Human Factors in Esports:

Investigating performance measures, coaching practices, and stress training in League of Legends

by

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Author's Declaration

This thesis consists of material all of which I authored or co-authored: see Statement of Contributions included in the thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Statement of Contributions

- Chapter 4 (Study 2) is a co-authored published paper:

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Abstract

This thesis examined a constant problem in Esports in which players do not perform to their expected potential when under stress (also known as choking). The Esports scene is growing exponentially, with teams valued at hundreds of millions of US dollars and average salaries for professional Esports players around $62,500 annually. League of Legends (LOL) is the most popular, viewed game in Esports, peaking at 4.1 million concurrent viewers and 664,100,000 hours watched in 2021. Additionally, the average LOL professional player's salary is $350,000, which is significantly higher than the average salary in Esports. The LOL salaries and team's values are still growing, and thus sustaining and improving LOL players' performance are essential to protecting investments and minimizing risks. This work, therefore, aims to investigate the existing literature on Esports performance indicators, the causes and potential interventions for choking in Esports, and to understand the literature gap that may prevent this study from solving the related problems that exist in Esports, using LOL as an example.

In the literature, training under stress is a well-known choking intervention that has worked in other domains (e.g., traditional sports and the military). When applied to Esports, this technique is used to attempt to familiarize a person with the stressful conditions they will encounter during a big-stage competition by training them under conditions that have physical and social stressors similar to those present in the stage environment. This is done in the belief that the more significant the differences between the stage and training environments, the higher the chances a person may choke. However, designing such a training solution requires knowledge of the stressors affecting Esports players, and additionally, a game activity (an

activity that, if improved, will influence a game's result) and its performance indicator are required to assess the effectiveness of the intervention. The existing literature does not provide enough information to determine the stressors (physical and social) causing choking in Esports, nor does it provide a suitable activity and performance indicator for this study to test an intervention. To this end, three studies were conducted to bridge the literature gap and tailor a solution to choking in LOL Esports

Study 1 analyzed over 150 in-game variables, of which 14 were statistically significant between the winning and losing teams. However, while most variables seemed to be associated with wins, they were not seen as being causes of the wins. Creep scores per minute (CSPM) was identified as a suitable task and performance indicator for the experiment in Study 3. Finally, Study 1 produced and tested two new performance indexes that may have potential: spending efficiency and champions' damage utilization.

Study 2 allowed this thesis to, first, determine the stressors (physical and social) affecting Esports players in order to tailor a suitable intervention, and second, understand in great detail the current coaching methods and the challenges coaches face. Furthermore, Study 2 identified nine future research directions that LOL Esports coaches might benefit from.

The coaches In Study 2 expressed that Esports players are more sensitive to stress training than players of traditional sports. For example, when they experimented with stress training, it failed and led to burnout. However, this research argues that their interventions failed because the training was not designed properly, as most of their interventions lacked one or more of the intervention's main elements, i.e., a social stressor, a physical stressor, and a relative game activity, time to adapt, and performance measure. The coaches also added,

however, that focusing on training a player’s mechanical skills without stress improved their performance under stress.

In Study 3, an experiment was designed to test a tailored intervention on an experiment group (who trained under stress) and compare its effectiveness with the method the coaches suggested for the control group (who trained without stress) over a period of five days. The findings from Study 3 imply that training Esports players’ mechanical skills without stress may improve their performance under stress by a small amount, but also, and in comparison, training under stress improved the experiment group’s performance under actual game stress by more than five times relative to the control group. Moreover, the participants in the experiment group initially showed signs of burnout as their performance declined on Day 2, but then they recovered on Day 3 onwards; this pattern suggests that such training requires time to show its benefits.

Finally, this thesis provides some of the missing details in the literature, enabling future researchers to identify the current state and the pain points to generate solutions suitable for Esports players, coaches, and teams. This study explains choking interventions in such a way that can guide a coach to tailor a solution suitable for their choking triggers (a physical and social stressor).

Keywords: Esports, professional Esports, League of Legends, choking, performance measures, coaching, stress, training under stress.

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Chapter 1: Human Factors in Esports

1.1 Introduction

Competitive and organized video games, also known as Esports, have been rapidly growing for several years and are projected to become a $1.5 billion market by 2023 (Christina, 2020). The majority of games in the Esports genre are fighting games, real-time strategy (RTS), first-person shooters (FPS), and Multiplayer Online Battle Arena (MOBA) games, with MOBA being the largest Esports scene (Amin, 2020; Gabriel, 2020). League of Legends (LOL), a MOBA game, is one of the most popular games in the latter genre (Newzoo, 2019). According to Statista, the 2018 League of Legends Championship Finals had 99.6 million viewers (Statista, 2018a), which was significantly higher than the NBA Finals that year, which averaged 17.7 million viewers (Statista, 2018b), and very close to the 2018 Super Bowl game, which had an estimated 103 million viewers (CBS NEWS, 2018). Esports tournaments are played in traditional sports arena/stadiums that can host tens of thousands of fans, in which the players' setup is in the center of the arena with large screens overhead for the fans to watch, as seen in Figure 1.1. This photo was taken by Bader Sabtan, the author of this thesis, in 2019 in Detroit, Michigan, at Little Caesars Arena (22,000-person capacity), which hosted the North American summer LOL playoff semi-finals and finals that year. However, LOL tournaments had been taking place in large stadiums long before that. In 2013, tickets for the LOL finals, hosted at Los Angeles's Staples Center that year, sold out in an hour (Tassi, 2013).

Figure 1.1: North America League of Legends Semi-finals 2019, Little Caesars Arena, Detroit, Michigan (Taken by the Author)

In 2020, during the COVID-19 pandemic, LOL Esports tournaments were not canceled because unlike traditional sports, there is no need for players to be in close proximity to each other (Emily, 2020a). In fact, the number of Esports leagues has increased during the pandemic. For example, Ontario Post-Secondary Esports, which is a new Esports league located in Ontario, Canada, launched in fall 2020 (Matthew, 2020).

An increasing number of universities are also starting to accept Esports gaming as a sport, and some are now offering scholarships for Esports players (K. McGrath, 2019). Robert Morris University (RMU) was the first university to recognize Esports as a varsity sport in its Athletics Department, offering scholarships to Esports players in 2014 (RMU, 2014), and there are many other universities now offering Esports scholarships to students, such as the

University of California-Berkeley (matthew, 2018), University of Utah (Chang, 2018; Utah.edu, 2017), and Western Kentucky University (WKU, 2016). Some Ivy League universities have fielded their own teams to intercollegiate and intramural gaming competitions, such as the Harvard College Esports Association (Harvard, 2020), University of Pennsylvania eSports Association (Penn Clubs, 2011), and Columbia University eSports (Columbia Esports, 2020).

This growth in popularity has attracted investors, that include billionaires and celebrities, such as Mark Cuban (Lingle, 2015), Michael Jordan (NBA Staff, 2018), Shaquille O'Neal (Bob, 2016), Ashton Kutcher (Jr, 2018), and Jennifer Lopez (Mike, 2017). Moreover, traditional sports fans have an average of over 40, while the average age of an Esports fan averages around 29 years old. As a result, hundreds of traditional sports clubs began to partner with Esports teams to attract younger audiences, such as golden state warriors, FC Barcelona, and Paris Saint-Germain Football Club (Scholz et al., 2021).

The growing popularity and increased numbers of investors caused the value of Esports teams to boom. For example, *Cloud9*, an Esports team participating in LOL and other games, was valued at $400 million USD in 2019 (Settimi, 2019). Additionally, the average salary of professional players in North America was $410,000 in 2020 (Kai, 2020). With such growth and accompanying huge investments, the need to protect such investments and ensure the quality and performance of players is becoming increasingly important. The dollar values of teams and players are extremely volatile, as the Esports scene is in its early stage. In addition, there have been many cases in which players and teams have not performed to their expected potentials under stress, which is known in traditional and Esports as “choking”. Such a phenomenon is usually triggered by a social stressor and a physical stressor, which will be explained within two choking theories in the literature section.

The author of this Thesis is a League of Legends player who was rated in the top 1% of players in solo queue games in 2019 and 2017, and has a total of 8 years of experience playing the game. Additionally, he has a close relationship with several of the coaches and players in professional LOL Esports, which puts him in a unique position to understand the game, identify the scene's needs, and to bridge the gap between Esports and the academic field.

1.2 Research Problem

As the Esports industry continues to grow, the need to assess the performance of teams and individual players is increasing. Teams are constantly in pursuit of the best players in the world in order to win international tournaments; however, there is no accurate metric or best practice to quantitively assess and analyze a player’s performance, making it hard for teams to find new talent. To this end, a statistical analysis was conducted (Study 1) on LOL game data to find a key performance indicator (KPI) for players. This game data allows analysts to access a raw match and tournament information through an application programming interface (API), and the LOL API provides access to over 150 in-game variables. Study 1 focused on finding a KPI to help teams evaluate players, and also to enable follow-up studies to identify if a proposed intervention solved an existing problem (e.g., choking).

Due to stress, Esports players sometimes do not perform to their expected potential on big stages (Ouellette, 2019; ScienceDaily, 2019; Starkey, 2020), and so in order to investigate this phenomenon, we first looked into the literature. This phenomenon occurs every year and in almost every LOL Esports region around the world (Beres et al., 2021; Nicole et al., 2021; John, 2022; josh, 2019). Research on the stressors that causing Esports players to choke is limited and is not enough for this study to draw conclusions or generate solutions. Additionally, there is limited existing research showing how players are trained and coached. Most of the coaching information can be found on Esports news websites and blogs, as well as from interviews on YouTube and from individual journalists. As a result, an interview study was conducted (Study 2) in which we contacted all 47 coaches in the major regions, of whom six accepted to participate in this study to gain a deeper understanding of the current state of coaching, why players choke under stress, and the main stressors affecting a player's performance. , of whom six accepted to participate in this study.

The findings from Study 1 showed that coaches currently distance their professional players from public opinions and social media in order to avoid burnout and choking. As a result, my hypothesis is that players do not develop tolerance to such stressors, leading to them choking on big stages, and especially in tournament

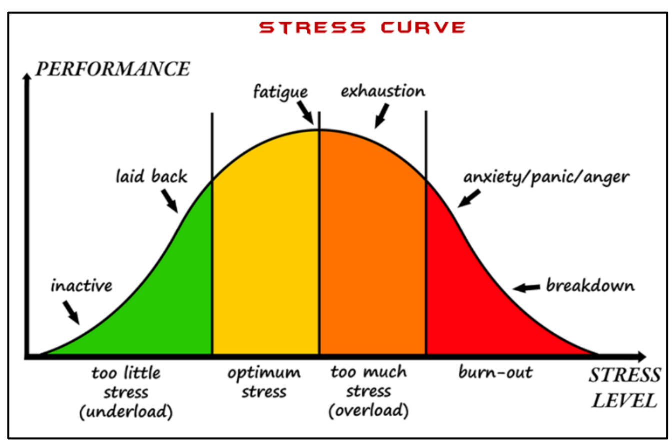

Figure 1.2: Yerkes Dodson Curve
(Reconstructed by the author)

final games in which the winner of the tournament cup is decided. Esports coaches believe that improving a player’s skills will increase their confidence, which would in turn enhance their tolerance to social stress on stage. However, this study argues that both training a player’s skills and exposing them to social stress may significantly improve their tolerance. Studies have shown that training under stress improves performance under stress and might prevent choking in traditional sports (Alder et al., 2016, 2019; Hadnett, 2015; R. R. D. Oudejans & Pijpers, 2010). However, coaches expressed that Esports players might be different from players of traditional sports because they are used to playing from the comfort of their rooms and do not socialize as often as traditional sports players.

Additionally, there are no existing studies showing whether practicing under pressure will help Esports players actually perform better when under stress. We will use the Yerkes-Dodson human stress curve, shown in Figure 1.2, to illustrate this study’s perspective and that of the coaches. The Yerkes-Dodson curve shows that if stress is either too low (green area) or too high (red area), performance will be low (Dobson, 1982; Mellifont et al., 2016); however, there is an optimal level of stress at which a person will perform at their best. The coaches believe that their current practice routines generate enough stress (yellow area) and that adding social stress may push them over the limit, leading to burnout (orange and red areas), but during the interview study, most coaches complained that players lacked the motivation to practice and were not taking practice seriously enough.

In 1959, Broadhurst found an association between task difficulty and motivation, and he used the Yerkes Dodson law to establish this connection (Broadhurst, 1959). Parallel to this, I believe that the reason players are lacking in motivation and not taking practice seriously is because they are in a “laid back zone” and are not challenged enough, a hypothesis which is supported by Broadhurt’s 1959 findings. Proving and quantifying this hypothesis may enable a coach to make informed decisions based on the risks and rewards. For example, if training the player under stress will only increase their performance under pressure by around 3%, a coach can make the informed decision to not take that risk because it might not be worth it.

1.3 Research Questions:

RQ1- Is it possible to assess performance by analyzing the game data?

RQ2- Is it possible to predict a match’s outcome by analyzing the game data?

RQ3- Is it possible to find a Key Performance Indicator (KPI) using game data?

RQ4- Why do Esports player's choke on big stages?

RQ5- What are the stressors affecting Esports player's performance?

RQ6- Does improving a player's mechanical skill help them perform under stress?

RQ7- Does training under stress improve their performance under stress or burnout?

RQ8- What is the performance gap between training with and without stress?

1.4 League of Legends Gameplay

In LOL, two teams of five players compete against each other to destroy each other’s Nexus, which is a structure located inside a team’s base (Riot, 2020b). There are three lanes in the arena (Top, Middle [Mid for short], and Bottom [Bot for short]) with a jungle area separating the lanes, as seen in Figure 1.3. The Top and Mid lanes almost always see one player fielded in each, whereas the Bot lane see two players fielded: a damage-dealer and a support player (usually a utility champion to enable or protect the damage-dealer) (Mobalytics, 2019). The jungle is where the 5th player goes, and this player is referred to as a "jungler".

Figure 1.3: League of Legends Arena (Reconstructed by the author)

During a match, first, the players will enter the "champion select" phase, in which each player is assigned a lane, and a champion (a character to control in-game) is chosen from a pool of approximately 150 champions that have different strengths and abilities. The players will then enter the arena and move to their designated lanes. Each player in a lane, sometimes referred to as "laners", will kill creeps (i.e., non-player characters constantly generated by the game to fight for each side) to obtain gold, an in-game currency that will be used to purchase items to strengthen their champions, as well as experience that will level up champions for more stats (ability points). Creep-scoring per minute, referred to as "CSPM", is one of the standard performance measurements in LOL (Lingle, 2014; Mobalytics, 2017b). This phase of the game is referred to as the "laning" phase. Moreover, during the laning phase, players will try to attack their opponents, hoping to either kill them or distract them from killing creeps. An example illustration of laning can be seen in Figure 1.4, in which the larger characters are champions, i.e., characters controlled by the players, and the smaller ones are the creeps, which are also referred to as minions.

Figure 1.4: League of Legends Lanning Phase
(Captured and constructed by the author)

During the laning phase, the jungler kills monsters in the jungle, also referred to as jungle camps, to gather gold. Sometimes, a jungler will assist laners by ambushing opponents in a lane to help their teammates gain an advantage. Killing an opponent's champion is rewarded by approximately 10 times more gold compared to killing a creep.

A laning phase usually ends when a team gathers enough gold and experience and believes they are strong enough for a team fight, in which they group up to complete objectives such as destroying towers (Mobalytics, 2017a). Towers are structures that defend a battlefield, and each team has a total of 10 towers spread across the map. Destroying an opponent's towers enables a team to control a battlefield and move closer to the enemy's Nexus, which is the main objective. A team usually wants to prevent the enemy team from destroying a tower, and in some scenarios are forced into a fight in order to defend the tower. The stronger team will usually win the fight and attack their enemy's tower until it is destroyed and/or the enemy is dead. Players' champions remain dead for a few seconds before spawning again and returning to the battlefield. A team will have to destroy all the towers in one of the lanes to reach the Nexus, and the team that destroys the enemy's Nexus first wins the game (bagelsen314, 2020).

1.5 Terms Used in MOBA Games

Scrim: This term is derived from "scrimmage", and is used to describe a practice match between teams in Esports (for both professional and casual players) (Bonnar, Lee, et al., 2019).

The meta: This is a term used to describe the best way to play the game by utilizing characters, items, or other variables within a game. LOL undergoes small changes every two weeks, which result in a “shift in the meta” or a change in the optimal way to play the game (C.-S. Lee & Ramler, 2017).

“Int”, “run it down”: This means intentionally dying in the game. This is also referred to as “intentional feeding”, because a player intentionally dying will reward (“feed”) an enemy with gold and empower them. Such behavior is punished by the game client if players report it. In contrast, in professional Esports, an “int” or a player “running it down” is considered to have died in a foolish way, sometimes due to lack of focus or due to being distracted (Türkay et al., 2020).

Trolling: is any toxic behavior with the intention of negatively impacting another players experience such as trash talk or intentionally feeding (Kniffin & Palacio, 2018). However, professional players use this term in official match as a code for “this player made a mistake and we should do an immediate action to punish it”. This is their effort to speed up communication because opportunities such as this has a few microseconds window of execution.

Tilt: This is a mental state in which a player becomes frustrated and then loses focus. Sometimes a tilt result in players giving up or make desperate plays (Wu et al., 2021).

MMR (Match Making Rating): is an index used by the game developer which represents a casual player’s skill level. In a 5vs5 game, MMR is used to match teams of similar skill and compete.

Ranked Solo queue: is a feature in games in which players (professional or casual players) is joined with other random players to compete against other teams with similar skill levels

This means going into a game and competing with other random players.

"**Buffs" and "nerfs":** In the context of the in-game balance patches, buffing or nerfing relates to an increase or decrease in specific attributes. For example, if a champion is "buffed", this means that the champion has gained more power or influence in the game, while in contrast, if a champion is "nerfed", this means that the champion has lost some power or influence. The terms buffs and nerfs applies to champions and in-game items.

Finally, the next chapter will examine the existing literature to understand the stressors in Esports, performance measures, the current coaching methods in Esports, choking models, and choking interventions. This review may allow us to tailor solutions to the existing problems in LOL Esports.

Chapter 2: Literature Review

A literature review was conducted to find some answers to our research questions (RQs) or at least guide this research to answer the RQs. The existing literature does not examine the reasons for choking in LOL Esports. However, choking have been examined in other domains such as traditional sport and the military. In this section, we will identify the research gap to generate solutions based on what is known and what is missing in the literature.

2.1 Stress and Anxiety

In the literature, stress has several different definitions under different conditions. The American Psychological Association (APA), defines stress as: "*a normal reaction to everyday pressure, but can become unhealthy when it upsets your day-to-day functioning* (American Psychological Association, 2019)."

McGrath (1976) broadly defined stress to incorporate most of the different definitions. McGrath defined stress as the interaction between three main elements: perceived demand, perceived ability to adapt to the demand, and the perception of the consequences of adapting or not adapting to the demand. This definition suggests that stress is not just a discrepancy between the demand and someone's ability, but rather their perception of the demand, the ability to deliver, and their inclination to adapt.

G. Fink (2016) had several definitions to stress based on the circumstances. However, they argued that stress can generally be defined as: "*an individual is aroused and made anxious by an uncontrollable aversive challenge—for example, stuck in heavy traffic on a motorway, a hostile* *employer, unpaid bills, or a predator."* They also added: "*The magnitude of the stress and its physiological consequences are influenced by the individual's perception of their ability to cope with the stressor.*"

G. Fink also defined stress as: "*Perception of threat, with resulting anxiety discomfort, emotional tension, and difficulty in adjustment*" and "*Stress occurs when environmental demands exceed one's perception of the ability to cope.*"

McGrath's definition of stress seems to encapsulate most of the definitions mentioned in the literature. It is the most related definition to this study due to its conceptualization of the three elements which factored in the task's complexity (perceived demand), the skill or performance of a person (perceived ability), and their engagement (perceived ability to cope).

Stress is usually stimulated by a social stressor (i.e., fear of evaluation), or a physical stressor (i.e., noises) (Mary, 2020). On the other hand, anxiety is usually triggered by worrying thoughts that do not fade away when the stressor is absent. The APA defines anxiety as: "*an emotion characterized by feelings of tension, worried thoughts and physical changes like increased blood pressure* (American Psychological Association, 2020)." Both stress and anxiety involve mental and physiological responses to the triggers and have almost identical symptoms such as irritation, fatigue, digestion problems, sleeping disorder, concentration issues.

Stress and anxiety have similar interventions such as physical activity, meditation, and diet, but they are different when it comes to their effect while the stressor is present or absent. In our studies, we will use acute stress instead of anxiety to avoid inducing a long-term effect, and because it is the least harmful type of stress (CSHS, 2020). An acute stress does not need to be life threatening. It can be a mild acute stress like an alarm clock or a loud phone ring while relaxed in a quiet room. Moreover, a threat to ego can be a form of acute stress.

2.2 Stress Assessment

Stress is usually assessed by measuring physiological changes, biochemical markers, or self-reporting.

2.2.1 Self-reporting

Self-reporting is commonly used because it is difficult to objectively measure stress. It is a convenient, low cost, and non-invasive method that generally does not require sophisticated equipment (Masood et al., 2012). However, some of the self-reported methods are lengthy and require the participant to answer a lot of questions (sometimes 90 to 200 questions) (Helton & Näswall, 2015). The Dundee Stress State Questionnaire (DSSQ) is one of the commonly used stress measures that has been shown to be reliable and valid by a number of recent studies (Green & Helton, 2011; Helton & Näswall, 2015; Matthews, 2020; Matthews et al., 2013a). The DSSQ contains 90 questions given in a pre-post task experiment. In 2014, in his paper, Helton argued that there are evidence showing that such a long questionnaire increased the possibility of the participant being exhausted, which may jeopardize the useful information obtained from the DSSQ. As a result, Helton developed the Short Stress State Questionnaire (SSSQ), which contains a maximum of 24 items, which enables a user to target fewer than 24 questions based on their importance and their weight. The SSSQ measures three primary states, Engagement, Distress, and Worry. The SSSQ also shows which of the questions are needed to obtain a measure a specific state (Helton & Näswall, 2015)(Matthews et al., 2013a).

2.2.2 Performance

Individual performance is significantly affected by stress. A 2015 study examined performance as a stress assessment method. According to its author, "*tests that evaluate performance in given tasks, for which standard performance measurements are known, can be a good indicator of the effects of stress on the individual* (Carneiro et al., 2019)". For example, assessing the performance of a player over time can give an estimation of the expected performance on a given day, and if the performance significantly shifts away from the mean, it can indicate that stress had an effect. However, this method is an indicator with significant noises associated with it.

Initially, the plan was to use multiple stress measurements methods such as HRV, GSR, and self-reporting, as the literature recommended this approach to increase the accuracy of our reading (Carneiro et al., 2019). However, due to COVID-19, any measure that involves physical contact or being near the participants is exceptionally challenging and is not recommended at the current time (University of Waterloo, 2020). As a result, we used self-reporting to assess stress and performance to assess the effect of stress. Our goal from stress assessment measures is to confirm the existence of stress during an experiment in Study 3, and not necessarily to accurately quantify it.

2.2.3 Physiological changes:

1- Galvanic skin response (GSR), also known as Electrodermal activity EDA, is a method that measures the changes in sweat glands caused by stress. This is usually done by placing sensors on the palm, fingers, toes, or foot (Villarejo et al., 2012).

2- Heart Rate Variability (HRV). The heart does not beat in an even interval. We have natural variability in the spacing between our heartbeats. HRV is used as a health marker to measure both the body's readiness to training and the body's stress and fatigue levels. High variabilities indicates that a person is less stressed and ready to perform, while low HRV is linked to stress, depression, pain, inflammation, and low emotional flexibility. This measure is done using an electrocardiogram (ECG) placed on the chest, wrist, or fingers (Acharya et al., 2007a). In fact, one Esports team was experimenting with HRV to direct their training methods, and during a 6 week period, their feedback was positive (Sabtan et al., 2022).

3- Pupil size. The change in the pupil diameter is an indicator that the body is under stress. Sophisticated equipment and sensors are used to measure the changes in pupil diameter that can be wearable equipment on the head or remote equipments placed in front of the participant (Yamanaka & Kawakami, 2009).

2.2.4 Biochemical markers

Biochemical markers usually involve measuring the cortisol (stress hormone) levels in the blood, saliva, or urine. This kind of testing usually is time-consuming but is relatively more accurate than other measures (Hellhammer et al., 2009).

2.3 Choking

In sports, choking occurs when a player fails to perform in high-stakes games, such as the final game in a tournament. Baumeister, in 1984, defined choking as: "*performance decrements under circumstances that increase the importance of good or improved performance* (Baumeister, 1984)". This definition suggests that a suboptimal performance is labeled a choke if the performer could perform better but could not due to the circumstances' stressors.

Despite months or even years of practice, a player may fail when it matters the most. This phenomenon is widespread in sports (D. M. Hill et al., 2010; Leith, 1988; Masaki et al., 2017, 2017; Murayama et al., 2010; Murayama & Sekiya, 2015; R. R. Oudejans et al., 2013; Wallace et al., 2005). The literature on choking shows that there are two theories as to why choking can occur: the distraction theory and the self-focus theory (Beilock et al., 2004; Beilock & Carr, 2001; Christensen et al., 2015; DeCaro et al., 2011).

2.3.1 Distraction theory

The distraction theory suggests that a person under stress will experience cognitive stress (i.e., worrying), which requires a diversion of attention (working memory resources). As a result, irrelevant thoughts (i.e., relating to fears and doubts) will compete for attention with relevant thoughts (such as focusing on the main task). Since the working memory has limited capacity, the amount of attention directed to the main task will be reduced, which in turn reduces the person's performance and leads to choking (Engle, 2002; Wilson, 2008). Most athletes practice their skills until they become automatic, but in stressful situations such as a high-stakes match, these automatic tasks, which are normally performed subconsciously, are forced to be processed by the working memory, causing a players' attention to be split between their automatic skills and their doubts, making them vulnerable to choking (D. Hill et al., 2011).

2.3.2 Self-focus theory

The self-focus theory suggests that when stress increases, athletes focus their attention on movement execution, meaning that instead of allowing their actions to be executed automatically, they over-analyze and process their actions step-by-step, leading to a drop in performance or a choke (Masaki et al., 2017). One study published in 2009 found that elite golf players who monitored and controlled their strokes instead of allowing them to go automatically had lower performance (Bell & Hardy, 2009).

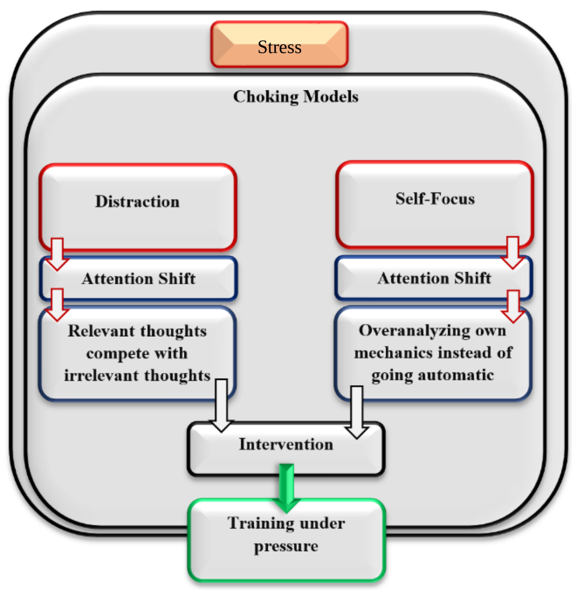

Figure 2.1: Choking Theories
(Created by the Author)

Both theories boil down to a shift in attention. The distraction theory suggests that worrying competes for attention with the task at hand, while in contrast, the self-focus theory suggests that attention is shifted from automatic control to over analysis. These theories are illustrated in Figure 2.1, where choking may be triggered due to social stressors (e.g., worrying or self-doubt) or physical stressors (e.g., noises and fan distraction) (Gröpel & Mesagno, 2019).

