Improving eSports performance

Conducting stress measurements during Fifa gameplay

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Bachelor Thesis

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Abstract

eSports is an upcoming scene in the sports industry which is set to become one of the biggest phenomena in this time. The ones participating in eSports are eSporters. This paper describes the process of creating an informative stress feedback device for eSporters to help them gain insight into their stress levels. Right now, there is no stress measuring technology available for eSporters that is solely created to perform stress measurements on eSporters. To create such a device, the following research questions were set. The main research question:

"In what manner can insight in stress levels be obtained in fifa eSporters during a game of Fifa and how can this be translated into informative feedback?"

This question has been divided into three different sub-research questions:

"How can insight in stress levels be obtained?"

"How do stress levels alter in Fifa eSporters during a game of Fifa?"

"How can stress levels be translated into informative feedback?"

By conducting a state-of-the-art research, the possibilities for such a device are exposed. After this research, requirements and ideas were gathered in the form of a stakeholder analysis, brainstorm, and interviews. The findings from these information gathering methods were used to create a prototype. The most important requirements for this of device are:

- The whole device is to be setup in three minutes (functional)
- The electrodes must be able to be setup in two minutes (functional)
- The device must keep the focus of the user while playing a game of Fifa (non-functional)
- The feedback must keep the focus of the user while playing a game of Fifa (non-functional)
- The setup must obtain data about stress without the use of sound measurements (functional)
- The feedback must be displayed on a different screen as on which Fifa is being played (functional)
- The controller output wire must keep the focus of the user while playing a game of Fifa (non-functional)
- The device must keep the user relaxed, so it does not cause stress generative feelings (non-functional)

The prototype idea contains four sensors: ECG, GSR, Tilt and Facial sensor. These sensors obtain data which will be converted into a line graph as a form of providing informative feedback. Within the realisation, it was found that -due to time constrictions- the full prototype could not be realised. An Empatica was used to recreate the data obtained from the unrealised sensors. From the setup, it could be concluded that stress levels alter in Fifa eSporters during a game of Fifa in short bursts and over longer time spans. The short bursts of stress are generated by events that occur close -in distance- to a goal. During a full game of Fifa, measured stress levels have a higher general level near the end of the game in comparison to the beginning. From the measurements, it could not be concluded if the difficulty of a game influences the perceived stress levels.

In the future, this device could be capable of improving eSports performance in every game, the device could be capable of better coaching methods during training and competitive gaming and could be capable of creating more insightful gaming streams for viewers. However, before this can happen, there will be a need for more testing opportunities and performance improvements. In addition, the prototype should obtain more features before it can be called a full product.

Preface

To start, I want to thank the people that helped me during the project. To start of, I want to thank my supervisor Guido Bruinsma. He is the person that I could contact if there was a problem and I could expect an immediate response. Next would be Erik Faber. As my critical observer, he helped me with his feedback and pushes in the right direction if needed.

I am thankful for FC Twente and their eSports department. They provided me with all the information I needed and never turned me down. A special thanks to the eSporters of FC Twente Enis Tokdemir, Brent Weerink and Jelte Golbach. These guys were able to provide information and perform small interviews almost any time of the day. They were super supportive in the thinking process of this project and even liked doing so.

Lastly, I want to thank my parents for helping me during this period of corona. During the project I have lived with them instead of being alone in Enschede. I thank them for their support, even though I was annoying sometimes. Thanks for making (y)our house available for stationing an office to work and sometimes going out of your way if there was a stressful moment.

Without these people, the project would not have turned out as it has. Therefore, I want to thank them one final time!

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1. Introduction

This chapter will provide a brief description of eSports, stress, and the implications of stress on the human body. Then, based on that information, the objectives and challenges of the project will be discussed. Later, the research questions and sub questions will be addressed.

1.1 Background

eSports is a version of gaming in which gamers compete in tournaments all over the world to become the best and win. eSports varies in type of competitions since there are eSports tournaments in which people compete by themselves, but also within teams. It is stated by Kemp et al. (2020), that eSports has a global fan base of over 454 million people. However, despite its popularity and commercial support, eSports is disregarded as a credible form of competition. It is said that the International Olympic Committee contends that eSports may be considered a sporting activity in the future, but it is limited based on its sedentary nature and poor governance.

Figure 1.1, eSports live tournament

As said, eSports is not yet seen as an actual sport by the masses, since it is seen as a less active thing in which one does not move as much as a normal sport (Kemp et al.). eSports is a type of gaming that is described in an article by Monteiro Pereira et al. (2019), as a sport just like any other “conventional” sports. As said by Monteiro Pereira et al., “Sports can be defined as a game, competition or activity needing physical effort and skill that is played or done according to rules, for enjoyment and/or as a job.” It is stated in this article and by Funk et al. (2018) that eSports consists of those requirements. Furthermore, Monteiro Pereira et al., state that it could even reaches the same competitive level as “traditional” sports.

It is said by Jenny et al. (2017) that eSports are games in which the focus is not physical capability, but mental processing capability. However, this should not imply that eSporters do not have to be in proper physical shape since physique also plays its part. In addition, it is stated that eSporters themselves need to possess tactical thinking, fast reflexes and perfect hand-to-eye coordination. Jenny et al. and Monteiro Pereira et al. both state that eSports is not just indicating one thing. eSports is a general term used to indicate

all kind of different competitive games like first-person shooters, strategy, battle royal and actual sport games.

Figure 1.2, eSporters training

1.2 Goal and Challenges

According to Kemp et al. eSports is one of the biggest growing sports in the world. Therefore, there is a need to give it a bigger and more professional approach than it already has. The overhaul of eSports cannot be done in an instance. That is why, in this research, there will be looked at a manner to improve the performance of all types of eSporters. eSporters are professional gamers, who just as soccer and football pros are the best of the best in what they do (Funk et al., 2018). To be the best, eSporters must practice in their respective games. Unlike other sports, eSporters train by spending most of their time gaming and rewatching played games to improve their tactics and refining their skills (Funk et al., 2018). This training does not always come with state-of-the-art technology to help eSporters improve, as it does with for example soccer players. This research will help improve eSports player's performance by creating a state-of-the-art tool. To do so, the first type of eSporter that will be taken in consideration are Fifa eSporters. Fifa is a game in which two opponents both have their respective soccer team and play a soccer match against each other. They can set up their own tactics, choose their players and with that, try to score as many goals as possible. To play the game at a high level, it requires great tactical thinking and stress handling capabilities.

As said before, Fifa eSporters do not use specific equipment to help them out with training regime yet. They play thirty games during the weekend in what is called "weekend league", they play during the week for fun and compete in the eDivisie which is the equivalent of the Eredivisie but with the usage of Fifa. There are a lot of ideas, which would be capable of improving the training regime of Fifa eSporters. However, the most requested tool would be a tool which measures stress of the eSporter and gives him/her feedback. This tool must be a perfect start to improve eSports performance since stress is a known indicator of feeling uncomfortable and experiencing hard moments. Knowing these moments, it is possible to improve one's self in these situations. Training in these stressful situations will greatly improve performance since those situations will most likely be weak points in the eSporters gameplay.

The goal is to improve the performance of fifa eSporters by providing them with information about their stress levels, the main objective of this research is as follows: *Creating a device with which stress can be measured of an eSporter and provide informative feedback about it.*
The main challenge in this research is finding the best working solution to measure stress experienced by the gamer. There are already a lot of ways to measure stress, but it is wanted to find the best stress measuring method in a gaming environment. Within this challenge, there must also be looked at the type of feedback, the use of sensors and how the device will be used.

1.3 Research (sub-) Questions

This bachelor thesis will give the solution to the following main research question:

"In what manner can insight in stress levels be obtained in fifa eSporters during a game of Fifa and how can this be translated into informative feedback?"

To find the answer to this question, it is divided into three sub-questions. These sub-questions are:

"How can insight in stress levels be obtained?"

"How do stress levels alter in Fifa eSporters during a game of Fifa?"

"How can stress levels be translated into informative feedback?"

The sub-questions will be discussed throughout the thesis. Based on the findings, a stress feedback device will be created which can be used by Fifa eSporters.

2. State of the Art

This chapter is divided in multiple parts. At first, there will be a small description about stress in general. This section is followed by an in-depth research about the different methods used to measure stress and what is measured to indicate stress. Next, there will be talked about technologies that make use of these principals and are already being used for commercial purposes and within eSports. Second to last, there will be looked at existing ways of providing feedback on stress levels. Afterwards, there will be looked at causes and effects of stress for eSporters. This information will later be used in the ideation phase.

2.1 What is stress

Stress is seen as a reaction from the human body to the environment. Stress is not just one thing on its own, it is a name for multiple different reactions in the body (Engert et al., 2019). These changes in the body occur due to “stress causing factors”. These factors are situations in which a person is uncomfortable or when someone experiences big workloads both mentally (mental stress) or physically (physical stress) (Bruinsma, 2010). Workload is a term used to indicate the amount of physical and/or mental work, that must be done to complete a task. In addition, the bigger or more difficult a task is, the higher its workload will be. It is known that a high workload on its own is can not cause stress. However, when a person is experiencing long term high workloads, these workloads can cause stress (Bruinsma, 2010).

There are two types of stress. Firstly, there is acute stress. According to several studies (Folkman & Moskowitz, 2000), acute stress is the type of stress that is experienced on short term. This type of stress is most common in unknown or scary situations because these situations usually do not last long. Secondly there is chronic stress. Chronic stress is said to be the stress that people experience during longer periods of time (Wirkner et al., 2019). This type of stress is caused by long term effects on the body like high levels of workload. It goes without saying that these two types of stress can be experienced apart from one another, yet it is also possible to experience both types at the same time. According to Reisman (1997), when a person experiences both types of stress at the same time, nothing significant happens. However, both stresses will stack and thus create higher stress perception. Importantly, acute stress is not said to cause bigger reactions within the human body in comparison to chronic stress (Hidalgo et al., 2019).

