battlegrounds in Heroes of the Storm has two or three lanes.

Experience: experience is a measurement unit. Experience is gathered by killing enemy minions, enemies or doing objectives. When the experience reaches a certain point the team will gain a new level.

Hero: a hero is a playable character.

Spawn: come to life or when an objective begins.

Death timer: the death timer is how long it takes for a hero to return to battle after a death. The death timer increases the longer a game lasts.

Mount: in Heroes of the Storm players can use a mount to move faster across the battleground.

Pings: pings are a way to issue information quick to your team. A ping will show up on the mini-map, create a sound and add text to the chat box.

Talents: in Heroes of the Storm players can choose talents when they level up to specific levels (1, 4, 7, 10, 13, 16 and 20). Talents can improve talents or the hero's trait or add new talents.

Questing talent: talent that require the player to complete a certain task to unlock the full potential.

Mercenary camp: monsters that players can kill and capture that will push one of the enemy's lanes.

Soak: to soak a lane means to stay in range of dying minions to get experience.

Objective: battleground mechanic that gives the winning team an advantage.

1 Introduction

eSports has grown to be very popular both for players and viewers (Schubert et al., 2016). Professional players can earn millions of dollars in prices, and eSports has become a crucial part of youth culture. With a growing popularity the teams face higher competition and new ways of improving and understanding gameplay can be explored.

The first attempts trying to figure out how the human eyes works by eye tracking can be traced back to 1792 (Thite & Brown, 2015). Recent years eye tracking has become more accessible and affordable for the general public with products like the SteelSeries Sentry eye tracker (Tamburro, 2015) or Acer's new monitors with built in eye tracking (Miller, 2016).

1.1 Motivation

Work on this thesis is motivated by the curiosity that occurred when trying eye tracking for the first time. Several options using eye tracking were suggested before deciding to use eye tracking to gather data from MOBA games.

1.2 Research Questions

The main goal of this study is to experiment with eye tracking and game data to find out which data can be interesting for game analysis.

1. Is it possible to gather eye tracking data in multiplayer online battle arena (MOBA) games?
2. Does eye tracking data add value in gameplay analysis in MOBA games?

The research was focused on answering these questions as eye tracking is not commonly used as a training tool in electronic sports, this research looks if it is possible to use eye tracking for players or coaches to gain a deeper insight into to where a player is focusing, and finding areas upon which the player can improve. The answer to these questions is given by analyzing gameplay is analyzed to identify specific episodes in which eye tracking data can be useful as a training tool and suggestions as to how eye tracking can be used to add additional value to improving eSports players' performances in MOBA games, and for use as a tool for training gameplay.

1.3 Thesis Contents

The thesis is organized into 8 chapters and the following is an outline of the thesis.

Chapter 2: *Background* introduces the fields of eye tracking, eSports and the game used in this study.

Chapter 3: Method describes the research methods used in this study.

Chapter 4: The eye tracking application gives an overview of the application developed to conduct the study.

Chapter 5: Empirical study describes the implementation of the study.

Chapter 6: Analysis includes analysis of the data sets that was generated in the study.

Chapter 7: *Discussion* includes a discussion about the study and the data gathered.

Chapter 8: Conclusion presents the results and conclusions of the research.

2 Background

This chapter provides the background for the research. First the technique and field of eye tracking is introduced. Then the videogame to which eye tracking will be added is described. The chapter ends by giving examples of eSports analytics.

2.1 Eye Tracking

Eye tracking refers to using the movement of the eye to determine where the user is looking (Zhang, 2008). Eye tracking can be used as input on a computer as a "pointer" on the screen to allow users to interact with it. Eye tracking can also be used in research to determine where an individual is looking at any given time to help HCI researchers to analyze visual and display-based information processing (Poole & Ball, 2005). Commercial eye tracking vendor Tobii claim that eye trackers can determine your presence, attention, focus, drowsiness, consciousness or other mental states (Tobii, 2015a).

2.1.1 Anatomy of the Eye

The human eye detects light and can perceive color, shape and depth by using the visual cortex (Zhang, 2008). Figure 2.1 shows the basic anatomy of the eye. When light enters the eye through the cornea bends the light to enable the rays to freely pass through the pupil (National Keratoconus Foundation, 2015). The cornea is a clear mass that covers the eye and works as a clear window. The pupil is the opening in the center of the iris. The iris can enlarge or shrink based on the amount of light that is entering the pupil and it works like a shutter in a camera. After the light has passed through the iris, the light rays go through the eyes lens which shorten or lengthens to be able to focus the light rays properly. The light then passes through the vitreous, which fills the globe of the eyeball and helps it keep the right shape. The retina processes the light into light impulses through nerve endings and sends them to the optic nerve.

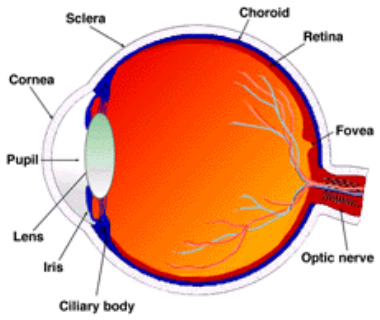


Figure 2.1: Sagittal section of the adult human eye (Kolb, 2012)

2.1.2 The Evolution of Eye Tracking

Studies on eye tracking are dated as far back as 1792, where Wells used visual observations to understand movements of the eyes (Thite & Brown, 2015). In 1879, Javal used mirrors to examine subjects while reading. He saw eye movements as series of jerks (Richardson & Spivey, 2004). Javal counted the jerks by placing microphone on a closed eyelid to record the number of jerk movements the eye performed while the subject was reading. In 1897, the first recorded eye movements were recorded by Delbarre (1898), when he fixed used a plaster-of-Paris and a lever to record eye movements. Edmund Huey improved this method by using a surface covered by black powdery substance to record the eye movement (Thite & Brown, 2015). Dodge and Cline used a non-invasive method to record reflections from the cornea of the eye in 1901 (Jacob & Karn, 2003). The subject had to remain motionless for the method to work, but it could show both horizontal eye motion and the time used. Buswell (1935) and others had a breakthrough in 1930 when they were able to record eye movements to a film reel. Jung used a technique in 1939 that could process real-time gaze data by applying electrodes to the skin closest to a subject's eye (Singh & Singh, 2012). Fitts, Jones and Milton (1950) saw an opportunity to use eye tracking in 1947 by recording a pilot's eye movements during airplane landing and they could use this data to find the best placement of instruments inside the cockpit. A year later the first head-mounted eye tracker was invented by Hartridge and Thompson (1948). In the 1980s, computers got improved specifications, which led to the possibility to do real-time eye tracking. Today several eye trackers are available, not only for researchers but also for the community marked. Much of the advancement today regarding eye tracking in the current state is the balance between allowing the user to move their head and body freely while obtaining a high-precision record of an observer's point-of-regard (Richardson & Spivey, 2004).

2.1.3 How the Eye Tracker Works

Several different methods have been used to track eye movements. Today, most commercial eye trackers use a "corneal-reflection/pupil-center" method (Poole & Ball, 2005), which by using an infrared camera enables a computer to track the eye's movements through an image processing service.

Figure 2.2 is a simple explanation of how the Tobii (2015b) eye trackers work. By connecting an eye tracker to the computer the eye will reflect a pattern of near infrared light, which is seen by the camera. The eye tracker then uses algorithms to calculate both the position of the eyes and gaze point on a computer screen.

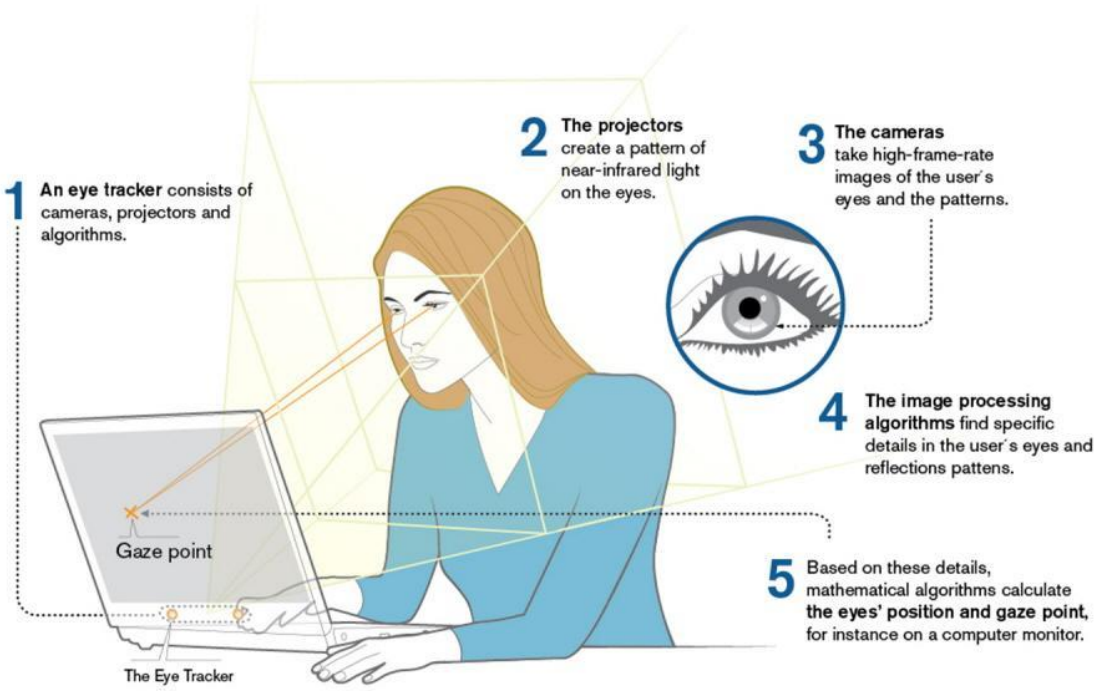


Figure 2.2: How Eye Tracking works (Tobii, 2015c)

The infrared light used in most eye tracking systems is reflected in the eye to make them easier to track (Poole & Ball, 2005). The eye then reflects the light back to the tracker and makes the pupil appear bright. The infrared light also causes a reflection in the cornea that can be used to calculate the position of the light and the eye tracker can determine where you are looking on the screen. Figure 2.3 shows how the reflection can be used to determine where the eye is looking. To be able to use a video-based eye tracker each person must go through a calibration process where the user looks at a 9- to 13-grid point-pattern, and the computer collects the data and calibrates the eye tracker according to your eyes.

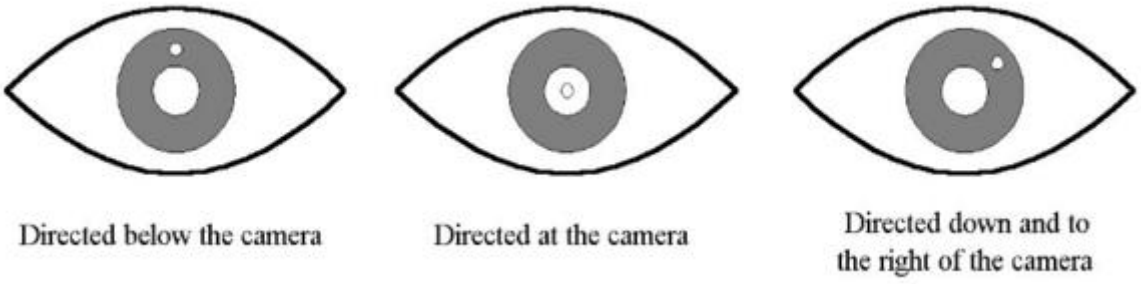


Figure 2.3: Figure 3 Corneal reflection changing according to point of regard (Poole & Ball, 2005)

2.1.4 Areas of Use

Eye tracking can be used as an input device to control computers in place of a traditional mouse and keyboard. Zhang (2008) claims that the use of an eye tracker as a pointer and a button for choosing can be faster than using a mouse. When using a mouse, the user has to scan the area to find the object they are looking for, then move the mouse to the correct area and click a button to select. When using an eye tracker, the user locates the intended target by looking at it, and can immediately follow up with a selection by either gazing at the object or pressing a button. Some eye trackers might also support a head movement or blinks as a selection method. This input method is especially useful for people with disabilities, where an eye tracker can be the only source of communicating with other people.

Eye tracking can also be used for market research and advertise testing (Drewes, 2010). The eye tracker can see if a person looked at a product or how much time he or she used to look at the company logo.

In the field of usability, eye tracking studies can be helpful when designing interfaces and information placement by analyzing where people look. The designer develops an understanding the user's behavior enabling them to enhance the user experience.

Eye trackers are being used to study the cognitive, perceptual, and social-emotional development of children from infant to early-adulthood (Tobii, 2015a). Eye tracking is also used in different fields of psychology and neuroscience to gain a better understanding of how and why we move our eyes and how we gather information. By analyzing eye movement, information researchers are also trying to accurately identify disease and disorders.

There are portable eye trackers that can be used for gaining a better understanding of where people look and fixate. By using a portable eye tracker, human performance can be analyzed. Martin, Cegarra and Averty (2011) used an eye tracker to analyze the mental workload during air control trafficking tasks. To understand where successful and less successful people look during tasks enables better training techniques and understanding of the task.

An eye tracker can also be used to improve education and learning processes. Slykhuis, Wiebe, & Annetta (2005) used eye trackers to study the attention students pay to photographs in a PowerPoint during science education.

Eye tracking can also be used for entertainment. The first triple-A game featuring eye tracking was Assassins Creed ® Rogue PC game (Tobii, 2015d). The eye tracker is used as an extension of the screen to allow the user to move the screen to where the user looks. Fove (2015) is developing the world's first VR-headset with eye tracking and claims that the user will be able to aim with their eyes, focus the vision, make eye contact with other characters, and move naturally within a virtual world.

2.2 eSports

Competitive computer gaming, also known as eSports, "is an arena of sport activities in which people develop and train mental or physical abilities in the use of information and communication technologies" (Wagner, 2006). eSports refers to "situations where computer games are played competitively" (Schubert et al., 2016). eSports has become a million-dollar industry and one of the biggest eSports events in 2016, The International, offered over $20,000,000 USD in prizes (Valve, 2016). Figure 2.4 shows a graph of eSports prize money per game per year.

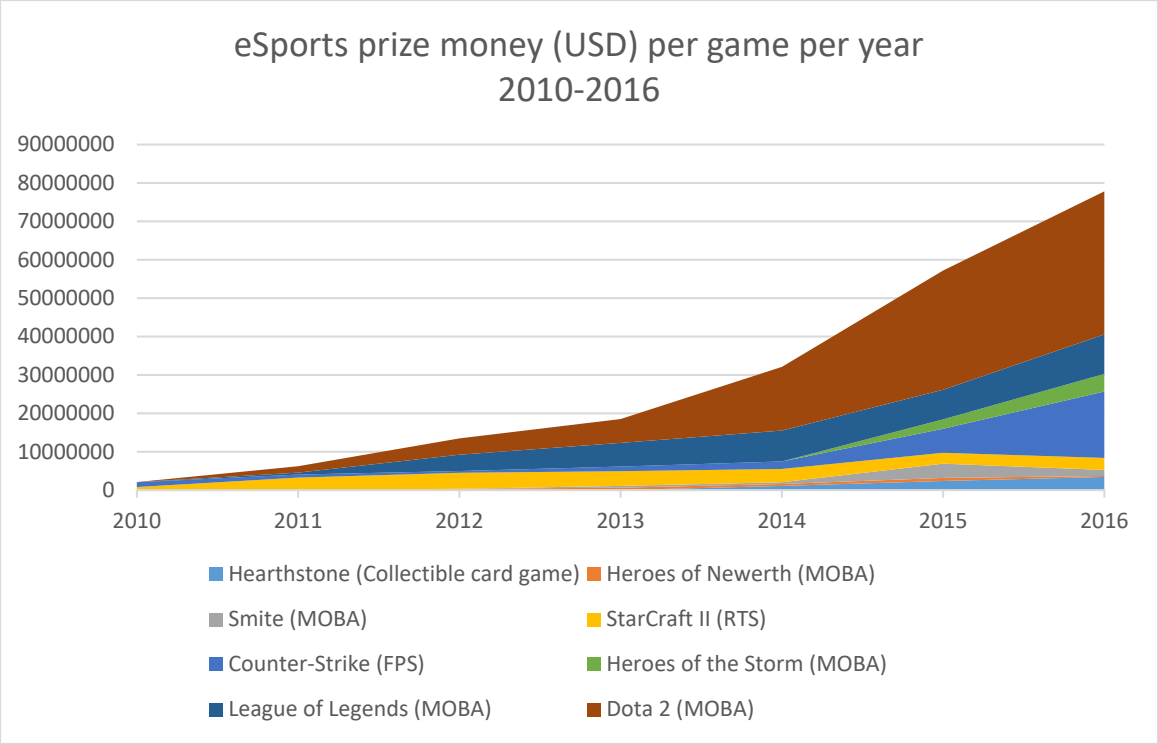


Figure 2.4: eSports prize money per game per year. Data gathered from esportsearnings.com (2016)

Multiplayer online battle arena (MOBA) is a game genre in which two teams compete against each other on a single battleground (Niedhardt et al., 2015). MOBA titles include League of Legend (Riot Games, 2009), Dota 2 (Valve Corporation, 2013) and Heroes of the Storm (Blizzard Entertainment, 2015a), and in 2016 these three games occupied three of the top four spots in tournament prize money (esportsearnings.com, 2016). In this thesis Heroes of the Storm will be used because it is a game which is easy to learn but hard to master (Kuchera, 2014). The game is less focused on micro managing heroes and more focused on team play.

2.3 Heroes of the Storm

Heroes of the Storm (HotS) is a MOBA created by Blizzard Entertainment (IGN, 2015). The game was released in 2015 on Windows and OS X (IGN, 2015). The game revolves around 5-versus-5 matches. The games last from 15-25 minutes and ends when one team destroys the enemy team's core. The gameplay consists of killing enemy heroes, non-playable characters, destroy forts and towers and by doing so your team gains experience points that make your heroes stronger.