Choking theories provides a model that may enable this study to answer RQ4 (Why do Esports player's choke on big stages?), however, the stressors causing Esports professional players to choke need to be identified. Choking is a phenomena occurring in many different scenes, such as: athletes (basketball (Fryer et al., 2018), baseball (Rob, 2004), golf (D. Hill et al., 2011), dart (Klein Teeselink et al., 2020), and soccer (Jordet & Hartman, 2008)), musicians (Pell, 2020), academic exams (Beilock et al., 2004), police officers (R. R. D. Oudejans, 2008), and military personnel (Tenenbaum et al., 2008). Choking in Esports has been widely reported in Esports news outlets (EMOTAI, 2020; theScore esports, 2019; Wolf, 2015), but limited academic peer-reviewed studies have examined it. A few papers, however, discussed stress in Esports in general (Ouellette, 2019; Poulus et al., 2020). To answer RQ4 and RQ5 (What are the stressors affecting Esports players' performance?), we need to, first, verify our findings by asking the Esports coaches (Study 2), and second, conduct an empirical study to validate if underperformance linked to stressors which stem from worries about their performance (Study 2). Our Study 2 will not aim to verify a specific theory but will be used to familiarize players with stress which may improve their performance under stress according to both choking theories.

2.4 Choking Intervention

In 2019, Peter Gröpel conducted a systematic review on the existing choking interventions in which they examined 47 empirical studies. The most reported effective interventions were training under stress, pre-performance routine (PPR), and quiet eye training (Gröpel & Mesagno, 2019).

2.4.1 Training under stress

One of the most commonly used interventions to prevent choking is training under stress (R. R. D. Oudejans & Pijpers, 2009b, 2010). Oudejans, in a 2010 study on dart players, examined whether training under mild stress would help maintain performance under higher stress levels. Oudejan triggered stress by telling participants they would be video recorded and that the recordings would be used on a popular TV program in which experts would analyze the video. The experiment comprises a pre-test, a post-test, and two training days. The results showed that practicing under mild stress had reduced perceived stress slightly but did help the participants maintain their performance under higher stress than the control group's performance, which deteriorated under high stress (R. R. D. Oudejans & Pijpers, 2010).

A study published in 2008 examined whether practicing under stress may prevent the degradation of handgun shooting performance for police officers. The study had a pre-post-test design, in which they fired 30 shots against cardboard targets, and another 30 shots against an opponent that fired back using marking cartridges (colored soap), which added stress to the police officer. The police officers had three training days in which the control group practiced their shooting on a standard cardboard target, while the experiment group practiced against an opponent. The results showed that both groups performed equally worse in the pre-test against an opponent firing back compared to the cardboard targets. However, in the post-test, the experimental group's performance no longer deteriorated against an opponent firing back and the control group showed no improvement from pre-test to post-test (Nieuwenhuys & Oudejans, 2011; R. R. D. Oudejans, 2008).

Oudejans also examined if training under stress will improve the basketball player’s performance under stress in 2009 (R. R. D. Oudejans & Pijpers, 2009a). 17 expert basketball players practiced free throws for five weeks with stress (experiment group) and without stress (control group). Stress was elevated using ego-stressor methods. A total of five stressors were used:

1- The group that has the best score wins an amount of money, which introduced an element of competition.
2- The participants were told that they will be video recorded
3- The participants were informed that experts will watch the recordings to evaluate their technique
4- Participants were asked to imagine that they are performing in a decisive game situation
5- Their coach and other players watched the shooter to further increase stress.

The results showed that the experiment group’s performance no longer deteriorated under stress in the post-test compared to the pre-test, while the control group was negatively impacted by the stress in both pre-test and post-test, confirming the hypothesis that training under stress has a positive effect on performing under stress. Some of the current studies in sports and on training with stress indicate that training without stress may not improve a player's performance under stress.

2.4.2 Pre-Performance Routine (PPR)

Moran, in 1996, defined PPR as “*a sequence of task-relevant thoughts and actions which an athlete engages in systematically prior to his or her performance of a specific sports skill”*(Moran, 1996). The Objective of PPR is to focus attention on thoughts relevant to the task while ignoring irrelative thoughts. PPR is generally described as a suitable intervention for the distraction theory (Cohn et al., 1990).

A study in 2008 examined whether PPR would alleviate or diminish choking on bowling players (Mesagno et al., 2008). Participants performed a 10-shot warm-up before starting the test. The test consisted of 60 shots with one minute break separating every 10 shots. Stress was induced by videotaping all shots, 8 audience watching, and a performance contingent financial incentive. The PPR involved a series of physiological, psychological, and behavioral steps. The author used cue words for “optimal arousal levels” and what they called “shadow shots” (shots without a ball). The results suggest that using PPR improved performance under stress by an average of 29% compared to their performance before using PPR.

Another form of PPR is deep breathing and cue words to improve concentration and improve performance under stress. A 2010 study by Mesagno examined the effect of deep breathing and cue words on the performance of football players under stress. The participants were asked to shoot a ball to a target and assess their accuracy. Stress was induced by having other participants watch the experiment, and they were told that the results will be reviewed by respectable known players. The participants in the intervention group understood a group specific PPR education for the deep breath and cue words, in which the research explained and demonstrated the interventions to each participant. The results of this study further confirmed that PPR improved performance under stress compared to the control group. They also found that combining (mixing) different PPR (deep breath and cue words) resulted in better performance than using only one of them.

2.4.3 The Quiet Eye

In 1992, Joan Vickers examined expert golfers and found that experts have consistent pattern of eye fixation between the hall and the golf ball. Experts also have a steady “quiet eye” fixation in the moment during and after the putt (Vickers, 1992).

A 2011 study by Samuel Vine examined the effectiveness of a brief quiet eye (QE) training intervention on the performance of elite golfers under pressure (Vine et al., 2011). They examined 22 elite male golfers (mean age = 20.95, SD = 2.66).

The eye gaze was tracked using an Applied Science Laboratories (ASL) Mobile Eye Tracker. Stress was applied by compensating the participants based on performance, and comparing their results to other participants, in which they showed that their performance is in the bottom 30% and that they need to improve or their data would be of no use for the study. The results suggest that the QE trained group improve their performance by 5% under stress compared to the control group.

Some of these interventions are currently used in Esports and can be seen on the public tournament channels, specifically, PPR (deep breath, cue words) (Sabtan et al., 2022). The players are seen repeating words, practicing deep breathing and huddling before matches, and in some cases, the coaches give them speeches. Additionally, a paper published in 2021 illustrated a few other PPRs that has potential in Esports (Iwatsuki et al., 2021). These interventions were investigated and discussed with the coaches we interviewed (Study 2).

2.5 Esports Existing literature

Although studies on Esports research are rapidly growing, researchers acknowledge that such studies are still in their early stages, with LOL being the most researched MOBA game (Mora-Cantallops & Sicilia, 2018b) (Bányai et al., 2019).

2.5.1 Stress in Esports

In a qualitative study, Nilsson and Lee, looked at the factors affecting the mental health of Esports players by interviewing five professional and ex-professional Esports players (Nilsson & Lee, 2019). They found that stress from parents, fans, social media, and toxic behaviors is a common factor affecting mental health of MOBA players. Another study explored the correlation and influence stress, and coping on mental toughness, and suggested that Esports players may benefit from using psychology interventions (i.e., mental toughness training) designed for traditional sports athletes (Poulus et al., 2020). A 2021 study found that expert gamers had higher cortisol response than non-expert gamers when a game is perceived as an important match. However, the experts in this study were armature players who are ranked above average in the ranking ladder (Mendoza et al., 2021). Minerva Wu, in 2021, studied the frustration in LOL games in which they surveyed 95 amateur Esports players in high school and found that players are mostly frustrated by their teammates rather than opponents in solo que games (a solo que game is a non-official game in which an individual is grouped with another 4 random players) (Wu et al., 2021). This frustration (also known as "tilt") is a common challenge for most players playing MOBA games. A paper published 2022 looked at the basic psychological needs of Brazilian professional players and studied the importance of empowering coaches to create a motivational climate. They found that a motivational climate predicts needs satisfactions while the existing environment (focuses mainly on performance, goals, and peer comparison) increased needs-thwarting (Vilas Boas Junior et al., 2022). A 2020 qualitative study looked at emotion regulation in Esports, and found that some factors triggering emotional response are similar to traditional sports while others were unique to Esports players such as game design and social identity. They also explore the importance of emotion regulation skills through the use of technology such as digital platforms to share their emotions (Kou & Gui, 2020).

2.5.2 Performance analysis in Esports

Research of performance analysis is very limited. A recent study analyzed the variables associated with performance in MOBA esports, such as the numbers of Towers and Inhibitors destroyed in the match; Towers and Inhibitors are structures in game, and destroying them is a core objective to win a match. (Novak et al. 2020). However, further research is required to determine the effectiveness and relevance of these variables because the results showed association that may not be causation. Another study in 2021 analyzed the variables of LOL 2019 world tournament and found that team structure (champions used), number of deaths, earned gold, and natural objectives were significant predictors of a wining match (Castellanos & Corps, 2021). However, because the game is constantly changing (minor changes every two weeks), the best team structure continues to change over time, making it challenging for teams and coaches to determine the best team structure (also known as the “meta”). An additional limitation to this study is that number of deaths, gold earned, and securing natural objectives are an end result of the team who won the fight, which suggests that these factors might not be a causation but a correlation to the wining team.

The literature on performance analysis, although limited, suggests that the data provided by the game are rudimentary statistics, and there is a need to combine these variables to find create performance index. Most of the variables are associated to the winning team and not causing it.

2.5.3 Esports vs. Sports

Although there is still a debate over whether Esports are actually sports, more people have begun to welcome this type of sport (Jonasson & Thiborg, 2010; D. Lee & Schoenstedt, 2011; Pizzo et al., 2018; Thiel & John, 2018). This debate was reviewed and discussed in a 2018 paper by Hallmann and Giel (Hallmann & Giel, 2018). The argument stems from the definition of "sport". According to the Council of Europe's Sport Charter, a sport "*means all forms of physical activity which, through casual or organised participation, aim at expressing or improving physical fitness and mental well-being, forming social relationships or obtaining results in competition at all levels*" (Council of Europe, 2001). Physical activity is a key factor that should be present in a sport, but Esports lacks this aspect. However, others have argued that Esports overlaps with five out of six characteristics of sports: 1) they include the aspect of play; 2) they are organized (i.e., governed by rules); 3) they involve competition; 4) they involve skill (not chance); and 5) they have a broad following (Jenny et al., 2017). The main conflict is over the physicality part. According to Jenny et al. (2017), the physicality part can be interpreted as either physical power and physical skill, and physical skill is present in Esports. Moreover, governments, and universities are treating Esports players as athletes; for example, foreign Esports players have been issued athlete visas when competing in the US and Europe (Graham, 2019; Happonen & Minashkina, 2019a).

2.5.4 Esports player's personality

Esports players are facing problems that mainstream domains like traditional sports have long-since solved. Naturally, esports teams would just replicate what has worked for these successful domains in the past, but there remains one problem. decision makers within Esports believe that their players are more sensitive to social stressors such as performing in front of crowds, being “booed” at while performing, or being criticized in social media, because they are used to play from the comfort of their rooms and don’t socialize as often as traditional sports players. In fact, a 2020 study found that a streamer performing in their bedroom to a remote-viewer crowd is enough stress to have a negative effect on esports player’s performance (Matsui et al., 2020).

2.5.5 Other Esports topics

Researchers also found that video game players’ reaction time starts dropping by the age of 24, leading to a relatively young retirement age of 25 (Nikkei Asia 2018; Happonen & Minashkina 2019). A 2022 paper explored rule enforcement to prevent match fixing in Esports. According to Renkai, match fixing might emerge as a new challenge for Esports due to the increasing number of betting websites on matches outcome (MA et al., 2022). Another emerging challenge in “ranked” video games is the increasing number of boosting services (in which a player shares their account with a skilled player to increase their rank). Consequently, when the original player plays at a higher rank, they will negatively impact other players' experience and increase the frustration because they may lose due to the “boosted” player is not skilled enough (Conroy et al., 2021).

Other notable papers: what motivates an Esports player to player LOL (Y. Sun, 2017) (Q. Sun, 2019). Exploring toxic behavior within ranked (in which random casual players compete) LOL games (Kou, 2020) (Mora-Cantallops & Sicilia, 2018a). Studying players retention in LOL (Demediuk et al., 2018)

2.6 Summary:

The literature review confirmed the existence of choking in many other domains (i.e. traditional sports and the military). Training under stress is a choking intervention that is well understood within the literature; This method does not appear to change the perceived stress dramatically but rather familiarizes the performer with an environment. Most stress training methods use both physical and social stressors similar to the ones present on the main performance stage (For example, the military trains their army with sounds of explosives and an enemy firing back at them (using paintballs)).

This chapter also explored the methods used to measure stress, each of which has its own trade-offs, mainly based on time, cost, invasiveness, and accuracy. For example, self-reporting methods are relatively cheaper but may not be as accurate as physiological measures such as EDA or HRV. The literature on Esports chokings and the stressors affecting a player is limited. Additionally, the existing literature does not allow this study to understand the current choking prevention methods used. A few studies explore performance indicators by analyzing the game database but do not provide a performance indicator at the individual's skill level. The existing performance indicators appear to be correlated to the winning team but not causing it, and in some cases, are not factors that can be controlled or improved (such as side selection on the game map). The existing studies also analyzed around 50 in-game variables, while the game provides access to over 150 variables. The game client is constantly updating, and the number of accessible variables is increasing yearly; this may explain why the current studies looked at some of the existing variables.

Since Esports literature is in its early stages, this Thesis aims to bridge the current literature gaps and provide a suitable choking intervention for Esports players. As a result, three studies were proposed in order to answer the research questions:

Study 1 (Chapter 3: Investigating Performance Measures): The literature on performance indicators in esports helped guide Study 1 by informing this study on what was done and which areas are still under-explored. Study 1 analyzed the available 150 variables from the game client, and also analyzed the 2021 global official LOL tournaments and world championship data. This study aims to answere the following RQs:

RQ1- Is it possible to assess performance by analyzing the game data?

RQ2- Is it possible to predict a match’s outcome by analyzing the game data?

RQ3- Is it possible to find a Key Performance Indicator (KPI) using game data?

Study 2 (Chapter 4: Coaching Practices): professional LOL coaches were interviewed to understand the challenges and stressors affecting Esports players. Additionally, the findings helped establish a baseline of knowledge in coaching practices which may help future researchers understand the current state of training and coaching. Finally, choking interventions were discussed with the coaches to know if they use any of them and to tailor a solution based on their feedback. This study is designed to answer the following RQs:

RQ4- Why do Esports player's choke on big stages?

RQ5- What are the stressors affecting Esports player's performance?

Study 3 (Chapter 5: Stress training): In this chapter, an experiment was conducted in which we tested the effectiveness of two choking interventions. The first intervention is training under stress which is proven to be effective in other domains. However, both the literature and the coaches expressed that Esports players are relatively more sensitive to social stressors than traditional sports athletes, and the coaches added that such intervention would lead to burnout based on their experience. As a result, the coaches suggested a second method in which they focus on improving a player's skill and strategy to increase their confidence, which they believe improves a player's performance under stress. Finally, this study will answer the remaining RQs:

RQ6- Does improving a player's mechanical skill help them perform under stress?

RQ7- Does training under stress improve their performance under stress or burnout?

RQ8- What is the performance gap between training with and without stress?

Chapter 3: Investigating Performance Measures – Study 1

3.1 Introduction

As Esports industry continues to grow, the need to assess a team's and player's performance is increasing. Teams are constantly in pursuit of acquiring the best players in the world to win international tournaments. But there is a lack of analytical indexes or diagnostic tests to measure different factors that contribute to the overall ability to win. If a team needs to select a new player, they cannot distinguish between two applicants who have relatively similar qualities. The current work aims to investigate the possibility of creating a quantitative measure (key performance indicator (KPI)) to distinguish between good and great players LOL players. Additionally, finding a KPI is needed to evaluate the effectiveness of training methods in the chapter 5 (Study 3).

3.2 Study 1 - Research questions:

RQ1- Is it possible to assess performance by analyzing the game data?

RQ2- Is it possible to predict a match's outcome by analyzing the game data?

RQ3- Is it possible to find a Key Performance Indicator (KPI) using game data?

3.3 Methods

Riot Games, the developers of League of Legends, provides an application programming interface (API), a software that allows users to export and analyze the game data. The API provides information for each individual game played on the public server, such as:

1- Participant information (i.e., player name, rank, historical record)

2- Match information (i.e., the overall amount of gold gathered, and kills, assists, and deaths for each player)

3- Player stats (i.e.., damage done or taken by each player during a match)

There are approximately 150 different variables (i.e.., player stats, champion picked … etc.) for each match. The API allows the user to access all historical records of matches played on the public server for the last few years. Additionally, this study was given access to the 2021 official tournaments, regional and world championship tournaments to search for a KPI. These databases were statistically studied to find a reliable performance indicator that would predict a match's outcome (by comparing winning teams to losing teams) and another that would enable this study to assess individual players. To extract the data from LOL API, we built a python application (MatchGrabber).

3.4 MatchGrabber

Our MatchGrabber is a user interface we built from the ground up with the help of Eng. Haoze "Gary" Zhou, a University Research Assistant (URA), using Python and PyCharm. The Match grabber exports the user's required amount of match information after applying the filters of their choice, such as, grabbing all the matches played between a specific date that includes a specific champion, on a specific range of ranks, and on a specific role (TOP, MID,..Etc)

3.5 Game Data Results and Analysis

We conducted an independent sample t-test and paired t-test to test the significance of differences between winning and losing teams. A total of 170 games were examined using the SPSS Paired t-test. We examined the winning team's variables versus the losing team in each match. 13 variables had a significant difference between the winning team and the losing team. The variables are defined in Table 3.1, and the SPSS results can be seen in Figure 3.1.

K	Champions Killed
d	Number of times a player died
a	Assisted kills, the number of times a player was involved in a fight that resulted in a kill
fb	First Blood: the first kill in a match
dmgtochamp	Damage to champions: the amount of damage a player deals to a champion during a match
dmgtochampperminute	Damage to champions per minute: the amount of damage a player deals per minute in a match
wards	The number of wards used in a match. Wards are used to grant temporary vision to the team
wpm	Wards per minute: the number of wards placed in a minute
Goldspent	Gold Spent: the total amount of gold a player has spent to purchase items
GSPD	Gold Spent Percentage Difference
CSPM	Creeps Scored Per Minute: how many minions are killed every minute
Goldat10	Gold difference between both teams at the 10^{th} minute of the game
Goldat15	Gold difference between both teams at the 15^{th} minute of the game

Table 3.1: LOL variables code names and definition

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	k - kL	8.398	4.750	.363	7.681	9.115	23.121	170	.000
Pair 2	d - dL	-8.392	4.756	.364	-9.110	-7.674	-23.075	170	.000
Pair 3	a - aL	20.427	12.868	.984	18.484	22.369	20.758	170	.000
Pair 4	fb - fbL	.146	.992	.076	-.004	.296	1.927	170	.056
Pair 5	dmgtochamps - dmgtochampsL	13610.807	14298.844	1093.460	11452.299	15769.315	12.447	170	.000
Pair 6	dmgtochampsperminute - dmgtochampsperminute L	421.3275440	424.6150841	32.47112704	357.2289967	485.4260913	12.975	170	.000
Pair 7	wards - wardsL	3.579	20.661	1.580	.460	6.698	2.265	170	.025
Pair 8	wpm - wpmL	.1159317996	.5764337020	.0440809869	.0289151949	.2029484043	2.630	170	.009
Pair 9	goldspent - goldspentL	5702.529	4198.584	322.017	5066.836	6338.223	17.709	169	.000
Pair 10	gspd - gspdL	.2240596347	.1756100404	.0134686753	.1974711168	.2506481525	16.636	169	.000
Pair 11	cspm - cspmL	2.216869573	2.724939890	.2089933493	1.804295709	2.629443437	10.607	169	.000
Pair 12	goldat10 - goldat10L	473.441	1234.776	94.703	286.488	660.394	4.999	169	.000
Pair 13	goldat15 - goldat15L	1538.612	2277.351	174.665	1193.806	1883.418	8.809	169	.000

Figure 3.1: LOL API data analyzed (SPSS software output)
(Conducted by the author)

These variables are statistically significant factors to a winning team, however, most of them can be factored out because they are associated with a winning team. For example, “gold spent” happens after a given team wins a fight. A team that won a team fight will have more gold to spend relative to the losing team. Moreover, kills, assists, and deaths are the end result of a team fight, which cannot predict a winning team before they start the fight. On the other hand, CSPM, happens throughout the game from the beginning to the end of a match. A team with higher CSPM, especially during the early phases of the game, has better chances to win the next team fight because they will generally have more gold than the opponent, which means they could have bought more items (to empower their champions) relative to the enemy.

This analysis was repeated on the tournament data (149,496 official tournament samples in 2021), and the results showed that 14 variables were significant. 13 out of the 14 variables were the same as the public games. The additional variable was “Champion”, indicating that some champions impacted the chances of winning or losing a game. Unfortunately, a champion that can influence a game (referred to as OP “over-powered”), is a hindsight information. Teams are constantly searching for such OP champion on a daily bases, because the game by design, buffs (increase the effectiveness) or nerfs (decrease the effectiveness) champions every two weeks. The developers of LOL make changes to champions to keep the game balanced by looking at champions win-rate; Their goal is to keep the champion’s win-rate at 50% and the tolerable range is usually between 45% and 55% (Kica et al., 2016).

The game data in its raw form is not enough to generate an index that would predict a winning team or distinguish between players. As a result, this study combined some of the variables in an effort to find a KPI. A few potential indexes were explored:

3.6 Spending efficiency

The previous analysis showed that damage done to champion and gold spent were statistically significant. However, these values are associated to a winning team. As a result, in an effort to find a performance indicator to distinguish between players, we hypothesized that better players would, on average, have higher gold efficiency. A good player may do more damage than another player while having the same amount of gold, this is due to the players being able to utilize their champion better given the amount of gold they spent (players spend gold on item to improve their stats including damage) This was done simply by calculating “damage done to champion” and divide it by “gold spent”. This index illustrates, for each gold spent, how much damage can a player do. This was referred to as spending efficiency in this study. Official tournament matches were and analyzed by comparing the spending efficiency of the winning team against the losing team. First, we determined which role (a team has five roles) had the highest damage in a game. The results showed that the role “Mid” and “Bot” had the highest damage share within a team. As a result, we analyzed the remaining sample (N= 49,792) after removing the other roles (Top, Jungle, and Support). The independent sample t-test, seen in Figure 3.2, showed that spending efficiency is a statistically significant factor with a p-value < 0.000, indicating that this factor may predict a winning or a losing team.

One-Sample Test

		Test Value = 0					
						95% Confidence Interval of the Difference	
result		t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
0	spending_Efficiency	429.110	24903	.000	1.27254	1.2667	1.2784
1	spending_Efficiency	485.861	24887	.000	1.43421	1.4284	1.4400

Figure 3.2: Spending efficiency independent t-test (SPSS software output)

3.7 Damage Utilization

A major aspect of a player’s performance in LOL is dealing damage to opponent players. The LOL game client software provides the total damage done throughout a game. However, this value provides only the absolute damage without putting it into context. There are more than 160 characters (Champions) (Riot Games, 2022) that a player can choose from, and each one varies in the damage-dealing potential. Therefore, there is a need to have a reference point for the potential of each champion.

This study hypothesis that a better player will utilize their champion to its full potential, given the opponent they are facing. For this metric to be calculated, we need to determine the factors influencing the damage done. After that, we can determine how much damage could a player output given their current situation. This metric will be named “Champion Damage Utilization” (DU).

Maximum Damage (MD) is the potential optimum damage that a specific champion can produce during the fight. The calculation must consider many factors in LOL. Calculating the MD is challenging because a champion’s damage scales with champions level and champions items. Additionally, each champion has a unique set of spells, and each ability has a “cooldown,” which limits the number of times a player can use the ability over a duration of time. For example, the champion “Syndra” has a damage dealing spell named “Dark Sphere”. This ability deals 70 to 210 hit points based on the champion’s level. The damage is further increased by 65% of Syndra’s “ability power” (a stat obtained from items and levels).

Furthermore, the damage done is mitigated based on the opponent's “magic resist” (a stat obtained from items and levels). To sum up, a champion's Maximum Damage depends on its and its opponent current level, the champion’s basic stats, the current items. The equations for these variables are available publicly. However, an application was needed to automate the process. Fortunately, Felix “Crixaliz” Bücher, a graduate student from the University of Lubeck built a tool that calculates the damage done for all champions given their and their opponent's level and items, which greatly assisted the research to calculate the MD (Felix, 2018). This tool was built using Microsoft Excel, Felix did a great job designing this tool. Figure 3.3 illustrates the maximum damage tool. The tool takes a few minutes to fill and automatically illustrates the maximum possible damage a champion can inflict on an enemy by factoring-in all the variables enhancing an attacker's damage, and the variables of the enemy that can mitigate the damage.

Actual Damage (AcD) is the amount of damage a given player does using a specific champion over the fight duration. This is required to determine the utilization (DU). Due to the lack of automated algorithms to measure the actual damage during a fight, this measure is currently calculated by watching the video of the fight, frame by frame, and manually recording and totaling the damage output by the player. In future work, algorithms will be developed to do the calculation. However, for now, this manual work is to prove if the concept works or no. Figure 3.4 illustrates the manual process of calculating the actual damage done, the numbers inside the circle are manually counted and the duration of the fight is recorded (a fight usually last a few seconds).

Figure 3.3: Excel application to calculate MD

(Designed by Felix “Crixaliz” Bücher (Felix, 2018))

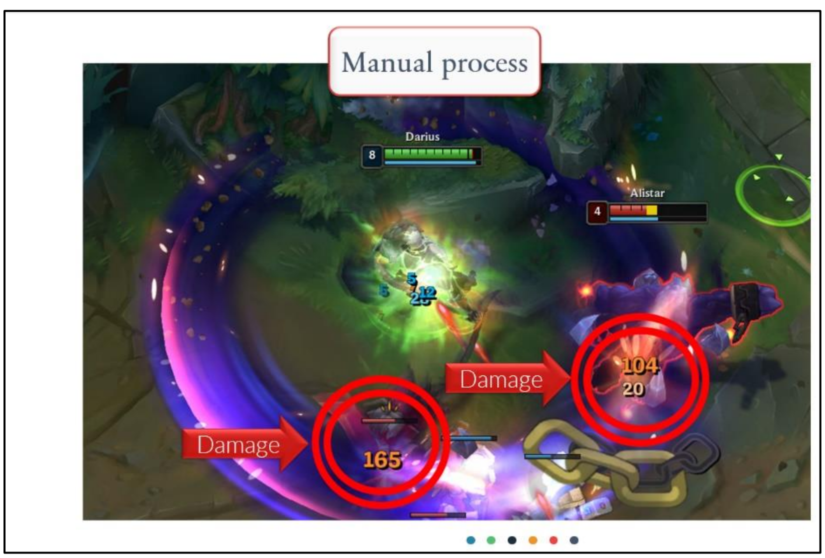

Figure 3.4: Screen shot of a one vs one fight

(Reconstructed by the author)

Champion Damage Utilization (DU) represents how much a player utilized a given champion’s maximum damage-dealing potential over a period of time by comparing the AcD to the MD.

DU = AcD/MD * 100%

When a player starts a fight, AcD will be recorded throughout the fight and then compared to the MD to identify the gap. Example: Player A, using Champion X, started a fight, which ended in 3 seconds. The total damage done during the 3 seconds was 900 = AcD. However, Champion X could have done 1600 damage (MD) (which will be obtained from the Excel sheet app) over the same duration (3 seconds). Therefore, DU = 900/1600 = 0.5625 or 56.25%. We hypothesize that the winning player or team should have a higher DU than the losing player or team.

One of the benefits of DU is that it shows how much damage a player can deal on a specific champion compared to the ideal case or (MD). The DU can be used as an indicator to measure other factors such as “zoning”. Zoning is when a player is threatened by another (stronger) player, forcing him to move backward and away from the threat and also from the range of the team fight. This usually happen when a team has an “assassin,” type champion which can kill a damage dealing targets quickly. The assassin simply needs to stay relatively close to the enemy damage dealer to threaten him, and that would deny the enemy from being close to the team fight and deal damage. In DU, the zoned player will have significantly lower damage, and a coach can guide his “eye test” towards that moment to investigate what happened, instead of watching the whole match (the average match duration is around 25 minutes).