Stress is known to cause many different reactions on the body. In this paper, these reactions will be divided into two sections: measurable stresses and unmeasurable stresses. The measurable changes have to do with cortisol levels, heart rate, heart rate variability (HRV) (Hoffman, 2020), facial recognition, breath rate, brain activity and blood pressure. Firstly, several studies (Radenbach et al. 2015; Reisman, 1997) show that cortisol levels go up if a person experiences stress, however this is only measurable during chronic stress (Wirkner et al., 2019). Secondly, during stress, the body needs more oxygen flowing to the muscles and organs. To do so, the body not only increases heart rate (Guidotti, 1992; Bevilacqua et al., 2018) but also blood pressure (Marazziti et al., 1992). To add, it is shown that blood volume in the periphery (Lastowiecka-Moras and Kozyra-Pydys, 2016) decreases during stress to increase the blood volume within the core of the body (Reisman, 1997). Thirdly, it is said that HRV goes down during stress (Bevilacqua et al., 2018; Staal, 2004). HRV is the variation in time intervals between two heartbeats in milliseconds. The drop of HRV during stress likely has to do with the increase of heart rate, making it impossible to have big time differences between heartbeats. Next, it is said that if one is experiencing a stress causing moment, brain activities will rise (Weerda et al., 2010). Second to last, Breath rate said to increase due to stress (Radak et al., 2013). Lastly, Bevilacqua et al. (2018) state that facial expression can also be a measure of stress. When looking at changes in facial expression, it is hard to determine whether the change occurs due to stress or to something random. However, in this paper, it is also said that facial expressions can be used as a measure of stress, if done with the right equipment.

Stress has three major factors which can alter one's performance. Firstly, stress is known to have an influence on people's memory (Staal, 2004; Hidalgo et al., 2019). Both acute and chronic stress have influence on memory. That said, it is known that memory retrieval worsens within periods of stress and memory storage improves. Secondly, stress can cause heavy emotional reactions (Radenbach et al., 2017). Emotional changes are not only a reaction to stress but also a way to cope with it. This coping mechanism can cause negative emotions as well as extremely positive emotions. This negative emotion coping can lead to tilting. Tilt is a term used in the gaming sector to indicate an emotion takeover of one's actions. It causes people to scream, button mash and smash things (Wei et al., 2016). Lastly, within the study of Radenbach et al. (2017) there is shown that stress influences people's behaviour. To put it in other words, the stress changes people's behaviour from rational choice making, to habitual behaviour (van den Bergh et al., 2019).

2.2 Measurable factors and technology

Eye measurements

These measurement methods make use of changes in the eye which occur due to high workloads, which is previously said to be a stress causing factor. According to Duchowskie et al. (2018), workload has two ways of expressing itself in eyes. The first is a change in pupil diameter, and the second has to do with eye tracking and fixation. To make use of these methods, the needed hardware will be a camera and a computer. The camera will be used to obtain the data from the user's face, and the computer will be used to process the data. The computer will also need processing software to process the data. This can be done with Python for example.

In the article, it is said that pupil diameter increases with work difficulty. To add, Kahneman and Beatty (1966) suggested that pupil diameter provided an effective index on momentary load as a subject performed mental tasks. Duchowskie et al. say that in general, difficult problems evoke a bigger pupillary dilation, meaning that bigger workloads increase the diameter of the pupil. With this method it is thus needed to look at increases in pupil diameter to gain insight into the amount of workload. However, it is also stated that there is a downside to the usage of pupil diameter as a means of measuring cognitive load. Pupil diameter also increase or decrease as a response to light (Beatty and Lucer-Wagoner, 2000). With this said, when using these kinds of measurements, it is key that there is little to none change in the amount of light facing the eye. If this method would be applied to Fifa, it will be likely that the downside, to the use of pupil diameter as a measure of stress, will not be a big issue. This theory comes forth of the fact that, while playing the game, there are no big colour changes thus making pupil change due to light almost none. However, this will need validation. This method will show stressful moments in general, while gaming.

Next, Duchowskie et al. say that difficult tasks are known to cause implicated eye fixation, e.g., duration and number. The fixation is thought to be involved with information processing. Just and Carpenter (1976; 1980), state that the more difficult a task is, the longer the eyes will fixate on the stimulus until it is processed completely. In addition, shorter saccades are also said to be an indicator of higher cognitive loads (Velichkovsky et al., 2005; Kreitz et al., 2016). A saccade is the time in which the eyes move from one fixated point to another. To measure stress using this method, it is thus needed to look at changes in fixture time and saccade length. It is wanted to find longer fixture time and a shorter saccade time in order to indicate stress. If this method would be used in Fifa, it would probably be best at detecting moments in which a player needs to make a pass, crossing, dribble or defend a free opponent. It will also be possible to see where the player is focussing on, even predicting his next move. These moments will probably be the moments in which a player have fixed eye moments with shorter saccades.

Heart measurements

These kinds of measurement methods make use of changes in the heart. When experiencing stress, the body releases the hormone adrenaline. This hormone temporarily causes heart and breath rate to speed up and blood pressure to rise (Jensen et al., 2011). There are two mayor methods with which one can measure stress by looking at the heart. The first measure is a change in heart rate and the second is a change in heart rate variability (Bevilacqua et al., 2018; Garde et al., 2002).

As said by Bevilacqua et al. and Garde et al., the measure of heart rate show changes when a person finds him-/herself in a stressful situation in comparison with a boredom situation. During “resting mode” of the heart, one’s heart rate should be between 60 to 100 beats per minute (Laskowski, 2018). However, it is said that during a stress causing moment, the heart rate will rise, and this could happen for longer periods or short intervals. With this known, it is thus needed to calibrate a normal heart rate to a null factor, and then check for raising heart rates to see stress occur. If this method would be applied to Fifa eSporters, it should be possible to pinpoint at which moments a person encounters stressful situations. In addition, it is also possible to check whether a game is stressful in and of itself.

Heart rate can be measured with lots of technologies. The best way to measure heart rate is with the use of an ECG sensor. If an ECG sensor is used it is possible to monitor the electric signals send from the brain to the heart. By doing so, it is possible to add all these signals up to a value of BPM (Sakaue et al., 2014). ECG signals can be measured in all sorts of ways, for example: with electrodes on the chest, conductive cloth (Smart textile: Leal-Junior et al., (2019)) and with a sensory chest band. It is also possible to use a PPG. This device is used to measure blood pressure. Due to heartbeats the blood pressure fluctuates. This fluctuation is an indicator of a heartbeat and therefore usable to measure heart rate. It is to be said that a PPG is commonly used around the wrist. With this measuring device further away from the heart, it is harder to accurately measure heart rate and is therefore less beneficial (Ishikawa et al., 2017).

Next is the method of HRV measurements. In a “resting state”, the HRV of a normal human increases, when one experiences stress causing factors, HRV naturally decreases (Hoffman). Just as with heart rate measurements, in order to gain insight into stress via HRV, it is needed to calibrate the normal heart rate variability to a null factor, and when this is done, obtain knowledge of lowering HRV values. This method should give the same insight into the game as the heart rate measurements. However, it is to be said that HRV is harder to detect in short bursts of stress, therefore making the shorter stressful situations sometimes undetectable (Castaldo et al., 2015).

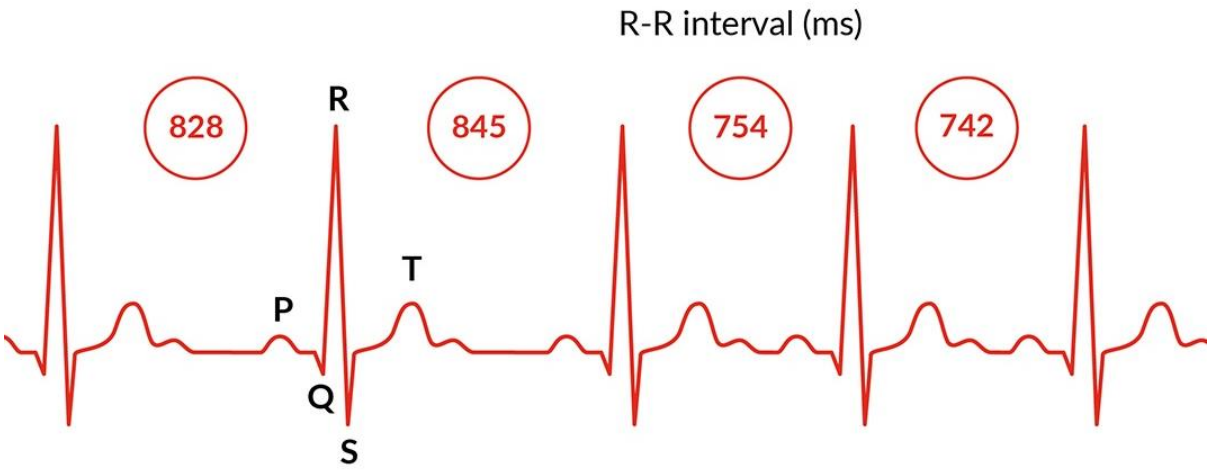

Figure 2.1, HRV changes.

The technologies used for HRV measurements are the same as the once used for Heart rate measurements. The best way to measure HRV is using ECG sensors. When it is known at what time stamps heartbeats take place, it is possible to determine HRV (Karthikeyan et al., 2013). In this case, it is not recommended to use PPG, however it is possible. Due to PPG not always being able to detect a heartbeat, some of the intervals are measured wrong. With that in mind, it is possible that these measurements will entirely misguide the process. It is however also possible to exclude wrong measurements, but it is probable that this will also worsen the validity of the data.

Breath measurements

This measurement method makes use of pattern recognition of breathing in order to see if one is experiencing stress. While experiencing stress, there are two things that can change within human breath rate patterns. The first is a general outcome which occurs in all people, our breath rate goes up, meaning that people will take in oxygen faster (Radak et al., 2013). The reason for this, is that during stress, the human body goes into a sort of “enhanced state”. With this, the muscles and some organs need to take in more oxygen in order to function faster. Due to some organs and muscles working faster, the human body creates more heat. It is said that breath rate also increases to get rid of the extra heat (Katramiz et al., 2020).