The game currently has 55 heroes in four different roles: warrior, support, assassin, and specialist. Table 2.1 describes the different roles.

Table 2.1: Hero roles in Heroes of the Storm (Blizzard Entertainment, 2016p).

Hero role	Definition
Warrior 	"First in, last out" Warriors traditionally have high health totals or self-healing. They don't do the best damage, are melee characters and often have crowd control.
Support 	"Like a rock" Assassins are all about killing things. They don't usually have a lot of health, but they do large amounts of damage.
Assassin 	"Bring the pain" Support characters have the task of keeping the team alive. They usually don't do much damage, but they have strong healing capabilities.
Specialist 	"Unconventional warfare" Specialists are a unique category in Heroes of the Storm, and it includes a diverse pool of heroes. The most common element among the heroes is that they have the ability to push lanes and do a lot of siege damage. Beyond that they are very different and rarely have the same playstyle.

When a game begins each hero has three standard abilities and all heroes also have a trait. Some traits might be active, which means that the player must press a button to use it, while others have passive traits. A fourth ability, the heroic ability, is available when a team reaches level 10. Some heroes might have more abilities available for example the hero Xul begins the game with a shield as a fourth ability. The assassin Tracer begins the game with her heroic talent, but can upgrade it when she reaches level 10. At levels 1, 4, 7, 10, 13, 16 and 20 each player can choose a new talent which might add another ability or upgrade an existing one.

The different hero roles have different playstyles and strategies. A team usually comprises one healer, one warrior, and three specialists or assassins, but with continuous updates and balancing of the heroes and battlegrounds, team compositions may vary.

HotS has several different maps (battlegrounds) that each have different objectives which help the team to reach the ultimate task of killing the core. For example, on the battleground "Infernal Shrines" the battleground objective is to kill 30 guardians on one of three shrines (Blizzard Entertainment, 2016i). The

shrines spawn one at the time and the first shrine spawns[1] two minutes into the game. When a shrine spawns one player must click on the shrine to start the objective. When one team kills 30 guardians a Punisher will spawn and help the winning team to push a lane. The punisher focuses on attacking the heroes on the enemy team. Figure 2.5 shows a map of the battleground "Infernal Shines" and a timeline that roughly outlines a normal game played on this map.

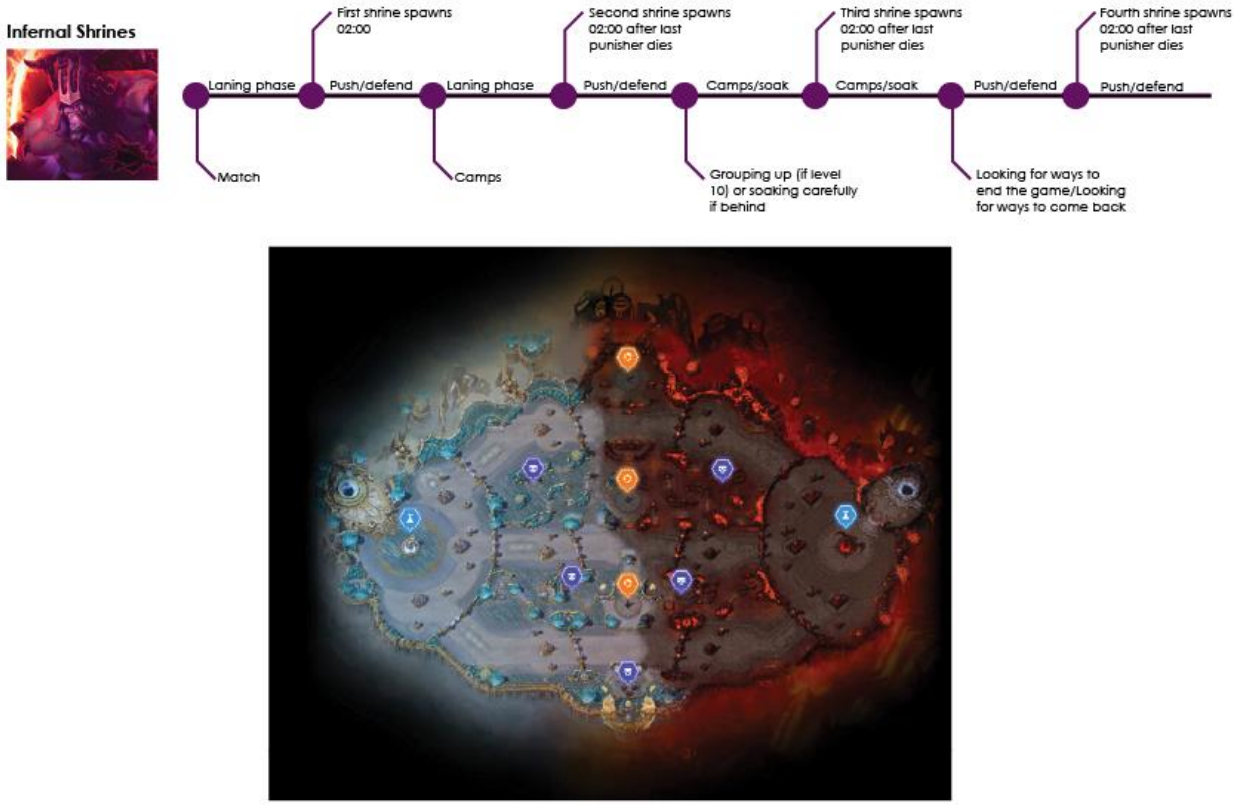


Figure 2.5: Infernal Shrines map and typical gameplay

There are currently 12 different battlegrounds in the game, including Infernal Shines. The battlegrounds are listed in table 2.2.

[1] Spawn means come to life and may be used when heroes comes to life or objects are available.

Table 2.2: Overview of battlegrounds in Heroes of the Storm (Blizzard Entertainment, 2016a)

Battleground	Number of lanes	Objective(s)	Advantages gained by completing objective
Towers of Doom	3	Channel shrines, kill the boss or escort camps to attack the enemies core. There is no way for heroes to attack the core itself.	Shots to the enemy core
Infernal shrines	3	Kill 30 guardians when a shrine spawns.	Punisher (monster) that attacks heroes and structures.
Battlefield of Eternity	2	Two Immortals spawns in the middle of the map. Kill the enemies Immortal before they kill yours.	Immortal that does damage to structures in a single lane
Tomb of the Spider Queen	3	Gather gems that drops from enemy minions and heroes when they die.	Turn in gems to get Webweavers that spawn in all three lanes.
Sky Temple	3	Stand on a shrine and defeat the shrines guardians-	Laser beams that does structure damage.
Garden of Terror	3	Kill terrors and collect seeds.	Controllable Garden terror that does structure damage.
Blackheart's Bay	3	Collect coins from chest that spawn or camps and deliver them to Captain Blackheart.	Cannonballs that does damage to enemy structures.
Dragon Shire	3	Stand on a shrine to channel it for your team. Get both shrines on the same time and channel the Dragon Knight.	Controllable Dragon Knight that does structure damage.
Haunted mines	2	Gather sculls.	When all sculls are collected a Grave Golem spawns. The team that gathered most sculls gets the most powerful Grave Golem.
Cursed Hollow	3	Gather three of the Raven Lord's Tributes.	Enemy team gets cursed. Cursed forts will not attack, and enemy minions are reduced to 1 health.
Braxis Holdout	2	Capture both beacons at the same time to fill your Holding Cell with Zerg. The Holding Cell will open once one of the teams reaches 100%.	Zerg wave that pushes one of the two lanes. The team with the most filled holding cell will get the most powerful Zergs.
Warhead Junction	3	Gather Warheads.	Warheads that can be channeled to nuke enemy structures.

Alan Dabri, is a senior developer for Blizzard Entertainment, and Chris Sigaty, the lead producer of Starcraft II (2010) created a video for IGN (2015) where they summed up some of the most important aspects of

Heroes of the Storm. They identified the following points as the most important strategies for new players to follow:

1. The tutorial is your friend.
    a. The tutorial is an introduction to the Heroes of the Storm that you need to play the first time you start the game. It introduces the controls and basic mechanics.

2. It's a little different
    a. Heroes of the Storm is different than other MOBAs in that there are several battlegrounds and a team shared experience.

3. Focus on one character
    a. Dabri and Sigaty recommended to focus on one character when learning the game.

4. Situational awareness matters (be aware of positioning and mini-map).
    a. This means that players should be aware of their positioning and the mini-map. Warriors should be in front to block enemies from coming into the backline while an assassin should move around according to the other team. They also warned players from chasing down a low health character on the enemy team to avoid getting into a disadvantaged position. For more advanced players, it is recommended to check the mini-map when idle.

5. Farm XP early
    a. Early game killing minions in the lane grants more experience than kills. Early in the game it is important to keep someone in all lanes before map objectives spawn.

6. Pay attention to team composition
    a. Use the statistics screen before the game begin, to check which heroes you have on your team and which heroes are on the enemy team. This can help you choose talents to help you against the enemy team. You can also see which talents the enemy team has chosen.

7. Comebacks are always possible
    a. Heroes of the Storm's game mechanics makes it possible to turn a game around even if you have a bad start. Stay positive and take advantage of opportunities.

8. Communicate

a. The game has a built in ping system that enables players to quickly communicate with each other by pressing one button on the keyboard while dragging the mouse to the appropriate command. Players can also ping specific objectives on the map.

9. Work as a team
    a. Heroes of the Storm is a team-oriented game. A bad decision can be a good one if all five players is on the same page and works as a team.

The three first points on the list are not relevant for the research, but they are guidelines for completely new players. Points 4-9 are a basic walkthrough of what to think about regarding strategy, and will be used in the replay analysis developed in this thesis.

Heroes of the Storm includes several different game modes. The game modes include Versus A.I. (computer controlled characters), Quick Match, Unranked, Ranked (Hero League and Team League), Brawl, and Custom Games. In Versus A.I. you can play with other players or with computer controlled teammates and fight against five computer controlled enemies. In Quick Match you can choose any hero you want and group up with four other people to play 5v5 matches on a random battleground. In Unranked you queue up either alone or as a group. When a match is made you are informed which battleground you are going to play on. A draft/ban phase the game begins where teams picks and bans heroes takes place. A walkthrough of the pick/ban phase is listed in table 2.3.

Table 2.3: Overview of the pick and ban phase in Heroes of the Storm

Turn	Team 1	Team 2
1	Bans one hero	
2		Bans one hero
3	Picks one hero	
5		Picks two heroes
6	Picks two heroes	
7		Bans one hero
8	Bans one hero	
9		Picks two heroes
10	Picks two heroes	
11		Picks one hero

Hero League works as in unranked mode, but in this mode wins and losses affect your Hero League rank. Hero league is restricted to solo players. Team League requires two, three, or five people in a group to play and wins and losses affect your Team League rank. Brawl is a completely different game mode where rules change every week. It is played on different battlegrounds either with pre-selected heroes or with a choice of

three heroes. You can queue alone or as a group with up to five players. It is a relatively new game mode, is quick paced and the rules may change from week to week. Custom Games is a game mode where you can configure a map, players, and heroes to your own preferences.

Matchmaking is the process of matching two or more people together, and in HotS the matchmaking is based on your matchmaking rating (MMR). This is a hidden value that defines your skill. The matchmaking differentiates the different game modes. The goal of the matchmaker is to match players within the same skill range resulting in more even games and around a 50%-win rate (Blizzard Entertainment, 2014).

Heroes of the Storm is a team-based game where good team play is crucial for success. The players can communicate through text based chat or pings. The text chat takes time away from playing the game to type, and is the less efficient way to communicate. It does, however, provide a way to write suggestions that are not possible to communicate through pings. Pings are quick commands that are issued by either pressing "G" and drag the mouse to the appropriate pings. The pings available here are "Danger", "Defend", "Assist Me" and "On my way". They can either be issued in the game, or on the mini-map. A "Retreat"-ping can also be issued by pressing the "V"-key. Pressing "Alt" on the keyboard and clicking on the map will issue pings accordingly, for example "Defend" on a friendly keep and "Attack" on an enemy keep. "Alt" can also be used to ping your health and mana status, enemies or teammates, objectives, camps, bosses, a spot on the map and so forth. A player can issue three pings in a row before a timeout occurs to avoid players from pinging unnecessary. An overview of the communication methods can be seen in figure 2.6.

Figure 2.6: Overview of communication methods in HotS.

2.4 Third Party Statistics for Heroes of the Storm

The matchmaking rating (MMR) in HotS is hidden within the game, but a website called Hotslogs has their own way of calculating the MMR based on game replays (Barrett, 2016). For each game a player plays the

game provides a log file that can be uploaded to Hotslogs. Hotslogs uses the game replay to calculate MMR gain or loss, provide game statistics and generates graphics that summarizes the games. Hotslogs is a web site developed by Ben Barrett and is not a product by Blizzard Entertainment (game producer of HotS). It is community driven and open for everyone to use.

Player	Hero	Score	TD	Kill	Assist	Death	Time Dead	Hero Dmg	Siege Dmg	Healing	Self Heal	Dmg Taken	XP
kaldra	Zeratul	76.6 %	11	9	2	0	00:00:00	43,603	95,706		0		15,655
haganah	Valla	68.1 %	16	3	13	1	00:00:18	69,957	102,352		4,107		12,677
Vipaffe	Lunara	63.1 %	14	4	10	2	00:01:28	85,190	65,194		9,912		13,128
DeSoto	Diablo	61.5 %	16	1	15	4	00:00:20	55,669	149,978		0	135,278	12,916
L4bb4net	Lt. Morales	58.2 %	13	2	11	2	00:01:13	13,398	30,097	135,189	12,355		10,301
MetaCat	Tassadar	48.1 %	8	1	7	2	00:01:03	37,957	83,635	32,843	11,749		9,456
Memmolhaus	Thrall	46.2 %	8	1	7	3	00:02:13	60,572	78,723		35,273		10,017
Alkibiades	Zarya	44.8 %	7	3	4	4	00:02:44	38,239	109,334		0	75,838	9,943
EliOneKenobi	Zagara	37.8 %	7	0	7	5	00:02:46	53,940	119,152		4,621		10,502
Deathcall	The Butcher	32.4 %	8	3	5	5	00:03:27	38,733	54,676		0		7,905

Figure 2.7: Example of game statistics from Hotslogs

Figure 2.7 shows the player name, which hero they played and a score based on a specific algorithm. The algorithm consists of kills, teamwork (takedowns which is kills and assists), deaths, role (hero damage, heal and/or selfheal and warrior damage taken per death), siege damage (damage to minions, objectives, camps and structures), and experience. It also shows how many takedowns, kills assist, deaths, the time spent while dead (the longer a game goes on, the longer it takes for a player to re-spawn after a death), damage done to heroes, siege damage, healing (supports), self-heal, damage taken (warriors) and experience provided.

2.5 Related Research to eSports Analytics

Eye trackers are also being used in eSports to analyze where the player looks at the screen to be able to develop an understanding of where experienced players look and to be able to correct mistakes. Acs (2015) has suggested different approaches to how to use eye tracking in eSports. He suggested that eSports can take note of previous research on eye tracking in other sports to develop strategies for eSports athletes. He suggests three different approaches: 1) either using the results as a mentor to make expert athletes aware of their gaze strategies, the expert athlete can then train amateurs; 2) create a research program to gather knowledge available from sports research; and, 3) use Artificial intelligence to analyze eye tracking data.

Schubert, Drachen and Mahlmann (2016) defines the field of eSport analytics as "the process of using esports related data, primarily behavioural telemetry but also other sources, to find meaningful patterns and trends in said data, and the communication of these patterns using visualization techniques to assist with decision-making processes". In their article they look at a technique for defining encounters in MOBAs as MOBA games generally do not have a natural structure. They define an encounter within the game as "when two or more heroes (units) from opposing teams are in range to affect each other". Typically, a match is summarized by statistics which means that it describes the metrics for "unit values, defeated units, and/or gained resources per team".

2.6 Summary

The field of eye tracking have been used within several research fields to analyze human behavior. The eSports-scene has grown and now has a large fan base and millions of dollars in prize pools for the players, and using eye tracking might be useful for the field of eSports analytics.

3 Methodology

The goal of the study reported in this thesis is to research the possibility of adding eye tracking to MOBA games and to investigate how the eye tracking data can be used with other data sources to analyze gameplay. This study uses the Design & Creation research strategy (Oates, 2006) as a guide. Design & Creation is a relevant research strategy for projects that that develop new IT applications and connecting it to literature and making a contribution to the knowledge base (Oates, 2006). Hevner *et al.* (2004) propose design science research guidelines that are relevant for this work. These are presented in table 3.1 and are explained below.

Table 3.1: Design-Science Research Guidelines by Hevner et al. (2004)

Guideline	Description
Guideline 1: Design as an Artifact	Design-science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation
Guideline 2: Problem Relevance	The objective of design-science research is to develop technology-based solutions to important and relevant business problems.
Guideline 3: Design Evaluation	The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods
Guideline 4: Research Contributions	Effective design-science research must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and/or design methodologies
Guideline 5: Research Rigor	Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact.
Guideline 6: Design as a Search Process	The search for an effective artifact requires utilizing available means to reach desired ends while satisfying laws in the problem environment.
Guideline 7: Communication of Research	Design-science research must be presented effectively both to technology-oriented as well as management-oriented audiences.

1 Design as an Artifact: the artifact developed in this project is a functional eye tracking application that can be used to count for how long and how many times a player is looking at a certain area of the screen while playing Heroes of the Storm. The application was necessary to be able to answer the research.

2 Problem Relevance: This study aims to look at eye tracking and how it can be used to gather meaningful information in MOBA games. Wagner (2006) claims that eSports is a phenomenon that has become an element in today's youth culture and is therefore a relevant research area. Acs (2015) claims that eye tracking can be used as a resource in research on eSports as current eye tracking systems are affordable enough to be used in the real world, and thus can be used as a tool for analyzing eSports gameplay.