3.8 Results

The DU performance metric was tested on two scenarios, a one vs one fight, and a five vs five fight.

One vs. one scenario: the sample tested was a fight between two professionals in an official match in 2019. Player A used a champion named “Skarner” and Player B used a champion named “Reksai”. The fight duration was 12 seconds, which ended with Player B killing the champion of Player A. The AcD, MD, and DU can be seen in Table 3.2. The MD of both players is relatively close, indicating that both champions did not have a significant edge over the other. However, Player B (Winner) was able to get the most out of his champion, resulting in a DU of 93.58% compared to 73.46% DU for Player A (Lost the fight). Notice that in Figure 3.5, the utilization of the champion can easily be identified, the blue colored bar indicates the MD, and the gray bar indicates the AcD. Using such a KPI and illustrating it using numbers and figures allows a coach to quickly assess what went wrong and also assess the room of improvement by looking at the gap between the MD and AcD. In contrast, without this illustration, the viewer will only see the total damage done without knowing how well a player performed relative to their champion’s maximum potential, and will need to relay on the eye-test (visually inspecting the fight in slow motion).

Case two - Five versus Five: During the LoL Champion Series in North America in 2019, Team Liquid played against Fly Quest. At minute 20 of the match, there was a five versus five fight, and Fly Quest won that fight. The DU values for Team Liquid and Fly Quest can be seen in Table 3.3 and Table 3.4, respectively. The total AcD of both teams are relatively close. However, the gap between the AcD and MD is large, meaning that there is a lot of room for improvement for both teams, specifically for Team Liquid on that fight having 32.4% DU. A coach using this method is efficiently guided by looking for the fights in which their player's had lower than expected champion damage utilization and improve it.

Player	B	A
AcD	1041	781
MD	1112	1063
CDU	93.58%	73.46%

Table 3.2: the damage metrics for the one vs one fight

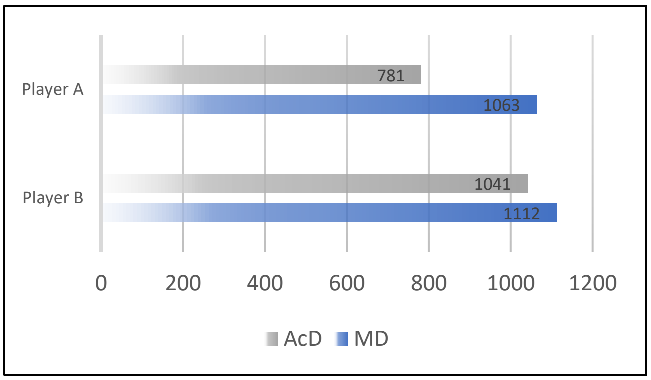

Figure 3.5: the gap between AcD and MD of both players

Figure 3.6 and Figure 3.7 show the gap between the AcD and MD for Team Liquid and Fly Quest. Notice that, overall, Fly Quest utilized its champions more effectively compared to Team Liquid. Moreover, the deficiencies can easily be spotted on the DU graph, and therefore, speed up the process of pinpointing the opportunities of improvements.

Team Liquid – Lost the fight			
	DU	**AcD**	**MD**
Player 1	50%	2,012.00	4,041.40
Player 2	38%	302.00	789.40
Player 3	0%	-	2,348.10
Player 4	11%	299.00	2,681.80
Player 5	73%	1,053.00	1,448.50
Total	**32.40%**	**3,666.00**	**11,309.20**

Table 3.3: illustrating Team Liquid's damage metrics for the five vs five Fight

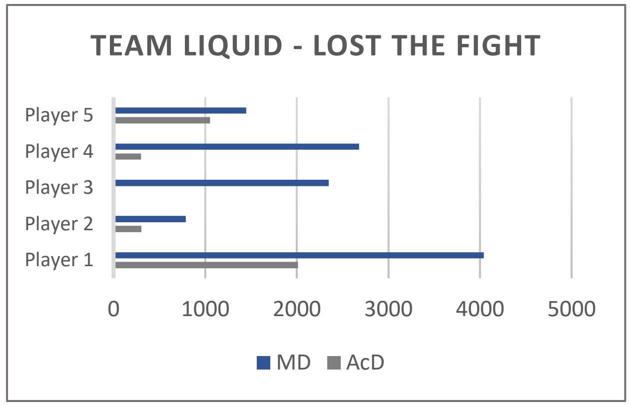

Figure 3.6: Team Liquid's gap between AcD and MD of both players

Fly Quest Won the fight			
	DU	**AcD**	**MD**
Player 1	69%	1298	1883.3
Player 2	40%	465	1148.8
Player 3	65%	1506	2314.7
Player 4	41%	868	2137.3
Player 5	58%	565	972.7
Total	**55.60%**	**4702**	**8456.8**

Table 3.4: illustrating Team Fly quest's damage metrics for the five vs five Fight

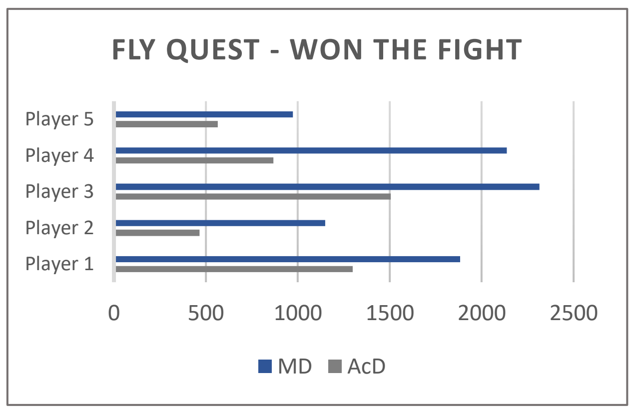

Figure 3.7: Team Fly Quest's gap between AcD and MD of both players

Coaches usually review the footage of a match from each player's point of view (total of five players in the team), the game screen-record the game for each player, also known as Pro-view", which allows the coach to see minor but impactful mechanical details, such as mouse clicking, and mouse location. Notice that player 3 in Team Liquid had zero AcD damage, and his MD is the second highest in his team, player 3 could have had a significant impact if they utilized their champion better; this information can guide the coach to go and watch a specific player to figure out what went wrong.

3.9 Conclusions

Both the public game data (data of casual players) through API and the official tournament data were examined. The analysis found 14 statistically significant variables similar to the ones in the literature; this finding suggests that the new accessible variables do not add additional value to a user searching for a performance indicator. This study explored the significant variables and found that they (excluding CSPM) are likely to be correlated to wins, while CSPM can be a possible performance indicator. Furthermore, Study 1 proposed two potential KPIs, spending efficiency and champion damage utilization. However, both methods must be automated and updated with each LOL patch to remain reliable.

The DU performance indicator has been tested on only two samples because the data collection is done manually. It takes about four hours to obtain the data to calculate the AcD and MD for a one-on-one fight (two players). As the number of players increases, the time required to obtain the information will increase exponentially due to the interaction between multiple champions. The initial test on two samples suggests that this metric has the potential to predict a winning team by measuring a player's champion damage utilization (DU).

The findings from this study showed that it is possible to assess and predict a player's performance using CSPM; this KPI was later used (Chapter 5: Study 3) to evaluate the effectiveness of the proposed training methods. Additionally, at least 13 variables are associated with the winning team; this suggests that game data can predict a match outcome. However, the challenge was to determine whether they are causation or a correlation; these findings may answer the following RQs:

RQ1- Is it possible to assess performance by analyzing the game data?

RQ2- Is it possible to predict a match's outcome by analyzing the game data?

RQ3- Is it possible to find a Key Performance Indicator (KPI) using game data?

Finally, a KPI and a task (CSPM) is one of the major requirements to design a choking intervention. Next, the physical and social stressors need to be identified to finalize the design of the intervention. In the next chapter, the coaches will be interviewed to understand the current states of coaching, the training methods used, and if they experimented with stress training.

Chapter 4: Coaching Practices- Study 2

4.1 Introduction

Although Esports are becoming increasingly popular, there is almost no existing literature on Esports coaching methods and the challenges coaches face. Most of the information available on Esports coaching can be found in blogs and Esports interviews. As a result, further investigation was required to understand the current state of coaching, and this was done by interviewing professional LOL team coaches to provide the knowledge foundation for future research. The coaches were asked for their opinions on our RQs as well as about our findings from the literature (choking interventions) and from Study 1 (KPIs).

League of Legends has four major competitive regions and a total of 47 major teams: 10 teams in North America (NA), 10 teams in Europe (EU), 10 teams in Korea (KR), and 17 teams in China (CN). With its rapid growth and the huge investments going into Esports, the need to protect such investments and ensure the quality and performance of players is becoming increasingly important. In the first two years of LOL's 11-year history, most teams had no coaches, but starting from the third year, teams started to hire coaches after realizing their importance. Currently, all professional teams have coaching staff, typically including a head coach, an analyst, and sometimes an assistant coach (Hasan, 2021). In the current study, we interviewed LOL coaches to understand the challenges they face and to find research opportunities that would address and aid in solving these challenges.

4.2 Interview Setup

As noted above, in professional LOL there are four major regions of play (North America, Europe, China, and Korea). We contacted all 47 teams using their public contact information, and six teams agreed to participate in this interview study. Among the six representatives interviewed, there were five males and one female, with ages ranging from 26 to 33 years old (average 28.8 years). Two of them were from North America, and four were from Europe. Their roles included head coach (four), analyst (one), and general manager (one).

The interviews were conducted to gather data and to allow each coach to express their thoughts and concerns. The participants were given a list of questions in advance in order to shape the overall theme, and then individual meetings were scheduled using an online platform of each participant's choice, such as Skype, Discord, or Hangouts. The general theme of the questions revolved around performance assessment methods, training in Esports, general game knowledge, and challenges a coach faces in Esports. The participants were asked for their consent at the start of the interviews. During each interview, they were asked to talk about the current state of the league in general, without the need to reveal specific information about their respective teams.

The average time for each interview was one hour. The participants volunteered their time and were not paid or compensated. This study was reviewed and approved by a research ethics committee at the University of Waterloo. The interviews were audio-recorded using Open Broadcaster Software (OBS), and the recordings were then transcribed to text manually because transcription software failed to recognize game-specific terminologies such as “scrim”, “meta”, and “int”. Two researchers independently performed thematic analysis using a combination of deductive and inductive approaches, and since comparison of the coded data from the two researchers showed high similarity and consistency, the results were merged and grouped into a hierarchical structure of themes and keywords. The following section presents the details of the results.

4.3 Data from the Interviews

The information obtained from the interviews was categorized and grouped into different sections. The major findings were then grouped into two categories with accompanying subcategories, as follows.

4.4 Esports coach general information

4.4.1 Role of a coach

Each coach had their own philosophy, perhaps because the challenges facing each team were different. For example, Coach #2 said, “*The role of a coach depends completely on the roster*. *Each team will need a varying level of skill based on their needs*.” Although there was no consensus on a best practice for coaching, there was a unanimous consensus over five key objectives of a LOL coach: identifying players’ potential and creating winning conditions for the team; developing synergy and trust within the team; developing the micro and macro play of the team; setting goals in order for players to continuously improve; and motivating players to improve and maintain their peak performance.

Players' potential. Each player has their own strengths and weaknesses, and a team usually aims to pick a roster in which each player's strengths are complemented and their weaknesses are covered. However, the number of variables that account for the strengths and weaknesses of players are unidentified and differ between roles. In LOL, there are five core roles: top, jungle, mid, Attack Damage Carry (ADC), and support. Each of these roles has its own sub-role, which basically involves the style a given player uses to execute an objective. For example, a support role can generally be a utility player, a "play-maker" player, or a damage-dealing player (there can be more sub-roles, but this is a simplification to illustrate the potential amount of variables), and these sub-roles can be executed with many different champions. There were over 150 LOL champions as of 2020 (Riot, 2020a), and this number is increasing by approximately six champions per year (Reav3, 2020). These variables collectively shape the strengths and weaknesses of players and teams, and head coaches are expected to utilize these variables for success. The reason for adding new champions is to add new gameplay opportunities for players to engage with, which is viewed as "mini-expansions" according to the game's developers (Dev, 2020).

Synergy and trust. According to the coaches, synergy and trust go hand in hand. For example, Coach #3 coach stated:

> "*If you want to have a good team, then you need to obviously have a bond of trust between players so that players feel they are able to make mistakes in order to take opportunities. If you are constantly afraid of making mistakes, you won't take*

opportunities that you have. The same goes for if the player is not trusted, the team will not follow up with his calls, which leads to bad synergy."

In LOL, players are constantly making decisions, and since in many cases there is not enough time for a player to communicate their thoughts with their team-mates, therefore as soon as an opportunity presents itself, individual players are expected to react swiftly. These reactions collectively determine whether an objective is achieved. Players need to know what their team needs from them at any given time and act on it with minimum communication, because the window of opportunity might only be measured in seconds (sometime milliseconds (MS)). As soon as a player sees an opportunity, they should react and trust that their teammates will follow up with whatever actions necessary to win in that situation. This trust takes time to develop, and head coaches try to ensure that the trust and bonds between players are as strong as possible. There is no standard approach to developing such bonds; however, some coaches try to arrange for the players to do activities together outside of practice and competition, such as watching TV shows or going for short trips on vacation days.

Micro play. Generally, micro play skills involve a player's ability to control his individual champion and press advantages in a game (Team Dignitas, 2017). They depend on many factors, such as knowledge about different champions' abilities, optimal ways to use those abilities, positioning their character in a game, and landing skill shots. Individual players may be lacking in some of the micro aspects of the game, and coaches are expected to either train them through "positional coaches" or avoid putting them in positions where the enemy can capitalize on their weaknesses. A positional coach usually has enough game knowledge to train a player's micro skill during practice days. This aspect of LOL relies heavily on what is referred to as "mechanics", which refers to the player's hand-eye coordination and response speed.

Macro play. Macro play involves the bigger picture and relates to the strategic side of the game, which involves how the team moves around the map and executes its overall strategy to achieve objectives (Team Dignitas, 2017). This aspect of the game relies on game knowledge and awareness. The head coach and an analyst, along with the players, will develop the macro play of the team. One way of developing a team's macro play is by analyzing its opponents and creating a countermeasure strategy.

Goal setting. Coaches are expected to set weekly goals to improve the players and the team overall. The goals depend on the current strengths and weaknesses of teams and players, and the players aim to achieve these goals by practicing in scrims and solo queue games. The goals may be related to macro play, micro play, or communication. For example, a team might be underperforming because their leader is not decisively communicating their thoughts, so their teammates will hesitate to follow up, and a head coach usually identifies this through discussions after the game and then sets a goal on practice days for the leader to be more decisive in the hope that the practice strategy will be reflected in success on actual game days.

Motivating players. Because the game is constantly changing, players need to routinely practice to maintain their skills, as optimal tactics and best game character choices keep changing with game updates and balance patches. Keeping the players motivated to practice long hours is difficult, and the coaching staff are expected to help the players with this aspect. This is a constant issue, and coaches are always looking for the best ways to motivate players.

4.4.2 Coaching positions

There are four main coaching positions in LOL teams, as follows.

Head coach. The head coach is responsible for the team's overall performance. A head coach's role in a team is to determine "*whatever the team needs in order to perform at peak performance*" (Coach #4), from managing the players and their environment to planning practice routines and strategies. Additionally, they are responsible for developing synergy and trust within a team.

Assistant coach. The assistant coach is expected to complement and assist the head coach. Additionally, they schedule and supervise scrims and make sure that goals are being met.

Analyst. An analyst works together with the head coach and assistant coach to generate strategies based on information obtained from their team or their opponents. Both the team members and opponents are analyzed, and their strengths and flaws are pinpointed to develop a strategy that can utilize the strengths and flaws of a team. The information is usually obtained by either analyzing game stats or analyzing match replays, both of which are provided by the game developer.

Positional coach. A positional coach focuses on improving individual players based on their roles or "positions" in the team. This is done by identifying opportunities for improvement and then working together with players to achieve the set goals. Additionally, they record information related to each player in order to assess and help the players improve.

Two other notable positions are:

Scouts. Scouts are responsible for identifying players that have potential in order to recruit them. This is usually done by monitoring solo queue games across regions and also with academy teams.

Sport Psychologists. Sport psychologists are becoming more popular in Esports; however, not every team has one. The role of a sport psychologist depends on a team's needs. This ranges from managing the stress levels of players performing on big stages to creating a team atmosphere that supports trust and growth. The reasons not every team has one include cost and because some coaches believe a sport psychologist cannot understand or connect with Esports players, perhaps because they are unfamiliar with the situations or the gameplay.

4.4.3 Coach skill requirements

The coaches surveyed unanimously agreed that coaches needed four essential skills: leadership, communication, ability to set goals, and game knowledge. When it comes to game knowledge, a team with established, veteran players will need a coach that can work on the environment and control the team's discussions, because veteran players are good enough to fix their own game-related problems, and the coach's role in this case is to have enough game knowledge to identify whether things are getting off-track. In contrast, a team with new talent (rookies) will need a coach that has greater game knowledge compared to someone coaching for a team of veterans.

4.4.4 Stress in LOL Esports

All the coaches agreed that stress has a significant and noticeable impact on a player's performance. Coach #6 said,

> "*We are spending so much time practicing the game, and spending very little time nurturing the mind and managing stress levels*," and "*Mechanical skills is what gets you there but it does not make a difference if you cannot manage the stress*."

The coaches' concerns related to players' stress can be summarized into five categories, including: translating scrim performance to stage performance; stage nerves; social media; disappointing the organization and fans; and being evaluated. The factors triggering stress are overlapping and interconnected.

Translating scrim performance to stage performance. This is the most common cause of stress for players, according to the coaches we interviewed. Teams usually practice specific strategies during their scrims; however, most teams seem to struggle to perform the same way when they play on stage. Some coaches argued that playing in front of crowds might be affecting the players, while others said that their opponents in scrims play in a more risky manner than they do on stage. In scrims, players can develop methods to punish such risky behavior, but on stage, their opponents may play more conservatively, which is a style the players did not practice against. This issue of players playing in a riskier way in scrims and then switching to a conservative style seems to be a recurring issue, and some teams struggle because during scrims they do not get to practice against teams that play conservatively. As a result, in some cases, even when the players perform very well in scrims, they lack confidence going into a stage game out of fear that they may face a different style than they prepared for. This issue also reduces the efficiency of training before stage games.

Regarding risky behavior, most players prefer to play that way in scrims to "test their limits", as it is a quick way to understand what works and what does not work before an important match; this kind of attitude may help the player who took risks in a scrim, but it gives a false scenario to the opponent they practice against. Coach #5 partially supported the risk-taking behavior in scrims, and added,

> "*They have always developed by being decisive, not by rationally thinking if every single move is the optimal move. They check if it is the optimal move by going for the instinct of decision… it's a massive process of trial and error*." He also pointed out a downside for this trial-and-error process: "*by focusing on their individual development, they are making it harder for the rest of the team to individually develop, because the rest of their team isn't able to play on what you can say stage circumstances.*"

Stage nerves. Esports players are not used to playing on a stage in front of thousands of people. They are young adults who spend most of their time alone in their rooms in front of a computer, and the transition from their rooms to a stage is a relatively huge step compared to traditional sports. In 2020, due to the COVID19 pandemic, the League of Legends European Champion (LEC) tournament was played online and not on stage, and two teams with new rookies were able to stay at the top of the league, and qualified for the world championship. However, the world championship was played on stage in China, and that seemed to affect the players in these two teams. Their performance was below expectations, and their coaches expressed on Twitter that their players were nervous and new to such exposure, and asked the fans to go easy on them on social media. This incident supports the claim that choking is due to the training environment being different than final stage environment, and an intervention such as stress training will allow the players to be familiar with such conditions. Regarding the impact the difference in playing environment has, Coach #3 said:

> "*I don't think the fear of stage is due to a social stimulus… I think it is just a very new environment where things are very different to what they are used to, the lights are different, the smell is different, the temperature is different, the sound is different, and all those are distractions*."

Coach#3 is trying to replicate the conditions, but focused on one element, the physical stressors, while choking interventions requires both, the physical and social stressor to be present in the training enviroment.

Coach #3's approach was to minimize the effects of physical stressors by replicating the stage physical experience. This included using the same setup (table, chair, screens, temperature, etc.) as one that could be expected on stage. Figure 4.1illustrates an example of how some players prepare their gear before a match, as most players want a setup that will feel similar to the one in their practice rooms (Kristine, 2021), such as the mouse speed, mouse pad, chair height, arm rest height, size of the monitor, distance from the monitor, and location and angle of the keyboard (some players prefer to tilt their keyboards).

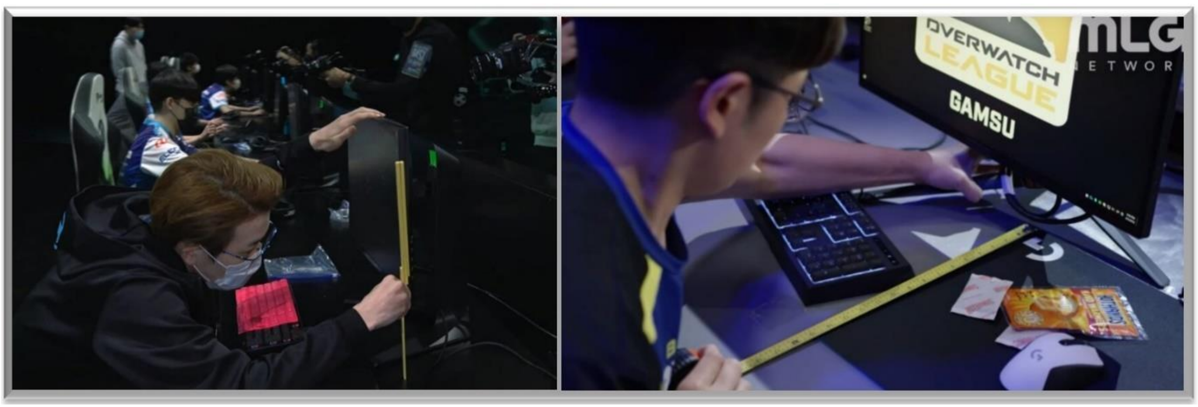

Figure 4.1: Players preparing their gear setup and measurements (Kristine, 2021)

These elements are more important to some players than others, but generally, any change in a given setting will be reflected in a noticeable impact on their performance, as they are operating on autopilot or what they called "the feel", and this feel is disrupted by such changes. Additionally, players on stage play with "white noise" in the background so that they do not hear the fans (as required by the game rules to ensure competitive integrity); however, players are not used to having white noise at home or during practice, and sometimes the verbal communication quality is reduced. Verbal communication on stage is done through headsets, and the players can only communicate with each other. Even though the coaches cannot communicate with the players during the match, however, they can listen to the players' communications for evaluation purposes. As a result, most teams have started to use white noise in the background during scrims in order to reduce this physical stressor when they go on stage (Eric, 2016).

Social media. In Esports, a professional player is more connected to their fans compared to traditional sports, because the player can randomly meet fans during solo queue games (the public server) or during streaming. This is because the fans of Esports players can watch their favorite players stream their solo queue games on streaming platforms like Twitch, which enables them to watch and communicate live with a player. Moreover, professional players are active on Twitter, where they communicate with and respond to fans. Another platform used extensively by the community is Reddit, in which fans can post any topic related to the game and in some cases express their opinions on players. Players have grown used to regularly checking Twitch, Twitter, and Reddit, and with the huge amount of information, especially when related to their performance, it becomes hard for the player to stay focused on the game. This sometimes leaves the players so stressed out that they play very passively because they do not want to make mistakes. According to the coaches, this type of issue seems to be common among new players, but not so much veteran players, and therefore coaches ask new players to distance themselves from social media to reduce such distractions.

Disappointing the organization and fans. Fears of disappointing the organization or of losing their jobs are apparent in many players. Coach #1 said, “*A lot of the pressure comes internally from the organizations themselves . . . disappointing the organization and risk of losing your job…. a lot of organizations base their opinions of social media*”.

These players are mostly young adults, usually between the age of 18 and 27 and with an average age of 21 (Smith, 2018), who are often not used to doing much on their own, and so the transition from their quiet home environments to a gaming house where a team trains is often a significant shock. Also, given the amount of time they spend playing and practicing, they have little time to develop skills that would help them transfer to another job outside of the Esports industry, and so the stakes involved with losing their game-playing job are relatively high.

Being evaluated. Social media shapes the public opinion on a given player, which may impact their job. New players are more affected by this than established players. Most of the coaches agreed that players are stressed about public perception as they enter the stage. Players are being judged by the fans, teammates, opponents, and the casters (shout casters commentating on the game). Additionally, spectators (fans watching the game) can watch the game from the players’ points of view, which allows the spectators to easily detect mistakes and post them on social media. Fans of an opposing team will usually do this as a form of social media harassment.

All of these stressors can lead to players choking on stage. As a result, during the interview, stress training was proposed as an intervention to choking by exposing the players to social stressors during practice, but the coaches believed that the players were currently challenged enough and that more stress might lead to burnout. The coaches have tried what they called “fan meets”, in which a professional player meets a few fans and discusses the game they just played. However, they noticed that fan meets after a losing game had a negative impact on the player’s mentality. Additionally, the coaches believe that Esports players are relatively more introverted, and that choking interventions (training under stress) worked on traditional sports players better due to them being more extroverted relative to Esports players. The coaches expressed that Esports players don’t socialize as often as traditional sports players, which makes them more sensitive to social stressors.

4.4.5 Evaluating the performance of coaches and players

The coaches unanimously agreed that there is no single best practice to evaluate coaches and players; however, the current evaluation approaches are as follows.

Evaluation of coaches. This depends on the role of a coach and the goals they are expected to achieve within the team. Currently, teams evaluate coaches based on results (e.g., win/lose ratio), pre-defined goals, and in some cases, through feedback from the players. Coaches are relatively hard to evaluate, as their roles involve more qualitative factors.

Evaluation of players. Players are evaluated by coaches based on their growth, progress in week-to-week goals, and overall results (e.g., in-lane wins or losses). For example, a player in the Mid lane can “lose the lane” by being killed by their opponent. However, there are no standard quantitative key performance indicators for teams to assess their players.

The coaches mentioned that fan feedback on social media platforms can influence a team's decisions and shape fans' opinions on players and coaches, and as a result, there have been cases where teams have either removed or recruited players due to community (fan) pressure. Increasing the number of fans will make the players feel more support on stage, which will in turn increase their confidence. Additionally, more fans mean more revenues from advertisements and sponsorships. Currently, teams are sponsored by a wide range of international companies such as energy drinks, gaming peripherals, multiple gaming PC brands, insurance companies, and car companies.

Selection of coaches. Most of the coaches agreed that there was no single best practice for recruiting and evaluating a coach. Sometimes a team's top management will ask for players' feedback after having a specific coach for a time, but most coaching activities take place behind the scenes, and it is very difficult to assess a coach's impact on a team. Currently, there is no defined career path for someone to become a coach. Ideally, a coach should be a professional player first, and then transition into coaching. Still, due to Esports being a relatively new scene, there are not enough professional players who have retired to transition into coaches. An experienced player transitioning into coaching will have excellent game knowledge and can therefore earn players' respect relatively easily, since some coaches currently suffer from players not respecting their opinions due to the coach not being mechanically skilled in the game.

Selection of players. There is also no single best practice for assessing and acquiring a player, but it is a relatively simple task compared to acquiring a coach. Teams and coaches rely on the "eye test", in which they will observe and evaluate a player's public games. LOL has a "Pro-view" feature which enables spectators to watch tournament games from a player's point of view; this feature aids the spectator in understanding and evaluating a player's movements, responses, awareness, and other macro and micro skills. What is lacking, however, is a method to evaluate new players (rookies). Even though the solo queue game records of rookie players are publicly available, this is not enough to evaluate a player, as they are playing both with and against random players, so skills such as teamwork and performing under stress in high-stakes games are hard to assess. LOL has an application programming interface (API) in which in-game data are recorded to be used for analysis; however, coaches have expressed that the data available are not sufficient and seem to be associated with wins and losses rather than the causes.