The second change is a more personal change and does not occur with everyone. People sometimes tend to irregulate their breathing pattern when experience a stressful moment, for example, holding your breath before doing something crucial. There is one method that can be used to measure breathing patterns and that is measuring when and how one is breathing.

As said, breathing rate increases when one experiences stress. However, it is hard to determine acute stress with the use of changes in breath rate since this pattern doesn’t alter in an instant. Therefore, it can be said that this measurement is only useful for using it for long term stress measurements (Tonacci et al., 2018). To measure short term stresses with the use of respiratory information, it is better to look for irregularities within breathing patterns like holding one’s breath. When these irregularities are found, it must be easier to find moments which were stressful for a person. If this methodology would be applied to Fifa, the change of breath rate would be useful in order to see in which played games, the gamer felt stressed. The usage of the irregular pattern would be useful in order to determine crucial moments like a shooting on goal or performing a risky tackle.

Breathing rate can be measured with 3 different technologies. It is possible to use smart textile within a shirt (Leal-Junior et al., 2019). In this sort of shirt, there are electrodes that change resistance when inhaling and exhaling. With this change, a sort of wave will be created which will be the “pattern”. If this wave goes faster or is disrupted, there is an indication of stress. It is also possible to use a PPG device as a measurement device for breath rate (Park and Lee, 2014), as well as an ECG sensor (Charlton et al., 2018; Charlton et al., 2016). The last two methods rely on heart rate measurements which have been altered with algorithms to obtain insight into breath rate.

Blood pressure measurements

This measurement method makes use of changes in blood pressure which occur during stress causing moments (Hjortskov et al., 2004). Blood pressure is said to rise while experiencing stress, due to the heart which starts beating faster. As said before, this is caused by the hormone adrenaline which is released while experiencing stress. There are two types of blood pressure. The first is systolic blood pressure, which is the pressure in the arteries when the heart is pumping, and the diastolic pressure, which is the pressure in the arteries when the heart is resting between beats (Iliades, 2009). By looking at these pressures, it is possible to know how fast the heart is beating. Blood pressure can be measured with two methods. The first makes use of a sphygmomanometer which measures the overall blood pressure and the second makes use of a PPG device which measures switch rate between systolic and diastolic blood pressure.

A sphygmomanometer is mostly used in healthcare to measure blood pressure. This method makes use of information of the pressure of the blood on the arteries in order to gain insight in stress levels. To use the sphygmomanometer, a cuff is placed around the arm and is inflated until blood circulation is cut off. Then, it is slowly deflated until there is a tiny bit of blood coming through during systolic blood pressure. The doctor listens with a stethoscope on the arm to hear when there is systolic or diastolic blood pressure. The blood pressure is different in both pressures, low within diastolic pressure and high in systolic pressure. The numbers on the sphygmomanometer are the indicators of the blood pressure (Yang, 2008). With this method, it is key that, the higher the blood pressure the higher the stress level. However, this method is not handy in order to measure stress, because the arm with which is measured does not get enough blood circulation due to the device. Therefore, it will get numb over time and even cause permanent damage. It is thus not useful for this device to be used on the long term. It is also to be said that when using these devices, a certain skill is required (Vischer and Burkard, 2016).

PPG on the other hand, is a useful device to make use of blood pressure measurements on the long term. A PPG (photoplethysmogram) is an optically obtained plethysmogram which can detect blood volume changes within the body. This method looks at how fast the blood pressure switches between systolic and diastolic pressure in order to gain insight into stress. The faster the switches continuously occur, the higher the stress is experienced. A PPG can come in different kinds and shapes but one that is commonly used is a wristband (Riaz et al., 2019). With a PPG, it is possible to detect systolic and diastolic blood pressure as can be seen in *figure* 4.

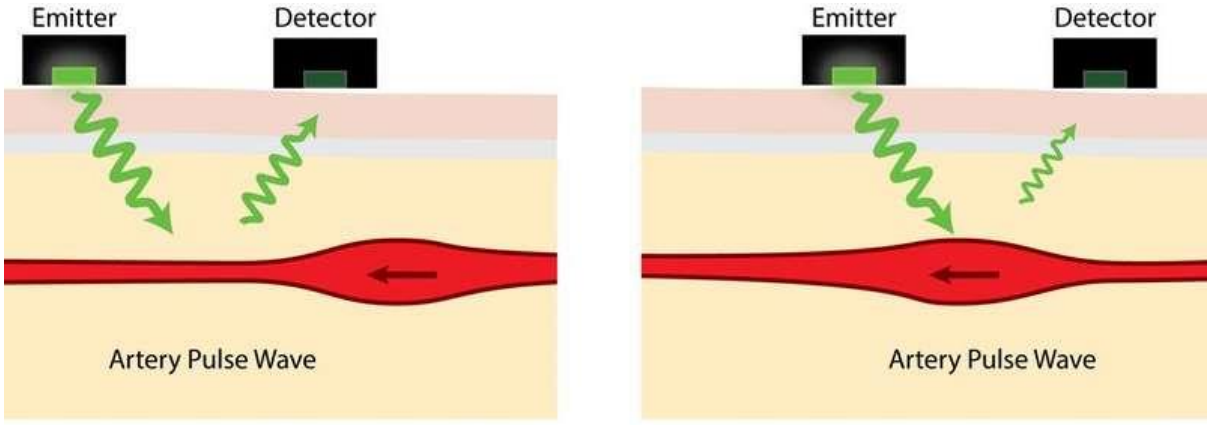

Figure 2.2, Detection of blood pressure through PPG.

When this method would be used for Fifa, it should able to detect whether a game is stressful for the gamer, but it would also be possible to detect acute stress experiences. This last option, however, proves to be more difficult due to the possibility that it will mis read a systolic pressure wave, therefore giving wrong data (Ishikawa et al., 2017).

Facial measurements

This measurement method makes use of changes in the face which occur during stressful moments. Bevilacqua et al. (2018, 2016), Bartlett et al. (1999) and state that stress expresses itself through multiple facial details, for example, blinking, lip deformation, cheek, and head movement. It is needed to say that this detection method is a tricky one. Within the facial expressions, there is no clear guideline on what will change or in what way, except for the fact that stressed people are known to blink more often (Rosenbaum, 2014). In addition, it is known that changes in the face mostly have to do with emotion. A happy person can be seen smiling and an upset person can be seen frowning. As said before, emotions are affected by stress. Therefore, emotions drawn from the face can be an indicator of stress (Daudelin-Peltier et al., 2017). It is to be said that every person can display changes in different features. Therefore, it is hard for a general program to look for stress, in comparison

to personalised programs. It would be advised and useful to cross reference data obtained by the facial measurements with other stress indicators. Thus, with the knowledge of when one's facial expression changes, it is possible to gain insight into stress.
One method to gain insight into stress with facial recognition is described by Dinges et al. (2005). They talk about the use of optical computer recognition algorithm (OCR). This is a piece of software, which is trained to determine changes in the face like movements of the eyebrows and asymmetries in the mouth. This is done by storing all kinds of images and videos of different facial expressions, and then cross referencing those with the live feed. By doing so, it will set a "no stress" set of facial expression, and if those change, it can indicate stress. It is needed to state that to use any of the methods like the OCR method, all need a camera and a processor to obtain and process the data.
Another method used to measure facial movement is the use of facial EMG. In this method, electrodes are placed on the face on places where muscles are located, *see figure 5*. These electrodes will detect electric signals send to these muscles and with that, are able to see what changes in the face (Shapiro et al., 2017). In order to gain insight into stress with the use of facial EMG, there must be looked electrical signals located in the face.
When both methods would be applied to Fifa, they are able to locate specific moments in which one experiences stress. Since it will only check changes in the face which appear in some points in time, it will be hard for this method to see whether or not one is experiencing stress on the long term.

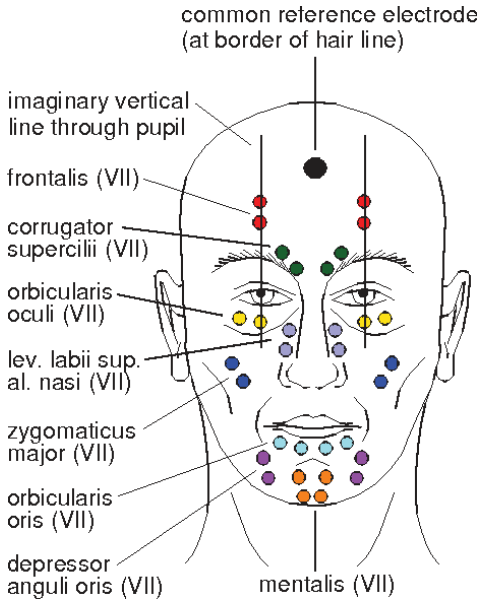

Figure 2.3, Electrode placement for facial EMG

Brain measurements
This measurement method makes use of changes in brain activity. During stress, the brain is said to become more active. This extra brain activity can be measured with the use of two devices. The first is an EEG measuring device and the second is a fNIRS measuring device.

An EEG is a device which can measure electrical activity within the brain (Meyer et al., 2020). When the brain becomes more active, the electoral activity will also increase. Therefore, to gain insight into stress with the help an EEG, it is needed to look at increases of electrical waves. Most EEG devices are not handy when it comes to measuring fast, due to them having to stick lots of electrodes to the head. However, in this paper of Shon et al. (2019), another type of measuring device has been used to measure brain activity. These types of devices are thus much handier if one wants to measure stress without lots of preparations, *see figure 6*.