3 Design Evaluation: the quality and utility of the developed artifact is discussed in chapter 7 by using the data collected by the artifact to look for patterns and meaningful value.

4 Research Contributions: Hevner (2004) states that effective design research must provide clear contribution in one or more of the following criteria: the designed artifact, foundations and methodologies. The artifact itself is most often the contribution of the design-research itself. The artifact in this research is developed specifically for this study and is not suitable for commercial use (discussed in chapter 4.3.3), however the foundation of the application is outlined in this thesis together with the creative development and evaluation methods.

5 Research Rigor: limitations and challenges are discussed in the final chapter.

6 Design as a Search Process: Hevner (2004) states that design science is iterative. The artifact developed in this research has been developed by using an iterative method of continuous testing and improvement until the artifact was as close as possible to the initial requirements. The development cycle used to develop the artifact used in the thesis is described in section 3.3.

7 Communication of Research: the last requirement is that "design-research must be presented both to technology-oriented as well as management-oriented audiences". This requirement is fulfilled by this thesis, where the both technology-oriented audience and non-experts are addressed. A thorough explanation of the background for the study, as well as presentation of the findings both for technology-oriented audience and a not-so-technology-oriented audience.

3.1 Design and Development of the Eye Tracking Application

A number of methods are used during these steps including desk research, design, development, and user testing.

3.1.1 Desk Research

Desk research refers to secondary data, which means data that can be collected without field research. The desk research for this study included choice of eye tracker, identifying background, and gathering game knowledge through watching professional eSports players streaming while playing games or playing in tournaments. The desk research is documented in chapter 1 and 2 as well as chapter 4.

3.1.2 Prototype Development

Hevner (2007) claims that "the internal design cycle is the heart of any design science project". The cycle iterates rapidly between development, evaluation and feedback. Simon (1996) explains the development cycle as a generator-test cycle. The cycle can include several generate-test cycles. The tests guarantee that consequences of the design problem are noticed. During the development the application was tested rapidly to uncover consequences of changes and to ensure that the design of the application was as good as it could be. This method of working led to new ideas that were tested in the next cycle.

To ensure progress in the development process personal scrum was used. Scrum is "A framework within which people can address complex adaptive problems, while productively and creatively delivering products of the highest possible value" (Schwaber & Sutherland, 2016). Scrum is initially based on organizing a team with a Product Owner, the Development team and a Scrum master, however Davidson (2014) has provided a suggestion as to how Scrum can be used in a solo project. The reason for using Scrum as a framework for the development process was to have a clear understanding of the tasks ahead while still being able add tasks during the project. Scrum is based on development periods called sprints. Each sprint is planned before it is started. The planning process consists of selecting tasks from a backlog, which is a list of tasks needed to be done in the project. The backlog lists function requirements, ideas, and fixes. Scrum involves several events. Davidson (2014) recommends to run sprints lasting one week, spending two hours to plan each sprint. A daily scrum lasting for five minutes to inspect and adapt your plan. After each sprint an hour of reviewing the sprint will give you the chance to check that your work is on the right track, and an hour of sprint retrospective will give you time to reflect on how you're doing. Each sprint in the project was planned in advanced by selecting work from the backlog. The backlog consisted of post-it notes with features and bugs in the application. The backlog was dynamic and new tasks were added when necessary. A daily scrum was used to get an overview of the day's tasks.

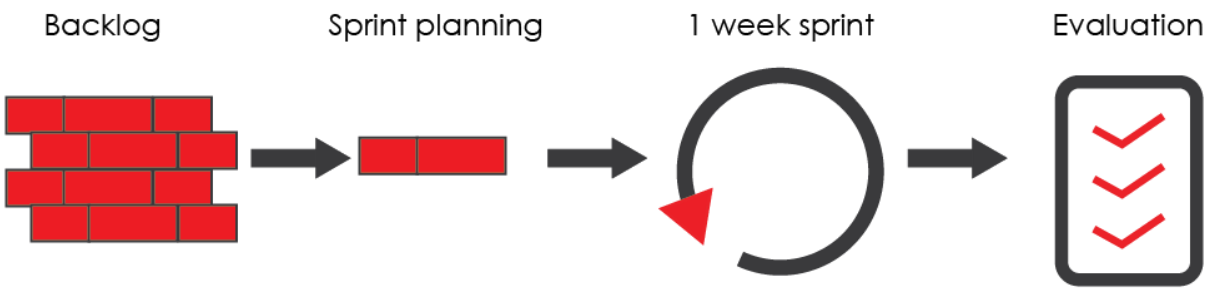


Figure 3.1: Overview of the scrum process

Figure 3.1 outlines the development process that was used during the development process. The method was used until the eye tracking application was of an acceptable standard and was capable of collecting data necessary for the study.

3.2 Empirical Study

An empirical study was carried out to test the eye tracking application and to collect data on gameplay.

3.2.1 Participants

The data in this study were gathered by getting three participants to play three games each. While playing, the gameplay and eye movements will be recorded, the replay files generated by the game will be saved and the eye tracking application will run and gather data.

3.2.2 Design

The participants were guided through a standard calibration process for the eye tracker before they played. When starting a game, the screen capture program was started. The participants were instructed to start the eye tracking application when they entered a game, and to display the statistics when the game ended. The participants were observed during the games to ensure that they remembered to do the instructed tasks and notes were taken about the gameplay to use in the replay analysis. Some of the participants asked questions during the gameplay sessions, and questions about the study and application were answered, but questions regarding the game itself were not answered.

3.2.3 Data Collection

Four data sources will be collected during the empirical study. These include:

1. Observation notes written while observing the gameplay of the participants
2. The data from the eye tracking application
3. A video recording created by Open Broadcast Software (OBS) with a gaze overlay from SteelSeries
4. Statistics of gameplay generated by Hotslogs.com

3.3 Data Analysis

The empirical study resulted in three different data sets, which included a recording of the games played by the participants with an eye tracking layer, game statistics from Hotslogs generated by uploading replay files from the game, and the data gathered by the eye tracking application.

A study that uses more than two data generation methods is called triangulation (2006).In this study a data source triangulation has been used. Thurmond (2001) claims that benefits of triangulation include "increasing confidence in research data, creating innovative ways of understanding a phenomenon, revealing unique findings, challenging or integrating theories, and providing a clearer understanding of the problem".

Using different data sets will make it possible to look at the gameplay from different angles and to gain insight into the gameplay.

3.4 Summary

This chapter has introduced the overview of the research methodology and methods used in this study. Several methods have been used to research the possibility to add eye tracking to MOBA games and how eye tracking data can be used together with other data sources to analyze gameplay in MOBA games.

4 The Eye Tracking Application

This chapter first describes the HotS user interface (UI). Then an overview of the development process of the eye tracking application is given. The chapter concludes with a description of the challenges that occurred while developing the application.

4.1 Heroes of the Storm User Interface

Figure 4.1: In-game screenshot from HotS

Figure 4.1 shows an in-game screenshot of the user interface (UI) in Heroes of the Storm. An info-bar (a) shows the time, experience, and level of your team is seen at the top of the screen. If a teammate has fallen in battle, a portrait and time until the player respawns (b) will show to the left, and the same goes for enemy players on the right. To the bottom left a portrait of your hero (c) shows together with a health and mana bar and an icon that displays if you have the possibility to use a healing fountain (a clickable element that refills health and mana that is placed around the map) or the time left until you can use one. Depending on which hero you play, different icons might be visible. Some heroes have talent choices that you need to stack throughout a game. Certain heroes have additional mechanics that will be portrayed in the same area. In figure 4.1 Greymane has a combo counter that shows the number of auto attacks hit in a row with a certain ability activated (yellow circle). In the center bottom of the screen a bar (d) shows the heroes abilities and

their cooldowns. To the left an icon shows the cooldown of hero's mount (a creature that the hero can use to move around the map faster and is marked with the letter "z") and to the right the cooldown of the hearthstone (a channeled ability to go back to the team's base to get health and mana and is marked with the letter "b"). The mini-map (e) is located to the bottom right together with information about the map objective.

Figure 4.2: Health bars in HotS

Figure 4.2 shows the health bars associated with each player. Players and monsters in the game have a health bar located above their head. If a hero uses mana or rage to use abilities this will be shown below the health bar. The tallest bar on the top shows the health, and the smaller bar underneath shows mana. Teammates are colored blue (a), the players character is green (b) and enemies are red (d). Minions and monsters have health bars as well (c), where friendly minions are blue and enemy minions are red.

There are also two UI elements that can be toggled. The first is the hero's talent choices (default "ctrl"). It will be displayed above the hero's' portrait. When a new talent is available a text will be displayed on the hero portrait, as seen in figure 4.3. The other is displayed by pressing a button (default "tab") as seen in figure 4.4. This shows the game statistics, talent choices, and a death recap. The statistics screen (left) displays kills, takedowns, deaths, siege damage done, hero damage done, role specific statistics (healing by support players and damage taken for warriors) and the experience you have contributed with. The statistics shows numbers both for

Figure 4.3: Talent choices

teammates and enemies. The talents screen (middle) shows the talent choices by all heroes. The death recap screen (right) shows the damage done to you before you died with name of the abilities, from which unit and how much damage. A player can switch between the screens by pressing the buttons in the bottom center.

Figure 4.4: Statistics (left), talents (middle), and death recap (right)

4.2 The Eye Tracking Application

An application has been developed to count the number of times a player looks at a specific area on the screen as well as how long the player is looking at the area. The goal of the application was to be able to count the number of times a player looks at certain areas of the screen and for how long they are looking at it. For example, important events in Heroes of the Storm is when a team levels up. Especially if your team or the enemy team gains a talent advantage (4, 7, 10, 13, 16 and 20). A team that ahead with a talent advantage can get an even larger lead by taking a team fight with a talent advantage. The idea was that a good player who looks at the levels would be more prepared for deciding when to take a team fight and when to play passive. The data could then be compared across the participants to look for trends within good games, to see if the number of looks and time spent looking at the areas had a noticeable effect on the gameplay.

The application has been developed to minimize the amount of UI elements the players see on the screen during gameplay in order to prevent players from becoming distracted. The reason for this was that during the development phase it became apparent when testing that if the areas that are being tracked is too visible, a player might be looking more at the areas than he or she would in a regular game. However, it was necessary to keep a small indicator of when the eye tracker registers that a player is looking at an area, to be able to see the application in the game replays. When a player is playing the game an orange line is visible on the screen that indicates the area the where player is looking at. The line is only visible if a player looks at the area to ensure minimal interference. The line can be seen on figure 4.5 in the top middle of the screen below the information bar.

Figure 4.5: In-game screenshot with the eye tracking application running.

4.3 Development

The development process of the eye tracking application is divided in to three parts. The choice of eye tracker, the development process, and challenges with developing the application.

4.3.1 Choice of Eye Tracker

The first step in developing the eye tracking application was to choose the eye tracker itself. The SteelSeries Sentry Eye tracker was chosen for the task. It is a consumer eye tracker that is easy to use. The eye tracker is produced by SteelSeries, a company that sells and produces gaming peripherals (SteelSeries, 2016b), together with Tobii, that is world leading in the field of eye tracking (Tobii, 2016).

Ferenc Arc (2015) claims that the SteelSeries Sentry eye tracker "is sufficient to do research about fixation behavior, but not suitable for a precise analysis of eye movements". He suggests that the eye tracker has about a 4° gaze position accuracy, which means it has approximately a 4 cm precision on a 27" 16:9 computer monitor.

4.3.2 Development

Step 1 The analysis application used in the study was created for the Steel Series Sentry Eye Tracker, and the application has been developed using JavaScript, CSS and HTML. Tobii has developed a software development kit (SDK) for a software called Overwolf, which was used to develop the application. Overwolf is an application that adds overlays to games and works as a framework for applications. Overwolf does not interfere with the game itself, but can be used to provide overlays that add useful information or functionality.

Step 2 The development began by analyzing an application developed for Overwolf called Gamer Eye Trainer. The application is not available within Overwolf, but was developed for a competition Tobii, SteelSeries, and Overwolf held when the SDK for Tobii was released in Overwolf. The application works by allowing developers to place squares on the screen. The squares will light up within a time set by the user and draws the attention of the user. The square will disappear and the timer resets when a player looks at it. When analyzing the application, it became apparent that large squares took a lot of attention away from the game, and forced unnatural gameplay by forcing the player to focus at an element on the screen when it might not be necessary. However, the application is a prototype to test the capabilities of the eye tracker.

Step 3 The application works up by adding four transparent squares on the screen that count. The four areas are the main UI elements of the HotS interface. The application tracks the eye movements and each time a player looks inside one of the four squares the application counts it as one look and starts a timer. When the player looks away from that square the timer stops. Four areas were chosen for the application, as seen in figure 4.6. These are the health/mana bar to the bottom left (a), the cooldown bar to the bottom center (b), the map on the bottom right (c) and the level/time indicator in the top center (d). To control the application a button bar is added to the top left (e).

Figure 4.6: In-game screenshots displaying the areas tracked by the eye tracking application (a-d) and the application controls (e)

The application control bar (figure 4.6 (e) and figure 4.7) is not placed at the top of the screen because the game has an option to display Internet connectivity status in the topmost area and this is a useful tool that should not be covered. The buttons from left to right have the following functionality: start eye tracking, show statistics, show indicators (orange lines) and exit application.

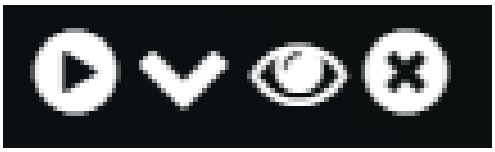


Figure 4.7: Application controls

Figure 4.8: Eye tracking statistics

The application has an option to show the eye tracking statistics real time when playing a game, see figure 4.8, and can be toggled. The statistics shows the number of looks and the time spent looking at the map, time/levels, cooldowns and health. The statistics were not visible to the participants when they were playing the games. This was to prevent the players from paying attention to the eye tracking application and play the games as they normally would.

4.3.3 Challenges with the Eye Tracking Application Development

In the first iteration of the development the application was set up with several windows to handle the eye tracking areas. When testing the application during the development, it stopped working after 8 minutes. A HotS game usually lasts between 15 and 25 minutes. After extensive troubleshooting and testing it seemed like Overwolf was causing the issue. In the first iteration each area tracked by the application was its own window including the button bar and statistics screen, which totals five individual windows. When the timer function was added the application started crashing. The solution was to reduce the number of windows to two. One to handle controls and one to handle eye tracking.

The Tobii SDK is limited in terms of functionality. It sets up a continuous eye tracking that returns coordinates horizontal (x) and vertical (y). It is based on JavaScript and it offers a small subset of the Tobii EyeX Engine API (Robert [Tobii], 2014). The continuous running eye tracking made it difficult to execute functions in a way that did not take too much memory from the computer and crash Overwolf. To get the timer function to work it was necessary to test several options before a solution was found.

The SDK requires four input sources to track an area: horizontal x and z, and vertical x and z. Complex shapes are not possible to set up. This means that each UI element in the application has some error margin that cover blank space outside of the element itself.

Limitations in the Tobii API for Overwolf made it impossible to exclude blinks from the data generation. That means that if a player, for example, is blinking while looking inside one of the areas the application is tracking, the application will count two looks at the area. This means that the raw data from the eye tracking results will be inaccurate as opposed to an application that could exclude blinks. An average blink lasts about 1/3 seconds and a human adult blinks approximately 12 times per minute (Kwon et al., 2013), which means that the amount of time spent looking at certain areas of the screen could be 4 seconds higher than if blinks were excluded per minute. Other studies, however, have suggested that the number of blinks per minute is lower while playing games. According to Patel *et al.* (1991) the blink rate while using visual display units may

be as low as 3.6 ± 1.8 blinks per minute which means that for each minute spent looking at an area an average of 1,2 seconds might be subtracted for blinking per minute. The data in the study has been kept raw and the blinks have not been subtracted as the players were of similar age, none wore contact lenses or glasses, and they played under similar conditions. In addition, the data was not being compared to data generated where blinks are removed.

The different battlegrounds have different mini-map sizes. The application is not set to handle the differences, but is set to an average mini-map size. This means that the application may record looks outside of the map area on battlegrounds with smaller mini-maps.

Health and mana for the player's character is located both in the bottom left, and above the character's head. Since the SDK is limited, there was no way to track the top of the character's head for health and mana status. This is a limitation in the tracking results. The results show that the players where using the status bar above the player's head more than the one in the bottom left. The bottom left UI element also includes information about special abilities for specific heroes and questing talents. The results from the application might be the checking of these UI elements rather than the health and mana, even though the health and mana bars is a large portion of the UI element.

The eye tracking application was developed for a 27" 16:9 screen. As mentioned Ferenc Acs (2015) suggests a 4 cm preciseness on this screen size. The results from the eye tracking therefore has a slight error margin. The screen size also affected the player's comfortability while playing. To make the eye tracker precise enough, the player needs to sit at the right height so that the eye tracker picks up all eye movements. This might make some players uncomfortable and force them to sit in a way they are not used to. The application is therefore suitable for a research study where screen size and sitting position of the players can be controlled, but not for a commercial product.

4.3.4 Effort in Development

The eye tracing application took several months to develop as the limited Tobii API for Overwolf made it difficult to set up the intended functions. In the early phase of the development an Overwolf issue caused the application to crash after 8 minutes into the game. There was no feedback as to why this was happening and to track down the error was time consuming.

While testing the eye tracking application an issue with displaying the application on top of the game forced several restarts of both Overwolf and the game to make it work as intended. This resulted in a lot of time lost while developing.

4.4 Summary

This chapter has described the development of the eye tracking application used to measure how often and for how long players look at certain areas of the screen. The application will be used in an empirical study described in chapter 5. The data generated during the empirical trial will be used be used as part of eSports analytics.