Teams and coaches value the following aspects of a player: their growth potential, communication skills, attitude, and sometimes language in the case that a certain player is from another region.

4.5 Challenges in LOL Esports

4.5.1 Practice routines in LOL Esports

Coaches and players set weekly goals that they aim to achieve through scrims and solo queuing. Scrims usually last 6 hours, which includes 6 games against another team and discussions between games. On top of that, they practice in solo queues for an average of 6 hours at a time. Total daily practice times are 12 hours on average, with minimums of 8 hours and maximums of 15 hours. There are 4 break days during a month (i.e., once a week), but even on those days, some players choose to play in solo queue games in order to stay ahead of the competition.

During scrims, teams practice their strategies against other professional teams; however, the level of cooperation between teams is limited. For example, if a team wants to practice against a team with a specific composition, they do not ask their opponent to adopt that composition. One reason for this is because a team that cooperates will deviate from their own objectives, and then the practice time from their point of view will not be sufficient. Additionally, teams are afraid of revealing information during practice, which disincentives teams to cooperate. As a result, most cooperation happens between a team and an academy team, which is a sub-team within the main team's organization. Every major team has an academy team, and these teams have their own small tournaments for the purpose of developing new talent. Sometimes a team practices against its academy team when they do not want to reveal strategic information to potential opponents.

The coaching staff struggle to keep the players motivated, which leads to players sometimes not taking scrims seriously. This is common among most teams, perhaps because of the long working hours, as it is difficult for a player to stay focused when they practice for 12 hours a day, six days a week. Additionally, the game does not have any practice tools for teams to train on a specific phase in the game or under specific scenarios. As a result, if a team wants to practice a team fight where all player characters are at their maximum levels, they will have to play through all the previous phases of the game to level up to that maximum level before practicing the real deal. This not only wastes time but also makes players feel less motivated during practice because they have to play through the "boring" part of the game first. The reason players need to practice for long hours is because the meta, the best way to play the game, is constantly changing due to the high frequency of game patches. Approximately every two weeks, a new "balance" patch is applied to the live servers, in which some champions and items are "buffed" and "nerfed". These constant and frequent changes cause the meta to shift rapidly, and players are therefore continually searching for the best way to play the game as a result.

4.5.2 Attitude of players

A player with a negative attitude and non-cooperative personality can be damaging to a team's environment. There have been many incidences in which players do not cooperate with their coaches; this seems to stem from the fact that professional players are not used to playing in a team environment because their initial experiences before becoming a professional player were in solo queue games with random players, and they gained their skills without the need to listen to others. One coach said in a public interview:

> "*I think it is hard for them to respect a coach, I think, part of it is because their success is derived from them disobeying their parents pretty much, so like, they have had success by not listening to the big authority figure in their life*."
>
> He further added:
>
> "*Putting them in a situation where now they have to go listen to someone, well I mean they got to where they were not listening to people and now they are being forced to*

> *listen to, like that's a weird kind of transition to what they have been used to*." (Travis Gafford, 2020)

This is a struggle that coaches face when they recruit so-called "ego players"; these players are usually very skilled but are "hot-headed", and it takes a great deal of effort to transform them into team players. Coaches in general avoid recruiting such players, since even though they are very skilled, they can be very damaging to a team's environment, and there are no known ways to deal with them. Coach #1 stated,

> "*Toxic behavior of Esports players are an issue. In traditional sports they are usually weeded out through middle school, high school and collegiate programs, where you learn that such a mentality is not beneficial. But in Esports you don't have that growing up into it.*"

Stress Management. There is no single best or common approach to stress management in Esports. Some teams have started using meditation, sport psychology, and/or going to the gym, which may reduce players' stress levels. However, there is no empirical evidence as to whether these methods result in a positive impact on a team.

After evaluating their players' readiness to practice, one team began using wearable fitness-trackers to track their heart rate variability (HRV) and sleep to help plan their training sessions. HRV can be used to assess one's readiness to tolerate stress on a given day, which can help a user to determine if they should train or rest that day (Acharya et al., 2007b). However, at the time of the interview with the coach, that team had only been using HRV training for 6 weeks, which was not enough to confirm whether it was having an impact or not.

However, the coach was optimistic and felt that this approach seemed to have potential in Esports training.

4.5.3 Health issues in LOL Esports

The coaches expressed concerns for both the physical and mental health of the players.

Physical health. The most common physical health issues facing teams are wrist and back injuries, which are believed to be due to the extreme number of hours players practice with bad posture. Even though it sounds easy to fix, it is hard to change the players; while they do fix their form initially, they quickly revert back to bad posture as they start focusing on matches. Even with good posture, though, long hours of playing and training can still cause repetitive strain injuries, and teams usually resort to a physical therapist to treat such conditions. However, players prefer not to rest or take time off because they feel they may lose their competitive edge and be replaced, and as a result, there have been cases where players have had to retire at a relatively young age due to the severity of their health issues. For example, a 22-year-old player known as "UZI", previously one of the most valued Chinese LOL players, had to retire in June 2020 due to chronic shoulder and wrist injuries (Emily, 2020b). UZI added, in a public record, "*One time I went to the hospital for a checkup and the doctor said my arms are similar to that of a 40 to 50 year old.*"

Coach #5 and one of his players had wrist issues, and they solved them by lowering the DPI settings on their gaming mice. DPI stands for dots per linear inch, which controls the mouse's sensitivity and speed. When the DPI increases, the mouse's sensitivity and pointer speed will increase. Coach #5 argued that reducing the DPI helped him and his player fix their wrist issues by gradually adapting to playing with a lower DPI, which is worth exploration in future research.

Mental health. Players are under a lot of mental stress due to the competitive nature of the game, and it is very easy for a player to burn out and collapse from the extremely long practice hours. Also, Esports players take a big gamble by not continuing their studies, because if they fail at Esports, they have very few skill sets that can be transferred to other professions.

An additional problem noted by one of the coaches was the issue of substance abuse. This coach expressed his concerns over the growing habit of using Adderall, a stimulant drug that is used to help increase players' ability to focus in order to maintain their performance and stay competitive. We looked into the literature and found a few papers supporting the coach's claims that some Esports and casual players in general, not just specific to LOL, are using performance-enhancing drugs such as Adderall and Ritalin (Bonnar, Castine, et al., 2019; Holden et al., 2018).

4.6 Need for Future Research

Esports coaching is a nascent research field, and the data in this domain have thus far been very limited. In the current study, we provided a broad overview of coaching practice by gathering opinions and comments from professional League of Legends team coaches. A limitation of the current work is its qualitative approach, but the findings from this study could support future work to focus on specific issues using quantitative methods, such as training under stress which was tested in the next chapter (Chapter 6 – Study 3). The coaches in this study were asked what answers they hoped to find from the research community and to suggest what types of research they hoped to see that would help Esports teams, and their requests are presented as follows:

Identify players' fatigue levels. Because of the long practice periods, many players burn out during the season, or at best have a reduced efficiency during practice, and there is a need to find methods to identify whether a player needs more practice or more rest.

Identify the conditions for peak performance. Each team or player has what the coaches called a "pop-off" moment, in which a player performs at their peak, and the coaches expressed the desire to explore whether there is a scientific method that would help them identify what the conditions were leading up to a particular pop-off moment. Additionally, they mentioned that they struggled to get their players "in the zone" (i.e., extremely focused), and did not know whether this was related to a game situation, a mental state, or some other factor.

Coaching best practice. Currently, coaches try their best to help their teams win, with the methods used depending completely on what the team needs, and they try their best to educate themselves through looking at other sports. They all agreed that there was no best practice for coaching, and that they were continuously trying to learn and improve without any source of guidance. All the coaches expressed the need for a standard for coaching. Also, due to the lack of performance measures for coaching, it was very difficult to know whether a coach was doing a good job.

Identify key performance indicators for coaches and players. Currently, there are no key performance indicators for coaches or players. Coaches think that it is not currently possible to evaluate coaches due to their roles being mostly qualitative relative to those of the players. Additionally, a player's performance measures will be different for each role, and currently they rely mostly on the "eye test" (expert subjective evaluation of player game play).

Experimenting with shorter practice time duration. The average daily practice duration is around 12 hours. Most coaches would like to see if shorter practice times would yield better results; however, they were not willing to take the risk of the strategy failing, causing them to fall behind in a tournament. Another solution would be to increase practice efficiency. Currently, the game client does not allow a player to customize the game, which means that during practice, both teams will have to join a normal game and play through all phases of the game, meaning that if a team wants to practice a certain situation in the game, they cannot skip through the early phases of the game and just practice that situation. As a result, it would be interesting to study the impact of having such a tool on practice time.

Automation. When coaches and analysts prepare for a match, they need to review footage of their opponents to identify their strength and weaknesses. Additionally, they also need to review footage of their own team to identify the same factors in order to generate strategies and practice routines for that specific match. This process is currently done by actually watching the games, which is both time-consuming and tedious, and the coaches hope that with the aid of image-tracking, coding, or other methods, they could review footage more quickly and reach conclusions faster. Right now, it is not possible for coaches to analyze all their opponents, and sometimes they must prioritize which opponents to study and which to ignore. For example, if a team wants to study only one match for a particular opponent, they need to review a game, which is on average 30 minutes long, five separate times, because there are five players on every team and they need to know how each player behaves in certain situations, thereby identifying the strengths and weaknesses of that team. Of course, to reach a concrete conclusion, an analyst will need to review more than one match for a particular team.

Supplements. The coaches were concerned about wrist and back injuries, and they wanted to know whether certain supplements like Omega-3 would reduce or delay such injuries. According to them, the literature on these subjects was conflicting. They also asked if there were any natural supplements that would improve cognitive function or at least increase endurance.

Talent development. This is becoming a trending issue in the North American (NA) region. Most of the LOL teams in NA rely on imports who are established players from other regions, and do not cultivate local talent. There is no one clear reason for this lack of talent development, but it seems to stem from the lack of a method to evaluate a player's performance. An additional reason that has been expressed publicly by many experts is the lack of good scouts. These two problems might be connected in a way, because if there is no good performance indicator metric, it is hard for a scout to identify good players. The problem of talent development was discussed heavily on social media platforms after the LOL 2020 world championship, where NA teams were criticized for their performance, which was perceived as being below expectations. The Cloud9 team owner, Jack Etienne, said on Twitter:

“*I'm incredibly disappointed by the results of our region so far at #Worlds2020. All of our teams need to reevaluate how we operate as this is not acceptable. Our talent development, recruitment, and training strategies need to be reviewed and improved for positive change*.” (Oct. 10, 2020, Twitter)

4.7 Conclusions

The results from this interview study allowed us to understand the general information of coaches such as their roles, their different positions and skill requirements, and evaluation processes. However, all the coaches expressed a lack of proper performance measures for coaches and players, with coaches being the hardest to evaluate due to their role having more qualitative factors.

Esports coaches are facing many challenges, and there are many opportunities to make their job a little easier. Large portions of their job are done manually and consume a significant amount of time, such as reviewing match games comprehensively, which takes hours for that task alone. We were able to understand how coaching is approached in LOL Esports; however, there does not seem to be a common practice involved because each coach is trying to address a different problem based on their team’s specific needs. Therefore, there are many research directions in LOL Esports to explore.

When comparing Esports coaching with traditional sports coaching, three clear differences are apparent. First, the game rules are constantly changing in Esports. For example, in LOL, new champions (player-controlled characters) are regularly added to introduce new ways of playing, and character strengths are also frequently adjusted to balance the game. As a result, coaching staff need to explore the new game mechanisms in order to identify the best strategy, and players need to practice for extremely long hours to maintain their competitive edge by remaining up to date with the best ways to play after each change. This demanding workload has caused many players to burn out and be forced to retire at relatively young ages (e.g., 25 years old), and primarily because of this human toll, better Esports coaching strategies are needed in order to adapt to the fast pace and rapid evolution of game rules.

Finally, coaches are not willing to add social stress to their training methods because they believe that Esports players are generally sensitive to social stressors. In fact, the coaches actively shield players from these stressors during practice sessions, which goes against current choking intervention theories. The literature shows that a performer should train under the same conditions they will face on stage, and since Esports players face many social stressors under actual tournament conditions, these stressors should also be present during practice.

The findings from this study answer the first 5 RQs, and provided enough information to design an experiment in the next chapter (Study 3), and choose stressors that is relevant to Esports players.

4.8 Limitations

The current study only interviewed LOL coaches from North America and Europe, and coaches from China and Korea did not participate in this study. LOL Esports experts believe that Western regions have significantly different practices than Eastern regions (wavee, 2015);

(Dafaesports, 2017). A 2018 study explored the LOL culture in eastern regions and their findings suggests that their training methods are tougher than western regions.

Chapter 5: Training Under Stress - Study 3

5.1 Introduction

Based on our findings from Study 2, we now know that player's performance on stage is significantly affected by both physical and social stressors. The literature on choking intervention suggests that a performer should train under conditions similar to the environment they will eventually face. For example, if an Esports player will perform on stages with large crowd noises and cheers, they should be familiar with that environment. The literature suggests that if the performer feels a large shift in the environment (between practice and stage), they will choke. In contrast, the literature also suggests that Esports players are more sensitive to social stressors than traditional sports athletes, and the coaches in Study 2 agree with this claim based on their experience. The coaches have asked their players to meet fans after the games to chat and discuss their performance. They noticed that negative feedback from the fans significantly impacted the player's mental health and performance and stopped conducting such an activity.

This study aims to verify if training an Esports player under stress will improve their performance under stress or burn them out, as the coaches suggested. This was done by conducting an experiment in which Esports players trained under social and physical stressors . Study 3 targets the remaining three RQs:

RQ6- Does improving a player's mechanical skill help them perform under stress?

RQ7- Does training under stress improve their performance under stress or burnout?

RQ8- What is the performance gap between the training methods?

5.2 Procedures

To conduct this experiment we need to, first, determine the task in which participants will execute to evaluate their performance with and without stress. Next, choosing the physical and social stressors in the experiment, and how they will be induced. After that, the experiment design, components, and hypothesis will be illustrated. Following, the methods in which players will participate in this experiment will be defined. Finally, the data will be collected and analyzed to answer the three remaining RQs.

5.2.1 Choosing a task

In the stress training literature, usually a task or action is chosen that is easily replicated and controlled, such as basketball free throws. Below is a list of some of the main actions an LOL player performs in a game:

1- Skill shots

2- Dodging skill shots

3- Creep scoring

4- Skill shot combo timing

There are many other skills in LOL that test the player's mechanical skills, but they are harder to replicate.

5.2.1 Skill shots

A skill shot is an ability that requires a player to aim their attack accurately and then launch it at a target. It may hit or miss based on three factors (Schmidt, 2018):

1- The player's accuracy

2- The range, speed, and hit-box of an attack (a hit-box is the width or radius of an attack; it can be very narrow like a small thin bullet or very wide and circular, like throwing a huge ball at the target), as seen in Figure 5.1 and Figure 5.2. In Figure 5.1, the indicator in front of each champion shows the width and range of an attack. The red arrow indicates the width or hit-box of an attack. Also shown in Figure 5.1, there are four additional abilities that a champion can use, some of which are skill shots and others being "point-click" abilities, meaning that relatively no skill accuracy is required; e.g., if you point the ability at a champion, it will land on that champion and hit them. Figure 5.2 shows a comparison between an ability with a small hit-box and one with a large one. An ability with a smaller hit-box is generally faster than an ability with a relatively larger hit-box.

Figure 5.1: a Champion's abilities indicators and the hit-box indicator

(Taken by the author from a custom game)

Figure 5.2: Illustrating small and large hit-boxes (taken by the author from a custom game)

3- Predicting a moving target's position. Players try to keep their champions moving in random directions to make it harder for an enemy to predict the champion's location. If a champion is standing still, it is a relatively easier target than a champion that is moving and constantly changing directions.

To use this task in our experiment, the target of the skill shot (which would be another player) should behave in a similar manner with all participants. We can then assess the participants' performance by counting how many skills they hit or miss with. However, since it is challenging to control and assess their target behavior, this may add an element of human error to the data.

5.2.2 Dodging skill shots

Dodging skill shots is an essential skill that an LOL players need in order to survive or win a fight. This skill depends on the speed of the skill shot, the reaction speed of the player, and the range between them and their attacker. Players usually dodge attacks either by reacting to them, predicting them, or juking. Juking refers to when a player moves their character in an intentional pattern to trick an opponent that is trying to predict their direction.

Similar to skill shots, this task may add an element of human error because the player launching the skill shot need to maintain a consistent aim accuracy against all the participants to assess their dodging skills.

5.2.3 Skill shot combo timing

Timing is the most important element to amplify the impact of a combination of abilities launched in a sequence, also referred to as "comboing" or a "wombo combo". A combo can be a combination of some or all of the four abilities of a player, or it can be a combination of the player's and their team-mates' abilities in order to maximize an effect or to increase the chances of accurately striking a target. For example, some champions have relatively slow abilities, but their damage is greater than an average attack, and so a team-mate can help by using abilities to slow down or lock the target in place, also referred to as crowd control abilities (CC for short), which would increase the chances of a slow but strong attack hitting a target.

Combo timing can be a determining factor in whether a team fight is won or lost. Players therefore usually choose champions that complement each other's abilities, and during the game, they expect that each player in the team knows exactly when to combine their abilities. When an opportunity presents itself, all the team members are expected to immediately launch their part of the combo, as the opportunity window is sometimes a fraction of a second, which is not enough time to communicate or call the shot.

This skill is also challenging to replicate with every participant, as it requires more players to be involved in one sample. Additionally, there are many iterations for a combo since it is not binary, making it a hard task to control in an experiment.

5.2.4 Creep scoring (CS)

Creep scoring (CSing for short), is a standard task a player performs during a regular game in order to gather gold, the in-game currency used to power up a character. This task depends on the hand-eye coordination of the players.

Figure 5.3 illustrates the task of creep scoring. Players will need to attack a creep (a computer controlled character, also known as a minion) by right-clicking with the mouse on a specific creep. As soon as the player clicks the mouse, the champion (a character controlled by the player) will swing his weapon, launching a basic attack, referred to as an auto-attack (AA for short). This AA travels from the champion's location to the creep's location, and strikes it.

Figure 5.3: Creep scoring (Taken by the author from a custom game)

The attack can be seen in Figure 5.3 as a green-colored projectile on the champion's right side. When an AA strikes a creep, it will lose health points, also referred to as hit points or HP, based on the strength of the champion. The amount of damage depends on an Attacker's and the attacked target's level, items, and basic stats. These factors affect the amount of damage suffered by the target. Knowing the amount of damage is important because the player must deliver a killing blow (i.e., their attack must kill the creep) to the creep in order to be rewarded with gold (game currency).

While the champion is attacking an enemy creep, that creep is also being attacked by allied creeps (the blue-colored creeps). As a result, the player needs to track how much damage he can deliver, how many HP the creep has, and how many allied creeps are attacking it before he can perform the killing blow. Additionally, since the champion's AA (projectile) is not instantaneous, taking a few fractions of a second to travel from the champion to the target creep.

A player can check a creep's remaining HP by first mouse clicking on the creep, and then they can read its remaining HP by looking at the top left corner of the screen as shown in Figure 5.3. Figure 5.4 is an enlarged image of the top left corner in Figure 5.3 showing the creep's remaining HP.

Figure 5.4: Creep's remaining HP, displayed on the top left side of a player's screen

A player also needs to factor in how many enemy creeps are attacking their creep. Since the amount of damage when CSing changes due to many dynamic variables, players will frequently attack creeps to read how much damage their AA is inflicting, as a number will appear over each creep they strike that indicates the damage done. Notice in Figure 5.5, a number is displayed indicating that the enemy creep has lost 48 HP due to the attack. Additionally, its HP bar, seen as a red bar over the creep, shows the remaining HP as a bar, but without numbers; a player can either estimate how much HP the creep has left based on how much damage they have dealt, or they can check the actual number by looking at the top left corner of the screen to read the amount of remaining HP. Usually, players prefer to estimate the creep's remaining HP rather than reading it from the top left corner, since in an actual match, they are doing this task while an opponent is directly in front of them and they cannot risk being distracted by looking away when the enemy may attack them at any time.

Creep scoring (CS) is a task that can be easily replicated because the behavior of creeps does not change. CSing is a relatively quick task that a player can repeat around 8 to 10 times a minute, meaning that each session can provide a decent amount of data points to analyze in order to distinguish the difference between participants. Additionally, CS is recorded by the game automatically.

Figure 5.5: Basic attack (AA) and illustrating the amount of damage done

(Taken by the author from a custom game)

Finally, it mimics the choices of tasks in the stress training literature, in which a participant repeats a task multiple times per session, and maintain the same task difficulty between samples.

5.3 Social and Physical Stressors

Stress training usually includes a social stressor and a physical stressor. The physical stressors used in in the literature focus mainly on noisy sounds such as sirens, alarm sounds, and car horns, while the social stress was induced by informing participants that they are being watched and recorded, and that their performance will be evaluated. Sometimes the researchers mention to the participant that a famous player will watch and evaluate their performance or that their performance will be streamed on live TV and evaluated.

We used a pre-recorded siren alarm sound as the physical stressor for the participants. Moreover, we used two stressors to induce the feeling of being evaluated. For the first stressor, an application was developed using C# in which a negative sound is prompted when wrong actions are made (e.g., participants missing a CS) and a positive sound for correct actions (e.g., participants killing a creep). Then, the scores were announced every minute so that the participants felt that we are tracking their creep score per minute (CSPM). Tracking CSPM adds pressure because most LOL players aim for 10 CSPM (Moss, 2021); however, 10 CSPM was not achievable in our 7-minute experiment due to a designed game limitation by which the creeps' spawn rate was not linear. The total number of creeps that could spawn in a 7-minute game was 68 creeps. We choose 7 minutes because it provides more than enough achievable samples per session, and at the same time, it is the tipping point at which 10 CSPM becomes achievable after minute 7 (i.e., minute 8 onwards). It also allows enough time to induce the stressors, and to minimize human error caused by the experimenter. The experimenter will need to track CSPM and announce it every minute, trigger the application that prompts correct and incorrect actions from minute 1 to minute 4 (we started from minute one into the game because that was when the minions spawned), and finally turn on the siren sound for the remaining 3 minutes (the siren was paused every minute to announce the CSPM, and then resumed).

Survey for expected score at 7 minutes

We wanted to know if players would feel pressured when their CSPM was lower than 10 during the experiment, and so a survey was conducted in which 59 participants (silver and gold ranked) chose one of four options:

In a 7-minute game, it is possible to for you!! to:

1. *have 10 CS per minute (a total of 70 CS)*
2. *have 9 CS per minute (total of 63)*
3. *have 8 CS per minute (total of 56)*
4. *Less than 8 CS per minute*

The survey showed that 64% of the participants thought 10 CSPM was achievable in a 7-minute game (70 creeps), and 24% choose 9 CSPM (63 creeps).

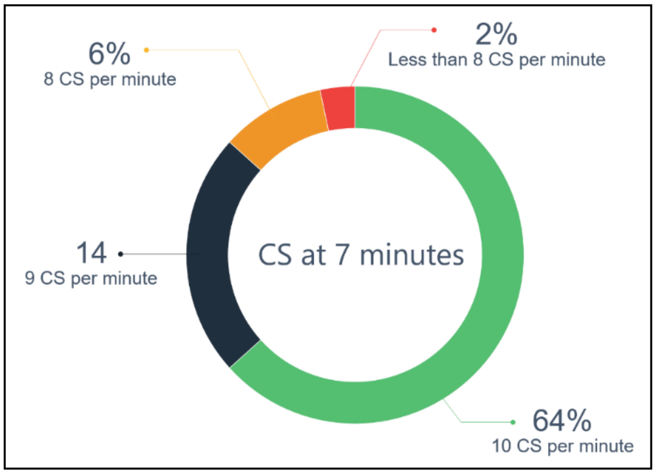

Figure 5.6: Survey response - How many creep scores are possible at 7:00 (CSPM)

These results suggest that at least 88% of the participants (64%+24%) expected results close to a perfect score or higher; we assume that this confidence was because they would focus mainly on CS and not be distracted by an opposing player. However, the game database showed that the silver and gold players in 2019 and 2020 (the same period as our experiment), had an average of 5.32 CSPM (SD: 0.54). Figure 5.6 shows the survey responses. This survey suggested that most players ranked silver or gold (our participants) may feel they had underperformed after performing the task.

5.4 Experiment Design

League of Legends ranks players according to their skill level, and places them into nine different tiers: Iron, Bronze, Silver, Gold, Platinum, Diamond, Master, Grand Master, and Challenger. The majority of players (65%) are in the Silver and Gold tiers and are considered as having average skills (Sabrina, 2022). The experiment followed a design paradigm similar to that used by Oudejans and Pijpers, where they trained dart players under pressure (R. R. D. Oudejans & Pijpers, 2010).

We chose a task that is considered challenging for League of Legends players ranked Silver and Gold on the public server in which they could develop their skills over time; a period of 3 days was considered enough to show noticeable improvements based on opinions of the coaches we interviewed and the skill levels of the players according to the LOL database.

We applied both social and physical stressors to players to train them under stress and assess their performance. Our choice of external stimuli aimed to distract them and trigger the internal feeling of being evaluated in order to mimic the same stressors Esports players face in competition, according to our findings from Study 1. Our method did not target a specific choking theory (Distraction or Self-focus theories), but rather familiarized the participants with stress, which may reduce both choking theories' effects (i.e., low performance due to stress).

Professional players sense the slightest change in the environment (between practice and stage games), an opinion the coaches unanimously agreed on, such as the height of the screen, the temperature of the room, and even the monitor backlighting (the contrast of light behind their monitor) (Sabtan et al., 2022). Therefore, in this experiment, we used two different maps to provide a change in the environment; one had a forest theme, and the other had a winter theme, as shown in Figure 5.7. The main differences between the maps (relevant to this study) are the theme, creeps' spawn rates, creeps' HP, and creeps' armor. The forest-themed map was used on test days, and the other one on training days.

Figure 5.7: LOL map theme

The experiment had a duration of 5 days, with a pre-test on day one, a post-test on day five, and three days of training in between. The required sample size was determined using GPower (Kang, 2021), an application that determines the sample size based on the required accuracy, type of statistical analysis, and number of measurements (here, once a day over five consecutive days). To achieve an accuracy of $\alpha = 0.01$, the minimum sample size is considered to be 54 to achieve the required accuracy in the analysis. However, we aimed for 100 samples because the experiments were done remotely (during the Covid pandemic, between 2019 and 2020), and it would be challenging to consistently collect the data for an online experiment. For example, challenges factored into the experiment design included the internet quality of both the participant and the researcher, participants forgetting to fill the forms, or participants simply not showing up on one of the experiment days.

Participants were divided into two groups, a control group that trained without stress and an experiment group that trained with stress. However, to ensure that both groups had similar portions of silver and gold ranked players among them, the participants were first pooled into two sets (gold rank in one set, and silver rank in the other) that were then randomly split into the control and experiment groups. Both groups experienced the same conditions (i.e., under stress) on the pre-test (to determine the baseline of the performance under stress), and the post-test (to measure improvements or changes compared to the pre-test). On the training days (Day 2 to Day 4), however, only the experiment group was subjected to the stressors, while the other group trained without stress. the sounds of both the siren and the applications during training days were different to the ones used on test days.

The experiment design can be seen in Figure 5.8. This is a mixed design experiment repeated measures, with the days of activity as the within-subject factor, and the type of condition (training under stress) as the between-subject factor.