The fNIRS makes use of near infrared light, which can measure changes in brain activity by looking at blood oxygenation (Maior et al., 2015; Solovey et al., 2009). When brain activity gets higher due to stress causing moments, there will be an increased concentration

of oxyhemoglobin and decreased concentration of deoxyhemoglobin in the prefrontal cortex (Hakimi and Kamaledin, 2018; Schaal et al., 2019). Thus, to gain insight in stress via a fNIRS device, there must be looked at an ascension in blood oxygenation in the brain. Just as most EEG devices, the fNIRS is not practical when there is no time for preparation. In addition, it is not that nice to wear. It is a big cap with lots of sensors, therefore making it uncomfortable to use, *see figure 7.*
When either one of these methods would be applied to Fifa, it is possible to see whether one is stressed during the game, but it is also possible to pinpoint certain stressful moments.

Figure 2.4, EEG measuring device

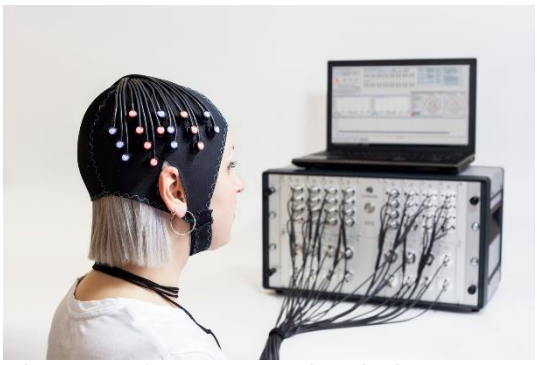

Figure 2.5, fNIRS measuring device

mental measurements (Tilt)
This measuring method makes use of the TILT principal during gaming. Tilt in gaming is the term used if one is “going mad”. Tilting is likely to occur when one is losing a game or is being annoyed by the other. During tilt, a player is likely to scream, forget tactic, button mash, blame equipment and punch the desk. The method used to measure stress is looking how hard and when a button is pressed.

First, Hernandez et al. (2014) say that the pressure put on a button while using a computer, is related to stress. The research of Hernandez et al. is related to the use of a keyboard, but the same principal can also be applied to consoles. It is stated that the harder one presses buttons, the higher the stress is. However, it is to be said that the amount of pressure one puts on a button differs. Therefore, everyone needs to have a proper calibration. Thus, to gain insight in stress with the use of button pressure, there must be looked at higher button pressures.

Next, the amount of times a button is pressed to perform a task goes up when one is experiencing stress. This is a theory not proven yet, however, it is a logical consequence. People tent to act faster due to the experienced stress, therefore, while playing a game, they will keep spamming a button for the wanted action to take place. For example, in Fifa, this could occur when one wants to pass the ball, and this does not happen fast enough. With this measurement method, it would be possible to see if one is experiencing stress in specific moments during the game.

Speech measurements
This measurement method makes use of changes in frequency in speech. When one is stressed, frequencies of the human speech are said to go up (Simantiraki et al., 2016). It is to be said that change in intensity in frequency in the voice does not occur due to stress itself. It is said by Sluijter and van Heuven (1996) and Simantiraki et al. (2016), that the change in intensity occurs due to the increase in physiological efforts, which are also known to cause stress. In addition, the changes in intensity mostly occurred above 0.5kHz (Sluijter and van Heuven). Thus, to gain insight into stress using speech, there must be looked at the intensity of the higher frequencies generated by the voice.

When this method would be applied to FIfa gaming, it would be able to detect when one is experiencing stress, both on the long and short term. However, there is a downside to this method. This method must cope with a lot of noise (Pearsons and Horonjeff, 1982).

When one is gaming in his room for example, maybe their parent call them and the measurements are compromised, or when an eSporter is playing with an audience, then the audience might cause disturbance. This method will therefore require a lot of filtering before it can be properly used. It is to say that there are already methods to filter noise (Pearsons and Horonjeff).

Cortisol measurements

This measurement method makes use of change in cortisol levels. These changes are being measured mostly by medical equipment but there are some cases of wearable measuring equipment (Paralak et al. 2018; Shirtcliff et al., 2015)

Cortisol levels can be measured trough many things like saliva from the mouth, blood, sweat and urine (Holgenelst et al., 2019). All these need to get extracted from a person after or during stressful moments. when the samples that are obtained, they need to be tested in order to see what the cortisol levels are within these samples (Shirtcliff et al., 2015). The cortisol levels in the samples will be high if the person experienced stress, and low if the did not. Thus, to gain insight into stress, high cortisol levels need to be found. It is to say that most of the measurement method that use medical equipment are not useful if one wants to do quick measurements or wants to give live feedback. Therefore, it is not recommended to use medical equipment for stress measurements during gaming. Using a wearable on the other hand would be much better. In the paper of Paralak et al. (2018), they talk of a wearable sensor in order to measure cortisol levels from sweat. However, this sensor is not made into a reality yet, thus not usable, *see figure 8*.

When this method would be applied to Fifa, it is able to detect whether one experienced stress during the game. It will not be able to detect at which points in the game someone experienced stress. However, this would be possible if made use of a wearable sensor.

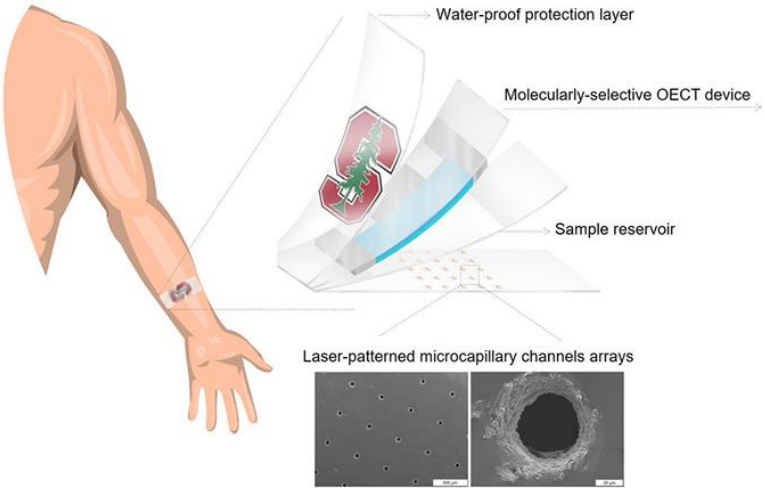

Figure 2.6, possible wearable cortisol measurement device

Skin measurements

This measurement method makes use of the change of skin conductance. While experiencing a stress causing moment, people tend to have more active sweat glands on the hands and feet. These sweat glands will not cause one to sweat as if he/she is doing sports, but they do create a substance on the skin. This substance is what is causing an increase in skin conductance. (Benedek & Kaernback, 2010; Critchley, 2002; Boucsein, 2013). The change in conductance is measured with a galvanic skin response (GSR) sensor. This sensor is mostly located around the hands and often makes use of the middle and index finger; however, it can also be used around the wrist and shoulders.

The GSR sensor works as follows. The GSR applies a constant low voltage to the skin through electrodes. Then, due to the substance created by the sweat glands, measures the amount of variation of conductance of the skin. (Benedek & Kaernback, 2010) The GSR will show a higher output in conductance if more sweat glands are active, and it will show a

lower amplitude in conductance when less sweat glands are active. To gain insight into stress through GSR, it is needed to look at higher amplitudes generated by the GSR, because that will indicate more active sweat glands. In addition, using a GSR around the hand is said to be an accurate measuring method for stress, as it can respond between 1-5 seconds from the stimuli. (Dawson et al., 2007) However, when this would be applied to a gamer, it might become intrusive. Therefore, it might be better to measure GSR on the shoulders, as the shoulder is just as good as a measuring location, but less intrusive (van Dooren et al., 2012).
When this method would be applied to measuring stress within Fifa, it would be a good way of establishing if one is experiencing stress. It is also possible to use this method to determine specific point in the game when the stress is experienced.

Measurement discussion
Within the various kinds of measurement methods, there is not one that can be compared to another. All the methods have their own respective features that could be useful in different kinds of situations. In the table below, some components have been named which could be useful to consider when later using a measurement method in the project. All the measurement methods have been ranked in the table to see in what degree they incorporate these features into their measurement methods.

Table 1, Summary of advantages and disadvantages of measurement methods

	Long term stress	Acute stress	Intrusive	Smart wearable	Extra knowledge needed to setup	Easy to setup	Calibration needed	Direct feedback possible	Hard to measure
Pupil diameter	X					X	X	X	X
Eye fixture	X	X				X	X	X	
Heart rate	X	X	/	/	/	/	X	X	
HRV	X	/	/	/	/	/	X	X	
Breath rate pattern	X		/	/	/	/	X	X	
Blood pressure, constant	X		X		X	/	X	X	
Blood pressure, systolic/diastolic	X	X	/	X		X	X	X	
Facial measurement, camera		X				X	X	X	/
Facial EMG		X	X		X		X	X	/
EEG	X	X	X	X	/	/	X	X	
fNIRS	X		X		X	X	X	X	
Tilt measurement		X				X		X	
Speech measurement	X	X				X	X	X	
Cortisol measurement, indirect	X		/		X	X	X		X
Cortisol measurement, direct	X		/			X	X	X	
GSR	X		/	/	/	X	X	X	

In the table, it is visible that almost all the methods need time to calibrate. In addition, most of them can provide direct feedback if needed. The amount of measures that can work with acute stress is as big as the measures that can work with long term stress and most of these are easy to setup. Some of the measurement methods are intrusive or could be intrusive, and almost all the intrusive measurement methods need some additional knowledge to set up. It is not to say that this additional needed knowledge will make it harder to set up the method. It can be said that all the measurement methods are suited to use in some situations, but not all are suitable for this project.

2.3 Commercial equipment

This part of the State of the Art will be about existing technologies, that are available on the commercial market, which are able to measure previous mentioned stress variables.

Tilt watch

Tilt watch is a piece of software that makes use of heartbeat sensors to give insight into stress to gamers. Tilt uses real-time monitoring of stress levels to raise awareness for the user of his/her mental state. This is said to increase the control over the in-game situation, due to the gamer being able to slow down or speed up game pace. At this moment, it is used by professional gamers, and it is optimised for racing games. Retrieved from https://tilt.watch/faq/.