5 Empirical Study

The empirical study was designed to gather the necessary data sets for the analysis. This chapter gives a walkthrough of how the study was conducted. First an overview of the participants, then an explanation of the practical details, followed by description of the data collection.

5.1 Design

The following section will give an overview of the design of the study from how the scenarios were prepared to the implementation and the data collection.

5.1.1 Preparing the Scenarios

Before conducting the empirical study, a through consideration of game mode, heroes, account and practical details was taken into account.

Game mode: The overall concern was the comparability between the players and the generated data. To set up nearly identical conditions for the participants it would be necessary for them to play games versus A.I. and in Custom Game mode. The greatest concern in the versus AI game mode was the predictability of the AI. While a new player might find the AI challenging, seasoned players might find them too predictable and thus play without caring about strategy. The game replays could not be uploaded to Hotslogs for review either as they do not analyze Custom Games on a single profile. The other option was Quick Match mode where the players can choose their own hero, but teammates and enemies are random. The battleground is also random. This means that the game's situations would be less comparable, but Hotslogs would be able to analyze the games. Given the experimental nature of the study unpredictability was weighted higher than comparability and Quick Match was chosen as the preferred game mode.

Heroes: The next concern was which heroes the participants should play. It was necessary that they played a hero they have played before so that they had basic knowledge of how to use the hero's abilities and the type of strategy they should use. It was also important that the players were somewhat comfortable playing the hero so they would pay attention to other game mechanics as well as their hero. It was therefore not possible to decide which characters they would play beforehand. To deal with this it was decided that the first player would play three different heroes with three different roles. Then the next players were presented with these heroes to see if some of the games could be played with the same hero, or heroes within the same role.

Accounts: To play Heroes of the Storm you need to have an account. All accounts have different MMR based on a player's skill and you need to unlock heroes as you go either with in game currency, through promotions or with real money. The replays also get bound to a specific account when they are uploaded to Hotslogs. The most practical solution was to get all the players to play on the same account. This means that the players would be matched against players within a certain range of skill even though that meant that for some players it would be easier than they are used to, and harder for others. The account they played on also had almost all of the heroes unlocked so it would not be a problem to enable them to pick the heroes they wanted. This was a reasonable solution given the research is focused on experimenting with the role the data can play in eSports analytics and not for the player improvement.

5.1.2 Set Up

The players played on the same computer with the same peripherals. They were given a brief introduction to how the eye tracker worked, and what data was being gathered. They were allowed to move the computer peripherals as they preferred. Before starting the game, they went through a standard configuration of the eye tracker where they looked at the screen to pop dots. Due to the placement of the eye tracker some of the players were forced to sit further away from the screen than they usually do when playing to ensure that the eye tracker saw their eyes. Figure 5.1 shows a picture of the screen and the eye tracker that the participants used. The eye tracker is marked with a white rectangle.

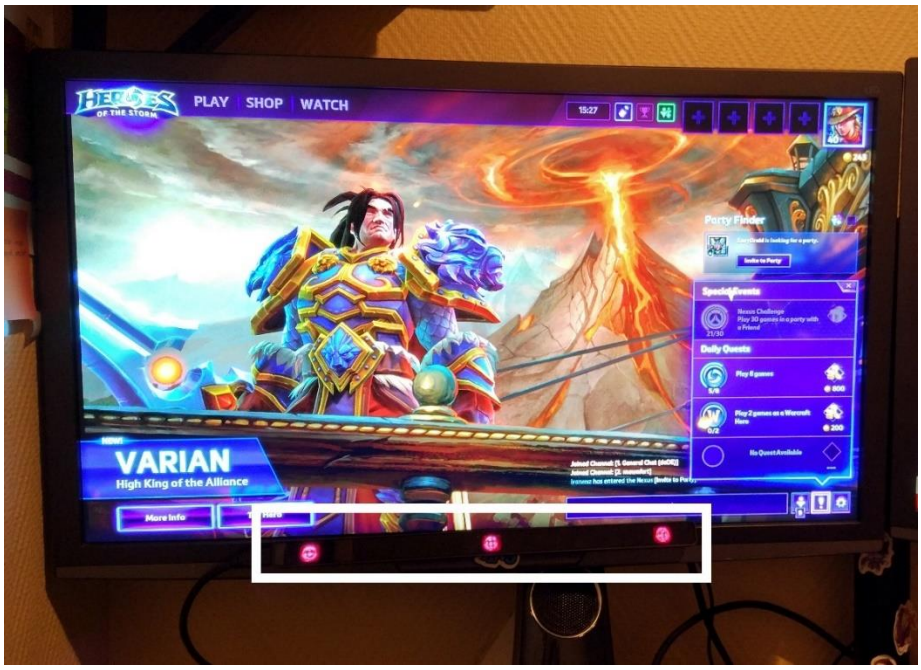


Figure 5.1: Picture of the eye tracker and the computer screen.

The players were observed while playing the games, but the gameplay was not commented during the play session or in between the games. The observer also had some rules to follow:

1. Instruct the participants to press the play button on the eye tracking application when entering the game
2. Only answer questions regarding the study (the eye tracking application, practical information or data collection), together with questions about the set up
3. Instruct the participants to press the statistics button when a game ended

Each game lasted between 16 and 25 minutes and each player played three games. With eye tracking set up and queue time between games each session lasted for about 1.5 hours. The sessions were spread over two days, where the first participant played one day, and the two other participants played on the same day.

5.1.3 Preparation for Data Collection

Before the data was collected necessary software for screen capture was downloaded, installed and tested. The software used in the study was Open Broadcaster Software (OBS). OBS (2016) is a free open source software that is primarily used for streaming gameplay to the Internet, however, the software included with the eye tracker used in the study includes the possibility to add an overlay in OBS recordings that displays where the player is looking at all times.

Folders for each video replay was set up and after collecting the replays they were also uploaded to a cloud computing service for secure storage.

HotS has a setting in the game client for storing replay files, and this option was checked to ensure that the game log files were saved. The files were uploaded to Hotslogs after the games were finished for calculation by using HotS Replay Uploader (2015) which is created by Vegsundvåg and is available for free on GitHub. The software finds the HotS replay files and automatically uploads them to Hotslogs.

5.2 Implementation

The following section will give an overview the experience each participant has with HotS and an explanation of how the data was collected.

5.2.1 Participants

The participants in the study were three players that knew the game and had played several games as can be seen in table 5.1. Player one also had experience playing other MOBAs while Players 2 and 3 have the most experience with Heroes of the Storm. Player 1 had played an extensive number of matches in the versus A.I. mode, while Player 2 had more experience from Quick Matches. Player 3 had more experience than Player 2 in versus A.I mode., but had played 66 fewer games in Quick Match. Table 5.1 gives an overview of the number of wins and losses for each participant sorted by game mode, gathered from their HotS accounts, together with the total number of wins, losses and games played.

Table 5.1: Overview of games played per participant

Game mode	Quick Match	Unranked	Hero League	Team League	Versus A.I.	Brawl	Total
Player 1 wins	68	0	2	1	400		471
Player 1 losses	55	0	2	1	105		163
							634
Player 2 wins	470	10	11	12	109	2	614
Player 2 losses	428	8	9	13	10	1	469
							1083
Player 3 wins	404	10	19	12	283	2	730
Player 3 losses	353	8	22	13	45	1	442
							1172

5.2.2 Gameplay

The study was conducted having three participants playing three games each. While playing the screen was captured with an added eye gaze overlay that was invisible to the players. The gaze overlay is a circular shape that moves with the eyes of the player. This enables the replays to include precise tracking of the eye movement, and enables a deeper understanding of the player behavior. The game logs for each game were uploaded to hotslogs.com, which analyzes the log file and provides statistics including number of deaths, kills and assists, details of when map objectives where completed and the amount of experience gained per minute.

The first participant was asked to play three different heroes with three different roles. The second participant was asked if he was comfortable playing any of the heroes the first participant played. He was comfortable with one of them, but as a second and third hero the player was able to choose the heroes within two

different roles. The third participant was comfortable with two of the three heroes that the first player played, and chose the last hero himself within a different role than the two first heroes he played.

Some asked questions, and questions involving eye tracking or the experience were answered, but questions regarding strategy or the gameplay were not answered as according to the observer rules. When the games ended they were reminded to press to check the statistics or answer questions if they forgot.

5.3 Data Collection

The study comprises of three data sets. The first set is the information gathered by the application created for the study. The data from the application was retrieved from replays. Once collected the data was inserted into tables for processing and comparison.

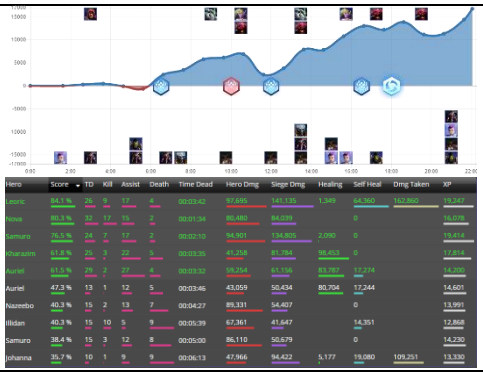
Each game was also recorded with the added eye tracking layer. The overlay is provided by SteelSeries Engine 3 (2016a). OBS can either use add-ins or predefined settings to capture specific elements on the screen, or it can capture the entire screen. Capturing the entire screen demands more resources from the computer (Jim, 2016). To ensure a good gameplay experience it was necessary to find a way to set up screen capture without interfering with the gameplay. Overwolf who handles the eye tracking application has a plugin to OBS that enables overlay capture. The eye tracking overlay can be seen on figure 5.2. OBS set up with game capture and overlay capture ensured minimal impact on the gameplay. When the matchmaker found a game for the player, a loading screen appears. The game capture was then started, and it was stopped when the player was at the statistics screen after a game. The files where saved as .mp4 files with filenames according to the player (1, 2 or 3), the game number and name of the battleground.

Figure 5.2: In game screenshot with eye tracking overlay

The third data set is generated by uploading the game logs to Hotslogs.com. Hotslogs then analyses the replays and provides statistics as described earlier and the data has been inserted into tables for easier comparison. The data was copied from Hotslogs and inserted into tables for easier processing and comparison between the games.

The study resulted in three data set which can be seen in table 5.2. Each data set provides an insight into the different games played by the participants and are used in the analysis.

Table 5.2: Overview of the data sets

Data set	Collection	Screenshot	Explanation
Eye tracking data	Eye tracking application during gameplay		Statistics on the number of times the participants looked at the screen areas inserted into a spreadsheet for processing and comparison.
Gameplay capture	Open Broadcast software with SteelSeries gaze overlay		Nine video files with the player perspective and eye movements.
Game statistics	Game replay logs uploaded to Hotslogs		Statistics from all nine games which includes a graphical representation of experience and deaths and detailed statistics for all players in the game.

5.4 Summary

This chapter has described the empirical study through which three data sets were generated about gameplay. An analysis of the data will be given in the next chapter.

6 Analysis of Gameplay

This chapter presents an analysis of the nine games the participants played. First an explanation of how each data set was analyzed is given, then the play of each player which includes an overview of the battleground and hero each player played as well as a written summary of each game and game statistics. The last section of the chapter uses the eye tracking data and compare the player results.

6.1 Data Sets

The eye tracking data has been analyzed by looking at the percentage of game time each player looked at the different areas of the screen. The time spent looking has been divided by the game time. The eye tracking data has also been analyzed by looking at the "score"- feature from Hotslogs, which is generated by an algorithm that uses game statistics to give each player in a match a score based on game performance.

The video files have been analyzed by using VideoLan (VLC), which is a video player, and using an add-on called Moments' Tracker. The add-on makes it possible to mark certain points in a video and give them names to make the analysis more efficient. While watching the gameplay video notes were taken of important events in the game, and the players movements and actions throughout the game, and compressed the notes to give an overview of each game played in the study. The games were analyzed with the beginners guide from Dabiri and Sigaty (2015) together with desk research to analyze important events in the games.

The video files included several sources of information that was used in the analysis. The gameplay itself, the UI, the eye tracking application, sound, pings, and chat. For example, the sound is an important source of information as some heroes and abilities makes specific noises that the player can use to its advantage. An example of this is the hero Falstad that can fly around the map. In the second game an enemy Falstad came flying in right in front of the player and into a bush. Falstad is invisible while in the bush, but the player retreated to not get killed. When looking at the replays he was visible in slow motion, but the audio que was more noticeable than the visual que and helped explaining why the player retreated.

The replay files were uploaded to Hotslogs for analysis and then the scores have been copied to an Excel document to remove formatting and for comparison before being used in the analysis.

6.2 Gameplay

For each game an experience and deaths graph has been downloaded from Hotslogs. The graph is split in half with one team on each side (see figure 6.1). It shows the experience difference between the teams in the middle, and when battleground objectives are taken. It also shows the deaths of each team, one on the top and the other on the bottom. Each graph is marked with which team is on the top or bottom side of the graph. The graph gives an overview of each game since it is set up as a timeline, and is useful to get an impression of how a match evolved. The graph can be viewed as a graphical summary of each game. The graph was also useful when analyzing the video replays as it made it possible to fast jump to important events in the replay.

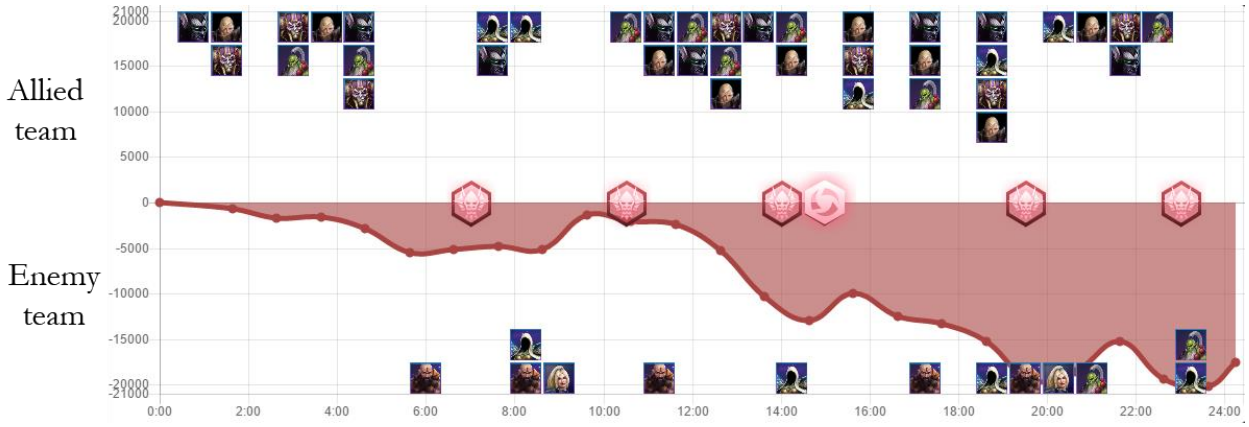


Figure 6.1: Experience and death overview from Hotslogs

The game statistics are shown in a table (see table 6.1) where the allied team statistics has a grey background, the player has black background, and the enemy team is white. The table is sorted by the score statistic which is explained in chapter 2.4. The table consists of the name of the hero, the score, take downs (kills and assists), kills (last hit on an enemy), assists (the hero has done damage to an enemy that died), deaths, time spent dead, damage done to heroes, damage done to enemy structures, minions, mercenary camps and monsters, healing, self-healing, damage taken (only warriors) and experience gained.

Table 6.1: Game statistics from Hotslogs

Hero	Score	TD	Kill	Assist	Death	Time dead	Hero damage	Siege damage	Healing	Self - heal	Damage Taken	XP
Leoric	84.1 %	26	9	17	4	00:03:42	97,695	141,135	1,349	64,360	162,860	19,247
Nova	80.3 %	32	17	15	2	00:01:34	80,480	84,039				16,078
Samuro	76.5 %	24	7	17	2	00:02:10	94,901	134,805	2,090			19,414
Kharazim	61.8 %	25	3	22	5	00:03:35	41,258	81,784	98,453			17,814
Auriel	61.5 %	29	2	27	4	00:03:32	59,254	61,156	83,787	17,274		14,200
Auriel	47.3 %	13	1	12	5	00:03:46	43,059	50,434	80,704	17,244		14,601
Nazeebo	40.3 %	15	2	13	7	00:04:27	89,331	54,407				13,991
Illidan	40.3 %	15	10	5	9	00:05:39	67,361	41,647		14,351		12,868
Samuro	38.4 %	15	3	12	8	00:05:00	86,110	50,679				14,230
Johanna	35.7 %	10	1	9	9	00:06:13	47,966	94,422	5,177	19,080	109,251	13,330

These data sources will be used to describe the play of each player in sections 6.3-6.5. Each game will be analyzed according to battleground, hero, experience and deaths, gameplay and game statistics. A summary for each player is also given.

6.3 Player 1

6.3.1 Game 1

Battleground

Figure 6.2: Dragon Shire map (Blizzard Entertainment, 2016e)

Dragon Shire is a three lane map. In the top and bottom lanes (orange markers) a shrine spawns at 1 minute and 15 seconds into the game (Weskimo Team, 2016). When a team holds both shrines they can channel a monster called the Dragon Knight in the middle lane (orange marker). The Dragon Knight is controlled by one player and does a massive amount of damage to structures and enemies, and can kick enemy players away. The shrines respawn 2 minutes after a dragon has died. There are five mercenary camps on the map, two on each side and one in the bottom lane.

Hero

Nazeebo is a specialist hero (Blizzard Entertainment, 2016l). His abilities are Corpse spiders (Deals moderate damage, and spawns three Corpse Spiders that deal light damage and lasts for 4 seconds), Zombie wall (a ring of zombies that surrounds the targeted area, deals light damage and lasts for three seconds) and Plague of Toads (A wave of three toads that explodes on impact and deals damage over 6 seconds). He is a ranged hero

and it is necessary for him to stay behind warriors in teamfights to not take too much damage and get killed. For his ultimate he can choose between a Gargantuan which is a NPC that guards an area for 20 seconds and can be ordered to stomp on nearby enemies and a channeled Spirit that deals moderate damage for 8 seconds. Nazeebo cannot move while using the spirit. Nazeebo's trait is Voodoo Ritual that deals poison damage over 6 seconds to Non-Heroic enemies. This trait is stackable, which means each time a minion dies while affected by Voodoo Ritual Nazeebo gains 4 health points and 1 mana point permanently.