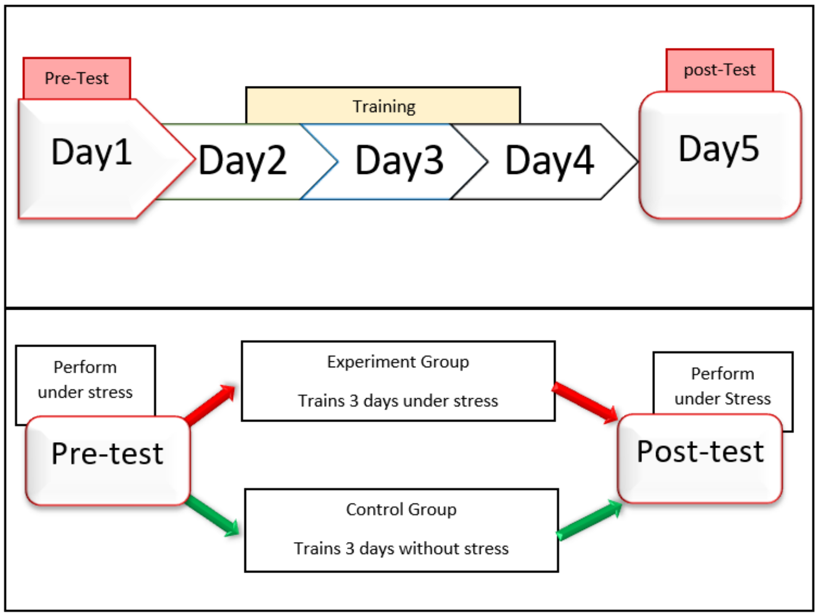

Figure 5.8: Experiment design (produced by author)

5.5 Experiment Components:

5.5.1 Dependent variables (DVs):

These are the variables we monitored to measure an effect.

1- Creep score percentage: We want to measure the creep score percentage, which will indicate whether or not a participant is improving under both conditions over time. The creep score is recorded by the game application, and the scores will have a range of 0% (no creeps eliminated) to 100% (all creeps eliminated)

2- Perceived stress: We want to capture the changes in perceived stress (after-minus-before the experiment) over the duration of the experiment, this will allow us to detect if the session increased or decreased their stress levels. The participants' stress levels were recorded using the Dundee Stress State Questionnaire (DSSQ) (Matthews et al., 2013b). The DSSQs were filled out by using a Google form before and after each experiment. The participants rated their responses from 1 (not at all) to 5 (extremely). Finally, the perceived stress results after the experiment will be subtracted from the results before the experiment to assess the changes in perceived stress due to this experiment.

5.5.2 Independent variables (IVs):

These are the variables that we changed to manipulate the values of the DV:

1- Type of training, training with and without stress, is the between-subject variable.

2- Duration of training, is the within subject variable. The experiment's duration is five days. This variable aims to verify whether training under stress over time will improve performance under stress.

5.5.3 Covariate:

1- Player's rank. The participants were chosen based on their ranks (silver and gold tier). However, within each tier, there are four sub-ranks (i.e., gold-1, gold-2, etc.). We captured their ranks when they filled out a Google application form. This covariate will be statistically tested if it has any effect on the dependent variables.

2- Age. Each player's age was collected using the Google application form. There is a debate among the Esports community over whether a player's mechanical skills deteriorate with age or not (a player aged 25 or older is considered “old”) (Horridge, 2017; Nick, 2020). This variable allows us to detect the existence of patterns in the dependent variables due to age.

3- Years of Experience playing LOL. We want to see if this variable has any effect on the dependent variables; specifically, stress tolerance.

4- Personality (Introvert/Extrovert). The coaches claimed that the stress training may not work on Esports players because they believe are more introverted. As a result, the participants’ personalities were measured by using the 16-personality test, which shows introversion and extroversion percentages (two variables) and where adding both scores result in a value of 1. The aim was to use one variable only. The variable personality was determined by taking the value of the introversion minus the extroversion. The personality value will have a range between +0.5 and -0.5; if the value is higher than 0, a person is more introverted, and vice versa.

5.5.4 Control Variables:

1- Champion: Some champions are easier to perform with when creep-scoring than others. All participants played using the same champion (character), named “Karthus” during this experiment. What determines an easy or a hard champion in this task is the speed of their attack (known as attack windup), and the amount of damage the attack delivers (known as attack damage [AD for short]). The champion Karthus is on the lower end of both of those aspects (LOLWiki, 2020).

2- Lane: Some lanes are longer than others, which affects the time creeps reach a lane. The creeps spawn from the Nexus, the main base, and then move through a lane until they clash with the opposing team's creeps. The crash location is usually in the center of a lane. The time it takes for a creep to reach the center of the lane varies from lane to lane (Mobalytics, 2018). We choose the Mid lane to remove any differences caused by lane choices, and also because the Mid lane is shorter, leading to the creeps arriving faster, which gives the participant less time to score.

The experimental design allowed us to learn whether the players in the experiment group would develop tolerance to the stressors, or burn out and quit (as the coaches hypothesized). The control group (training without stress) allowed us to verify and quantify the coaches' theory that training a player's mechanical skills would increase their confidence and help them tolerate the on-stage stressors. As well, observing the experiment group determined whether the participants would improve or burn out under social stress training. Finally, both groups were statistically compared and analyzed to determine which was the better method as well as the gap between methods. The gap between methods was studied in order to enable coaches to make informed decisions, given the risks and benefits, about whether they should train the players under stress or not.

5.6 Hypotheses

There are two hypotheses, ours and the coaches':

a- Coaches' Hypothesis:

The coaches' hypothesis posited that training an Esports player's mechanical skills would lead to improvements in their confidence, which in turn would lead to improved performance under stress. If players in the control group show improvement on Day 5 compared to their performance on Day 1, we can conclude that improving Esports players' mechanical skills does indeed improve their performance under stress.

Additionally, under the coaches' hypothesis, players will experience burnout if they train under stress, leading to a decline in their performance. Therefore, if the experiment group's performance deteriorated over time, it can be concluded that training Esports players under stress will lead to burnout.

b- My Hypothesis:

Under my hypothesis, training a player's skill under stress will significantly improve the player's performance under stress. If the performance of the experiment group shows an improvement on Day 5 compared to Day 1, it can be concluded that training under stress improves performance under stress. If so, then the coaches' hypothesis (that Esports players training under stress will experience burnout) will be rejected.

5.7 Recruitment

Participants were recruited using “team-finding” websites. Players use these websites to look for a partner to play together with. One can see a player's rank and match history, chat with them, and add them as friends on these websites. We used a Google form link to invite participants to the experiment. The Google form explained the relevant details of this study, and asked for the participants’ main information, such as their ranks, ages, years of experience playing the game, and contact information.

5.8 Results and Analysis

The information obtained from the experiment was collected and analyzed using SPSS (IBM Corp, 2019) to answer the three remaining research questions:

RQ6- Does improving a player's mechanical skills help them perform under stress?

RQ7- Does training players under stress improve their performance under stress or burn them out?

RQ8- What is the performance gap between the two approaches?

The demographics of the participants were analyzed first in order to ensure consistency between the control and experiment groups, followed by a paired-sample t-test to determine whether the differences in performance and stress between Day 1 and Day 5 were statistically significant. Finally, a repeated measures ANOVA test was conducted to identify factors that had a main or interaction effect on changes in the performance and stress during this experiment.

5.8.1 Demographics

72 samples were collected (70 males, 2 females), with age information *(M=19.91, SD=2.18, range 18-28 years)*, of whom 34 participants (33 males, 1 female) were assigned to the control group (which trained without stress), and the other 38 (37 males, 1 female) were assigned to the experiment group (which trained under stress).

The average ranking of the participants was between Silver-1 and Gold-4, with each tier, Silver and Gold, having 4 levels, 1, 2, 3, and 4, with 4 being the lowest ranking and 1 being the highest. Silver and Gold are the ranks where the majority (65%) of LOL global players are placed (Sabrina, 2022). Our sample covered the player ranks from silver-4 (lowest silver rank) up to gold-1 (highest gold rank). The breakdown of the players' ranks in our sample is further elaborated upon in Figure 5.9.

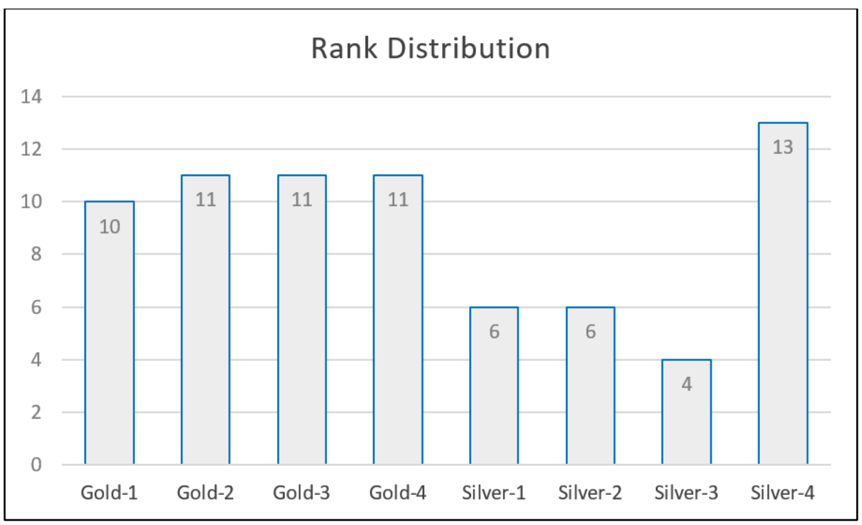

Figure 5.9: Rank distribution of Participants

Esports players believe that a player's mechanical skills deteriorate as they age, and one paper explored this hypothesis and found that players' performance levels started to decline after the age of 24 (Thompson et al., 2014). Using age as a covariate may provide a hint or show a correlation between the age of players and their performance. The age distribution can be seen in Figure 5.10, having the x-axis representing age and the y-axis representing number of participants. The participants had a mean age of 20.54 *(SD: 2.62, range 18 to 28 years old).*

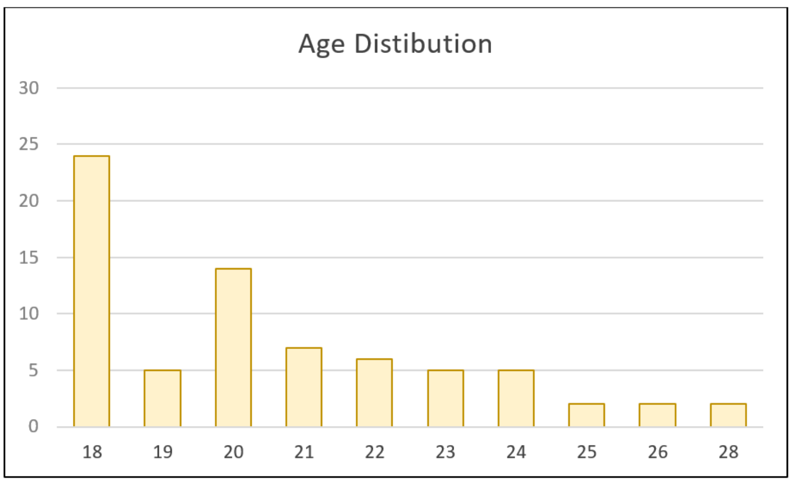

Figure 5.10: participants age distribution (x-axis represent the age)

The number of years of experience of each participant was collected, with the mean being 3.58 years *(SD=2.08, range 1-10 years).* Figure 5.11 shows the frequency distribution of the participant's years of experience playing LOL. The x-axis represents the number of years while the y-axis represents number of participants.

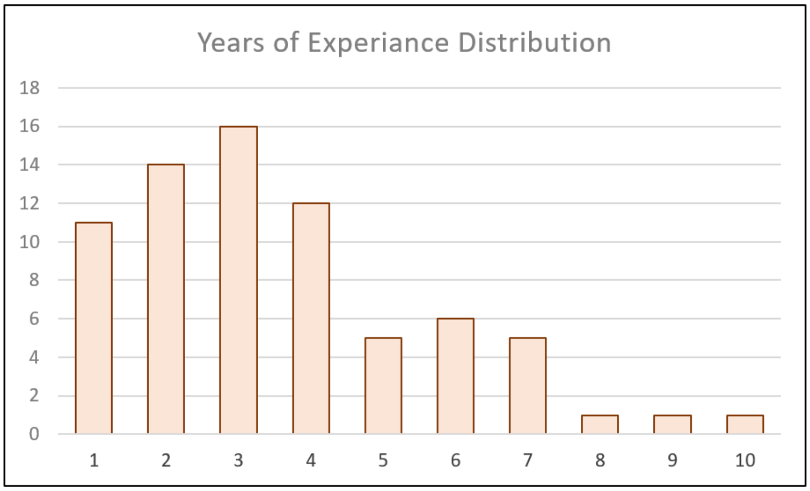

Figure 5.11: Participants experience playing LOL
(x-axis represent the number of years)

The 16-personality test score shows the introvert-extrovert scores on a scale. For example, a person with a 0.55 introvert score will have a 0.45 extrovert score (summing both scores will result in a value of 1). Therefore, the higher the introvert score, the more introverted a person is, and the less extroverted they are (a score of 0.50 is nuetral). The personality test showed that 57% of our participants are introverted and 43% are extroverted.

A meta-analysis of 58 studies by Allen et al (Allen et al., 2021), found that 39 of the studies showed that athletes were more extroverted than non-athletes (16 showed no difference, and 3 showed that athletes were more introverted). The studies showing that athletes were more introverted had very small sample sizes and were sports that they identified as "low-risk", which is generally considered a sport that is not in a team setting, and has low stakes and few fans watching (such as marathons, weightlifting, golf, bowling). Overall, there is convincing evidence that people who participate in sports are, on average, more extroverted than those who do not participate in sports, and studies have shown that extraverts make up 70% of athletes and 60% of the normal population (Allen et al., 2021; Reiter et al., 2007).

The participants personality data in the current experiment suggest that Esports players are more introverted than athletes in traditional sports and the normal population. This may explain the coach's claims that their players are senstive to social stressors.

5.8.2 Baseline of performance and stress on the pre-test (Day 1)

The differences in performance between the control group *(N= 34, M= 56.52, SD= 5.04)* and the experiment group (*N= 38, M= 57.85, SD= 4.38)* was not significant, (*t (70) = -1.20, p = 0.23)*. Also, the differences in the change in perceived stress (after the experiment compared to before the experiment) between the control group *(N= 34, M= 3.54, SD= 0.38)* and the experiment group *(N=38, M=3.49, SD= 0.41)* was not significant, (*t (70) = 0.55, p = 0.58).* As a result, both groups had similar baselines scores in the pre-test, as seen in Figure 5.12.

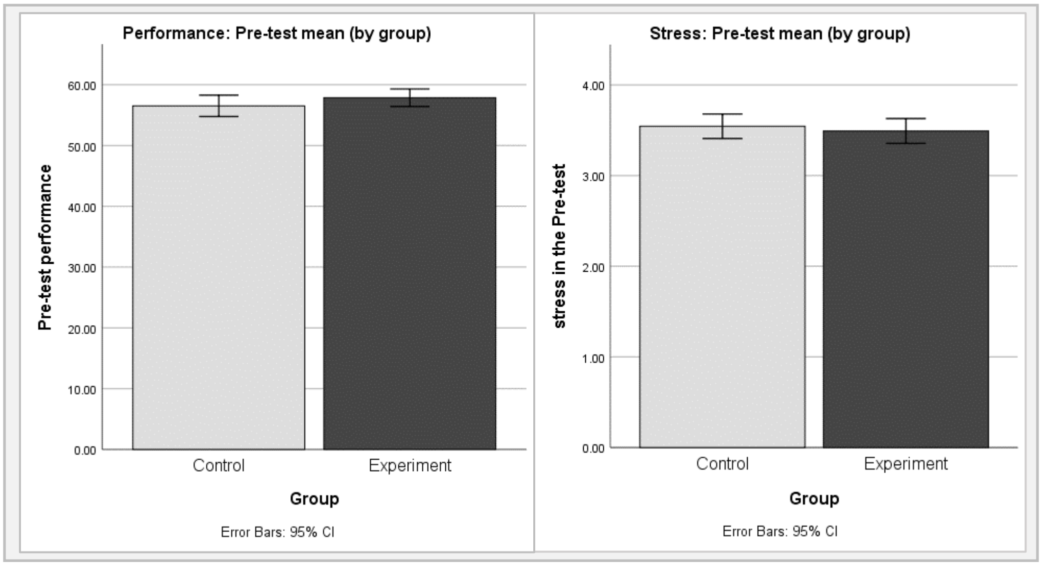

Figure 5.12: Performance and stress (stress after the experiment minus before the experiment) scores on the pre-test (Day 1)

(The differences between groups are not statistically significant)

(Error bars represent 95% confidence interval)

5.8.3 Paired T-Test

A paired sample t-test was conducted to determine if the differences between the means of pre-test and post-test were significant, first for the performance score, then the perceived stress score.

Performance: The control group's performance slightly improved on the post-test (Days 5) *(M=58.65, SD= 4.57)* compared to their pre-test *(M= 56.52, SD= 5.04)*, this improvement, 2.13, was statistically significant, ($t\ (33) = 2.06, p = 0.047$). On the other hand, the experiment group's performance had a large improvement on the post-test *(M= 71.01, SD= 4.26)* compared to their pre-test *(M= 57.85, SD= 4.38)*, this improvement, 13.15, was statistically significant, ($t\ (37) = 19.56, p < 0.000$).

Stress: The control group experienced less stress on post-test *(M= 2.79, SD=0.73)* compared to that on the pre-test *(M= 3.54, SD= 0.38)*; difference was significant, (*t (33) = -5.76, p < 0.000)*. The experiment group also experienced less stress on the post-test *(M= 2.35, SD= 0.75)* compared to the pre-test *(M= 3.49, SD= 0.41)*, which was a significant improvement, (*t (37) = -7.80, p < 0.000*).

Although both groups demonstrated better performance after the training, the experiment group (trained under stress) improved over five times more than the control group (trained without stress), as seen in Figure 5.13. On the other hand, both groups had a significantly lower perceived stress on the post-test than in the pre-test, shown in Figure 5.14.

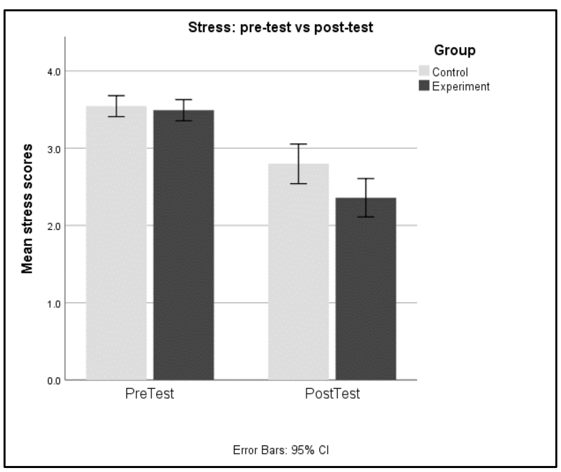

Figure 5.14: comparing the stress scores between the pre and post test for both groups

(Error bars represent 95% confidence interval)

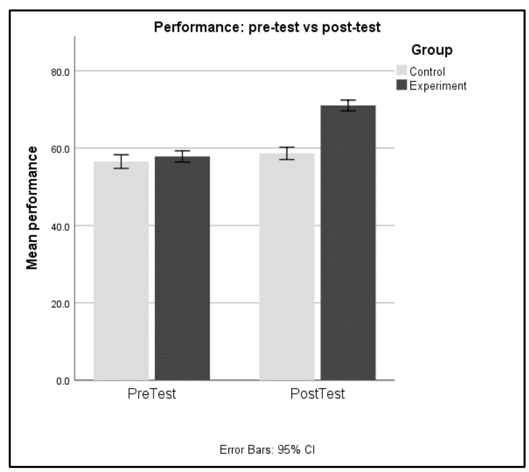

Figure 5.13: comparing the performance scores between the pre and post test for both groups

(Error bars represent 95% confidence interval)

5.8.4 Performance: test-days repeated measures ANOVA results and analysis:

The performance before and after both training methods can be seen in Figure 5.15, in which the experiment group's performance is noticeably larger than the control group's. Therefore, a repeated measures ANOVA was conducted to find the factors that had a significant main or interaction effect on the differences in performance during test-days.

The test days repeated measures ANOVA showed that the group factor (training with or without stress) had a significant main effect on the change in performance, ($F (1,66) = 61.63, P < 0.000, \eta_p^2 = 0.483$), and a significant interaction effect with days (test-days*group), ($F (1,66) = 74.33, p < 0.000, \eta_p^2 = 0.530$). The rank of players also had a significant main effect on the performance, ($F (1,66) = 18.17, P < 0.000, \eta_p^2 = 0.216$), but no significant interaction effect with days (test-days*rank), ($F (1,66) = 1.955, p = 0.167, \eta_p^2 = 0.029$). The significant factors that had a main or interaction effect on the performance can be seen in Table 5.1. The remaining factors, age, experience, and personality, had no significant main or interaction effect ($p > 0.05$). The details of the non-significant factors can be seen in Table 5.2.

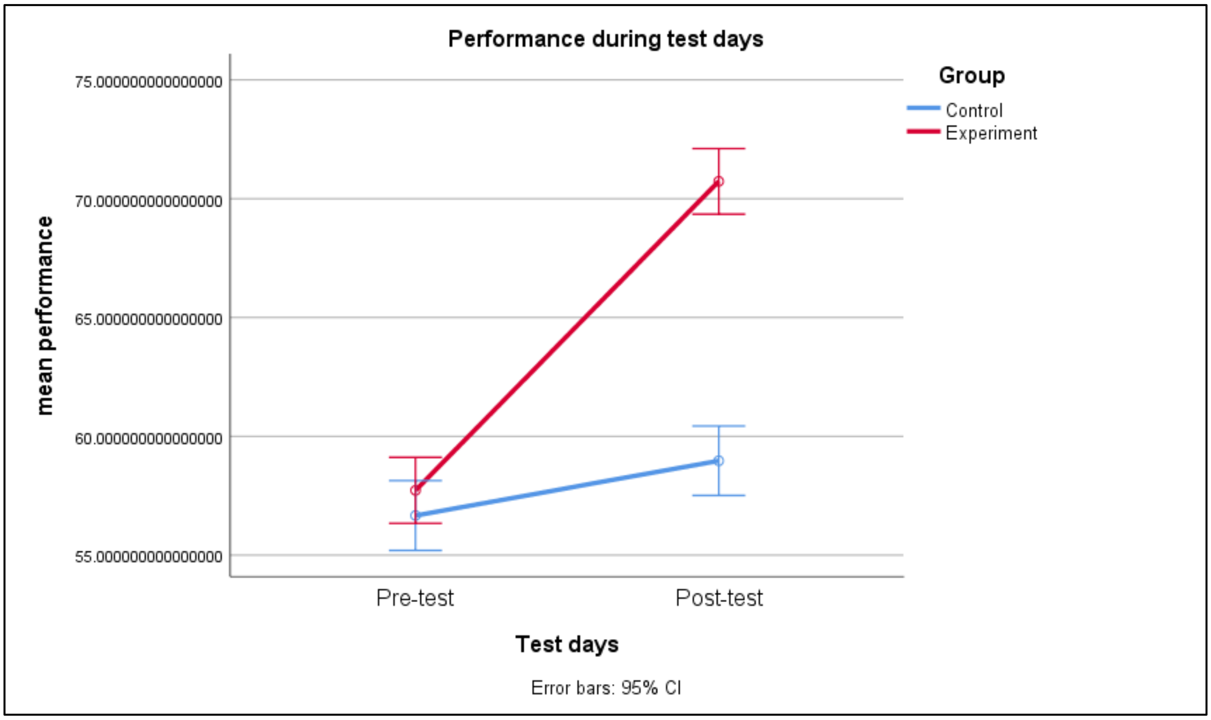

Figure 5.15: Performance during test days

(Error bars represent 95% confidence interval)

Main/Interaction Effect	*df*	*F*	*p*	η_p^2
Group	(1, 66)	61.63	<0.000	0.483
Rank	(1, 66)	18.178	<0.000	0.216
Test-Days × Group	(1, 66)	74.32	<0.000	0.530

Table 5.1: Significant main/interaction effect factors

Main/Interaction Effect	*df*	*F*	*p*	η_p^2
Test-Days	(1, 66)	0.243	0.624	0.004
Age	(1, 66)	0.171	0.681	0.003
Experience	(1, 66)	0.433	0.513	0.007
Personality	(1, 66)	2.232	0.14	0.033
Test-Days × Age	(1, 66)	2.448	0.122	0.036
Test-Days × Rank	(1, 66)	1.955	0.167	0.029
Test-Days × Experience	(1, 66)	0.125	0.725	0.002
Test-Days × Personality	(1, 66)	0.645	0.425	0.010

Table 5.2: non-significant main/interaction effect factors

5.8.5 Performance: training-days repeated measures ANOVA results and analysis:

Both groups showed a consistent improvement during the three training days. The control group's performance on Day 2 was *(M= 60.00, SD= 4.02)*, Day 3 *(M= 63.90, SD=4.72)*, and Day 4 *(M= 67.99, SD= 6.45)*. In contrast, the experiment group's performance on Day 2 *(M= 54.85, SD= 4.72)*, Day 3 *(M= 59.93, SD= 5.20)*, and Day 4 *(M=65.78, SD= 6.61)*. Overall, the control group had higher performance means during training days than the experiment group, as seen in Figure 5.16. A repeated measures ANOVA was used to determine if the differences in performance between groups were solely due to the group factor (training with and without stress), and if any other factors influenced the differences in performance during training days.

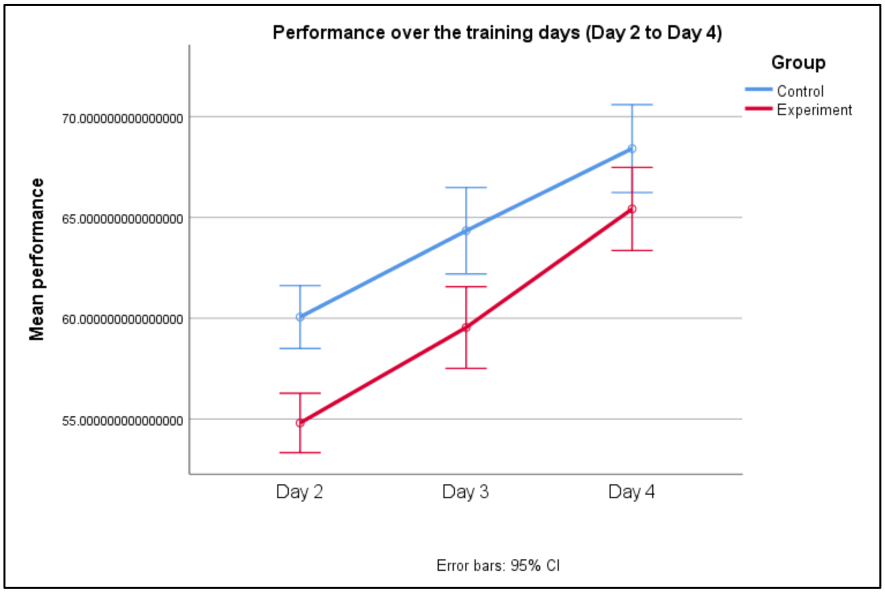

Figure 5.16: Performance during training days (day 2 to day 4)

Mauchly's test indicated that the sphericity assumption was violated, ($\chi^2(2) = 34.83, p < 0.000$). As a result, Greenhouse-Geisser corrected results were reported ($\varepsilon = 0.707$). The group factor had the highest significant main effect on performance, ($F\ (1, 66) = 14.43, p < 0.000, \eta_p^2 = 0.179$), followed by rank, ($F\ (1, 66) = 5.11, p = 0.027, \eta_p^2 = 0.072$), and lastly age, ($F\ (1, 66) = 4.42, p = 0.039, \eta_p^2 = 0.063$). Additionally, there was a significant interaction between rank and training-days (training-days*rank), ($F\ (1.14, 93.30) = 3.53, p = 0.049, \eta_p^2 = 0.051$), the significant main and interaction effects on performance can be seen in Table 5.3, and the remaining non-significant main or interaction effects on the performance during training days are listed in Table 5.4.