Hexoskin

Hexoskin is a shirt, in which smart textiles are used to give insight into heartrate, HRV and breath rate, *see figure 9*. There are three ECG sensors of which two are located around the chest, and one at the waist, and there are two breath sensors, of which one at the chest and one at the waist. Hexoskin is available for men, woman and kids. The shirts can be connected to apps on smartwatches and phones and is able to provide real-time information. In addition, it has its own API so people can use the data from the shirt quiet easily. The device is mostly used during physical activity, but it can also serve for other means as the data is accessible. Retrieved from https://www.hexoskin.com/pages/start & https://www.hexoskin.com/pages/health-research.

Figure 2.7, Hexoskin

Smartwatch

Smartwatches make use of PPG and or GSR in order give insight into heartrate, HRV, blood pressure and stress. However, most smartwatches differ and do not all measure and display the same information. Most smartwatches that measure heart rate and breath rate include a PPG in the bottom section, however there are also smartwatches that make use of GSR. The latter type is mostly used to only display stress levels and the first will be able to display information about heart rate, blood pressure and breath rate in addition to the stress. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6164766/.

Empatica E4 Wristband

The Empatica E4 can be said to belong to the smartwatches; however, this device is different from other smartwatches. This device is specifically made to conduct measurements on factors which are related to stress. The E4 has four sensors installed, a PPG to measure heart rate and breath rate, a GSR to measure skin conductivity, an infrared thermopile to measure temperature, and an accelerometer to measure movement. The Empatica will start measuring when turned on and stops when turned off. The time between these two actions will be stored as one measurement file within the wristband. When the wristband is connected to the e4 manager on a PC, it can show the obtained data in

separate graphs. The data is accessible through the manager and can be accessed any time if uploaded. In figure 10. the placement of the Empatica can be seen. The specific placement is used to accurately obtain the needed data. Retrieved from https://www.empatica.com/research/e4/

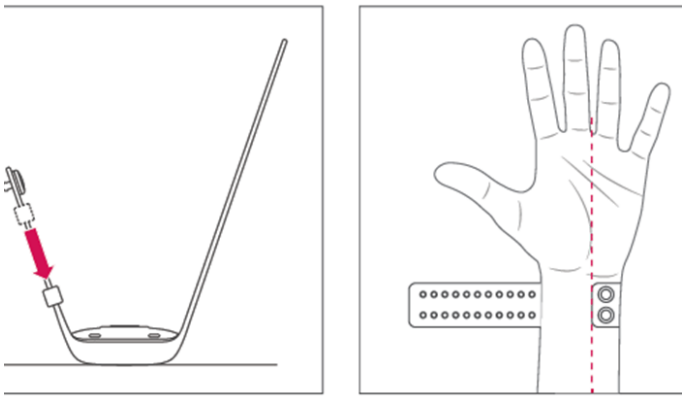

Figure 2.8, Placement of Empatica E4 wristband

Shimmer

A Shimmer is a piece of equipment with which skin conductivity, blood pressure and heart rate can be measured, *see figure 11*. For the Shimmer to measure GSR or ECG, it is possible to use additional kits, which are made especially for the Shimmer, to do so. This device is mostly used for research purposes and only measures raw data. There have already been made algorithms in order to convert the data to what is wanted to measure, however, most of the software that does so, requires the user to pay extra. Retrieved from http://www.shimmersensing.com/.

Figure 2.9, Shimmer placed at wrist

Figure 2.10, Heart rate band

Heartrate band

A heartrate band is a strip which can be attached around the upper body to give insight into heartrate, HRV. The band is made of an elastic band with a small electrode pad that presses against the skin, *see figure 12*. The data that is measured is than transmitted to another device which can process the data. The receiving devices can be smartwatches, computers, or phone. The electrode on the band needs to be moist to work properly. Retrieved from https://arstechnica.com/gadgets/2017/04/how-wearable-heart-rate-monitors-work-and-which-is-best-for-you/.

Raspberry Pi
The Raspberry Pi is a small computer which can be programmed to measure heartbeat, skin conductivity, Blood pressure and Breath rate. The Raspberry Pi is virtually capable of measuring anything. At first, the Raspberry will only measure raw data, but it is also possible to let it refine the data into measures that can immediately be used. It is to say that for the mentioned measures it can do, there are specific hardware kits which have already been developed. Retrieved from https://www.raspberrypi.org/.

Muse
Muse is a device which can be used to give insight into brain activity trough EEG measurements. Muse is a sort of headset that runs from ear to ear via the forehead, *see figure 13*. It has electrodes placed at the forehead and behind the ears to measure brain activity. It is also able to provide information about heart and breath rate through its obtained data. Muse comes with an app which can show the obtained data. The evice is mostly used for meditation purposes. Retrieved from https://choosemuse.com/muse-app/

Figure 2.11, Muse

2.4 Feedback for the player

In this part of the State of the art, there will be talked about known types of feedback. These ideas have been found on sites or are being used in other projects. The types of feedback will be used to gain insight into the different methods of feedback and will later be used as fuel for an ideation to later develop a feedback method/device.

Haptic vibration
Haptic feedback is a way of communicating with the user through touch. This method can be used for stress indication as feedback on measurements. For example, it is possible to let a watch or other object, shake if one is experiencing high levels of stress. It could also be possible to makes something vibrate when one is too relaxed or focused. This feedback could however disturb a player. If one is at a crucial moment in the game and suddenly, the device starts vibrating, it could distract the gamer and lose as the outcome. Retrieved from https://www.ultraleap.com/company/news/blog/what-is-haptic-feedback/

Line graph feedback
This is a style of feedback that can be used during and after the game. It is possible to let the stress levels flow in a graph over time, and with that, show when one experience(s/d) stress. There also lies an opportunity in this way of giving feedback since it is possible to also add key moments on the graph. For Fifa, these moments could be scoring a goal and getting a free kick or penalty. If this would be displayed on the screen while playing, it could give the user insight into their stress during the game, but this must be done in a way that it is not blocking view or distractive. A visual example is given on the site of Tilt watch. Retrieved from the following site: https://tilt.watch/

Stress meter
This feedback would be given during the game. This could be a bar chart or a sort of speed meter, which would increase and decrease together with the stress levels. This could give the player insight during the game and could thereby increase win rate. However, this could be distracting, thus it must be designed in such a way, that it will not distract the user. A visual example is given on the site of Tilt watch. Retrieved from: https://tilt.watch/

Colour feedback
This type of feedback would be using the same principal as the stress meter. This feedback method could use for example a light in a room, or on a wearable to indicate stress to the gamer. This method would use the colour green as a no stress indicator, and red as stress indicator. The gradients between these colours would give a gradient stress indication. However, this type of feedback must cope with colour blindness. Therefore, it might be a bit hard to use in general. An example is given about colour and indication on the following site: https://accessibility.psu.edu/color/colorcoding/

Listed feedback
This type of feedback would be the same as feedback given by Fifa as they show their in-game statistics. After a game, this feedback type would show at what point in time one experienced high levels of stress over an x amount of time. This feedback would be straight forward and easy to interpret, since it would only exist out of number values.

Coach feedback
This feedback would be provided by the coach. In this case, the coach receives the data of the player's stress levels and passes that intel on to the gamer. By doing so, the player is not distracted in any way and should just do what the coach tells him/her to do. It will be an easy system since the player already gets coached during a game.

On screen feedback
This feedback would be provided on the screen during gameplay. The visualisation could be anything going from a line graph to numerical values. This visualisation can provide direct feedback to the gamer and makes sure there is as less delay as possible. The only possible downside to this feedback, is that it could be distractive during gaming.

Feedback discussion
Within the various feedback methods, there is not one that can be compared to the others. The feedback methods all have their own respective features that might be useful in the future of this project. The most notable features that might be needed in the future of this project have been listed in the table below. All the previous named methods have been ranked in the table to see in what degree they incorporate these features into their feedback methods.

Table 2, Summary of advantages and disadvantages of feedback methods

	Distractive during game	Visualisation	Tangible feedback	Wearable feedback device	Live feedback	Afterward feedback	Viewer likability potential	Easy to interpret
Haptic vibration	X		/	X	X			/
Line graph feedback	/	X	/		/	X	X	X
Stress meter	/	X	/		/		X	X
Colour feedback	/	X	X	/	/		/	/
Listed feedback			X			X		X
Coach feedback			X		X	/		X
On screen feedback	X	X	/		X			

In the table above, all the methods can provide tangible feedback. Most of the feedback methods are capable enough to give live feedback; however, not all of those can also provide feedback after a game is played. The interpretation of all the feedback types is easy to some degree but most of them can distract a potential user. In addition, the visualisation types of feedback all have a potential viewer likability. It can be said that all the feedback methods are suited to use in some situations, but not all are suitable for this project.

2.5 eSports measurements

Within eSports, there is not much information about devices that are being used to measure stress. The only device, that could be found, is the Tilt Watch. This device has been discussed earlier. In contrast, there is a lot of information about stress within eSports in general, like what causes stress for eSporters, how do eSporters cope with stress and how does stress affect them. In this part of the State of the Art, those subjects will be discussed.

2.5.1 Stress causes for eSporters

There are many causes of stress for eSporters. In the article of Smith et al. (2019), all the causes of stress for eSporters have been described. In the article they make a distinction between team internal and external stress causes. The internal causes are related to the gaming team and personal issues, and the external causes are related to criticism from fans/opponents and planning issues from events.

Team issues

There are five stress causes described by Smith et al. that fit into this subject. The first is communication problems. This problem is described as a lack of communication or bad communication. The gamers stress due to them not receiving the intel that they should get in order to win the game or due to people not listening to what is said to them. The second stress cause is receiving criticism from the in-game leader and teammates. This cause is about receiving constant criticism from teammates, like being told that you are not good enough to play with them. With that criticism comes a fear of failure, therefore not being able to perform as you used to or should. The third is about a lack of confidence in team members. With this cause, it is said that the gamers have rising stress levels because they think their teammate is not good enough. They will constantly worry about the other and thereby bring down their own performance level. The fourth stress causing factor is “the outcome of losing”. When a team is losing, people often tent to get scarred of losing more, therefore going down a negative stress induced spiral. The last factor is about a lack of shared team goal. This stress causing factor is about the fact that some people feel that others do not strive for the same outcome as they do. eSporters mostly want to win, therefore, it is stressful if it feels like your teammate does not. These feelings mostly result

from team members not taking practise seriously, or if one of the team is goofing off during an important game.