Experience and deaths

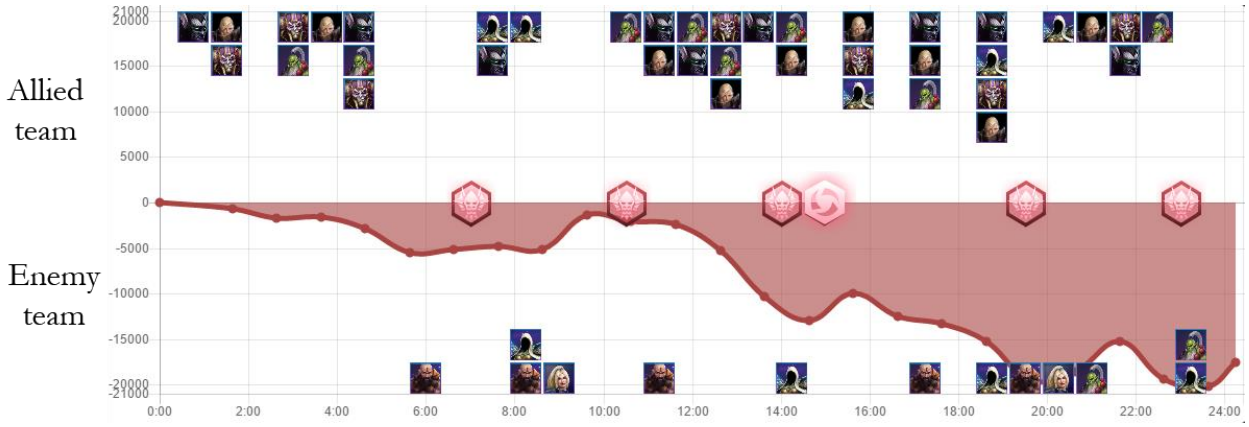


Figure 6.3: Player 1 game 1 experience and deaths from Hotslogs

Game overview

The player started the game solo in the top lane. When the first shrine spawned he got help from a teammate to take the shrine, but the player gets killed by Nova, that is an invisible character and the player did not see her coming. The player spends the time dead looking at the mini map. When he re-spawns he goes middle to try to stop the enemy team from taking the dragon. He manages to stall them, but gets chased down and killed by Leoric. When he re-spawns he groups up with two teammates middle. He rotates bottom together with two teammates to get the shrine, but ends up on the wrong side of the shrine resulting in a death. He re-groups with two teammates bottom when he re-spawns. After seven minutes the three players in bottom lane has to retread due to low health. Enemy team gets level 10, and the dragon. The player helps defend against the dragon and the enemy team cannot get much siege damage done. This enables the player's team to get level 10. The player rotates to bottom lane to defend. He realizes that a camp gets picked up by the enemy team behind him and manages to retreat before the enemies show up. Teammates comes to help out and they manage to get three kills, while losing one hero. When the next objective spawns, the player goes top to push the lane and capture the shrine. He then rotates middle as there is no teammates in the lane. He realizes that a team fight is going on in the bottom lane, and rotates there. That enables the enemy team to get another

dragon and pushes the middle fort. Three teammates get killed and the enemies continue to push. The player steps too far forward to try to help the warrior, and gets killed by the enemy team. The enemies kill the fort and three other players on the player's team. When the objective spawns the player's team cannot contest it because of dead teammates and that they are forced to defend against minions. The player and the healer clears middle then bottom lane, while two teammates get killed in the middle lane. They rotate middle to defend against the dragon, but they lose a keep. The team chases the enemy team down the middle lane, but ends up losing three members. The enemy team pushes out the middle lane. When the objective spawns, the player goes to the bottom shrine with the healer. They get ambushed by two members of the enemy team. Illidan and the healer chases forward while the player is hiding in a bush. The healer and Illidan gets killed, and the enemies comes back and kills the player and Samuro. The enemies get the Dragon Knight again, and uses it to kill the bottom keep. When the Dragon Knight dies the warrior and the player chases the warrior on the other team into a bush. The result is a team fight where the warrior and the player gets killed. The objective spawns again, and the enemy team manages to pick it up before the players respawn. They use the Dragon Knight to kill the top keep. The player's team kills three members of the enemy team, but the Dragon Knight still manages to kill the core.

During the game the player did not ping or write in the chat to communicate with his teammates. He did watch his teammates movements on the map.

Game statistics

Table 6.2: Player 1 game 1 game statistics from Hotslogs

Hero	Score	TD	Kill	Assist	Death	Time dead	Hero damage	Siege damage	Healing	Self - heal	Damage Taken	XP
Leoric	84.1 %	26	9	17	4	00:03:42	97,695	141,135	1,349	64,360	162,860	19,247
Nova	80.3 %	32	17	15	2	00:01:34	80,480	84,039				16,078
Samuro	76.5 %	24	7	17	2	00:02:10	94,901	134,805	2,090			19,414
Kharazim	61.8 %	25	3	22	5	00:03:35	41,258	81,784	98,453			17,814
Auriel	61.5 %	29	2	27	4	00:03:32	59,254	61,156	83,787	17,274		14,200
Auriel	47.3 %	13	1	12	5	00:03:46	43,059	50,434	80,704	17,244		14,601
Nazeebo	40.3 %	15	2	13	7	00:04:27	89,331	54,407				13,991
Illidan	40.3 %	15	10	5	9	00:05:39	67,361	41,647		14,351		12,868
Samuro	38.4 %	15	3	12	8	00:05:00	86,110	50,679				14,230
Johanna	35.7 %	10	1	9	9	00:06:13	47,966	94,422	5,177	19,080	109,251	13,330

6.3.2 Game 2

Battleground

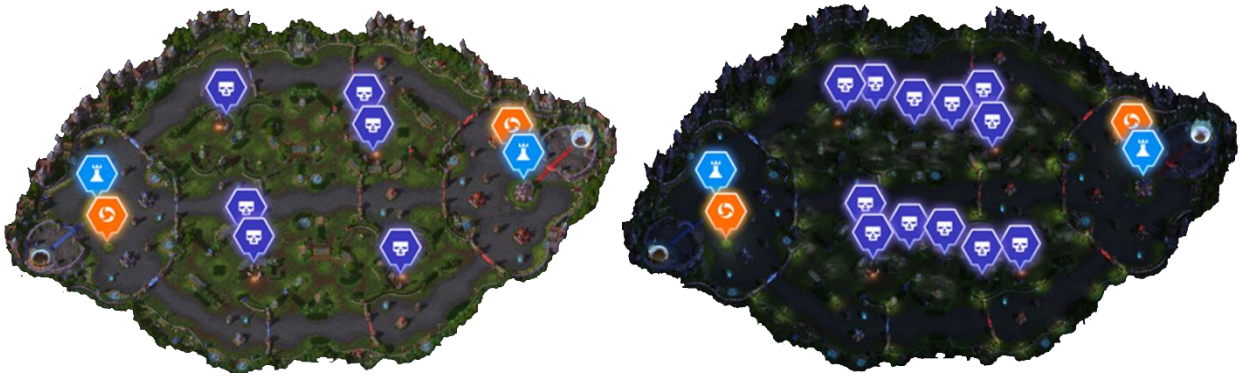


Figure 6.4: Garden of Terror map (Blizzard Entertainment, 2016f)

Garden of Terror is a three lane map. The map switches between night and day (Blizzard Entertainment, 2016f). At night Shamblers spawn which are non-playable characters and are neutral, which means they will attack which ever hero is attacking them or in their range. When players kill the shamblers it drops seeds and when a team has collected 100 seeds they can spawn a Garden Terror. The Garden terror can polymorph enemies, making them slower and unable to cast abilities. It can also spawn plants that disable enemy structures. Its basic attack does massive amounts of damage to both heroes and structures. At day time six mercenary camps are available. Three on each side of the map.

Hero

Rehgar is a melee support hero (Blizzard Entertainment, 2016m). His abilities are Chain Heal (heals targeted allay for a large amount of health then spreads to up to two allies for a moderate amount of health), Lightning Shield (A 5 second shield that does light damage to nearby enemies) and Earthbind Totem (Lasts 8 seconds and slows enemies in the area). His trait is Ghost Wolf and transforms Rehgar to a wolf that increases movement speed by 30%. When Rehgar attacks enemies in wolf form he does increased damage, but cancels the form. He can choose between Ancestral Healing and Bloodlust as his ultimates. Ancestral Healing is a massive heal that triggers after a short delay, while Bloodlust gives nearby allies extra attack and movement speed for 10 seconds. Rehgar needs to play balanced between dealing damage in team fights and playing safe to heal his team.

Experience and deaths

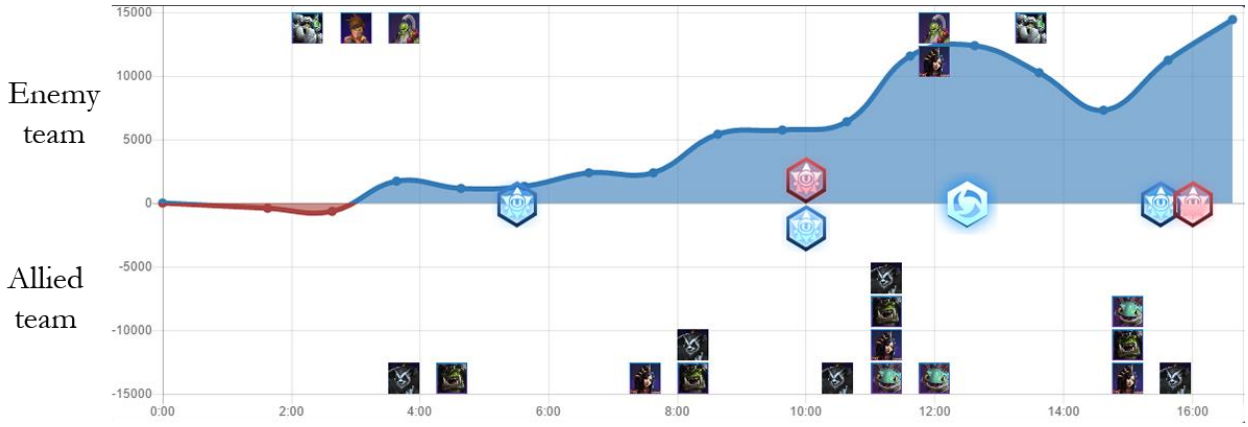


Figure 6.5: Player 1 game 2 experience and deaths from Hotslogs

Game overview

The player joins Gul'dan in the top lane when the game starts. The warrior is alone against three enemies middle. While the player is checking the map, he gets attacked in the top lane, but manages to escape. When the night spawns, he rotated down to the small seed camp on and kills Lt. Morales. The team groups up and gets the seeds from the top lane. He follows the team bottom, and they get a kill, but the enemy team strikes back and kills the player and their warrior. The player groups up with the team again in the bottom lane, but the enemies get a terror. The player follows the terror top to defend. When the terror expires the enemy team shows up, but no one dies in the team fight. The player helps his team to get a camp. While four members get the camp Li Ming dies. That gives the enemy a 10 to 9 level advantage. The player follows his team middle and they try to kill Lt. Morales, but they chase too far forward and the enemy team shows up from behind. With a level disadvantage the player and the warrior dies in the team fight. Just as the player re-spawns the night time begins. The player joins his team in the bottom lane to get seeds. They get enough for a terror, but so does the enemy team. The enemies push in the middle lane with the terror, while the friendly terror pushes bottom. The enemy team has now gotten a 13 to 12 level advantage. The terror rotates middle, and so does the enemy team. The members of the player's team come in from behind, and the enemies kills both the player and Li Ming. The enemies continue to push and kills a keep. The player's team gets three kills. The night spawns again and the player's team still has a talent disadvantage, but they manage to get two kills in the bottom lane. Both teams get enough seeds for a terror. The team rotates to the top, and get ambushed by four players of the enemy team. Three players get killed, and the enemy team kills the core with the Garden Terror.

The enemy team gained an advantage early, and the player's team continued to take fights and die instead of trying to soak the level gap. The player seemed to be aware of the level advantage on the other team, but he did not communicate this to his teammates, but tried his best to support his team.

Game statistics

Table 6.3: Player 1 game 2 game statistics from hotslogs

Hero	Score	TD	Kill	Assist	Death	Time dead	Hero damage	Siege damage	Healing	Self - heal	Damage Taken	XP
Tracer	75.9 %	15	10	5	1	00:00:19	42,582	45,641				8,912
Gul'dan	70.5 %	10	2	8	0	00:00:00	36,175	82,561		18,839		9,618
Li-Ming	66.8 %	14	0	14	1	00:00:44	41,974	94,098				9,086
Samuro	66.4 %	12	4	8	2	00:01:03	34,609	69,296				12,502
Lt. Morales	61.3 %	14	1	13	2	00:01:00	14,066	29,095	52,096	10,683		9,159
Li-Ming	55.1 %	10	5	5	3	00:01:36	36,749	52,793				8,716
Leoric	53.9 %	11	0	11	4	00:02:23	21,450	84,019		16,759	60,347	8,916
Brightwing	38.1 %	9	0	9	3	00:01:45	8,210	20,739	39,758			5,544
Chen	37.8 %	9	2	7	5	00:02:21	25,262	13,112		30,993	68,730	5,231
Rehgar	31.8 %	9	1	8	4	00:01:55	14,222	7,476	27,992			4,745

6.3.3 Game 3

Battleground

Figure 6.6: Sky Temple map (Blizzard Entertainment, 2016n)

Sky Temple is a three lane map. In each lane temples spawn at given times (Blizzard Entertainment, 2016n). When a hero stands on a temple and defeats the guardians protecting it, the temple will shoot laser beams at enemy structures. There are four mercenary camps on the map (two on each side), and a boss in the middle of the map.

Hero

Gul'dan is a ranged assassin (Blizzard Entertainment, 2016h). His abilities are Fel Flame (a wave of flame dealing massive amounts of damage), Drain Life (Drain life from enemies over 3 seconds, dealing damage and healing Gul'dan) and Corruption (Three circles of shadow damage over 6 seconds). His trait is active, which means that the player must press a button to use it. The trait restores mana to Gul'dan as he does not passively regenerate mana like other heroes. To restore mana, he must sacrifice health. He can choose between the ultimates Horrify and Rain of Destruction. Horrify fears enemies (enemies cannot control their hero) after a short delay and lasts for two seconds while Rain of Destruction summons meteors in an area for 7 seconds. Each meteor deals heavy damage, but Gul'dan must channel the ability. Since Gul'dan is a ranged

character he needs to stay in the background in team fights to avoid taking lethal damage, however drain life might be a helpful tool if a Gul'dan wanders too far forward.

Experience and deaths

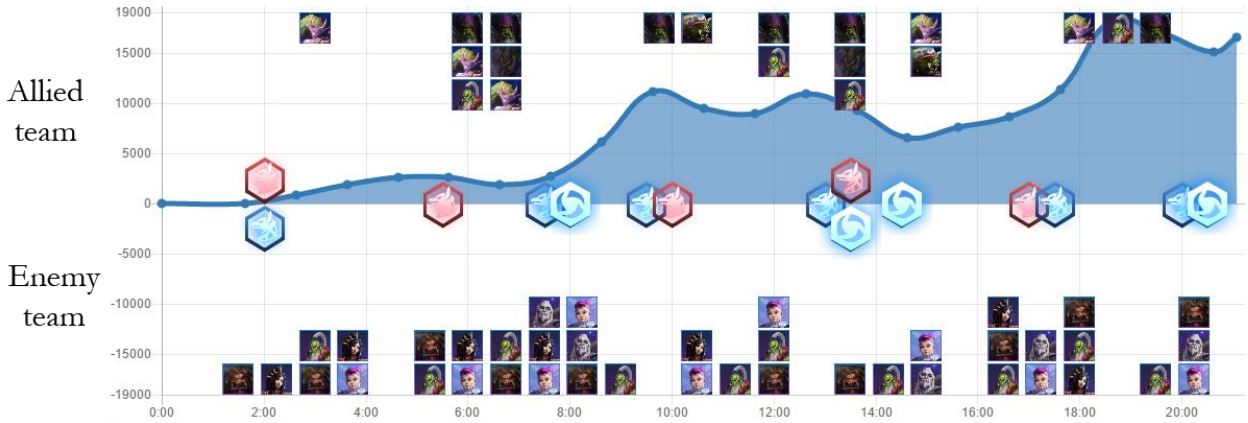


Figure 6.7: Player 1 game 3 experience and deaths from Hotslogs

Game overview

The player started the game in bottom lane with one other team member. When they arrive the team member writes in the chat that the player should go middle, and he listens, and responds in the chat. When the temples spawn the player and Dehaka rotates between the temple and middle lane to heal. They get a few shots and a kill. The player stays in middle and soaks until the temple spawns bottom. The player manages to kill Zarya, but Samuro comes from behind and kills the player. When he re-spawns he goes back to the bottom lane, and onto the shrine with Dehaka. He gets killed by Samuro and Li Ming. When he respawns he joins the team and picks up the boss. Dehaka and the player pushes in with the boss in the bottom lane. They continue to push when the boss dies, retreats, but goes back in. When they go back in both get killed. The bottom and top temple spawns. When walking back after respawning the player watches Gazlowe getting killed in the bottom lane, but decides to go bottom anyways as the team is rotating down. They kill three heroes on the enemy team. And pushes in the middle lane. The player hides in a bush when the enemy team re-spawns, and does not mount up. The enemy team finds him and kills him., it does not seem like the player notices the death timer and sees that the enemy players re-spawn. Two temples spawn and the player goes to the middle one together with Dehaka, while the rest of the team picks up the boss. Dehaka and the player gets ambushed by the enemy team and killed. When the player re-spawns he groups up with the team in the bottom lane. The player picks up a camp in the top lane, and notices that the team is fighting in the bot lane when he is done. He groups up with the team, and the kill four players. One temple spawned in the top lane,

and the player's team gets it. The player's team goes to capture the boss. Samuro shows up and kills the player. Two temples spawn while Gazlowe gets the boss. The temple shots are enough to kill the core.