Main/Interaction Effect	*df*	*F*	*p*	η_p^2
Group	*(1, 66)*	*14.43*	*<0.000*	*0.179*
Rank	*(1, 66)*	*5.11*	*0.027*	*0.072*
Age	*(1, 66)*	*4.42*	*0.039*	*0.063*
Training-Days × Rank	*(1.14, 93.30)*	*3.53*	*0.049*	*0.051*

Table 5.3: training-days significant main/interaction effects on performance

Main/Interaction Effect	*df*	*F*	*p*	η_p^2
Experience	*(1, 66)*	*2.41*	*0.125*	*0.035*
Personality	*(1, 66)*	*0.15*	*0.704*	*0.002*
Training-Days	*(1.14, 93.30)*	*1.06*	*0.331*	*0.02*
Training-Days × Age	*(1.14, 93.30)*	*1.36*	*0.256*	*0.02*
Training-Days × Experience	*(1.14, 93.30)*	*0.20*	*0.741*	*0.00*
Training-Days × Personality	*(1.14, 93.30)*	*0.04*	*0.915*	*0.001*
Training-Days × Group	*(1.14, 93.30)*	*1.54*	*0.222*	*0.023*

Table 5.4: list of non-significant main/interaction effects on the performance during training days

The performance of the five days experiment can be seen in Figure 5.17 and Table 5.5. This analysis indicates that both training methods had a statistically significant positive impact on performance under stress. Yet, training under stress was five times more effective than training without stress. The $\eta_p{}^2$ suggests that the group factor a large main effect and interaction effect with test-days on the changes in performance. Nevertheless, notice in Figure 5.17 that the experiment group under-performed on Day 2 compared to their performance on Day 1, indicating that the coaches' concerns regarding burnout might be correct. Still, the experiment group recovered from Day 3 onwards.

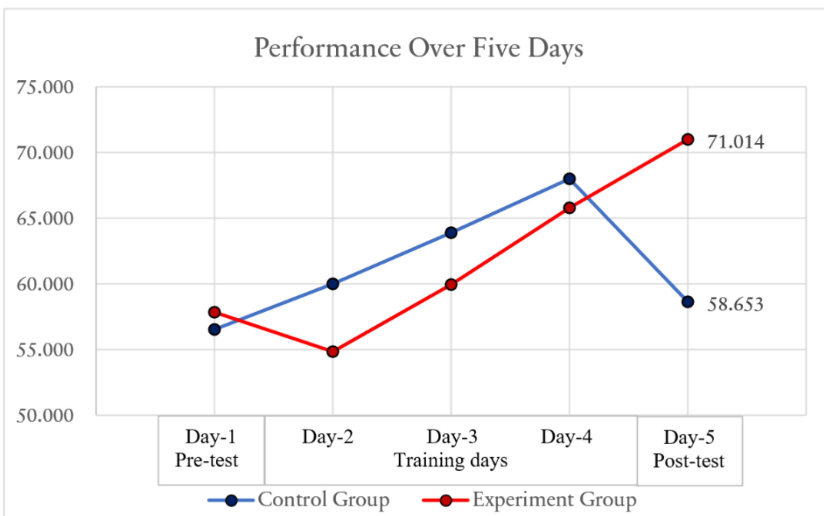

Figure 5.17: Participants performance overtime

	Day 1	Day 2	Day 3	Day 4	Day 5
Control Group	56.52%	60.00%	63.90%	67.99%	58.65%
Experiment Group	57.85%	54.85%	59.93%	65.78%	71.01%

Table 5.5: Participants performance values overtime

(The value represents the percentage of creeps scored)

5.8.6 Stress: test-days repeated measures ANOVA results and analysis

The paired t-test, in section 5.8.3, showed that the participants had less perceived stress in the post-test than in the pre-test, as shown in Figure 5.18. In this section, a repeated measures ANOVA was used to determine which factor had a main or interacting effect on the changes in perceived stress during test days. The results showed that all the factors had no significant main and interaction effects on the changes in the perceived stress changes during the test days. The details of the analysis can be seen in Table 5.6.

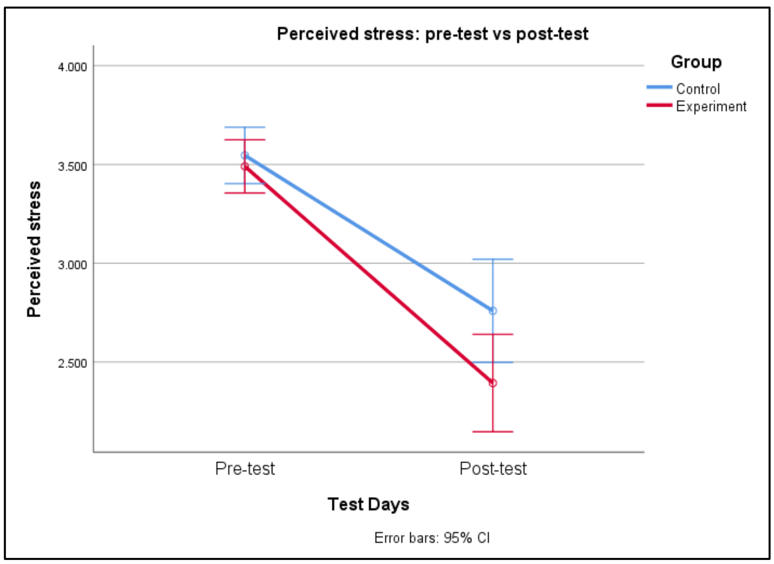

Figure 5.18: perceived stress during test days

(Error bars represent 95% confidence interval)

Main/Interaction Effect	*df*	*F*	*p*	η_p^2
Age	(1, 66)	*0.071*	*0.791*	*0.001*
Experience	(1, 66)	*0.621*	*0.433*	*0.009*
Rank	(1, 66)	*0.407*	*0.526*	*0.006*
Personality	(1, 66)	*0.479*	*0.491*	*0.007*
Group	(1, 66)	*3.915*	*0.052*	*0.056*
Test-Days(stress)	(1, 66)	*0.031*	*0.861*	*0.000*
Test-Days(stress) × Age	(1, 66)	*1.079*	*0.303*	*0.016*
Test-Days(stress) × Experience	(1, 66)	*0.104*	*0.748*	*0.002*
Test-Days(stress) × Rank	(1, 66)	*0.699*	*0.406*	*0.010*
Test-Days(stress) × Personality	(1, 66)	*1.498*	*0.225*	*0.022*
Test-Days(stress) × Group	(1, 66)	*2.312*	*0.133*	*0.034*

Table 5.6: list of non-significant main/interaction effects on the changes in perceived stress during test-days

5.8.7 Stress: Training-days repeated measures ANOVA results and analysis

The perceived stress decreased consistently during the training days. The control group's perceived stress on Day 2 *(M=3.08, SD=0.87)*, Day 3 *(M=2.65, SD=0.80)*, and Day 4 *(M=2.11, SD=0.56)*. In contrast, the experiment group's perceived stress on Day 2 *(M=3.46,* *SD=1.02)*, Day 3 *(M=2.68, SD=0.77)*, and Day 4*(M=2.04, SD=0.57)*. The changes in perceived stress during training days can be seen in Figure 5.19.

Mauchly's test indicated that the sphericity assumption was violated, ($\chi^2(2) = 14.83, p = 0.001$). As a result, Huynh-Feldt corrected results were reported (ε =0.831). The results showed that rank had a significant main effect on the changes in stress levels during the training days, $(F\ (1, 66) = 4.80, p = 0.032, \eta_p^2 = 0.068)$, while group and training-days (TrainingDays*Group) had a statistically significant interaction effect on the changes in the perceived stress levels, $(F\ (1.83, 120.63) = 4.279, p = 0.019, \eta_p^2 = 0.061)$.

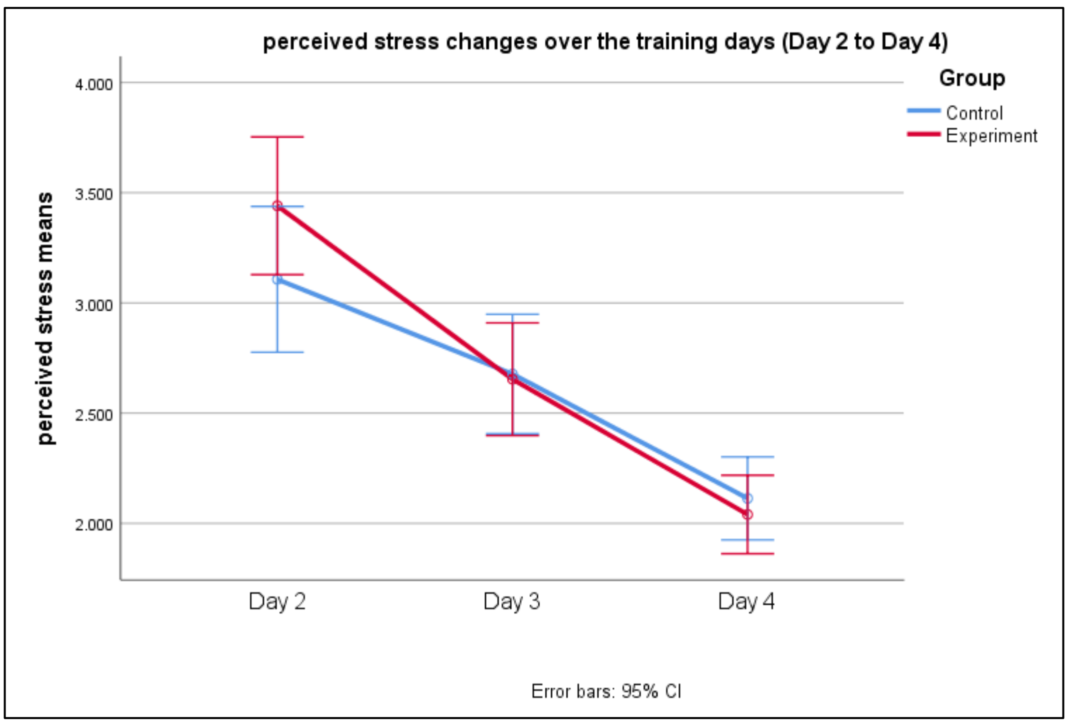

Figure 5.19: perceived stress changes during the training days

(Error bars represent 95% confidence interval)

Main/Interaction Effect	*df*	*F*	*p*	η_p^2
Rank	*(1, 66)*	*4.800*	*0.032*	*0.068*
TrainingDays × Group	*(1.83, 120.63)*	*4.279*	*0.019*	*0.061*

Table 5.7: significant main/interaction effects on the changes in perceived stress during the training days

The significant factor's main/interaction effects are listed in Table 5.7. The remaining factors had no significant main/interaction effects on the changes in perceived stress, and are listed in Table 5.8. The perceived stress over the five days experiments can be seen in Figure 5.19.

Main/Interaction Effect	*df*	*F*	*p*	η_p^2
Age	(1, 66)	*0.000*	*0.999*	*0.000*
Experience	(1, 66)	*0.172*	*0.680*	*0.003*
Personality	(1, 66)	*1.428*	*0.236*	*0.021*
Group	(1, 66)	*0.223*	*0.639*	*0.003*
TrainingDays	*(1.83, 120.63)*	*2.062*	*0.136*	*0.030*
TrainingDays × Age	*(1.83, 120.63)*	*0.416*	*0.642*	*0.006*
TrainingDays × Experience	*(1.83, 120.63)*	*1.070*	*0.341*	*0.016*
TrainingDays × Rank	*(1.83, 120.63)*	*0.575*	*0.549*	*0.009*
TrainingDays × Personality	*(1.83, 120.63)*	*0.123*	*0.867*	*0.002*

Table 5.8: list of non-significant main/interaction effects on the changes in perceived stress during training days

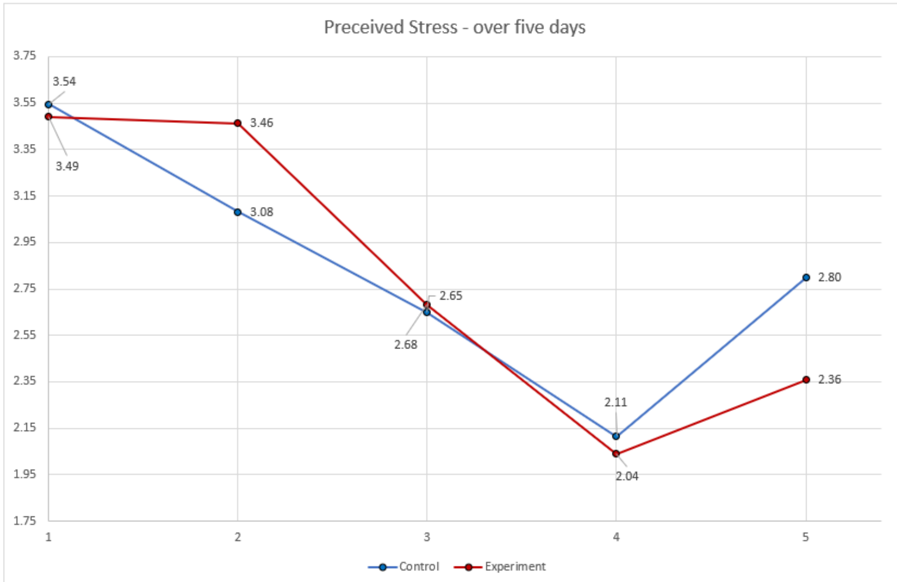

Figure 5.20: stress during the five day experiment

5.8.8 The relation between stress and performance:

This section examined the experiment data to determine if there is a relation between the participant's perceived stress change and their performance. Hence, a linear regression and correlation analysis was performed on the data for each group and each day separately (a total of ten tests, which includes the five days data for each group) to test if a relation exists, specifically, if the differences in performance might be affected by the participants perceived stress, which may, for example, explain why the experiment group had lower performance on Day2 compared to day 1, and also it may explain why the control group had lower performance on Day5 compared to Day4.

Only two out of the ten tests were found to be statistically significant: Day 3(only the control group) and Day 4 (only the control group). Day 3 (control group) regression analysis indicated that the two predictors (performance, and perceived stress change) may explain 19% of the variance ($R^2 = 0.19$, $F(1,32) = 7.49$, $p = 0.01$) and are significantly correlated ($r(34) = 0.43$, $p = 0.005$). Additionally, Day 4 (control group) regression analysis indicated that the two predictors may explain 14.5% of the variance ($R^2 = 0.145$, $F(1,32) = 5.42$, $p = 0.026$) and are significantly correlated ($r(34) = 0.38$, $p = 0.013$). The linear regression plot for Day3-control-group and Day4-contorl-group are shown in Figure 5.21 and Figure 5.22, respectively.

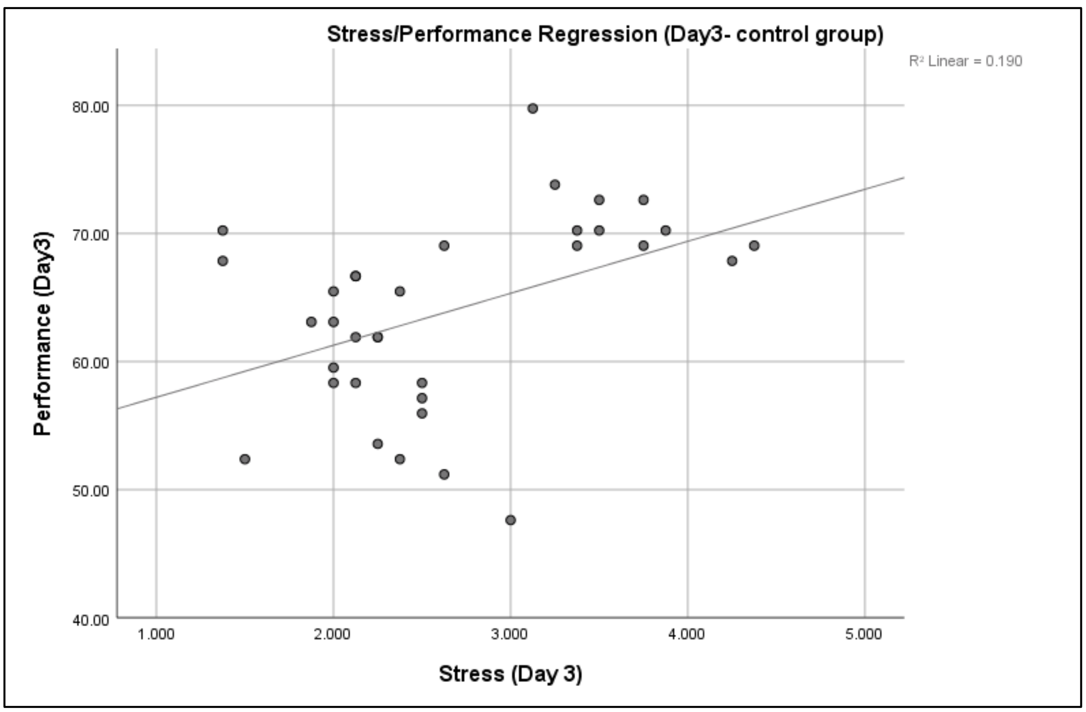

Figure 5.21: Day3-control-group regression

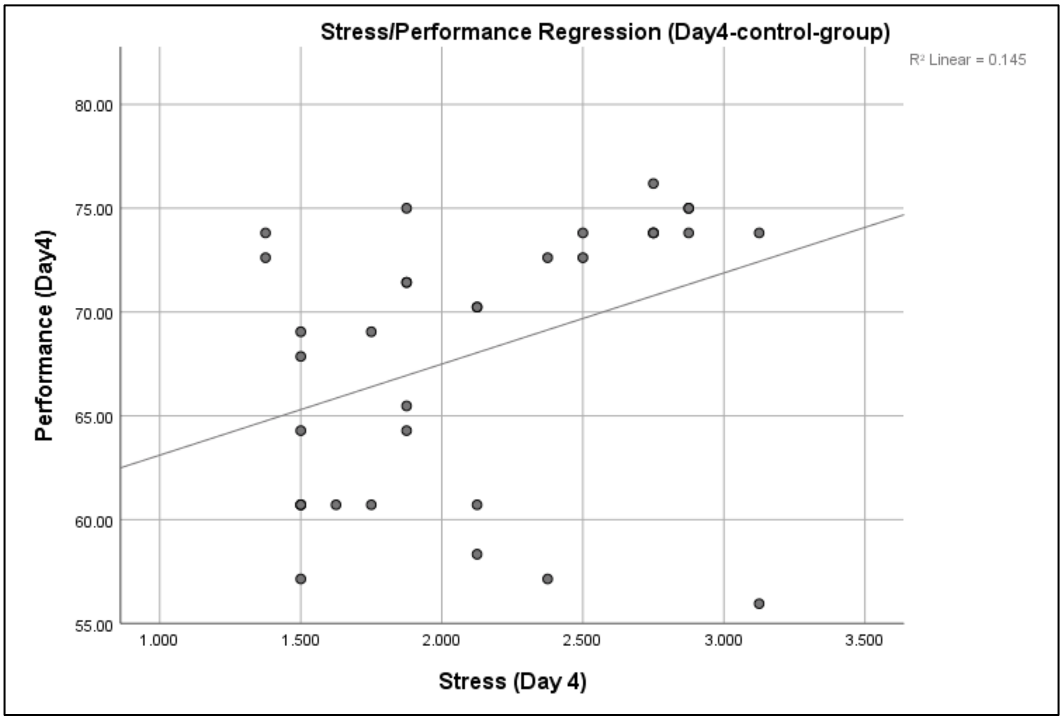

Figure 5.22: Day4-control-group regression

Although both Day3 and Day4 showed a significant relation between the performance and the perceived stress change, the R2 values are considered low. Moreover, eight out of the ten tests were not statistically significant ($p > 0.05$), indicating that the perceived stress changes may not influence the patterns and differences in performance over the five days experiment. This might be due to individual differences of stress tolerance. Since this study is not designed to examine such a relation within each individual, future studies might be needed to manipulate stress levels for the same participant on the same task complexity to detect if such a relation exists.

Finally, this finding is consistent with the results of training under stress in other domains. Training under stress may not necessarily reduce the perceived stress significantly but rather familiarize a person with the conditions (social and physical stressors) present in the environment.

5.9 Discussions and conclusions

The analysis results demonstrate that the participant's performance under stress improved in both groups and that the difference in performance between the two groups over time may be attributed primarily to the group in which the participant was assigned. The group factor had a significant large main effect, ($F\ (1,66) = 61.63,\ P < 0.000,\ \eta_p^2 = 0.483$), and a large interaction effect with days, ($F\ (1,66) = 74.33,\ p < 0.000,\ \eta p2 = 0.530$), on the improvement in performance. In other words, training under stress over time yields better results, and in this case, over five times better than training without stress over time. Moreover, the rank of players had a significant large main effect, ($F\ (1,66) = 18.17,\ P < 0.000,\ \eta p2 = 0.216$), on the performance improvements. The control group did improve under pressure by training their mechanical skills without stress, which is not similar to the findings in the literature. The literature on training under stress consistently demonstrated that training without stress in traditional sports and police subjects would not significantly improve performance under stress.

The rank of players had a significant main effect on the changes in stress, ($F\ (1, 66) = 4.80,\ p = 0.032,\ \eta_p^2 = 0.068$), and the group had an interacting effect with training days on the changes in stress during test days (*TrainingDays*group), (F (1.83, 120.63) = 4.279, p = 0.019,* $\eta_p^2 = 0.061$). The experiment group, remarkably, had less stress, *(M=2.04, SD=0.57),* on the last training day (Day 4) compared to the control group *(M=2.11, SD=0.56)*; These data points were analyzed and the results showed that the differences in stress between groups on Day 4 was not statistically different. Yet, it is interesting that both groups had the same perceived stress on Day 4 even though they were under different conditions. Training under stress did not change the perceived stress as dramatically as the performance between groups on Day 5, which is similar to the results in the literature.

The existing, but limited, literature suggests that Esports players a relatively more sensitive to social stress than traditional sports athletes, a statement that the coaches agree with based on their observation and limited experimentations. However, these claims are backed by limited studies and observations. The findings in our experiment may add some clarity to assessing the accuracy of their findings. The literature consistently found an association between introverts and sensitivity to social stress. Yet, the existing literature does not confirm that Esports players are generally more introverted, which, if true, would add more credibility to their statements.

Most of our sample are introverts (57% introvert, 43% extrovert) relative to traditional sports athletes (40% introvert, 60% extrovert), and based on the literature, and it is safe to assume that introverts (Esports players) are more sensitive to social stressors. However, our findings showed that such sensitivity was not significant enough to influence the effectiveness of training under stress.

The control group, just like the coaches hypothesized, improved under stress by training their mechanical skills only, which answered RQ6 (does improving a player's mechanical skills help them perform under stress?). The players’ skills consistently improved over the course of training; however, they were only able to retain 82% of their improvement from Day 4 on Day 5 (their performance dropped on average from 67.99% on Day 4 to 58.65% on Day 5, while under stress). In contrast, while the experiment group did show signs of burnout, as the coaches expected, over time, they demonstrated consistent improvement afterwards up to Day 5. These findings answer RQ7 and RQ8, allowing the coaches to quantify the risks and benefits and make data-driven decisions while selecting a training method. This study also provides the building blocks to design an intervention based on the current physical and social stressors that are influencing a player’s performance.

5.10 Limitations

In this chapter, stress was measured by using a self-reporting method, and it may be valuable for a future study to use physiological measures such as heart rate variability (HRV) or galvanic skin response (GSR) to eliminate any human-factor errors caused the participants mis-evaluating their perceived stress.

The introvert/extrovert data may represent the majority of the LOL population; however, our findings do not confirm whether or not professional Esports players are more or less introverted. The coaches are still convinced that professional players are generally extremely introverted, but our findings do not confirm or debunk whether players that become professionals and make it to the top (top 0.013% or 99.987 percentile) are extremely introverted.

Chapter 6- Contributions and Discussion:

This study investigated the repetitive choking phenomena in Esports by exploring the existing literature to find suitable solutions and implement them. Esports research is in its infant stages, making it hard to understand its current challenges and solve them with solutions from other domains such as traditional sports. Training under stress is a choking intervention that improves a person's performance by familiarizing them with an environment, specifically the physical and social stressors; this is achieved by training a performer under conditions similar to the stage conditions.

The literature on choking explains how training under stress improves performance under stress, which enabled this research to understand the elements required to tailor an appropriate solution for Esports players. First, an in-game task (an activity that, if improved, would influence a game's result) and its performance measure were required to detect the changes throughout the training. Then, the physical and social stressors affecting Esports players must be identified, along with the existing coaching and training methods, to know what is missing. However, the existing research on Esports does not provide enough information to design such an intervention for Esports. To this end, three studies were conducted to bridge these gaps and finding a solution to the constant occurrence of choking. Study 1, focused on finding performance indicators to assess the performance of a player before and after an intervention. Study 1 found that CSPM (creep scores per minute) is a consistent indicator in both the game public data and the official tournament data base. This finding was used later in Study 3 to assess the effectiveness of training methods.

Study 1 also suggested two new performance indicators that have the potential to predict games: spending efficiency and champion damage utilization. Spending efficiency was found to be a statistically significant factor between winning and losing teams. However, further investigation is required to verify its accuracy in predicting future games. The champion damage utilization (DU) was only tested on two samples (1vs1 & 5vs5 fights) because it can only be calculated manually. The 1vs1 (two players) fight took over 4 hours, while the 5vs5 fight (10 players) took a few days to calculate. The processing time to calculate the DU exponentially increases based on the number of players involved. The DU requires to be automated to confirm its viability.

The literature on Esports coaching and training method is nonexistent, prompting Study 2, in which we interviewed LOL Esports coaches to understand the details behind the scenes. Study 2 took the initial steps to establish a baseline of knowledge for coaching in Esports; specifically, the social and physical stressors causing a choke, the role of a coach in Esports, the current practices of coaching in Esports, and the challenges they face.

Study 2 showed that players train 12 hours a day on average, making it difficult for the coaches to keep the players motivated. Also, players face many mental stresses, with social stress seeming to be the most dominant. The most common health concerns are wrist and back injuries. Some coaches expressed a growing concern that some players across all Esports are using performance enhancing drugs such as Adderall and Ritalin.

The findings from Study 2 address some of the literature gaps and provide details that enable the reader to understand the current state of teams, coaching, players, and LOL Esports.

There are many opportunities to make Esports coaching a little easier. A large part of their job is done manually and consumes a significant amount of time such as reviewing match games, which will take hours to review from all the players' perspectives (10 players in an official 5vs5 match). Additionally, there does not seem to be a common practice because each coach is fixing a different problem based on the team's specific needs. There is a common agreement that coaching staff are essential to the success of a professional team. In particular, there is a need to hire more coaching staff to support the needs of the teams such as sport psychology.

This study found some significant differences between Esports coaching and traditional sports coaching. First, game rules are constantly changing in Esports. In LOL, new champions (the player-controlled characters) are regularly added to introduce new ways of playing, and character strength is also frequently adjusted to balance the game. As a result, the coaching staff must quickly understand the updated game mechanisms and identify the best strategies (known as "the meta"), and players need to practice for extremely long hours to adapt to the meta and maintain a competitive edge. This demanding workload has caused many players to burn out and have to retire at a relatively young age (e.g., 25 years old).

In traditional sports, players are often coached, trained, and selected from an early age; however, Esports players usually play on their own without any coaches until they join a professional team; This makes it hard for a coach to gain the trust and acceptance of Esports players. Additionally, it appears that Esports coaches and researchers need to focus on mental skills such as mental capacity, working memory, attention, workload, and mental stress. While in traditional sports, more time is dedicated to physical capacity and skills.

Some coaches tried to mimic the stage environment in their practice room because they observed that their players feel the slightest change in the environment, which affects their performance. However, they only focused on the physical stressorssuch as the temperature, the chair and monitor location, and the brightness of the room light. Though, they shielded the players from the stressors. This finding helped to determine the missing elements in their choking prevention that caused it to fail, and encouraged us to conduct an experiment in which Esports players are trained under conditions that includes both social and physical stressors. The stressors we identified range from external factors (i.e., crowds, environment, noises, team management, teammates, and coaching) and internal factors (i.e., worries related to performance, confidence, and fear of being evaluated).

Study 3 successfully illustrated that Esports players might benefit from training under stress. Moreover, the study quantitively identified the effectiveness of training with and without stress. Our result showed that player's performance might be harmed initially. The risk of burning out a player when training under stress exists in the first two days, but our results suggest that they can recover and continue to improve from Day three onwards. The experiment group performed over five times better under stress than the control group that trained without stress.