Personal issues
There are two stress causes described by Smith et al. that fit into this subject. The first cause is one of life balance. This factor causes stress due to eSporters not always being able to have a social life and be a professional gamer. It is said that the eSporters have a hard time to deal with this problem, causing them to stress. The second stress factor for eSporters in this subject is the difficulty of managing lifestyle. This factor is mainly about obtaining the sleep, food and activity to stay healthy. eSporters have a busy schedule, therefore it causes them stress when it is not possible to do “the essential tasks”.

Criticism form opponents/fans
There are two stress causes described by Smith et al. that fit into this subject. The first factor to cause stress is the opposition. There are two ways in which the opponents can cause stress for eSporters. The first is the thought of the opponent using “team chat”. If done so, the eSporter is not knowing what they are saying and doing, causing stress. The second is sound made by the opposition. It is stressful if an eSporter loses a game, and it will make it worse if you hear the opponent scream because he/she won. The last factor of this subject is social media. On social media, everyone can say anything about anyone without concequences, even if it hurts someone else. eSporters can get some irritating messages like being told that they are shit at the games they are playing. It is not nice to be called out and this can cause stressful moments.

Event issues
There are three stress causes by Smith et al. that fit into this subject. The first stress causing factor is the audience. The audience themselves do nothing wrong to cause stress. However, it is stressful to play high stake games in front of an audience. The second factor are interviews. Some eSporters do not mind doing interviews, however, there are those that do not like them. Those eSporters are known to get stressed by interviews. Lastly, logistics play a role in stress. Participants identified several stress causing factors related to logistics. One of them being the weird travelling schedules provided by the organisation. Another is that sometimes, there is no possibility to warm-up before a game, and the last is related to the use of equipment which the eSporters themselves have never used.

2.5.2 Stress coping for eSporters

According to the paper of Smith et al., there are five main strategies which are being used by eSporters to cope with stress. These strategies are emotion-focused coping, problem-focused coping, avoidance coping, approach coping and appraisal focused coping.

Emotion-focused coping is a strategy with which the user does extra activities to regulate stress levels, without changing the cause of the stress itself. These extra actions include smoking, comfort eating and vomiting. Most of the extra performed actions have a negative impact on the eSporters, therefore it is not the best coping strategy.
Next, there is problem-focused coping. This refers to the use of short-term or immediate solutions to change the stress levels. For example, cheering someone up after losing a game or providing positive communication from teammates when the eSporter is losing.
Then, there is avoidance coping. eSporters tend to disengage or ignore the stress causes completely. When this is done, it is called avoidance coping. This type of coping includes examples like not wanting to shake hand with opponents which are annoying, not engaging in social media or interviews and playing a game more passive so that they will not die/lose. It is also said that this coping method is bad while playing a game, because during the game, it is needed to fix the stress causing problem. It is said that this will not happen if one is not facing the problem.

Second to last is approach coping. This is a strategy which involves tackling the problem over time and deliberately trying to reduce the stress. An example of this method could be training to handle interviews better, living with your team so that you can handle and understand each other better or training on in-game situations to get familiar with them.

The last method is appraisal-focused coping. With this method, eSporters shift their focus from the “bad things” to the “good things”. For example, when eSporters get critiqued online, they will ignore those criticisms and focus on complements. With this method, eSporters basically ignore stress causes.

2.5.3 Effects of stress on eSporters

During a game of Fifa, an eSporter experiences all different kinds of stress levels. These differing stress levels also come with different performance states. When one experiences high levels of stress, it is said that this person will act different than when he/she experiences low levels of stress.

High stress levels have three major factors which can alter one’s performance. Firstly, stress is known to have an influence on people’s memory (Staal, 2004; Hidalgo et al., 2019) Secondly, stress can cause heavy emotional reactions (Radenbach et al., 2017). Negative emotion coping can lead to tilting. Lastly, within the study of Radenbach et al. (2017) there is shown that stress influences people’s behaviour.

The issue of stress, influencing memory, can be said to have negative impacts on performance. It is said by Pedraza-Ramirez et al. (2020) that not all types of memory affect eSports performance. The types that do impact performance are working memory, inhibitory control within perception, spatial cognition and top-down attention. When these types of memories get impaired, It could for example let a player forget tactics, forget button combinations or forget to use a certain button or forget. When a player forgets these things, it could mean the difference between a win or lose. There is also a minor advantage to the stress. It is said that during stress, the memory stores information better (Staal). Therefore, it must be easier to identify mistakes made during stress in comparison to mistakes made during rest.

The issue of stress, influencing emotional reactions, has a different negative impact on performance (Retrieved from: https://dotesports.com/league-of-legends/news/full-tilt-how-to-work-on-your-mental-game-and-why-its-important-7564). If an eSporter starts to tilt during a game, it is most likely that this person will lose “control” over the game and his/her actions. This means that they will start button mashing, instead of precisely tapping the button. They will lose the ability to communicate properly. It is stated by Karies (2019) that players also lose focus during a game since they are focusing on other insignificant events. On the other side of the spectrum, if one is too relaxed, it might cause the eSporter to lose his/her focus. It might even be possible that the eSporter does not focus on winning the game, but instead he is just playing for fun.

The issue of stress, influencing behaviour, has one mayor impact on the performance of Fifa eSporters. As said before, stress can cause one to go into a state in which they show more habitual behaviour (Radenbach et al.). This can cause a player to completely ignore known tactics to counter the opponent and lose.

In a study, conducted by SciSports, that with real life soccer players, it is possible to see which players has better decision making when subdued to stress (Retrieved from: https://www.scisports.com/study-conducted-by-scisports-and-ku-leuven-selected-for-mit-sloan-sports-analytics-conference/). This shows that not every person is as vulnerable to the negative effects of stress in comparison with others. Since these finding have been performed on real-time soccer players, it might not be a possibility to say that these measurements can also be applied to eSporters. However, in the future, it should be possible to identify which eSporters are more vulnerable to the negative effects of stress than others.

2.6 State of the Art conclusion

There are many ways to measure stress. All of them are useful, however, depending on what is to be measured and in what setting it will be used, some methods are better than others. Since this project will most likely look more at acute stress, a method should be chosen which can measure this stress type. That said, the most promising types of measurable bio signals are heart rate, HRV, blood pressure (systolic/diastolic), Tilt, speech and GSR. However, it is to be said that measurement methods could be combined to create a better suited feedback version for this project.
The measurement method must not impair or annoy the user. Therefore, the feedback method that might be used later can not be highly intrusive and must be easy to setup. The feedback methods also include lots of different possibilities. It is possible for any of the named feedback options to be used during a game. However, some feedback methods are more distracting than other, or need more hardware equipment. The need of any feedback method thus depends on what it will be used for. Since this project will most likely require feedback that is given directly to the user, listing feedback will probably not be used. In addition, the user will probably want to use the obtained measurements and its feedback after the game. Therefore, line graph feedback is one of the most promising types of feedback. However, it is to be said that feedback methods could be combined to create a better suited feedback version for this project.

The information about stress and stress coping will be useful when looking at the changes in stress levels during gaming. For following studies, it might be possible to look more into these problems. For this project it falls outside the scope. The coping mechanisms might be useful for creating the stress feedback device since the named coping mechanisms are indicators of stress subjection.

3. Methods & Techniques

This chapter describes methods and techniques with which help to answers the main and sub research questions of this project. To find these answers, the following tools will be used in chapter 4 – 7.

3.1 General design method

This section of the chapter will contain the method with which a suitable stress measuring device will be created. This plan contains an ideation, specification, realization, and evaluation phase. The use of this design process is created by Mader & Eggink (2014). The diagram to illustrate this process can be seen in *figure* 14

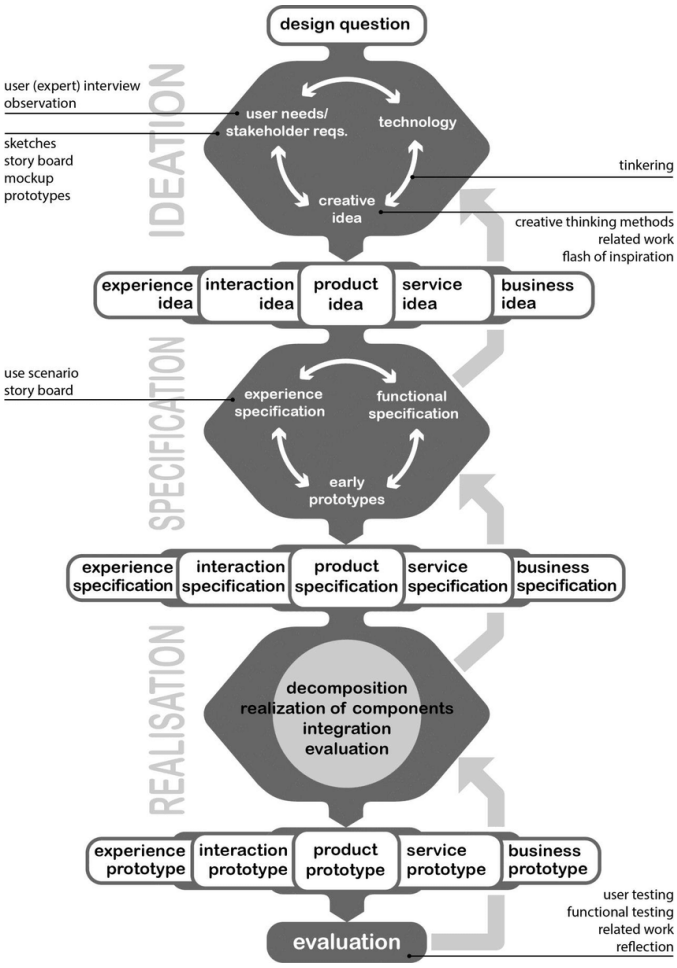

Figure 3.1, Design process by Mader and Eggink

Ideation phase

In the ideation phase, a creative inspiration, a client's desire, or a simple idea is used as the starting point of a project (Mader & Eggink, 2014). Within the ideation, relevant information is acquired from stakeholders. These requirements are used to create an initial design for a prototype.