Game statistics

Table 6.4: Player 1 game 3 game statistics from Hotslogs

Hero	Score	TD	Kill	Assist	Death	Time dead	Hero damage	Siege damage	Heal-ing	Self - heal	Damage Taken	XP
Samuro	76.6 %	27	15	12	4	00:03:27	56,623	63,193				18,434
Dehaka	74.8 %	26	3	23	2	00:01:28	43,647	61,037		24,455	77,523	18,880
Lunara	69.5 %	27	11	16	5	00:03:20	60,879	36,494		9,409		18,507
Xul	60.5 %	10	2	8	5	00:04:07	40,735	162,938		12,693		19,913
Gazlowe	56.3 %	12	4	8	2	00:01:49	40,217	65,354				17,753
Gul'dan	51.9 %	15	7	8	6	00:04:26	47,997	45,338		24,209		12,737
Li-Ming	51.2 %	14	6	8	7	00:04:17	47,542	85,116		3,357		15,500
Samuro	40.0 %	11	6	5	10	00:07:16	48,579	76,318				13,292
Zarya	30.6 %	10	3	7	9	00:06:12	30,161	32,189			58,689	11,946
E.T.C.	25.3 %	11	2	9	10	00:06:44	21,688	18,381		14,105	79,032	9,105

6.3.4 Summary

The player was concentrated on the mini-map in all three games, and was quick to respond to a lane without teammates to soak (gather experience from a lane).

The played did not use pings to communicate with his team. He did respond when teammates pinged or wrote instructions in the chat, but did not participate in decision making during any of the games.

The player won lost his two first games, but won the last one. The first game his Hotslogs score was 40,3% which was the 7th highest in the game and 2nd highest in his team. The second game he got a score of 31,8% which was the lowest of any player in the game and in the last game he got a score of 51,9% which was 6th place in the game and last in his team.

6.4 Player 2

6.4.1 Game 1

Battleground

This game was played on the battleground Sky Temple same as Player 1 game 3.

Hero

The player played Nazeebo same as Player 1 game 1.

Experience and deaths

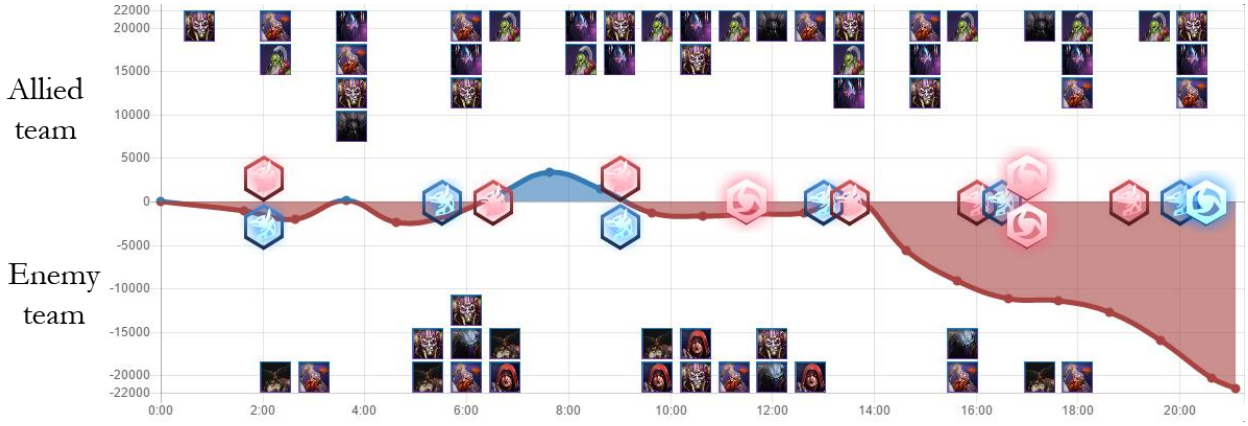


Figure 6.8: Player 2 game 1 experience and deaths from Hotslogs

Game overview

Falstad arrives late to the battle and is AFK for the beginning of the game. Player goes alone middle staying passive as only two enemies is visible on the map. Goes forward to clear minions and gets killed by the other three enemies. One of the enemies was invisible (can be seen by shimmer on the map). He was visible right before the player got attacked and the player started to retreat right before he got attacked. Pings and goes top after spawn, but moves middle as teammate is approaching top to soak middle when he notices the lane is empty. The temples spawn and player goes to middle temple. He escapes a 2 versus 3 fight, but body blocks friendly Falstad and he dies. The player retreats from the objective as a second teammate dies. Falstad comes middle when he respawns (Falstad's mount is a flight ability). Player sees Falstad hiding in bush and helps him kill enemy. The player has to hearthstone to get health. As he is channeling the ability he checks

top lane, and immediately walks there while pinging when health is replenished. The player tries to kill The Butcher 1 versus 1 but gets killed in the process. When the player respawns he pings top and walks towards the lane, but notices no teammates is in the middle lane, pings that lane and goes there instead. The Butcher tries to kill the player again, but the player baits him into friendly fort and Falstad comes for backup killing The Butcher. When the second temple is spawning in the bottom lane the player goes to the lane and pushes the lane while pressuring the enemies. The player moves down to the objective and two teammates gets killed in the lane. The player tries to help, but is too late. Gets a kill on Zeratul and doing enough damage on The Butcher so that he has to retreat, but Valla comes from behind and kills the player. Valla vas briefly visible on the map, but it does not seem like the player notices her, and there was no escape. The player pings the objective while dead to get a teammate to capture it. The player watches the mini-map while dead, and decides to go middle when he spawns as the objective will be finished by the time he arrives. The player continues to push the middle lane, and when he sees a team fight starting top, he pushes the enemy fort, retreating when it dies to get a camp. When the next shrine spawns the player waits for backup before going in. Four enemies show up and the player gets killed. While the player is dead he notices enemies are missing on the map, so he pings the boss. Teammates cannot contest with players down, and the enemies gets the boss.

After defending the boss, a team fight breaks out in the middle temple. Falstad kills Valla and gets killed. The player steps forward to try to help, but goes too far and gets killed by Zeratul. When respawning the player goes top to defend a camp. Two teammates die in the top lane, and the player goes too far forward and gets killed. The enemies proceed to take the boss. Player goes bot to defend while teammates fight top and gets killed. The temples spawn and the player continues to defend while waiting for teammates. Falstad is AFK in the spawn and the player notices, trying to ping him. He goes top to try to help Samuro to get the temple. Samuro dies right before he arrives, and the player gets killed too. The enemies rush the core and wins the game.

The game was close, but when it came down to it the enemy team got two bosses, and the player's team got none. They lost team fights and/or heroes at crucial times in the game giving the enemy team huge advantages.

Game statistics

Table 6.5: Player 1 game 1 game statistics from Hotslogs

Hero	Score	TD	Kill	Assist	Death	Time dead	Hero damage	Siege damage	Healing	Self - heal	Damage Taken	XP
The Butcher	82.2 %	23	8	15	5	00:02:45	38,750	113,548				20,082
Falstad	81.3 %	25	10	15	5	00:03:36	24,804	83,304		13,576		18,178
Zeratul	80.9 %	29	8	21	3	00:02:12	42,532	48,739				15,250
Abathur	74.2 %	14	3	11	3	00:02:09	23,961	131,590	4,541			22,285
Valla	73.0 %	23	6	17	4	00:02:30	26,017	95,587		1,237		17,534
Nazeebo	69.3 %	20	4	16	4	00:02:16	26,711	97,295				19,369
Falstad	61.2 %	15	9	6	7	00:04:56	31,918	51,440		9,278		12,588
Nazeebo	46.4 %	10	2	8	8	00:05:07	24,303	118,174				13,503
Samuro	44.0 %	11	5	6	9	00:06:38	35,249	57,244				11,089
Alarak	32.6 %	9	1	8	9	00:06:26	33,493	21,920		6,930		9,571

6.4.2 Game 2

Battleground

Figure 6.9: Tomb of the Spider Queen map (Blizzard Entertainment, 2016o)

Tomb of the Spider Queen is one of the smallest battlegrounds in the game. The battleground objective is to collect gems which drops from three of the minions in a minion wave, and three for each enemy killed. A

team needs to turn in 50 gems at one of the locations between the lanes (orange markers) to spawn Webweavers. The Webweavers spawn in each lane and primarily does siege damage to minions and structures. Each time a team turns in the next turn in gets 5 gems more expensive. There is one mercenary camp on each side of the map together with a boss in the top lane and a mercenary camp in the bot lane.

Hero

Diablo is a melee warrior hero (Blizzard Entertainment, 2016d). His basic abilities are Shadow Charge (charging an enemy and stunning them for 0.5 second, and 1 second if they hit an unpathable location while dealing moderate damage), Fire Stomp (8 small fire waves that deals moderate amounts of damage) and Overpower (moves the target to the opposite side of Diablo, dealing moderate damage and stunning the enemy for 0.25 seconds). Diablos trait is Black Soulstone that gives Diablo 10 Souls per hero killed and 1 per minions. Diablo can gather a maximum of 100 Souls. The Souls increase Diablos health by a small amount and if Diablo has 100 Souls and dies, he will spawn in 5 seconds and lose all his Souls.

Experience and deaths

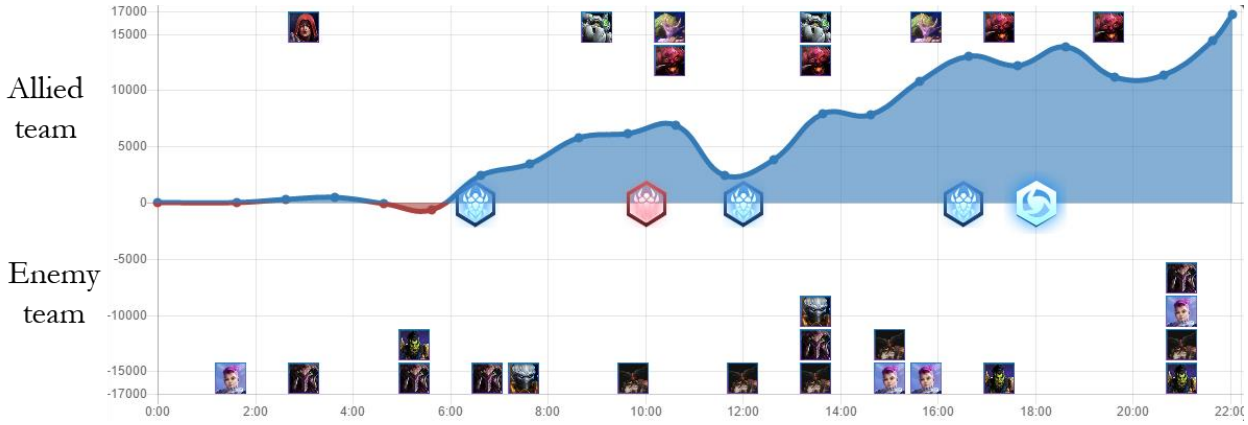


Figure 6.10: Player 2 game 2 experience and deaths from Hotslogs

Game overview

The player starts the game in the middle lane and harasses enemies while soaking experience. When necessary player moves between top and bottom lanes to help out. Zeratul moves between lanes and gets a few kills. Player tries to turn in his gems top, but gets ambushed by three enemies. Runs towards the healer and survives. In the meantime, Zeratul turns in his gems bot and the team get the first round of webweavers. The rest of the team gets a kill in the top lane and continues to push the lane. When the webweaver is almost

dead, the player moves middle to push. This gives the team a 10 to 8 level advantage. The player then soaks the top lane, but sees the team fighting enemies middle, and moves to help out.

While clearing middle lane of a camp, a team fight breaks out top. The player chooses to clear the camp, and the healer dies, however The Butcher on the enemy team steps too far forward and the player gets a kill. The player's team need to retreat to get health, and the enemies gets a turn in. The player steps too far forward while trying to clear the enemy webweavers and gets killed, but has enough souls to re-spawn after 5 seconds. The player goes to clear bot lane, before joining the team middle, and the enemies retreat. A team fight breaks out, and Zeratul turns in his gems bot for a new set of webweavers. The team pushes top, but the player goes too far forward and gets killed together with Lt. Morales. The team avenges their death and gets three kills. Player has enough souls and re-spawns after 5 seconds and goes back top to help the team. When Lt. Morales respawns the team groups as five bottom and pushes the lane. Lunara goes too far forward and gets killed. The player immediately pings for retreat. The player checks the status of gems on both teams while retreating and goes to turn in. Team pushes bot again. The player gets isolated from the team and dies, but re-spawns after 5 seconds again, and groups up with the team. Team kills Thrall in the meantime. The player's team has gained a 20 to 18 level advantage. The team retreats, but Lt. Morales gets focused by The Butcher. The player notices and helps her out. The team goes back into the fight, kills four players of the enemy team and proceeds to kill the core.

The player played a tank hero in this game, which means he has to stay in the front line to protect his team. The team did a good job of grouping up after reaching 10 and followed the player around. They got a solid lead, and was controlling large portions of the game which resulted in a victory.

Game statistics

Table 6.6: Player 2 game 2 game statistics from Hotslogs

Hero	Score	TD	Kill	Assist	Death	Time dead	Hero damage	Siege damage	Healing	Self - heal	Damage Taken	XP
Zeratul	76.6 %	11	9	2	0	00.00.00	43,603	95,706		0,000		15,655
Valla	68.1 %	16	3	13	1	00.00.18	69,957	102,352		4,107		12,677
Lunara	63.1 %	14	4	10	2	00.01.28	85,190	65,194		9,912		13,128
Diablo	61.5 %	16	1	15	4	00.00.20	55,669	149,978		0,000	135,278	12,916
Lt. Morales	58.2 %	13	2	11	2	00.01.13	13,398	30,097	135,189	12,355		10,301
Tassadar	48.1 %	8	1	7	2	00.01.03	37,957	83,635	32,843	11,749		9,456
Thrall	46.2 %	8	1	7	3	00.02.13	60,572	78,723		35,273		10,017
Zarya	44.8 %	7	3	4	4	00.02.44	38,239	109,334		0,000	75,838	9,943
Zagara	37.8 %	7	0	7	5	00.02.46	53,940	119,152		4,621		10,502
The Butcher	32.4 %	8	3	5	5	00.03.27	38,733	54,676		0,000		7,905

6.4.3 Game 3

Battleground

This game was played on Garden of Terror which is the same battleground as Player 1 played his second game on.

Hero

Greymane is a ranged and melee assassin (Blizzard Entertainment, 2016g). Greymanes trait is that certain abilities enable him switch between human (ranged) and Worgen (melee) form. His human abilities are Gilnean Coctail (throw a flask that deals moderate damage to first enemy hit and massive damage to enemies in a cone behind them), Inner Beast (increase attack speed by 3 seconds, and basic attacks refreshes the duration) and Darkflight (leap at an enemy and shapeshift to Worgen dealing heavy damage). His Worgen abilities are Razor Swipe (deal heavy damage in the area in front of Greymane), Inner Beast (as human form) and Disengage (rolles away and shapeshifts into a Human). He can choose between Go for the Throat and Marked for the Kill for his heroic ability. Go for the Throat works as the Human form Darkflight ability, but deals more damage. If the ability kills the targeted enemy the ability can be used a second time without spending mana. Enemy players that can be killed with the ability get an indicator above their head. Marked for the Kill shapeshifts Greymane to the human form and fire a shot at an enemy. The shot causes the enemy to take 25% more damage for 5 seconds, and the ability can be re-activated to leap to the enemy and

shapeshift into a Worgen. Since Greymane is both a ranged and melee character he has a unique playstyle. The Worgen form deals more damage, but leaves him more vulnerable to enemy attacks as he needs to be in the front line during team fights even though he does not have a large health pool.