The experiment findings are in line with existing literature regarding the benefits of training under stress. Nevertheless, the group trained without stress did show improvements when performing under stress, which conflicts with the existing literature. The literature suggests that training mechanical skills alone will not significantly impact performance under stress.

Our findings offer choices to the coaches showing the risks and benefits of each choice. If the coaches want to fix a problem and minimize the risks quickly, they can train them without stress, which may slightly improve their performance under stress. However, if they decide to train the players under stress, they risk a chance of burnout but gain an opportunity to significantly improve their performance. Training with stress seems to take a relatively long time due to the initial drop-down in performance. Thus, a coach who will adopt this method should choose this option if they have enough time to accommodate the initial drop in performance. These results were shared with some coaches (three out of the six coaches we interviewed and an additional two new ones). They had not expected training under stress to have such an impact, so the challenge was to tailor a solution for professional players. The creep scoring task under stress is not enough to challenge a professional player, but this research enables a user to understand how this model functions. If a coach wants to train players under stress, we suggest they mimic the social and physical stressors that are affecting their players performance. Final and semifinal matches usually host tens of thousands of fans, and players have expressed that the ground shakes when the crowd gets excited, and they can hear them cheer or "boo". Since the players can feel the fans' excitement, they can also hear them when their characters die because the enemy team's fans are cheering. This can be identified as a social stressor that might significantly negatively impact a player's mental state and performance during a match. Professional Esports players should train “scrim” under such stressors by artificially creating noise, ground-shaking, and cheer/boos when a player kills an enemy character or their character dies.

If we assume that a better training method might be relatively slower, then a team using such a strategy may initially see the performance illustrated in Figure 6.1 below, which shows the initial pattern of the performance over time (similar to the first part of the performance displayed in Study 3, Figure 5.17). Such a graph indicates that strategy 1 (green curve) is better than strategy 2 (blue curve).

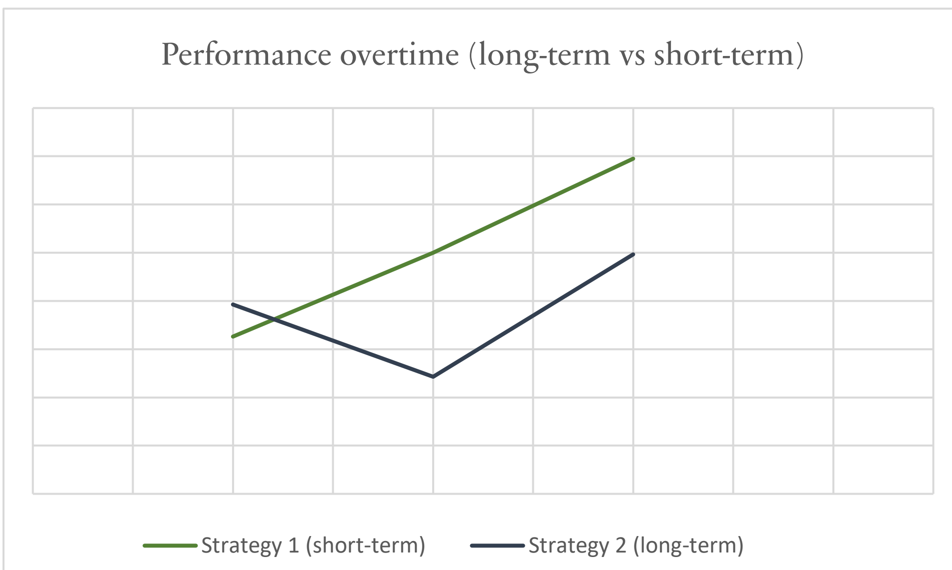

Figure 6.1: illustrating and compering the initial performance of the long-term and the short-term strategies

There have been many cases where teams opted into a "long-term strategy" or a "development roster" but quickly changed their strategy due to their initial results. For example, a team in 2022 decided to field and improve younger talent; however, two weeks into the spring season of 2022 (a season is 3 months long), the team decided to make changes to the roster even though they had expressed before the season that they were expecting a slow start and were aiming to peak in the summer season (which was about 6 months in the future) (Rand, 2022). Here, a team and its fans seem to be affected by watching other teams win in the short-term and quickly assume that a competitor's strategy is better than theirs, and as a result, fans on social media start to harass the teams and players that adopted the longer-term strategy, which results in teams making changes. One coach in Study 2 said: "*Fan feedback on social media platforms can influence a team's decisions and shape the opinion of players and coaches. As a result, there have been cases where teams removed or recruited players due to community (fan) pressure."*. Another coach in Study 2 expressed that they wanted to experiment with fewer practice hours, but they are worried that if this strategy fails, the fan pressure will be enough to remove the coach or a player. Usually, adopting a new strategy has a slow start, and short-term results are less likely. There is enough evidence showing that the challenges in Esports might not be solved by only proposing effective training methods because the decision-makers seem to be influenced by fan pressure. Therefore, this research suggests that stress training can be used initially to recruit new players by testing their skills under the same conditions (stressors) present in the final tournament stage; this approach may reduce the pressure on the decision-makers and also enables a team to assess their performance and distinguish between new players accurately.

Since teams are worried to use long-term strategies and endure fan pressure, it might be slightly more manageable for a team to adopt long-term strategies, such as stress training, with their academy team, a lower league in which the salaries and stakes are not as high, making it a less financially risky option. Moreover, Esports player’s retirement age is significantly lower than in traditional sports; this may influence their decisions, making them prefer short-term strategies. Perhaps, Esports individuals are more emersed in social media to an extinct that feedback from fans reaches them quicker than other domains. Moreover, Esports players practice on the public server daily, in which they join games with amateur players, making them more vulnerable to online verbal abuse and harassment than traditional sports players.

We hope our work could introduce more researchers to this domain with unique challenges and needs for academic research to support Esports coaches, players, and team managers. While some current findings may apply to other Esports games beyond LOL, future studies are needed to gather data from other games and identify common themes and implications.

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Appendices

Appendix A: Study 2: Coaches interview

Appendix A.1 Hierarchical structure of themes and keywords from thematic analysis.

1- Esports coach general information:

1.1 The role of a coach

1.1.1 Identify the players' potential and create winning conditions for the team.

Keywords: game knowledge, understand player strengths

1.1.2 Develop synergy and trust within the team.

Keywords: synergy, trust, rapport, empathy

1.1.3 Develop the micro and macro play of the team.

Keywords: game knowledge, balancing strengths and weaknesses

1.1.4 Setting goals to continuously improve the players.

Keywords: player weaknesses, player strengths

1.1.5 Motivating the players to improve and maintain peak performance.

Keywords: motivation, understand players motivations

1.2 Coaching positions

Keywords: coach, general manager

1.3 Skill requirements

1.3.1 Leadership

Keywords: leadership, coaching theory

1.3.2 Communication

Keywords: coach synergy, communication

1.3.3 Ability to set goals

Keywords: setting goals

1.3.4 Game knowledge

Keywords: game knowledge

1.4 Evaluation and Selection

1.4.1 Evaluation of Coaches

Keywords: team results, player feedback, qualitative

1.4.2 Evaluation of Players

Keywords: mechanical abilities, statistics, watching players, evaluation of goals, teammate feedback

1.4.3 Selection of Coaches

Keywords: game knowledge, setting goals, leadership, coach synergy, team needs

1.4.4 Selection of Players

Keywords: sense of team, mechanics, communication, game knowledge, player history, work ethic, talent, passion

2- Challenges an Esports coach faces:

2.1 Demanding practice routines

Keywords: long hours, rest days, team practice, individual practice, training

2.2 Stress

2.2.1 Translating scrim performance to stage performance

Keywords: performance, scrim to stage

2.2.2 Stage nerves

Keywords: different environment

2.2.3 Social media

Keywords: public image, social media

2.2.4 Disappointing the organization and fans

Keywords: internal pressure, external pressure, fans

2.2.5 Being evaluated

Keywords: losing one's job

2.3 Players' attitude

Keywords: player personalities, team building

2.4 Stress Management

Keywords: dealing with stress, sports psychologist, replicating stage conditions

2.5 Players' health issues

2.5.1 Physical health

Keywords: health, physiotherapy, nutrition

2.5.2 Mental health

Keywords: stress, burnout, motivation

3 Need for future research

3.1 Identify players’ fatigue levels.

Keywords: fatigue, burnout, sleep

3.2 Identify the conditions for peak performance.

Keywords: good performance

3.3 Identify best practice for coaching in Esports and how to achieve this.

Keywords: no coaching standards

3.4 Identify a key performance indicator for coaches and players.

Keywords: how to evaluate coaches, developing performance indicators

3.5 Experiment with shorter practice duration.

Keywords: practice length, burnout, fatigue, taking longer breaks

3.6 Automate some of the coaches’ tasks, such as game review.

Keywords: game review

3.7 Explore the impact of supplements on Esports players’ wrist and back injuries.

Keywords: supplements

3.8 Identify talent development in Esports for players, but especially for coaches.

Keywords: talent development

3.9 Investigate substance abuse.

Keywords: drugs

Appendix A.2: Study 2- Initial Contact Script

Dear [insert participant name], my name is Bader Sabtan and I am a PhD student working under the supervisions of Dr. Shi Cao in Systems Design Engineering Department at the University of Waterloo, Canada. I am contacting you because we are conducting a research study to generate a base of reference for researchers interested in studying professional MOBA game players. We are looking for League of Legends Experts to share their general knowledge of the game. Currently, there are not enough academic sources to provide information for researchers. Participants will be asked questions such as:

- The average practice time in Esports
- The challenges facing the teams
- How is performance evaluated for teams, players, and coaches?
- Why do players choke on stage and what are the stressors affecting them

Participants can choose to answer or not answer any question and will be given a choice to stay anonymous or provide their name as contributors to the research and future publication. We estimate that the interview will take around one hour, and the participants have the choice to stop the interview at any time. If they choose to withdraw, all records will be destroyed. Only audio (no video) will be recorded. The only purpose of the audio recording is for transcribing the interview into texts. The audio file (voice and speech) will only be reviewed by the research team and will not be used in any publication. With your permission, quotes from the transcript may be used in our research. You will have the choice of whether these quotes are anonymous (you will not be directly identified by name, and instead will only have your position noted, e.g. MOBA team coach or attributed to you. You will also have the opportunity to review selected quotes prior to there publication. Raw audio will not be used in any publications. Only the research team members, including me, and my Advisor, Dr. Cao, will have access to these recordings.

Attached is the “information letter” document, in which you will find the details of the interview.

I would like to assure you that the study has been reviewed and received ethics clearance through the University of Waterloo Research Ethics Committee. However, the final decision about participation is yours.

If you are interested, please contact me via my Email: bsabtan@uwaterloo.ca.

Sincerely,

Bader Sabtan

Appendix A.3: Study 2 – Information Letter

Project Title:	**Multiplayer online battle arena (MOBA) game expert opinion**
Student Investigator:	**Bader Sabtan, Department of Systems Design Engineering, bsabtan@uwaterloo.ca**
Faculty Advisor:	**Shi Cao, Department of Systems Design Engineering, shi.cao@uwaterloo.ca, 519-888-4567 x36377**

Overview

Esports is a booming industry. But little research has been done in this field about professional game players' performance and training. Currently, the academic field does not have a reliable source of reference for Esports coaching, training, and strategy. For example, if a researcher wants to improve the coaching style of Esport teams, they do not have a scientific source to know the methods currently used in coaching. There are not enough papers that provide insights about the professional players in Esports. The findings from the current study will provide the research community a better understanding of the practice and problems faced by coaches and players in Esports, MOBA games in particular.

Study Details

Your participation in this study is completely voluntary and you may decline to answer any questions you may wish. If you would like to stop the study or withdraw your participation at any time, you may do so by advising the researcher without any penalty.

Participation in this study involves a video interview in which you will answer general questions related to the Esports player’s environment which may take around one hour. You can request your data be removed from the study up until 30 days after the interview.

Interview questions:

The major points that will be discussed in the interview are as follows:

Performance assessment.

In this part we are interested to know “How” players, coaches, and teams performance is being assessed. We understand that some details are what gives your team and edge. We are looking for a general answer that informs us about the best practice in the scene.

1- How does an Esports team assess a player’s, team’s, and coaches’ performance?
2- How does a team find new talents?
3- Can a team evaluate a player without his tournament match history?

Choking and stressors affecting players

Why do players choke on stage. What are the factors and stressors influencing their performance on stage. Are you using any choking interventions such as (training under stress, pre-performance routines, deep breathing)

General Knowledge.

In this part, we want to verify some of the information that was obtained from blogs such as:

1- What is the role of a coach, general manager, analyst, and psychologists in the esports teams?
2- Why do “all-star” teams not work? And how did a team like “G2” make it work?
3- Is it hard to keep veteran players motivated?
4- What kind of problems do teams face? Personal? Practice? Health? And which ones affect their performance the most.
5- Some players have huge “Ego”, like “Dardoch” and “Piglet”. How does a team deal with such hard personalities?

Training.

1- How long do players practice?
2- What is the practice routine?

3- How do teams “scrim” each other? Do they agree on specific picks? Can they just practice early or late game? how much cooperation is there between teams when it comes to “scrims”

Factors influencing performance

1- How important is team synergy in comparison to the individual performance of a player?
2- What kind of problems do teams face? Personal? Practice? Health? And which ones affect their performance the most.
3- North America (NA) region spends the most among all other region and recruits the best players in the world, but the region is still lagging behind when it comes to performance on an international tournament. Why?
4- NA teams have a lot of imported players. Does the language barrier cause any performance issues between the players?

Extra details

In this part, the participant will be asked to add any information that might be relevant to our study.

End of the interview

Risks and Benefits

There are no anticipated risks in this study. There is no direct benefit to the participants. However, the results obtained from this study will contribute to the understanding of Esports player performance, which may help improve Esports training and practice in the future.

Data storage, security and retention

Your name will never be associated with your individual data unless you consent to allow the researchers to use your name with your quotes in publication. Data collected during this study will be retained for a minimum of 7 years in a locked office in a restricted area of the university. The data will be stored on a password protected computer to which only researchers associated with the study have access. Data will be de-identified (i.e. data such as names and identifying information removed) prior to submission to the repository/database and will be presented in aggregate form in online publications. This process is integral to the research process as it allows other researchers to verify results and avoid duplicating research.

Interview Location

Online interview using any communication software that is convenient.

Eligibility Requirements for Participation

All participants must be at least 18 years old, and have coached a team in NA or EU

Confidentiality

All information that you provide is considered completely confidential; your name will not be associated in any way with the data collected in this study, unless you consent to allow the researchers to use your name with your quotes in publication.

Ethics Review and Clearance

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE#41339). If you have questions for the Committee contact the Office of Research Ethics, at 1-519-888-4567 ext. 36005 or ore-ceo@uwaterloo.ca

Questions regarding participation in the study

If you have any questions regarding this study, or would like additional information to assist you in reaching a decision about participation, please contact Bader Sabtan at +1 226-898-4496 or by email at bsabtan@uwaterloo.ca

Appendix A.4: Study 2 – Consent Form

CONSENT OF PARTICIPANT

Project Title:	**Multiplayer online battle arena Experts Opinion**
Student Investigator:	**Bader Sabtan, Department of Systems Design Engineering, bsabtan@uwaterloo.ca**
Faculty Advisor:	**Shi Cao, Department of Systems Design Engineering, shi.cao@uwaterloo.ca, 519-888-4567 ext. 36377**

With full knowledge of all foregoing, I agree, of my own free will, to participate in this study being conducted by Bader Sabtan, a PhD student in the University of Waterloo's Department of Systems Design Engineering, who is working under the supervision of Professor Shi Cao of the Department of Systems Design Engineering. I have made this decision based on the information I have received in the email and after being verbally informed by one of this study's researchers about the contents, requirements, and benefits of this experiment. I have had the opportunity to ask any questions related to this study, to receive satisfactory answers to my questions, and any additional details I wanted.

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE#41339). If you have questions for the Committee, contact the Office of Research Ethics, at 1-519-888-4567 ext. 36005 or ore-ceo@uwaterloo.ca

	Please Circle One	
I agree to the use of anonymous quotations in any publication that comes from this research.	YES	NO
I agree to the use of direct quotations attributed to me only with my review and approval.	YES	NO

____

Participant Name

____

Dated at Waterloo, Ontario

____

Witness Name

____

Signature of Witness

Appendix A.5: Study 2 - Feedback Letter

FEEDBACK LETTER

Project Title:	**Multiplayer online battle arena Experts Opinion**
Student Investigator:	**Bader Sabtan, Department of Systems Design Engineering, Bsabtan@uwaterloo.ca**
Faculty Advisor:	**Shi Cao, Department of Systems Design Engineering, Shi.cao@uwaterloo.ca, 519-888-4567 x36377**

We appreciate your participation in our study and thank you for spending the time helping us with our research!

All information you provided is considered completely confidential. This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE#41339). If you have questions for the Committee, contact the Office of Research Ethics, at 1-519-888-4567 ext. 36005 or ore-ceo@uwaterloo.ca

Please remember that any data pertaining to you as an individual participant will be kept confidential, unless you give permission for use your name in conjunction with a quote. Once all the data are collected and analyzed for this project, I plan on sharing this information with the research community through a journal article, which will be shared with you after it has been accepted for publication.

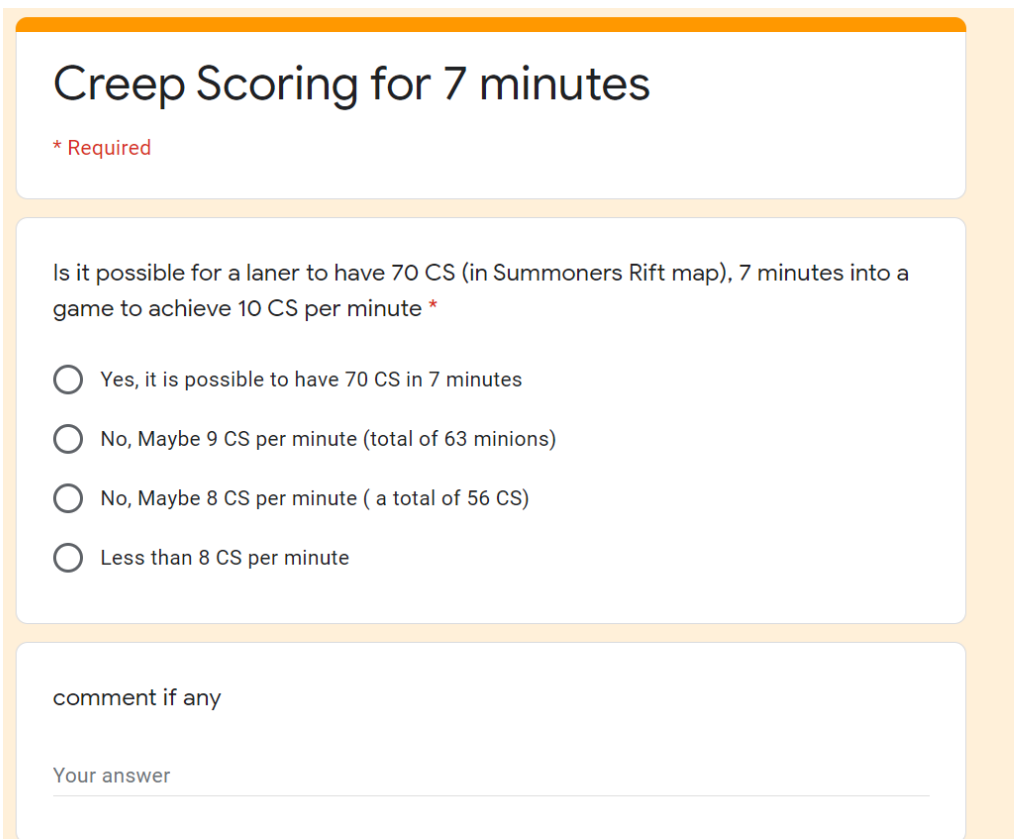
If you think of any other questions regarding this study, please do not hesitate to contact Bader Sabtan

We really appreciate your participation and hope that this has been an interesting experience for you.

Appendix B - Chapter 5 – Study 3 - Scripts

Appendix B.1: Study 3 – Participants Perfect Score Awareness

We used this form (B.1 Figure 1) to determine how many participants are aware of the perfect CS score that can be obtained during a 7-minute game. This information allows us to identify if players will generally feel they are behind when we announce that their score is less than the "perfect 10 CS per minute".



Creep Scoring for 7 minutes

* Required

Is it possible for a laner to have 70 CS (in Summoners Rift map), 7 minutes into a game to achieve 10 CS per minute *

- Yes, it is possible to have 70 CS in 7 minutes
- No, Maybe 9 CS per minute (total of 63 minions)
- No, Maybe 8 CS per minute (a total of 56 CS)
- Less than 8 CS per minute

comment if any

Your answer

B.1 Figure 1: Expected CSPM at 7 minutes

Appendix B.2: Study 3 - Contact Script

Dear [Insert name] my name is Bader Sabtan and I am a PhD student working under the supervision of Dr. Shi Cao in Systems Design Engineering Department at the University of Waterloo, Canada. The reason that I am contacting you is that we are conducting a research experiment to assess the impact of stress on the performance of League of Legends players

Participants will be randomly assigned to a group (control group or experiment group).

Participants in both groups will play a custom game for 7 minutes, two times a day, for 5 consecutive days. During the game, players will pick a specific champion of our choice and will creep score (CS, attack minions). During this 7-minute experiment, players will hear a positive sound when a correct action is made and a negative sound if a wrong action is executed. The purpose of these sounds is to induce the feeling of being evaluated. The control group will hear these sounds only on Day 1 and Day 5, while the experiment group will hear these sound during all experiment days (5 days). After 7 minutes, the score will be recorded.

The participant will be asked to rate a few questions from 1 (not at all) to 5 (strongly agree), to measure their stress levels, engagement levels, and the task's perceived complexity before and after the experiment using a google form.

Participants will remain anonymous in our research and future publication. If you choose to withdraw, all records will be destroyed. Only a screenshot of the in-game score will be recorded. No audio or video will be recorded during the experiment. The player's information and scores will only be reviewed by the research team. The combined scores of all participants will be analyzed and published in our research.

Participants will receive a thank you letter on the 5th day and will be given a compensation of $30. The participant will choose either Paypal or in-game currency equal to $30.

Attached to this email is the "information letter" document, in which you will find the details of the experiment.

I would like to assure you that the study has been reviewed and received ethics clearance through the University of Waterloo Research Ethics Committee (ORE#42767). However, the final decision about participation is yours.

If you are interested, please fill up the google form:

[Insert google form link]

Or contact me via my Email: bsabtan@uwaterloo.ca.

Sincerely,

Bader Sabtan

Appendix B.3: Study 3 – Information letter

INFORMATION LETTER

Project Title: Assessing the impact of social stress on League of Legends game player's performance
Student Investigator: Bader Sabtan, Department of Systems Design Engineering, bsabtan@uwaterloo.ca
Faculty Advisor: Shi Cao, Department of Systems Design Engineering, shi.cao@uwaterloo.ca, 519-888-4567 x36377

Overview

Currently, Esports Professional teams distance their players from public opinion and social media due to their negative impact. As a result, they don't develop tolerance to such a stressor, thereby leading them to perform on big stages in front of crowds. The coaches believe that by improving a player's skill, that player will become more confident and tolerate stress. However, we want to examine if training a player's skills under stress will improve their tolerance by a significant factor. This information is valuable for a professional team because it enables them to assess if such training is worth the risk. Coaches believe that continuous exposure to stress will lead to the players burning out quickly. If we can show that repetitive exposure can improve performance under stress, and by how much, the coaches will be able to do a calculated risk.

Study Details and Procedure

Your participation in this study is entirely voluntary, and you may decline to answer any questions you may wish. If you would like to stop the study or withdraw your participation at any time, you may do so by advising the researcher without any penalty.

The participants will play a game of league of Legends for 7 minutes in which they will perform a task in-game referred to as CS or creep score. The participant will stream the game window only (they will not use their camera) using discord, a communication software like skype. Their stream will only be visible to the researcher. During these 7 minutes, players will hear a positive beep sound when a correct action is made and a negative beep sound if a wrong action is executed. The purpose of these sounds is to induce the feeling of being evaluated (stress). The control group will hear these sounds only on Day 1 and Day 5, while the experiment group will hear these sounds during all experiment days (5 days). We have a total of two groups only (control and experiment group).

The participant will get into a discord call with the researcher and will launch the League of Legends game client. The participant will stream their game window only using the discord built-in stream option. The participant will then create a custom game in which they will play for 7 minutes and only creep score using auto attacks and not use any abilities or purchase any items. After the time has passed, the creep score will be recorded.

The participant will be asked to answer a few questions before and after each experiment from 1 (Not at all) to 5 (Strongly agree) using a google form, some examples are listed below:

- I am worried about other people evaluating me

- I felt concerned about the impression I was making during this task

- I thought about how others have done on this task

- I thought about how I would feel if I were told how I performed

- I wanted to succeed on the task

- I felt confident in my abilities

- I was motivated to do the task

The participants will also rate the task perceived difficulty from 1 (very easy) to 5 (very hard) using the same google form.

The total expected time per day is around 14 minutes and a total of approximately 70 minutes over 5 days.

Risks and Benefits

There are no anticipated risks in this study. The participants will receive a feedback letter and compensation of $30 US dollars. The results obtained from this study will contribute to the understanding of Esports player performance, which may help improve Esports training and practice in the future.

Data storage, security and retention

Your name will never be associated with your individual data. Data collected during this study will be retained for a minimum of 7 years in a locked office in a restricted area of the university. The data will be stored on a password-protected computer to which only researchers associated with the study have access. Data will be de-identified (i.e. data such as names and identifying information removed) prior to submission to the repository/database and will be presented in aggregate form in online publications. This process is integral to the research process as it allows other researchers to verify results and avoid duplicating research.

Interview Location

Online interview using any communication software that is convenient.

Eligibility Requirements for Participation

All participants must be at least 18 years old and ranked gold or silver in League of Legends public server.

Confidentiality

All information that you provide is considered completely confidential; your name will not be associated in any way with the data collected in this study.

Ethics Review and Clearance

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE#42767).). If you have questions for the Committee, contact the Office of Research Ethics, at 1-519-888-4567 ext. 36005 or ore- ceo@uwaterloo.ca

Questions regarding participation in the study

If you have any questions regarding this study, or would like additional information to assist you in reaching a decision about participation, please contact Bader Sabtan at +1 226-898-4496 or by email at bsabtan@uwaterloo.ca

Appendix B.4: Study 3 – Consent Form

CONSENT OF PARTICIPANT

Project Title:	**Assessing the impact of stress on League of Legends player's performance**
Student Investigator:	**Bader Sabtan, Department of Systems Design Engineering, bsabtan@uwaterloo.ca**
Faculty Advisor:	**Shi Cao, Department of Systems Design Engineering, shi.cao@uwaterloo.ca, 519-888-4567 ext. 36377**

With full knowledge of all foregoing, I agree, of my own free will, to participate in this study being conducted by Bader Sabtan, a PhD student in the University of Waterloo's Department of Systems Design Engineering, who is working under the supervision of Professor Shi Cao of the Department of Systems Design Engineering. I have made this decision based on the information I have received in the email and after being verbally informed by one of this study's researchers about the contents, requirements, and benefits of this experiment. I am aware that there are two groups (control group and experiment group) and that I will be randomly assigned to one of these groups. I am also aware that this experiment involves acute stress in the form of sound beeps that evaluate my performance in the task. I have had the opportunity to ask any questions related to this study, to receive satisfactory answers to my questions, and any additional details I wanted.

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE# 42767).). If you have questions for the Committee, contact the Office of Research Ethics, at 1-519-888-4567 ext. 36005 or ore- ceo@uwaterloo.ca

Please Circle One

I Agree to participate in this study YES NO

____

Participant Name

____

Dated at Waterloo, Ontario

____

Witness Name

____

Signature of Witness

Appendix B.5: Study 3 – Compensation Form

University of Waterloo
Research Participant s Acknowledgement of
Receipt of Remuneration
and
Self-Declared Income

Section A: To be completed by Principal Investigator or designate

Principal/Faculty Investigator's Name: Shi Cao

Researcher Investigator: Bader Sabtan

Department: Systems Design Engineering

Study Title: Assessing the impact of social stress on League of Legends game player's performance

---

Section B: To be completed by research participant

In appreciation of my involvement as a research participant in the above study,

I acknowledge that I have received $ ___________ from the University of Waterloo.