Specification

In the specification, a final theoretical prototype will be created. The specification will be used to get into a further detail of the functions of the prototype. These details will mainly focus on the technological aspect of the prototype.

Realization
Within the realisation, the prototype is built. The realisation will describe this process and give insight in made choses during the creation of the prototype. The prototype will be build based on the information provided in the specification.

Evaluation
In this section of the project, the prototype will be evaluated. In the evaluation there will be looked at the flow of the project as a whole and what could have been improved. In addition, there will be looked at the performance of the prototype and the feasibility of future improvement.

3.2 Stakeholder profile and usage context

To create a device which will satisfy all users, one must take the stakeholders into account while developing. The stakeholders are the ones who have an interested in the developed project and benefit from its creation. Not all stakeholders have the same influence on the project. Clients for example, will be able to change the project more than others however end users can decide whether the created product will be successful or not (Nguyen & Mohamed, 2018). The stakeholders can be divided into four different categories. These categories are user, decision maker, support, and potential stakeholder. **Users** are the people who will eventually use the product. **Decision makers** are the people who will benefit from the project and are closely involved. **Support stakeholders** are the people involved in the and aid the project. **Potential stakeholders** are the people who might not directly benefit from this product; however, they might be able to use it in the future.

As said, stakeholders have influence in what kind of direction a project will go. Therefore, it is needed to identify the stakeholders and see in what degree their interests should be satisfied. This can be done by categorizing the stakeholders into four categories (Sharp et al., 1999).
These categories are based on the power of the stakeholder and the interest of the stakeholder. Stakeholders with high power are the ones that can make or break a project; therefore, those stakeholders are the ones that need to be satisfied most. People with high interested are the ones that are most likely to help and or benefit from the project. These stakeholders are the ones that are likely to help you and would like to be kept close to what is being done. These two factors will be scaled out against one another and this will give a matrix as shown in *figure 15* (Bryson, 2004)

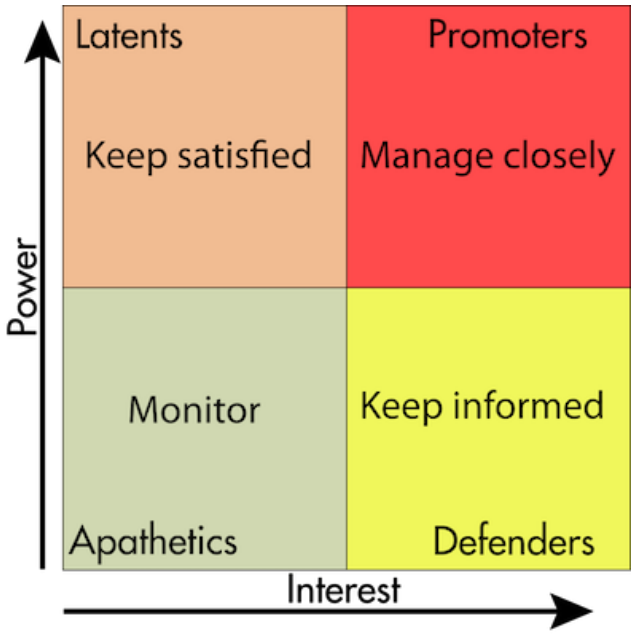

Figure 3.2, Power vs Interest matrix

When the stakeholders for this project are determined, they will be placed into this matrix to see which stakeholders' opinion should outweigh others.

When the stakeholders and their influence levels are known, there will be looked at the interaction of the stakeholders with the potential device. Each stakeholder will be individually listed, and a description will be made about their interaction with the device.

3.3 Brainstorm

A brainstorm is a method which is used to generate ideas. During a brainstorm, there is an open discussion in which any participant can say what he/she wants without receiving criticism. The generated ideas will not be analysed during the brainstorm since this can distort the creativity of the process. There are several techniques used for brainstorming (Retrieved from https://www.lucidchart.com/blog/13-effective-brainstorming-techniques)

Listing

Listing is technique which is used to generate a lot of ideas. With this method, the participants all write down their ideas about the matter on a piece of paper. The ideas can be made as weird as they want since there is no judgement involved in this session. In this session, participants can see what others wrote down and are therefore influenced by other participators.

Round robin

In this brainstorm style, much like with listing, the participants write down their ideas about a certain topic. These ideas will, unlike with listing, be shared to others by speaking about them to the other participants. All participants are given the same amount of time to share their ideas with the others. This type of brainstorming makes sure that participants can not influence others and their ideas.

Free form

In this type of brainstorming, all participants write down their ideas or answers to a problem. After all the participants have enough ideas, they share their vision with the others. The participants will then come together and work with each other to generate a list with the best ideas.

Gap filling
With this technique, you present the current state and the wanted state. The participants then come up with solutions to reach the wanted state. This is done by discussing the subjects and elaborating on ideas generated.

This project will make use of the gap filling brainstorm technique. The brainstorm session will feature members of the project group working on eSports performance. In the session, the problem is stated to the other members. Then, everyone will think of his/her own solution/idea to this subject. These ideas are shared with others, and later the best idea will be decided upon.

3.4 Interviews

To gain the opinion of the stakeholders about the initial idea created by the brainstorm and stakeholder analysis, interviews will be conducted. There are three different types of interviews that can be used: unstructured interviews, semi-structured interview, and structured interviews (Rose, 1994).

Structured interview: In a structured interview, the interviewer prepares all his/her questions on forehand. The questions asked during the do not diverge from these prepared questions. It can be said that this type of interview limits the amount of information that can be gathered since there will not be elaborated on any interesting extra topics.

Semi-structured interview: In a semi-structured interview, the interviewer prepares a set of questions/topics which will be discussed during the interview. The interviewer can ask additional questions to the interviewee to clarify answers. In addition, the interviewee can also go into further detail on certain topics if wanted/needed. It is imperative in this type of interview that the interviewer keeps the interview close to the topics.

Unstructured interview: This type of interview requires the interviewer to not prepare any questions ahead of the interview. It allows the interview to follow its own path and is not limited by any regulations.

For this project, a semi-structured interview will be used. This type of interview is chosen since this will give the possibility for the interviewees to contribute extra insight into the prototype. This style will generate better options and possibilities to generate the best possible outcome for this project.

3.5 IPACT analysis

IPACT stands for intentions, people, activities, context, and technology. The IPACT analysis is a method which is used by creators to understand the context in which their device will be used, and who the users are (Reinius, 2011). All the terms used in IPACT have their own addition in the analysis. The intention is used to make the goal of the product clear. The people are used to foresee possible users of the product and are illustrated by personas. In these personas, the people's physique, habits, lifestyle, likes, and dislikes are described. The activities describe in which way the users will interact with the product. This will provide insight of how to design the interaction, response times and sturdiness of the prototype. The context provides information about the environment in which it is being used, focussing on physical and social environment. Last, the technology describes involved technologies of the project. The technology can be divided into four categories: communication, content, input, and output. In addition, this project will also add a category "other technologies".

3.6 Requirements analysis

Within the ideation and specification phase of this project, requirements for the final prototype will be made. These requirements will not be equal in necessity; therefore, the requirements will be prioritized. The ranking will be done with the use of a MoSCoW analysis and will be divided by branding them functional and non-functional requirements.

MoSCoW

The Moscow analysis is used to rank requirements into four different sections: must have, should have, could have, and won't have. The **must have** requirements are those that need to be implemented into the project to make it succeed. If the product of the project does not meet these requirements, it is not performed to the best extend. The **should have** requirements are requirements that would be useful to include, but are not essential to the project. Without these requirements the prototype can still function but is not performing at its best. The **could have** requirements are the requirements that could be included into the project, but have less priority than the should have requirements. It would not matter if the could have requirements are not included, but it would be nice to do so. The **won't have** requirements are the requirements that could have been implemented into the project, but are too hard to achieve or are unrealistic in the given timeframe. The won't haves are used as a recommendation for future work (Browserlondon.com, 2019).

Functional and non-functional requirements

The requirements can be divided into two categories: functional and non-functional requirements (Sqa.org.uk, 2007). The two categories describe to what extend the requirement applies to what part of the project. Functional requirements are the requirements that have to do with system specifications. Non-functional requirements are constraints or demands at which the system must comply. For example, a functional requirement could be that the system must not be taller than 1 meter, and a non-functional requirement could be that the system must be easy to travel with.

3.7 FICS analysis

A FICS analysis is a way of visualizing a usage scenario from a systems perspective instead of a user perspective like the IPACT analysis did. The meaning of FICS is as follows: F stands for **function and events**; this describes how the system behaves and how it reacts to change. I stand for **interaction and usability**; this describes how the user is aided by the system when carrying out an activity. C stand for **content and structure**; it describes how the system stores obtained data and how this data is accessed. The S stands for **style and aesthetics**; It describes the visuals and feelings which are experienced with the system (Larburu et al., 2013).

3.8 Cognitive walkthrough

A cognitive walkthrough is a technique which is used to make the understanding of a system easier. The technique will be used to explain the data processing of the system. Since there are four data streams in this project, all four of these will get their own explanation and get connected in the end. After this walkthrough has been done, it will leave the reader with a better understanding of the system. In addition, the walkthrough will be a building block for the following activity diagram since it helps to indicate the major processes (Wilson, 2014).