Experience and deaths

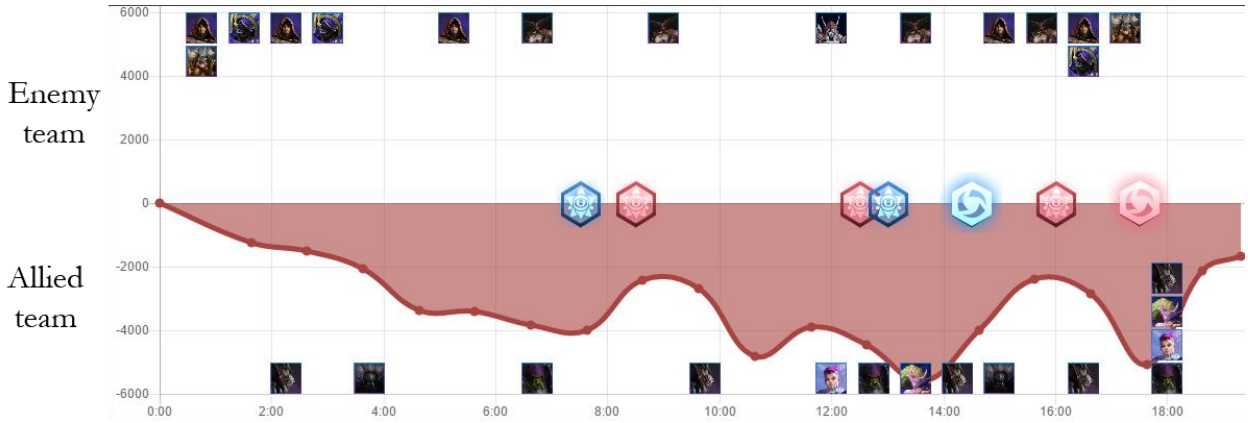


Figure 6.11: Player 2 game 3 experience and deaths from Hotslogs

Game overview

The player starts solo in bottom lane, and sees a lot of the enemy players in the top lane. His team runs top, and the player moves middle to cover for his team. He clears middle for minions, but pushes too far forward and Anub'Arak of the other team shows up and the player takes a lot of damage. Has to use his well. Lunara comes middle and together they kill Anub'Arak. The play moves bottom with low health to get seeds when the night starts. Medivh on the enemy team flies above his head, giving his team vision. The player gets killed instantly when trying to get the small seeds camp on the player's side of the map. When he re-spawns he joins up with the team in the bottom lane and gets the remaining seeds. The player proceeds to soak middle and bottom lane. Player hearthstones right before the second night spawn, and takes the small seed camp in the top to get enough for the terror. Hearthstones back and gets the terror. The player uses the terror to defend middle from enemies before pushing the bottom lane. He gets the fort and pushes the keep wall. Sylvanas shows up to defend. When the terror expires and the rest of the enemy team shows up and kills the player. When the player respawns he defends bottom lane before joining up with his team in the middle. They kill Sylvanas, and gathers seeds for another terror. Two team members dies bottom, while the player gets the terror. He uses it to push the middle and top fort. As the terror dies in the top lane Muradin and Medivh are there to defend, and manages to kill the player as he tries to run away. When the player re-spawns he tries to defend the bottom fort against a camp. He notices that a camp gets picked up behind him, which means that enemies are in the area. He tries to ping for help, but is in a bad spot and gets killed when trying to run back

to the base. When the player re-spawns his team has killed two of the enemy players and are going for the enemy core with the terror. The enemy team manages to defend, and kills four players in the process, including the player. The enemy team proceeds to rush the core and wins the game.

This was a close game where the player's team had an advantage on several occasions. The game was decided by a team fight that the players team lost after pushing in too far with a player disadvantage.

Game statistics

Table 6.7: Player 2 game 3 game statistics from Hotslogs

Hero	Score	TD	Kill	Assist	Death	Time dead	Hero damage	Siege damage	Healing	Self - heal	Damage Taken	XP
Lunara	79.1 %	13	8	5	2	00.01.55	61,670	44,393		10,577		9,976
Sylvanas	66.4 %	10	2	8	1	00.00.36	27,667	91,846		0,000		13,328
Abathur	66.0 %	11	0	11	2	00.01.16	32,104	106,169	9,240	1,365		14,565
Gul'dan	62.7 %	11	2	9	3	00.02.13	38,925	84,206		19,096		10,894
Anub'arak	61.3 %	7	1	6	3	00.01.36	20,103	109,783		12,032	47,345	15,330
The Butcher	60.6 %	8	7	1	4	00.02.38	26,996	62,997		11,868		13,308
Zarya	55.7 %	9	2	7	2	00.01.49	23,699	49,880		0,000	34,999	10,591
Muradin	52.2 %	6	3	3	2	00.01.17	14,272	23,744		21,258	45,038	8,508
Greymane	39.8 %	2	1	1	5	00.03.56	15,325	128,893		0,000		13,716
Medivh	34.6 %	9	1	8	5	00.02.45	22,084	32,422	15,595	0,000		7,463

6.4.4 Summary

The player used the ping system to notify his team of his movements and also if enemy team movements even when dead. The player used the time while dead watching the map, and was ready to go when he re-spawned knowing what he could expect in a lane.

Player 2's Hotslogs result was best in the second game where the player won. He got 61,5% which was 4th in his team and the best result in any of the games in the study. In the first game the player got 46,4% which was 8th in the game and 3rd in team, and in the last game the player got 39,8% and got 9th place, last in his team.

6.5 Player 3

6.5.1 Game 1

Map

Figure 6.12: Blackheart's Bay map (Blizzard Entertainment, 2016b)

Blackheart's Bay is a three lane battleground. The battleground objective is to gather coins that drop from two chests that spawn at different times (5 coins), four money camps (2 coins), five mercenary camps (2 coins) and boss (2 coins) (Blizzard Entertainment, 2016b). If a player that holds coins gets killed, he will drop the coins and anyone can pick them up. When a team delivers ten coins to Blackheart that is located in the middle of the map, cannonballs will be fired at enemy's structures. A team must turn in two more coins for each turn-in. The top and middle lane are rather close together and the bottom lane is more isolated.

Hero

Player 3 played the hero Nazeebo, which the same as Player 1 and Player 2 played their first game as.

Experience and deaths

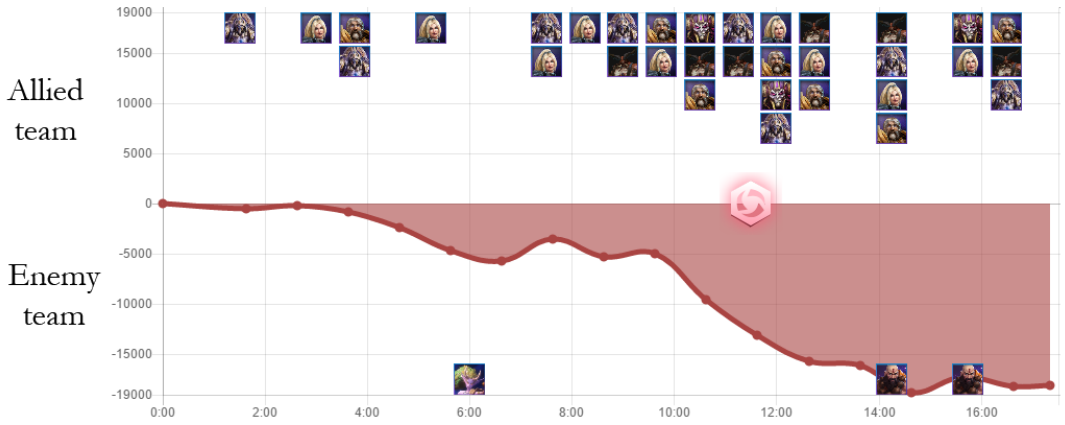


Figure 6.13: Player 3 game 1 experience and deaths from Hotslogs

Game overview

The game started out with a skirmish in the middle lane where all players contributed. The player then moves to soak the bottom lane. He plays passively and is carefully watching the map. When enemies are missing he retreats in the lane and avoids getting killed as two enemies rotate to the bot lane.

When the second chest spawn the player makes his way up to it and does not notice that enemies is turning in coins in the middle of the map (not visible on the mini-map, but in the map objective tracker in the bottom right of the screen). Kharazim is already on the chest and the player focuses on him, in the meantime Lunara shows up from behind. She was visible for a brief period, but the player does not notice it. Manages to retreat and survive.

The player then decides to group up with the team after looking at the mini-map. At this point the team is far behind in experience (7-10) and it does not seem like the player notices that the enemy team gets 10. The player recognizes that the team needs to clear the middle lane. The player recognizes that that his team gets level 10. The chest spawn and the player goes to get the mid one. He does not see that enemy players show up even though they were visible on the map for a brief period. Does survive. At this point one of the friendly players gets dropped for AFK-ing (away from keyboard) and get replaced by a bot.

Player goes after Cho'Gall and Kharazim (only enemies visible on the map). The rest of the enemy team shows up, and the player is too far forward and takes a lot of damage. Retreats from the fight, but goes back in and dies. The player spends the time dead watching the mini-map. When the player respawns he goes after Cho'Gall and Kharazim again and dies when rest of the team shows up. The team fights in the bot lane when

they respawn, and it seems like it goes in their favor, but the level deficit 13-17, turns out to be too much, and the enemy team kills The Butcher and Artanis. They manage to pick up a kill on Kharazim, but at the same time Uther and Nova dies leaving the player as the only surviving hero. The player proceeds to clear bottom and mid lane for minions. While clearing top lane, enemies are missing on the mini-map. The player seems to recognize that enemies might be on the camp to the right of his position after looking at it several times. The player is right, and does not back out right away when the camp is picked up, and ends up getting killed. Two players get picked up when they are far forward on the map, ultimately leading to the enemy team being able to go in and kill the core together with minions and a camp.

The game was affected by losing Artanis early in the game. He did come back to the game a couple of times, but was standing in the core doing nothing for most of that time. When a team gets a bot, they must ping it to make it follow them. If not, it will push a lane alone and not joining the team. The player's team got behind in experience around the 4-minute mark, and was never able to recover. At around the 10-minute mark the enemy team gained a significant lead, and Artanis was dropped for inactivity at 9:50 into the game.

Game statistics

Table 6.8: Player 3 game 1 game statistics from Hotslogs

Hero	Score	TD	Kill	Assist	Death	Time dead	Hero damage	Siege damage	Healing	Self - heal	Damage Taken	XP
Gall	86.5 %	29	10	19	0	00:00:00	64,772	98,766	9,466			12,524
Cho	80.1 %	29	3	26	0	00:00:00	40,809	61,756		38,418	95,65	12,524
Samuro	71.5 %	29	12	17	0	00:00:00	53,229	31,988				8,899
Lunara	63.9 %	28	5	23	1	00:00:23	38,083	47,840				11,595
Kharazim	49.1 %	22	3	19	2	00:01:52	15,216	16,866	57,83			7,640
Nazeebo	45.8 %	2	0	2	3	00:01:38	34,079	80,627				13,441
Uther	23.3 %	3	0	3	7	00:03:35	25,267	24,514	39,69			6,048
The Butcher	23.1 %	3	0	3	6	00:03:16	31,714	28,044				6,485
Artanis	18.1 %	3	2	1	8	00:03:41	27,207	17,945			59,389	4,355
Nova	13.7 %	2	1	1	9	00:04:13	33,581	10,408				5,040

6.5.2 Game 2

Battleground

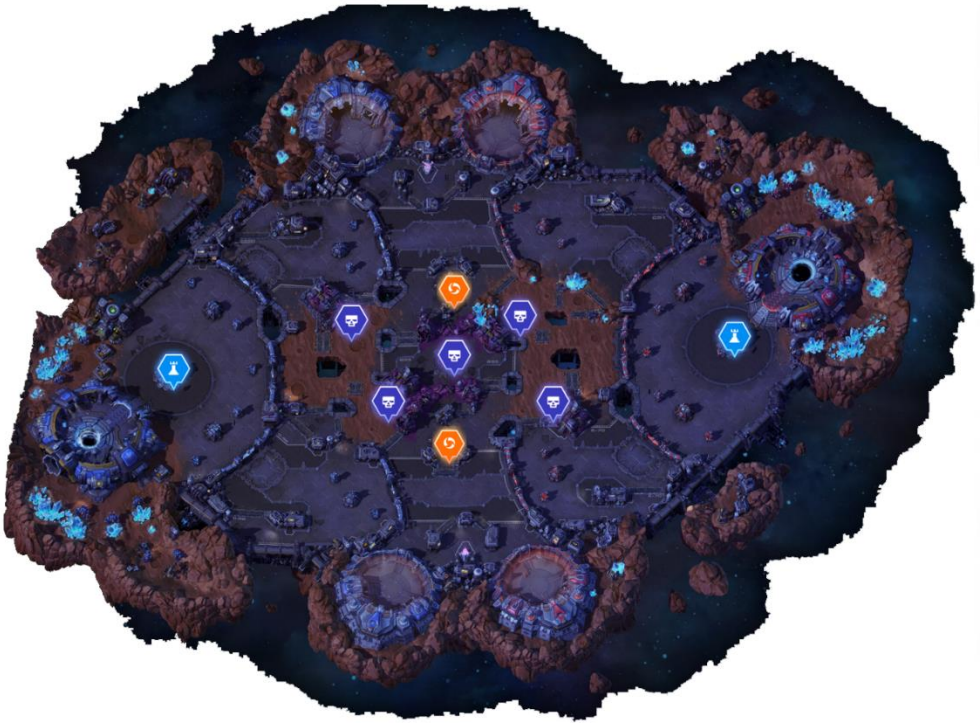


Figure 6.14: Braxis Holdout map (Blizzard Entertainment, 2016k)

Braxis Holdout is one of the newest maps in the battleground pool. It is a two lane map where the objective is to hold to shrines at the same time to fill your holding cell with zergs (Blizzard Entertainment, 2016k). Once one of the teams reaches a hundred percent the holding cell doors will open and zergs run into the lane doing structure damage. The team with the highest (Blizzard Entertainment, 2016l) percentage will get the strongest zerg rush. There are four mercenary camps on the map, two on each side, and a boss in the middle of the map.

Hero

The player played the hero Rehgar, the same hero as player 1 in game 2.

Experience and deaths

Figure 6.15: Player 3 game 2 experience and deaths from Hotslogs

Game overview

This game the player has chosen a healer. At the beginning of the game all five heroes go to the bottom lane, but no one goes top. The player pings the top lane, but no one responds, resulting in the player going top alone. Medivh on the enemy team also goes top, but the players team loses heroes bottom. When the first objective spawns, the player has low mana, and can't save teammates with healing. At level 7 the player does not check team composition. Level 7 is important for Rehgar as he can get an ability to free a teammate from an enemy stun. The enemy team got Tyrande which has a stun as one of her basic abilities. The player does not get the ability to free teammates. A 4 versus 4 fight ends up with three teammates losing their life and the player is again forced to stay alone in the top lane to gather experience. When the next objective spawns the player goes out of position to heal a teammate, the teammate survives but the player dies as he takes damage from enemy towers. When the player respawns he is slow to choose which lane to go to, resulting in it taking longer for him to reach his destination in the top lane. When the objective is cleared, the player stays with the team in the bottom lane. A team fight takes a bad turn and they lose three players. But the enemy team push to far and the player manages to get two kills by chasing Medivh and Valla leaving them in a favorable position for the next objective, however the enemy team shows up and manages to kill two heroes and continues to get the objective to 100%. At the next objective spawn, the team takes a 4 versus 4 team fight. The player chases Tyrande together with Medivh in the backline, but does not secure a kill and leaves teammates vulnerable. They manage to get a kill on Medivh, but Falstad dies when he comes top to join the fight. The player and Medivh tries to secure the top objective, and manages to get a kill, but the enemy team shows up from behind and Medivh and the players are forced to retreat towards the enemy base. Both get

kills and the rest of the team also dies in the fight. The enemy kills the core by pushing in with their 100% zerg rush.

The game was close in terms of experience, and the player's team got the two first objectives, but they still lost. The las team fight was lost due to bad positioning on several heroes so that the team could not work together.

Game Statistics

Table 6.9: Player 3 game 2 game statistics from Hotslogs

Hero	Score	TD	Kill	Assist	Death	Time dead	Hero damage	Siege damage	Healing	Self - heal	Damage Taken	XP
Valla	87.4 %	22	16	6	2	00.01.09	70,34	77,538				14,944
Tyrande	67.4 %	21	3	18	1	00.00.29	41,081	23,265	54,94			10,668
Nazeebo	65.8 %	16	5	11	4	00.02.26	51,458	104,243		6,117		12,452
Zarya	62.1 %	17	3	14	3	00.01.53	43,746	61,598			76,241	11,861
Rehgar	59.9 %	12	4	8	2	00.01.34	14,986	42,349	58,29			12,153
Falstad	54.4 %	7	3	4	6	00.03.34	56,461	122,17		10,102		10,348
Medivh	46.8 %	14	0	14	5	00.02.49	31,257	60,693	16,28			10,143
Zarya	45.7 %	5	0	5	6	00.03.23	45,051	96,181			80,578	11,146
Medivh	42.2 %	10	1	9	4	00.02.46	38,887	51,096	13,45			6,409
Lunara	33.4 %	10	7	3	9	00.05.16	47,853	24,581				6,164

6.5.3 Game 3

Battleground

Figure 6.16: Cursed Hollow map (Blizzard Entertainment, 2016c)

Cursed Hollow is a three lane map. Tributes will periodically spawn in one of six locations (Blizzard Entertainment, 2016c). When a team collects three tributes enemy structures will not attack and cursed minions are reduced to one health. The map includes four mercenary camps, two on each side, and two bosses.

Hero

Jaina is a ranged assassin (Blizzard Entertainment, 2016j). Her basic abilities are Frostbolt (a skillshot[2] that deals moderate amounts of damage), Blizzard (deals damage in a circle in three waves) and Cone of Cold (a cone shaped ability that does damage). Jaina's trait is Frostbite which makes all Jaina's abilities Chill the target. A chilled target tales 50% more damage from Jaina's abilities and slows their movement speed by 25%. Jaina's ultimate abilities are either Ring of Frost which deals massive amounts of damage and roots enemies for 3

[2] A skillshot is an ability that is hard to execute and that needs to be aimed precise at the target, often with a delay

seconds, and Summon Water Elemental that deals moderate damage and chills enemies nearby. The Water Elemental's basic attack splash for 25% of the damage and chills enemies. Jaina does massive amounts of damage, but she has low survivability and no abilities she can use to escape. It is important to stay in the backline to not get focused and killed by the enemy team.