I further acknowledge that:

- this amount received from the University of Waterloo is taxable
- that it is my responsibility to report the amount received for income tax purposes
- and the University of Waterloo will not issue a tax receipt for the amount received.

Participant's Name: ______________________________________

Participant's Signature: ______________________________________

Date: ______________________________________

Witness' Name: ______________________________________

Witness' Signature: ______________________________________

Date: ______________________________________

Appendix B.6: Study 3 – Feedback letter

FEEDBACK LETTER

Project Title:	**Assessing the impact of stress on League of Legends player's performance**
Student Investigator:	**Bader Sabtan, Department of Systems Design Engineering, Bsabtan@uwaterloo.ca**
Faculty Advisor:	**Shi Cao, Department of Systems Design Engineering, Shi.cao@uwaterloo.ca, 519-888-4567 x36377**

Dear [insert name], we appreciate your participation in our study and thank you for spending the time helping us with our research!

All information you provided is considered completely confidential. This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE#42767). If you have questions for the Committee contact the Office of Research Ethics, at 1-519-888-4567 ext. 36005 or ore-ceo@uwaterloo.ca

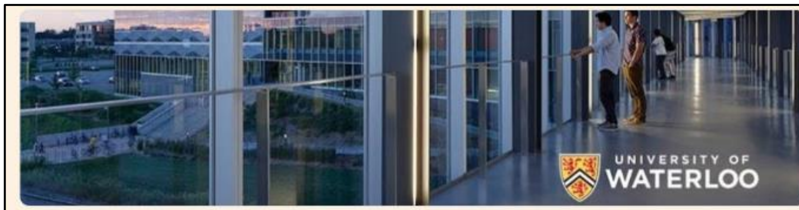
Please remember that any data pertaining to you as an individual participant will be kept confidential. Once all the data are collected and analyzed for this project, I plan on sharing this information with the research community through a journal article.

If you think of any other questions regarding this study, please do not hesitate to contact Bader Sabtan

We really appreciate your participation and hope that this has been an interesting experience for you.

Appendix B.7: Study 3 – Registration

Participants registered to the experiment by filling up a google form as seen in



Impact of Stress on Performance

Hi, am Bader Sabtan, a Ph.D. student working under the supervision of Dr. Shi Cao in the Systems Design Engineering Department at the University of Waterloo, Canada at the University of Waterloo is studying the impact of stress on the performance of League of Legends players.
Participants will play a custom game for 7 min a day, 5 consecutive days. During the game, players will creep score (CS, attack minions). After 7 min, the score will be recorded and the participant will be asked to answer a few questions such as their current stress level and the perceived complexity of the task
Participants will remain anonymous in our research and future publication. If you choose to withdraw, all records will be destroyed. Only a screenshot of the in-game score will be recorded. No audio or video will be recorded during the experiment. The player's information and scores will only be reviewed by the research team. The combined scores of all participants will be analyzed and published in our research.

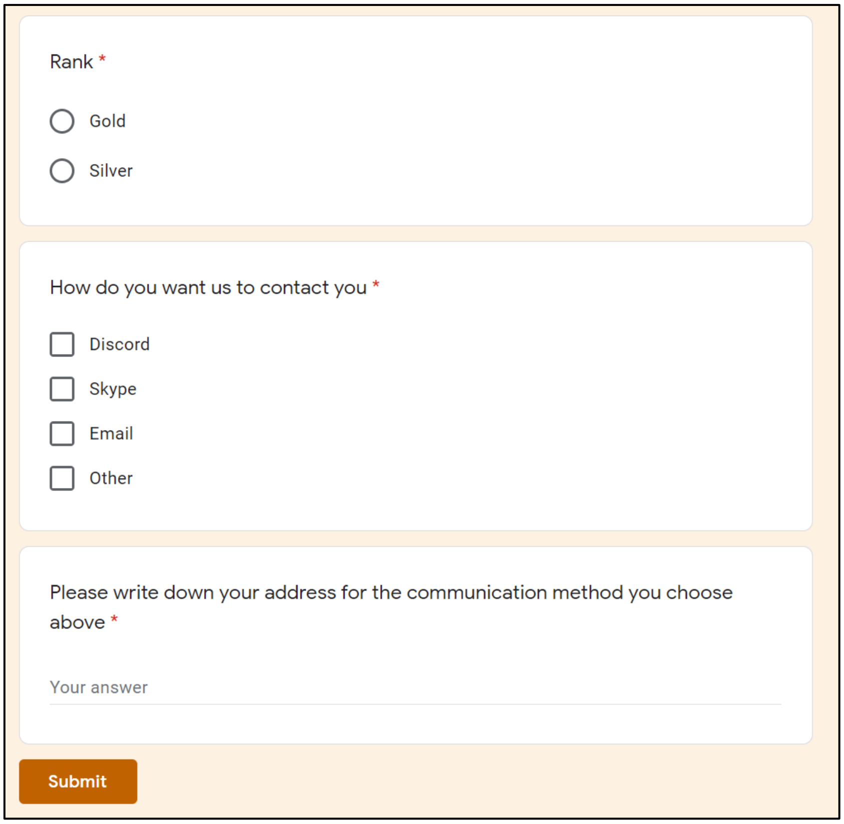
Participants will receive a thank you letter on the 5th day and will be given a compensation of $30. The participant will choose either Paypal or in-game currency equal to $30.

* Required

Please write your nickname or in-game name *

Your answer

B.7 Figure 1: A Google form to collect the participant's information (1 of 2)



Rank *

- Gold
- Silver

How do you want us to contact you *

- Discord
- Skype
- Email
- Other

Please write down your address for the communication method you choose above *

Your answer

Submit

B.7 Figure 2: Google form to collect the participant's information (2 of 2)

Appendix C: Chapter 5 – Study 3 – SPSS tables

Training Under Stress Experiment

Appendix C.1: Study 3 – Sample Demographics

Below are the demographic outputs from SPSS software.

Age

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	18	24	33.3	33.3	33.3
	19	5	6.9	6.9	40.3
	20	14	19.4	19.4	59.7
	21	7	9.7	9.7	69.4
	22	6	8.3	8.3	77.8
	23	5	6.9	6.9	84.7
	24	5	6.9	6.9	91.7
	25	2	2.8	2.8	94.4
	26	2	2.8	2.8	97.2
	28	2	2.8	2.8	100.0
	Total	72	100.0	100.0	

C.1- Table 1: Age frequency distribution

Experiance

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	11	15.3	15.3	15.3
	2	14	19.4	19.4	34.7
	3	16	22.2	22.2	56.9
	4	12	16.7	16.7	73.6
	5	5	6.9	6.9	80.6
	6	6	8.3	8.3	88.9
	7	5	6.9	6.9	95.8
	8	1	1.4	1.4	97.2
	9	1	1.4	1.4	98.6
	10	1	1.4	1.4	100.0
	Total	72	100.0	100.0	

C.1- Table 2: Experience frequency distribution

Rank

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Gold-1	10	13.9	13.9	13.9
	Gold-2	11	15.3	15.3	29.2
	Gold-3	11	15.3	15.3	44.4
	Gold-4	11	15.3	15.3	59.7
	Silver-1	6	8.3	8.3	68.1
	Silver-2	6	8.3	8.3	76.4
	Silver-3	4	5.6	5.6	81.9
	Silver-4	13	18.1	18.1	100.0
	Total	72	100.0	100.0	

C.1- Table 3: Rank frequency distribution

Personality

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	extrovert	31	43.1	43.1	43.1
	introvert	41	56.9	56.9	100.0
	Total	72	100.0	100.0	

C.1- Table 4: Sample personality (Introvert/Extrovert)

Appendix C.2: Study 3 – Paired Sample Tables

Below are the paired sample t-test outputs from the SPSS software. First, the performance tables. Then, the stress tables.

Performance Paired Samples Statistics

Group			Mean	N	Std. Deviation	Std. Error Mean
C	Pair 1	Post	58.653026	34	4.5723786	.78415646
		Pre	56.521739	34	5.0457292	.86533541
E	Pair 1	Post	71.014493	38	4.2621138	.69140615
		Pre	57.856598	38	4.3852881	.71138767

C.2-Table 1: Performance means (paired sample t-test)

Performance Paired Samples Test

			Paired Differences							
						95% Confidence Interval of the Difference				
Group			Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
C	Pair 1	Post - Pre	2.1312873	6.0362960	1.0352162	.02512405	4.2374505	2.059	33	.047
E	Pair 1	Post - Pre	13.157895	4.1457352	.67252706	11.795225	14.520564	19.565	37	.000

C.2-Table 2: Performance statistics (paired sample t-test)

Stress Paired Samples Statistics

Group			Mean	N	Std. Deviation	Std. Error Mean
C	Pair 1	PostTestStress	2.79779	34	.735990	.126221
		PreTestStress	3.54412	34	.387450	.066447
E	Pair 1	PostTestStress	2.35855	38	.754027	.122319
		PreTestStress	3.49158	38	.416297	.067532

C.2-Table 3: Stress means (paired sample t-test)

Paired Samples Test

			Paired Differences							
						95% Confidence Interval of the Difference				
Group			Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
C	Pair 1	Post-Pre	-.746324	.754411	.129380	-1.009550	-.483097	-5.768	33	.000
E	Pair 1	Post-Pre	-1.133026	.894625	.145127	-1.427082	-.838970	-7.807	37	.000

C.2-Table 4: Stress statistics (paired sample t-test)

Appendix C.3: Study 3 – Performance - Repeated Measures ANOVA

Below are the repeated measures ANOVA result from SPSS software. The test days performance analysis will be illustrated, followed by the training days performance analysis.

Appendix C3.1: Performance repeated measures ANOVA (Test-Days)

Mauchly's Test of Sphericity is suitable for comparing three or more levels of repeated measures ANOVA. In this case, we are comparing only two levels, pre-test, and post-test, which is why the table does not show a significant value.

Test-Days - Performance Descriptive Statistics

	Group	Mean	Std. Deviation	N
Pre	C	56.521739	5.0457292	34
	E	57.856598	4.3852881	38
	Total	57.226248	4.7228419	72
Post	C	58.653026	4.5723786	34
	E	71.014493	4.2621138	38
	Total	65.177134	7.6028748	72

C3.1 Table 1: Test-days performance descriptive statistics

Mauchly's Test of Sphericity

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon Greenhouse-Geisser	Epsilon Huynh-Feldt	Epsilon Lower-bound
TestDays	1.000	.000	0	.	1.000	1.000	1.000

C3.1 Table 2: Performance - test-days - Mauchly's Test of Sphericity (two days/levels)

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
TestDays	Sphericity Assumed	3.146	1	3.146	.243	.624	.004	.243	.077
	Greenhouse-Geisser	3.146	1.000	3.146	.243	.624	.004	.243	.077
	Huynh-Feldt	3.146	1.000	3.146	.243	.624	.004	.243	.077
	Lower-bound	3.146	1.000	3.146	.243	.624	.004	.243	.077
TestDays * Age	Sphericity Assumed	31.696	1	31.696	2.448	.122	.036	2.448	.338
	Greenhouse-Geisser	31.696	1.000	31.696	2.448	.122	.036	2.448	.338
	Huynh-Feldt	31.696	1.000	31.696	2.448	.122	.036	2.448	.338
	Lower-bound	31.696	1.000	31.696	2.448	.122	.036	2.448	.338
TestDays * Exp	Sphericity Assumed	1.616	1	1.616	.125	.725	.002	.125	.064
	Greenhouse-Geisser	1.616	1.000	1.616	.125	.725	.002	.125	.064
	Huynh-Feldt	1.616	1.000	1.616	.125	.725	.002	.125	.064
	Lower-bound	1.616	1.000	1.616	.125	.725	.002	.125	.064
TestDays * Rank_Code	Sphericity Assumed	25.304	1	25.304	1.955	.167	.029	1.955	.281
	Greenhouse-Geisser	25.304	1.000	25.304	1.955	.167	.029	1.955	.281
	Huynh-Feldt	25.304	1.000	25.304	1.955	.167	.029	1.955	.281
	Lower-bound	25.304	1.000	25.304	1.955	.167	.029	1.955	.281
TestDays * Personality	Sphericity Assumed	8.351	1	8.351	.645	.425	.010	.645	.124
	Greenhouse-Geisser	8.351	1.000	8.351	.645	.425	.010	.645	.124
	Huynh-Feldt	8.351	1.000	8.351	.645	.425	.010	.645	.124
	Lower-bound	8.351	1.000	8.351	.645	.425	.010	.645	.124
TestDays * Group	Sphericity Assumed	962.239	1	962.239	74.326	.000	.530	74.326	1.000
	Greenhouse-Geisser	962.239	1.000	962.239	74.326	.000	.530	74.326	1.000
	Huynh-Feldt	962.239	1.000	962.239	74.326	.000	.530	74.326	1.000
	Lower-bound	962.239	1.000	962.239	74.326	.000	.530	74.326	1.000
Error(TestDays)	Sphericity Assumed	854.450	66	12.946					
	Greenhouse-Geisser	854.450	66.000	12.946					
	Huynh-Feldt	854.450	66.000	12.946					
	Lower-bound	854.450	66.000	12.946					

a. Computed using alpha = .05

C3.1 Table 3: Performance - test-days - within subject (interaction effect)

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	7215.180	1	7215.180	322.098	.000	.830	322.098	1.000
Age	3.829	1	3.829	.171	.681	.003	.171	.069
Exp	9.691	1	9.691	.433	.513	.007	.433	.099
Rank_Code	407.200	1	407.200	18.178	.000	.216	18.178	.987
Personality	50.000	1	50.000	2.232	.140	.033	2.232	.313
Group	1380.600	1	1380.600	61.632	.000	.483	61.632	1.000
Error	1478.439	66	22.401					

a. Computed using alpha = .05

C3.1 Table 4: Performance - test-days - between subject (main effect)

Appendix C3.2 Performance repeated measures ANOVA (Training-Days)

Training-Days - Performance - Descriptive Statistics

	Group	Mean	Std. Deviation	N
Day 2	C	60.003349	4.0262991	34
	E	54.855890	4.7246093	38
	Total	57.286634	5.0856597	72
Day 3	C	63.900560	7.4933294	34
	E	59.931078	5.2022607	38
	Total	61.805556	6.6470861	72
Day 4	C	67.997199	6.4593932	34
	E	65.789474	6.6119990	38
	Total	66.832011	6.5884361	72

C3.3 Table 1: Training-days performance descriptive statistics

Mauchly's test indicated that the sphericity assumption was violated, ($\chi^2(2) = 34.83, p < 0.000$). As a result, **Greenhouse-Geisser** corrected results were reported (ε = 0.707).

Training-Days Mauchly's Test of Sphericity

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon Greenhouse-Geisser	Epsilon Huynh-Feldt	Epsilon Lower-bound
TrainingDays	.585	34.833	2	.000	.707	.772	.500

C3.2 Table 1: Performance – training days - Mauchly's Test of Sphericity (three days/levels)

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Days	Sphericity Assumed	32.811	2	16.406	1.057	.350	.016	2.114	.232
	Greenhouse-Geisser	32.811	1.414	23.212	1.057	.331	.016	1.494	.199
	Huynh-Feldt	32.811	1.545	21.239	1.057	.336	.016	1.633	.206
	Lower-bound	32.811	1.000	32.811	1.057	.308	.016	1.057	.173
Days * Personality	Sphericity Assumed	1.192	2	.596	.038	.962	.001	.077	.056
	Greenhouse-Geisser	1.192	1.414	.844	.038	.915	.001	.054	.055
	Huynh-Feldt	1.192	1.545	.772	.038	.930	.001	.059	.055
	Lower-bound	1.192	1.000	1.192	.038	.845	.001	.038	.054
Days * Exp	Sphericity Assumed	6.188	2	3.094	.199	.820	.003	.399	.081
	Greenhouse-Geisser	6.188	1.414	4.378	.199	.741	.003	.282	.076
	Huynh-Feldt	6.188	1.545	4.006	.199	.762	.003	.308	.077
	Lower-bound	6.188	1.000	6.188	.199	.657	.003	.199	.072
Days * Age	Sphericity Assumed	42.357	2	21.179	1.364	.259	.020	2.729	.290
	Greenhouse-Geisser	42.357	1.414	29.965	1.364	.256	.020	1.929	.245
	Huynh-Feldt	42.357	1.545	27.418	1.364	.257	.020	2.108	.255
	Lower-bound	42.357	1.000	42.357	1.364	.247	.020	1.364	.210
Days * Rank_Code	Sphericity Assumed	109.480	2	54.740	3.527	.032	.051	7.053	.648
	Greenhouse-Geisser	109.480	1.414	77.449	3.527	.049	.051	4.985	.545
	Huynh-Feldt	109.480	1.545	70.867	3.527	.044	.051	5.448	.570
	Lower-bound	109.480	1.000	109.480	3.527	.065	.051	3.527	.457
Days * Group	Sphericity Assumed	47.871	2	23.936	1.542	.218	.023	3.084	.323
	Greenhouse-Geisser	47.871	1.414	33.865	1.542	.222	.023	2.180	.271
	Huynh-Feldt	47.871	1.545	30.987	1.542	.221	.023	2.382	.283
	Lower-bound	47.871	1.000	47.871	1.542	.219	.023	1.542	.232
Error(Days)	Sphericity Assumed	2048.929	132	15.522					
	Greenhouse-Geisser	2048.929	93.296	21.962					
	Huynh-Feldt	2048.929	101.961	20.095					
	Lower-bound	2048.929	66.000	31.044					

a. Computed using alpha = .05

C3.2 Table 2: Performance - training-days - within subject using Greenhouse-Geisser correction - (interaction effect)

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	7598.795	1	7598.795	115.010	.000	.635	115.010	1.000
Age	291.903	1	291.903	4.418	.039	.063	4.418	.544
Exp	159.282	1	159.282	2.411	.125	.035	2.411	.334
Rank_Code	337.699	1	337.699	5.111	.027	.072	5.111	.606
Personality	9.615	1	9.615	.146	.704	.002	.146	.066
Group	953.736	1	953.736	14.435	.000	.179	14.435	.963
Error	4360.686	66	66.071					

a. Computed using alpha = .05

C3.2 Table 3: Performance - training-days - between subject (main effect)

Training-Days Performance Pairwise Comparisons

Measure: MEASURE_1

(I) TrainingDays	(J) TrainingDays	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b] Lower Bound	Upper Bound
1	2	-4.506*	.771	.000	-6.401	-2.612
	3	-9.483*	.740	.000	-11.301	-7.665
2	1	4.506*	.771	.000	2.612	6.401
	3	-4.976*	.394	.000	-5.944	-4.008
3	1	9.483*	.740	.000	7.665	11.301
	2	4.976*	.394	.000	4.008	5.944

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.

C3.2 Table 4: Training-Days - performance - pairwise comparisons

Appendix C3.3: Study 3 – Stress - Repeated Measures ANOVA (Test-Days)

The repeated measures ANOVA result from SPSS software. The test days performance analysis will be illustrated, followed by the training days performance analysis.

Test-Days Preceived Stress Descriptive Statistics

	Group	Mean	Std. Deviation	N
Day 1 Stress	C	3.54412	.387450	34
	E	3.49158	.416297	38
	Total	3.51639	.400978	72
Day 5 Stress	C	2.79779	.735990	34
	E	2.35855	.754027	38
	Total	2.56597	.772540	72

C3.3 Table 2: Test-days - perceived Stress - descriptive statistics

Since the Mauchly's Test of Sphericity is designed to compare more than two levels, the, the test will not show any values because it is comparing the post-test and pre-test (two levels).

Mauchly's Test of Sphericity

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon Greenhouse-Geisser	Epsilon Huynh-Feldt	Epsilon Lower-bound
TestDaysStress	1.000	.000	0	.	1.000	1.000	1.000

C3.3 Table 3: Test-days - perceived Stress - Mauchly's Test of Sphericity (two days/levels)

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
TestDaysStress	Sphericity Assumed	.011	1	.011	.031	.861	.000	.031	.053
	Greenhouse-Geisser	.011	1.000	.011	.031	.861	.000	.031	.053
	Huynh-Feldt	.011	1.000	.011	.031	.861	.000	.031	.053
	Lower-bound	.011	1.000	.011	.031	.861	.000	.031	.053
TestDaysStress * Personality	Sphericity Assumed	.522	1	.522	1.498	.225	.022	1.498	.226
	Greenhouse-Geisser	.522	1.000	.522	1.498	.225	.022	1.498	.226
	Huynh-Feldt	.522	1.000	.522	1.498	.225	.022	1.498	.226
	Lower-bound	.522	1.000	.522	1.498	.225	.022	1.498	.226
TestDaysStress * Exp	Sphericity Assumed	.036	1	.036	.104	.748	.002	.104	.062
	Greenhouse-Geisser	.036	1.000	.036	.104	.748	.002	.104	.062
	Huynh-Feldt	.036	1.000	.036	.104	.748	.002	.104	.062
	Lower-bound	.036	1.000	.036	.104	.748	.002	.104	.062
TestDaysStress * Age	Sphericity Assumed	.376	1	.376	1.079	.303	.016	1.079	.176
	Greenhouse-Geisser	.376	1.000	.376	1.079	.303	.016	1.079	.176
	Huynh-Feldt	.376	1.000	.376	1.079	.303	.016	1.079	.176
	Lower-bound	.376	1.000	.376	1.079	.303	.016	1.079	.176
TestDaysStress * Rank_Code	Sphericity Assumed	.244	1	.244	.699	.406	.010	.699	.131
	Greenhouse-Geisser	.244	1.000	.244	.699	.406	.010	.699	.131
	Huynh-Feldt	.244	1.000	.244	.699	.406	.010	.699	.131
	Lower-bound	.244	1.000	.244	.699	.406	.010	.699	.131
TestDaysStress * Group	Sphericity Assumed	.806	1	.806	2.312	.133	.034	2.312	.323
	Greenhouse-Geisser	.806	1.000	.806	2.312	.133	.034	2.312	.323
	Huynh-Feldt	.806	1.000	.806	2.312	.133	.034	2.312	.323
	Lower-bound	.806	1.000	.806	2.312	.133	.034	2.312	.323
Error (TestDaysStress)	Sphericity Assumed	23.016	66	.349					
	Greenhouse-Geisser	23.016	66.000	.349					
	Huynh-Feldt	23.016	66.000	.349					
	Lower-bound	23.016	66.000	.349					

a. Computed using alpha = .05

C3.3 Table 4: Test-days - perceived stress - within subject (interaction effect)

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	17.438	1	17.438	45.806	.000	.410	45.806	1.000
Personality	.182	1	.182	.479	.491	.007	.479	.105
Exp	.237	1	.237	.621	.433	.009	.621	.121
Age	.027	1	.027	.071	.791	.001	.071	.058
Rank_Code	.155	1	.155	.407	.526	.006	.407	.096
Group	1.490	1	1.490	3.915	.052	.056	3.915	.496
Error	25.125	66	.381					

a. Computed using alpha = .05

C3.3 Table 5: Test-days - perceived stress - between subject (main effect)

Appendix C3.4: Study 3 – Stress - Repeated Measures ANOVA (Training-Days)

Training-Days Stress Descriptive Statistics

	Group	Mean	Std. Deviation	N
Day 2 Stress	C	3.08088	.871955	34
	E	3.46382	1.020031	38
	Total	3.28299	.965741	72
Day 3 Stress	C	2.64706	.803915	34
	E	2.68092	.767640	38
	Total	2.66493	.779588	72
Day 4 Stress	C	2.11397	.560174	34
	E	2.03947	.569573	38
	Total	2.07465	.562416	72

C3.3 Table 6: Training-days - perceived Stress - descriptive statistics

Mauchly's test indicated that the sphericity assumption was violated, ($\chi^2(2) = 14.83$, $p = 0.001$). As a result, **Huynh-Feldt** corrected results were reported (ε =0.831).

Mauchly's Test of Sphericity

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon Greenhouse-Geisser	Epsilon Huynh-Feldt	Epsilon Lower-bound
TrainingDaysStress	.796	14.833	2	.001	.831	.914	.500

C3.3 Table 7: Training-days - perceived stress - Mauchly's Test of Sphericity (three levels) Huynh-Feldt correction used

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
TrainingDaysStress	Sphericity Assumed	.798	2	.399	2.062	.131	.030	4.125	.418
	Greenhouse-Geisser	.798	1.661	.481	2.062	.140	.030	3.426	.379
	Huynh-Feldt	.798	1.828	.437	2.062	.136	.030	3.770	.398
	Lower-bound	.798	1.000	.798	2.062	.156	.030	2.062	.293
TrainingDaysStress * Personality	Sphericity Assumed	.048	2	.024	.123	.884	.002	.246	.069
	Greenhouse-Geisser	.048	1.661	.029	.123	.847	.002	.204	.067
	Huynh-Feldt	.048	1.828	.026	.123	.867	.002	.225	.068
	Lower-bound	.048	1.000	.048	.123	.727	.002	.123	.064
TrainingDaysStress * Exp	Sphericity Assumed	.414	2	.207	1.070	.346	.016	2.140	.234
	Greenhouse-Geisser	.414	1.661	.249	1.070	.336	.016	1.778	.215
	Huynh-Feldt	.414	1.828	.227	1.070	.341	.016	1.956	.225
	Lower-bound	.414	1.000	.414	1.070	.305	.016	1.070	.175
TrainingDaysStress * Age	Sphericity Assumed	.161	2	.081	.416	.660	.006	.833	.116
	Greenhouse-Geisser	.161	1.661	.097	.416	.623	.006	.692	.110
	Huynh-Feldt	.161	1.828	.088	.416	.642	.006	.761	.113
	Lower-bound	.161	1.000	.161	.416	.521	.006	.416	.097
TrainingDaysStress * Rank_Code	Sphericity Assumed	.223	2	.111	.575	.564	.009	1.150	.144
	Greenhouse-Geisser	.223	1.661	.134	.575	.533	.009	.955	.135
	Huynh-Feldt	.223	1.828	.122	.575	.549	.009	1.051	.139
	Lower-bound	.223	1.000	.223	.575	.451	.009	.575	.116
TrainingDaysStress * Group	Sphericity Assumed	1.656	2	.828	4.279	.016	.061	8.557	.738
	Greenhouse-Geisser	1.656	1.661	.997	4.279	.022	.061	7.107	.679
	Huynh-Feldt	1.656	1.828	.906	4.279	.019	.061	7.820	.710
	Lower-bound	1.656	1.000	1.656	4.279	.043	.061	4.279	.531
Error (TrainingDaysStress)	Sphericity Assumed	25.548	132	.194					
	Greenhouse-Geisser	25.548	109.631	.233					
	Huynh-Feldt	25.548	120.634	.212					
	Lower-bound	25.548	66.000	.387					

C3.3 Table 8: Training-days - perceived stress - within subject (interaction effect)

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	24.169	1	24.169	17.134	.000	.206	17.134	.983
Personality	2.014	1	2.014	1.428	.236	.021	1.428	.218
Exp	.242	1	.242	.172	.680	.003	.172	.069
Age	3.880E-6	1	3.880E-6	.000	.999	.000	.000	.050
Rank_Code	6.771	1	6.771	4.800	.032	.068	4.800	.579
Group	.314	1	.314	.223	.639	.003	.223	.075
Error	93.099	66	1.411					

a. Computed using alpha = .05

C3.3 Table 9: Training-days - perceived stress - between subject (main effect)

Pairwise Comparisons

Measure: MEASURE_1

(I) TrainingDaysStress	(J) TrainingDaysStress	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b] Lower Bound	Upper Bound
1	2	.608*	.073	.000	.428	.788
	3	1.197*	.087	.000	.984	1.410
2	1	-.608*	.073	.000	-.788	-.428
	3	.589*	.057	.000	.448	.730
3	1	-1.197*	.087	.000	-1.410	-.984
	2	-.589*	.057	.000	-.730	-.448

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.

C3.3 Table 10: Training-Days - perceived stress - pairwise comparisons