Experience and deaths

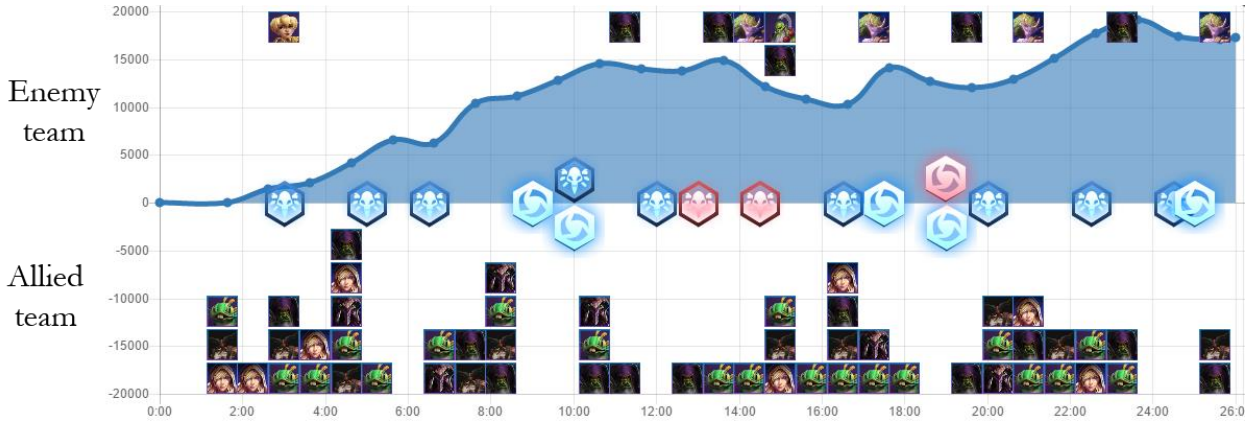


Figure 6.17: Player 3 game 3 experience and deaths from Hotslogs

Game overview

The game starts off with two players going mid lane, one top and two players are late to start the game. The player takes a lot of damage in the mid lane when enemies shows up, and is forced to use his healing well. He then takes more damage, and goes to the bottom lane when he sees that the lane is empty. He does not respect the damage of Gul'dan when he gets there, and with no healing well, he dies to poison damage. The player checks the statistics screen when he dies. The player goes back to bottom lane when he respawns, but once again dies to Gul'dan poison when the healing well is still not available The tribute spawns bottom, and the player goes back to bottom lane, even though the enemy team picked up the tribute. His team is dying to the tribute. He sees Gul'dan arriving with low health and decides to try to kill him, even though Lunara is right behind. He does not get a kill on Gul'dan and gets killed by Lunara, even though the healing well was available. This results in the Butcher writing "gg" in the team chat, and the player notices. "GG" is usually written at the end of a game, and when it is written this early it is negatively loaded.

When the player respawns the tribute spawns, and the player joins up with his team to help out. The enemy team has a level 7 to 6 lead. While the player goes directly to the tribute two teammates stay a bit further behind putting them in a disadvantaged position when the enemy team arrives grouped. With the team split

the entire team dies. The Butcher then suggests to let the enemy team win fast in the chat, and Zagara responds with "report him".

When the third tribute spawns in the top lane and the player is making his way up there, he has to stop and clear the middle lane for minions and a camp. Two of her teammates is in the top lane, and gets picked off when the enemy team gets the tribute. The enemy team has secured themselves a solid lead both in experience and structures. When the tribute ends two members of the player's team chases the enemy team, while Zagara and the player is a little bit behind them. When the player sees The Butcher charge into the enemy team he retreats to not get killed. Three members of the player's team dies. Gul'dan writes "no team – no win in the chat" and The Butcher blames the player. And the player responds with "I ran when you were 2 vs 5". Gul'dan blames the player for not looking at the map (which he was, the eye tracker proves that). The players team manages to pick up two tributes, but the enemy team gets three and gets the curse again. When they get cursed they go for their own boss which ends up with three players getting killed. There enemy team rushes the core and wins the game.

This game is a good example of how important team communication is in Heroes of the Storm. From the moment The Butcher wrote "gg" in the chat the player's team did not work well together and they took unnecessary risks making it hard to catch up in experience.

Game statistics

Table 6.10: Player 3 game 3 game statistics from Hotslogs

Hero	Score	TD	Kill	Assist	Death	Time dead	Hero damage	Siege damage	Heal-ing	Self - heal	Damage Taken	XP
Sylvanas	89.4 %	30	7	23	0	00.00.00	43,553	156,949		4,443		22,407
Gul'dan	77.3 %	26	9	17	5	00.04.40	46,806	82,127		25,451		17,120
Samuro	75.0 %	28	6	21	1	00.00.50	47,415	89,757				18,357
Chromie	70.1 %	30	7	23	1	00.00.19	37,922	62,065				15,023
Lunara	65.4 %	27	10	16	4	00.04.05	44,576	36,322				11,414
Zagara	55.3 %	7	4	3	6	00.03.24	41,429	134,767				16,911
Murky	42.7 %	11	2	9	5	00.01.57	14,778	68,074		8,643		14,668
Jaina	41.4 %	8	1	7	8	00.04.55	17,005	131,242				15,915
Gul'dan	32.5 %	6	2	4	12	00.08.04	30,241	60,699		24,926		8,894
The Butcher	29.3 %	8	2	6	10	00.06.30	14,548	71,812				10,493

6.5.4 Summary

The player was careful and often watching the mini-map. It seemed like the player had good control of where his teammates were at all times. But he did get tunnel-vision, however, that cost him his life on a few occasions, such as, where he chased a hero to get a kill, or did not notice a hero coming from behind.

The player never checked enemy hero's talents or friendly team's timer on heroic abilities. The games the player played forced him to often stay alone in a lane to soak experience due to teammates abandoning a lane or early deaths that led to an experience deficit.

The player did ping a couple of times each game, but teammates usually did not listen. Especially in game 2 where the player was forced to soak experience top as a healer. In this situation the player only pinged once, so more communication with the team might have solved the problem. The player also did respond to negative comments in the text based chat in the third game, without that helping the gameplay.

Player 3 lost all of his games, but he ended up 1st on his team the first two games, and 3rd in his team in the last game with 45,8%, 59,9% and 41,4%. This might mean that the player was unlucky in the matchmaking and got teammates that played worse than him, but it might also mean that the player was doing the right things, but it was not enough to win the games.

6.6 Eye Tracking Results

In this section we look at the eye tracking data across the players. Table 6.11 presents the data for each player per game versus the areas that were tracked. The eye tracking data has been divided by the game time for a percentage based comparison.

Table 6.11: Data gathered from the eye tracking application divided by game time

	Player 1			Player 2			Player 3		
	Game 1	Game 2	Game 3	Game 1	Game 2	Game 3	Game 1	Game 2	Game 3
Map	9,95	8,84	12,36	18,45	15,69	18,33	16,92	10,83	21,13
Time/levels	0,18	0,27	0,67	0,26	0,29	0,11	0,67	0,71	1,09
Cooldowns	3,15	2,55	3,60	3,89	3,27	4,88	3,16	5,92	2,22
Health	0,17	0,21	1,08	0,03	0,02	0,10	0,15	0,00	0,18

Table 6.11 shows the time the participants spent looking at the different areas of the screen from the eye tracking application divided by game time. The results from the eye tracking shows that player 1 spent the

least amount of time looking at the mini-map with an average of 10,38%. Player 3 spent an average of 16,30% time looking the map. This is mainly because player 3 had the game with most time spent looking at the map with 21,13% in game three. Player 2 was the one who spent the most time average time looking at the map with a 17,49%. A reason for player 2 having the highest average might be that he spent the time while dead focusing on the mini-map and pinging for his team, which was noticed on the video replays. Time spent looking at the mini-map differs from 8,84% to 21,13% which means that during a 20-minute-long game one player would spend 2,5 minute more looking at the mini-map.

All the players have a low amount of game time spent looking at the time and levels bar located in the top of the screen. When analyzing the video of the games it was difficult to identify the checking of levels. This might be because the looks are done quickly and it is therefore difficult to notice on the video. The number of time players looked at the level indicator ranges from 7 to 124 looks with an average of 37 looks per game. Player 3 had the game with the most looks at the time and level indicator. This was his third game where his team fell far behind from the beginning of the game, and was writing criticism in the game chat. The high amount of looks can be caused by the team being far behind and the player trying to catch up in experience, or that the player was either bored or angry and was looking at the clock to see how much longer the game would last.

The players spent an average of 3,63% of the game time looking at cooldowns. Player 3 looked at the cooldowns 5,92% of the game time in game number two. This game the player played the hero Rehgar which is a healer. This means that the player might have been using a lot of time watching the status of his healing spell to keep teammates alive, however, when player 1 played Rehgar in his game number 2, his time spent looking at cooldowns was the least of his three games (2,55%). This might be a result of hero familiarity. Player 1 might be more familiar with the hero and knows when the spells comes off cooldown, while player 2 does not have the same experience with the hero. The playstyle of the players might also have affected the results. Rehgar has a special mount where he does more damage while mounted. An aggressive player might utilize the mounted form more than a passive player. In player 3's game he was forced to stay alone and soak experience in the top lane alone, which might have led to an extensive use of the mounted form and thus the higher eye tracking result.

The players spent the least amount of game time looking at the health and mana indicator on the bottom left of the screen with an average of 0,22%. As mentioned each character has a mana and health indicator on top of the character's head which was not possible to track with the eye tracker. This low result indicates that it is the bars above the characters head the players use as the primary source for health and mana management.

6.7 Summary

This chapter has used the data sources to analyze the gameplay of each player. The eye tracking data is also examined in detail.

7 Discussion

This chapter will look at the analysis of gameplay and the results across the players.

7.1 Replay Analysis

During the analysis of gameplay, it became apparent that the replay analysis required a certain amount of game knowledge to be able to identify episodes that could help a player improve their skill. This means that the person analyzing the replays must know how the game works to be able to identify improvements possibilities.

Manual replay analysis is time consuming and the use of Hotslogs statistics to identify encounters was of great help to reduce time usage. The eye tracking layer on the replay analysis gave useful insight as to what information the player had while playing the games. For example, the analyst can see if a player checked the mini-map in certain situations. It is not necessary to ask the player if he or she noticed that enemies were moving towards the player's lane as the eye tracking layer will reveal the eye movements of the player.

7.2 Eye Tracking Data

The data from the eye tracking application is interesting, but might not be valuable until it has been tested in a lot more games that are directly comparable. By figuring out the percentage of game time spent looking at the areas, the numbers became more comparable, and showed interesting results.

Due to the matchmaking, especially player 3 got matches where either one teammate disconnected or teammates were writing unnecessary comments in the chat. In both cases this led to a lack of team communication and cooperation. The best way to test the application might be in matches where both teams have players that are of equal skill, or in relatively equal team setups, to be able to read the eye tracking results properly. In quick match a player might end up on a team with heroes that is would never have been picked together as a viable team composition and are at a clear disadvantage compared to the other team. This changes the team motivation and strategy, which makes it harder to determine if a player has played a good or bad match.

It was noticed during development when I was testing the application that because I knew the application was on I checked the mini-map more often than I would have regularly. It seems like this might have been because I wanted my results to be good, however, checking the mini-map too often might lead to other visual

clues on the screen being lost. One possibility be that the right amount of checking the mini-map might differ too much from situation to situation. An example of this is if your team is doing well and has a significant lead and you kill the entire enemy team when they are level 15 it will be 40 seconds until they respawn (Blizzard Entertainment, 2015b). When there are no enemies on the map, it might not be necessary to check it as often, and this might mean that the right amount of time spent looking at the mini-map might be different from games where your team is behind versus games where you are in the lead.

It is important to distinguish between a training situation and ranked games because the eye-tracker could be abused within a ranked game, by creating functionality that reminds the player to check certain areas on the screen. This would give a player an unfair advantage over the other team. For example, when an enemy team gains a level, there is no audio-clue that it is happening. The player has to actively check the status. An application that reminds the player to check it will certainly be an advantage against players who does not have the same opportunity. Further research would need to be carried out in order to determine how this could be useful in training.

7.3 Summary

This chapter presents a reflection over the use of the eye tracking data in understanding gameplay.

8 Conclusion

This chapter summarizes the results of the research and answers the research questions. The chapter will include a summary, an overview of the results, limitations, future work and a conclusion.

8.1 Summary

The research has been conducted by creating an application that gathers eye tracking data on the number of looks and the time spent looking at four areas of the screen in the MOBA game Heroes of the Storm. The application was used in an empirical study where eye tracking data, and video recordings were gathered as well as game logs that was analyzed by using Hotslogs. The different data sets were used to analyze gameplay.

8.2 Results

The goal of this research was to see if it was possible to gather eye tracking data in a MOBA game, and figure out if eye tracking data adds value in gameplay analysis.

Two research questions were posed.

1. Is it possible to gather eye tracking data in multiplayer online battle arena (MOBA) games?

The eye tracking application that was developed shows that it is possible to gather eye tracking data from gameplay within the MOBA game Heroes of the Storm. Using a screen recorder, it was shown that it is also possible to add a gaze overlay to video replays of the game. This overlay can be seen in figure 5.2.

2. Does eye tracking data add value in gameplay analysis in MOBA games?

The eye tracking data gathered in this research is not enough *on its own* to determine if a player has played a good game and if the player can improve in certain areas. The real value of the data comes when it is used together with other sources of data about the gameplay. In this research I used data source triangulation to combine the eye tracing data with a game video and play statistics in order to understand gameplay. So, in this way the eye tracking data does add value in gameplay analysis.

The eye tracking data on its own has shown interesting results and shows promise that it is possible to use the data to *compare* games and players. Furthermore, there is potential in using eye tracking for MOBA gameplay

training, however, eye tracking data from a large number of games would have to be analyzed to be able to see trends that could be used to design training episodes, and this was beyond the scope of this thesis.

Finally, the research shows that there is promise in triangulating these kinds of data, although the analysis is time consuming. While the gathered video replays take a lot of time and effort to manually analyze, if one could create analytics algorithms to identify certain episodes in the data from which the players could learn, it would be valuable information for players in terms of how to improve. By using the replay analysis data gathered from Hotslogs in such an analytics algorithm, it could be possible to automatically identify important events in a game. The experience and deaths graphics, for example, show when a team is leading in experience, and by comparing that data to moments in a game, it would be possible to figure out what a team did that was good or bad. The emerging area of multimodal analytics (i.e., capture, process and analyze multimodal data) is focused on just this kind of data combination (e.g., using computer vision machine learning algorithms to analyze video data to be combined with analytics of other types of data such as eye tracking) so one would expect that in the near future this would be possible.

8.3 Limitations

While doing desk research it became apparent that it would not be possible to compare the results in this study to other research, which led to the research methods chosen by comparing the data gathered to different data sets rather than other research. SteelSeries and Tobii did have a software called Game Analyzer that worked with the SteelSeries Sentry eye-tracker. Unfortunately, this was discontinued, so I was never able to see it in action. There are a few videos available on YouTube that shows some of its functionality. The software was available for Dota 2 and StarCraft II (Tamburro, 2015). At the end of a match a player would be able to see how many times he or she looked at the mini-map, tier items, mana and health bar and other in game UI elements.

The eye tracking data does not exclude blinks from the players. This means that the eye tracking data generated in this study should not be compared to numbers where the blinks has been excluded. By using another method of developing the application it would be possible to exclude blinks and gather more comparable eye tracking data. The time constraints of the master thesis did unfortunately not allow research into other possibilities to develop the application.

Due to a series of unfortunate events the topic of this thesis had to be changed, which resulted in the current topic. This did put an even larger time constraint on the research, but it came with a valuable lesson that creativity and hard work pays off in the end.

8.4 Future Work

Heroes of the Storm is a game based on teamwork. It would be interesting to look at data from all five players on a team to improve team coordination. In a professional eSports team, one player is usually a shot-caller. That means that this player decides the team's next move, and the team must follow. However, if a shot-caller makes the wrong call, it would be interesting to analyze the other players' eye movements, and see if they could have predicted that it was the wrong move.

Another future direction is related to time of looks. It would be interesting to look at the average time spent looking at the mini-map per look. This would give an indication of how fast a player can process the information given by the mini-map. If a player spends a long time processing the information this might be an area in which the player could improve. A player that spends a short time looking at the mini-map and does not process all of the information might also improve by using eye tracking data as a resource during training.

Overwolf recently launched an application called Replay HUD, which enables players to replay the last 20 seconds before they died from their perspective. By adding a gaze overlay to the replay the players could also view their own eye movements before they died, and this could be used as a manual approach to using eye tracking data in a training situation.

8.5 Conclusions

Eye tracking can be a helpful tool for understanding gameplay in MOBA games and adds an additional resource to analysts especially when using a replay analysis with the eye tracking layer. Eye tracking statistics about how many times a player looks at certain areas of the screen would need more a larger data set to give a clear indication as to how players can improve, but some trends can be seen from the limited data set in this study and is definitively interesting to take a closer look at.

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Appendix A: Data from the Eye Tracking Application

Player 1

	Game 1	Game 2	Game 3
Map	Dragonshire	Garden of Terror	Sky Temple
Hero	Nazeebo	Rehgar	Gul'dan
Hero Role	Specialist	Healer	Assassin
Map looks	107	93	244
Map time	02:19:80	01:23:76	02:30:47
Time looks	18	13	42
Time time	00:02:29	00:01:93	00:07:70
Cooldowns looks	325	176	318
Cooldown time	00:43:89	00:24:17	00:43:56
Health looks	12	11	34
Health time	00:02:23	00:01:59	00:13:13
Game length	23:30	15:53	20:20

Player 2

	Game 1	Game 2	Game 3
Map	Sky Temple	Tomb of the Spider Queen	Garden of Terror
Hero	Nazeebo	Diablo	Greymane
Hero Role	Specialist	Warrior	Assassin
Map looks	301	272	319
Map time	03:44:80	03:20:32	03:23:59
Time looks	22	22	7
Time time	00:02:70	00:03:40	00:00:74
Cooldowns looks	433	367	418
Cooldown time	00:46:92	00:41:46	00:54:20
Health looks	3	4	3
Health time	00:00:22	00:00:15	00:00:70
Game length	20:21	21:18	18:33

Player 3

	Game 1	Game 2	Game 3
Map	Blackheart's Bay	Braxis Holdout	Cursed Hollow
Hero	Nazeebo	Rehgar	Jaina
Hero Role	Specialist	Healer	Assassin
Map looks	142	259	258
Map time	02:47:93	02:22:47	05:20:20
Time looks	34	51	124
Time time	00:06:40	00:09:19	00:15:89
Cooldowns looks	144	352	167
Cooldown time	00:31:27	01:17:63	00:33:43
Health looks	14	2	25
Health time	00:00:92	00:00:2	00:02:48
Game length	16:36	21:58	25:16