3.9 Activity diagram

An activity diagram is a diagram in which the interaction between the system and the user are shown. The interaction is split in two activities of which inside is the user's activity, and the other is the systems activity. At the beginning of the activity diagram, a circle is placed. This circle will be the indication of the starting activity. Diamonds will indicate a point in which

a decision is made, a black bar indicates the start of parallel activities and the end point is indicated by the starting circle with a bigger circle surrounding it (Visual-paradigm.com, 2020).

3.10 Evaluation

The generated idea will be evaluated with the use of three methods, a functional test, an usability test and a validity test. The functionality test will simply be done with the use of a check list. This checklist will consist of the functional requirements, set within the specification phase.

The usability test will be conducted in an unconventional way. Due to corona, it is hard to get actual user input about the handling of the device. The usability test will therefore consist of me filming myself while setting up and using the ideated device. The video will be sent to the eSporters of FC Twente so they can form an opinion of the usage and outcome. Then, an interview will be conducted with all of them to see what their opinions on the idea are. In addition, the requirements will be labelled within these two tests to make sure that in later conclusions and evaluation, it is easier to refer to specific requirements.

The validity test will be conducted to see if the device has actual potential for the future and if it works at all. The test will work as follows. I, Sam Drijfhout, will measure my own stress levels with the prototype and Empatica while playing nine games of Fifa against the AI. The games will vary in difficulty but will always be played with the same teams, tactics, formation, and players to ensure the least number of variables. The games will not be played online since this will create different extra variables which make it harder to draw conclusions from the data. If a game ends in a draw, the game will stop, and no penalties or golden goal function will be used.

In a real game these extra variables would be there. However, without initial knowledge, these variables would take the research to far into the unknown, therefore creating a non-valid outcome. These games will be played over the course of three days on the same time. The first at 10 am, the second at 12pm and the last 4pm. The difficulty will differ on each time schedule. The schedule will look as follows.

Table 3, Schedule for testing

	Day one	**Day two**	**Day three**
10 am	Amateur	Legendary	Pro
12 pm	Pro	Amateur	Legendary
4 pm	Legendary	Pro	Amateur

4. Ideation

This chapter will cover the ideation phase of the project. The ideation will include the process of creating a concept for the stress measuring device and for the method with which the feedback will be provided. The ideation phase will start with a stakeholder analysis to find some early requirements. A brainstorm session will be conducted to create an initial prototype design after which interviews will follow. The interviews are used to improve the first idea and add additional requirements to the prototype. After the interviews, a final concept is generated which will be subjected to an IPACT analysis to gain a better understanding of the concept and the requirements. After the IPACT, a list of requirements will be drafted for the specification that will follow. This chapter will be a starting point to answer two research sub-questions:

"How can insight in stress levels be obtained?"

"How can stress levels be translated into informative feedback?"

4.1 Stakeholder analysis

The stakeholder analysis will be performed as described in chapter 3.2, To start of the analysis, a list of stakeholders must be made. The stakeholders will be put in a table which will include their role in the project and their relation to the project, *see table 4.*

Table 4, Stakeholders, and their roles

Stakeholder	Role	Relation
eSporters	User	The eSporters are the main user for this product since it is aimed at raising their skill level
eSports coaches	User	The coaches work closely with the eSporters and will make use of the information given by the device
eDivisie clubs (FC Twente & Heracles)	Decision maker and Support	The clubs want their eSporters to get better and work with the University to do so.
Other games	Potential stakeholder	This project will focus itself on Fifa eSporters. However, the outcome of the project is also applicable to eSporters playing other games.
Media organisations (Dreamhack & eDivisie)	Potential stakeholder	Stress measurements are not directly linked with media. However, with information about stress, it is possible to create visual information about the gamers which can entertain the viewers.
University of Twente/Guido Bruinsma	Decision maker and Support	Guido and the University are the initiators of the project. They help the

		project by providing information and resources and will gain from the knowledge coming fourth of it. A time frame for the project is also set by this stakeholder.
Team Guillit	Decision maker and Support	Team Guillit is a company which trains eSporters. With this system, they might be able to train their eSporters to reach higher levels.

Now that the stakeholders are known, they must be ranked according to their influence. This will be done with the method described in the previous chapter. To put it simple, decision makers will have will be ones with high power, support must have a high interest in the project and user influence depends on the user. When all these factors are known, the influence factor graph will go as follows, *see figure 16.*

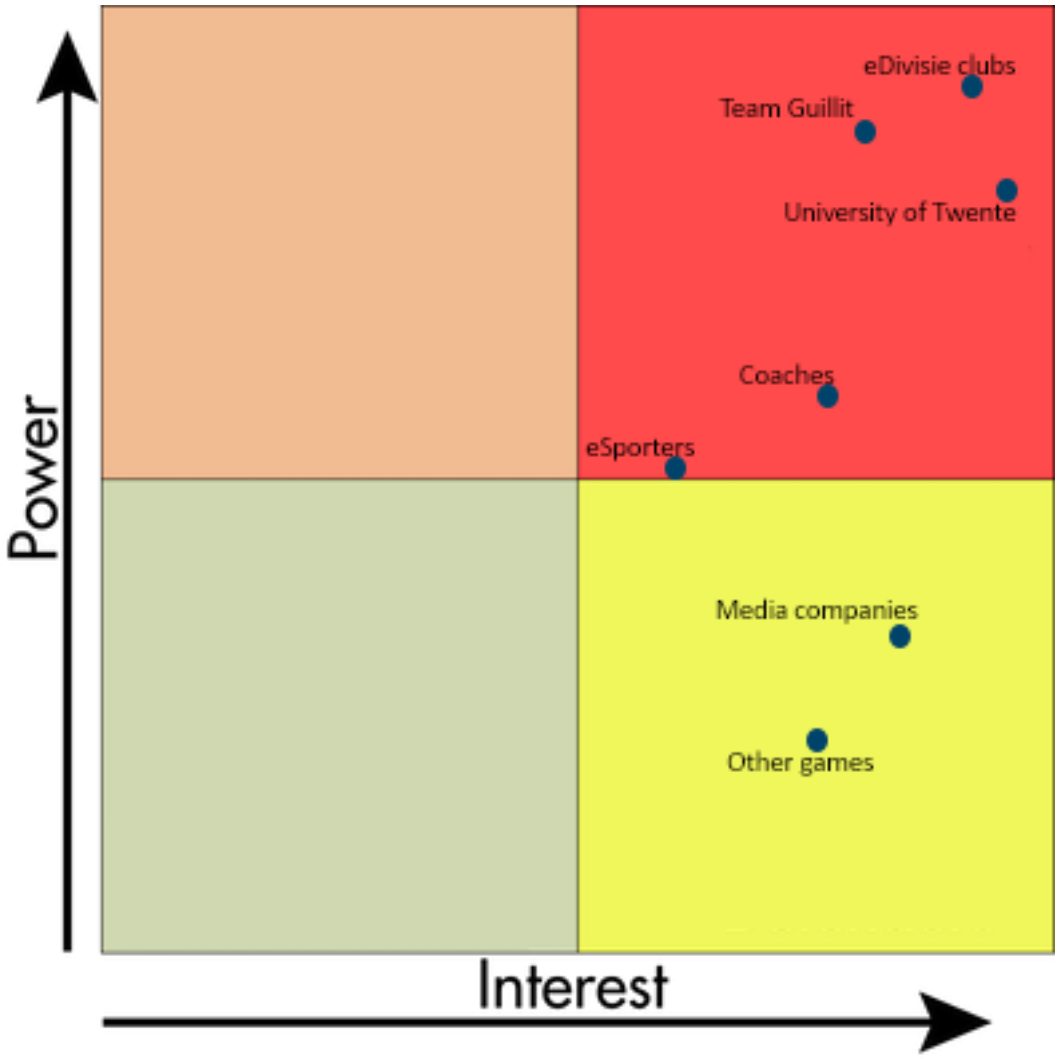

Figure 4.1, Graph of influence of the stakeholders

Now that the influence ranking has been conducted. Some information and possible requirements of the stakeholders are generated. This is done by going into further detail for each stakeholder as stated in chapter 3.2. In this section, only the requirements coming from each stakeholder will be mentioned. In appendix A, the thought process -of which these requirements come from- is noted. The process has been put in an appendix since it is elaborate and would not have additional value to the actual design. However, to leave it completely out of the report would create content without meaning.

eDivisie clubs

- The needs of the eSporters and coaches are high priority for this stakeholder
- Low calibration time needed
- Not that precise feedback but it must be truthful
- No size or equipment limit
- Low cost

Team Gullit

- The needs of the eSporters and coaches are high priority for this stakeholder
- Low calibration time needed
- Not that precise feedback but it must be truthful
- No size or equipment limit
- Low cost

eSporters

- Easy to setup
- Not intrusive
- Short calibration time
- Feedback easy and quick to understand
- Not distractive
- Not too much detail during game, indicate large stress moments
- Easy to transport
- No sound measurement

eSporter coaches

- Easy to setup
- Not intrusive
- Detailed measurements possible
- Easy to transport
- Detailed feedback which is accessible after the games
- Detailed or none detailed live feedback
- No sound measurement

University of Twente/Guido Bruinsma

- Truthful reasoning and information

Media organisations

- eSporter’s and coach’s needs are important
- No high costs
- Need visualisation
- Easy convertible feedback
- No sound measurements

Other games

- No Fifa specific data

4.2 First ideation cycle

Now that all the stakeholders and some of their demands are known, it is possible to start generating a concept. This concept is generated throughout a brainstorm session as described in chapter 3.3. The brainstorm session was conducted in a bit of an unorthodox way. The four project participants met via Google Hangout. During the call, the problem and some demands generated in the stakeholder analysis were stated. If any of the named ideas collided with other demands that were not mentioned yet, those demands would be named and implemented in the idea. No time limitations were set for the conduction of the brainstorm session.

After the conducted brainstorm, a concept was generated. The first design of the measurement device would consist of four different “stress sensors”. A GSR located at the shoulder, a heartbeat sensor located at the chest and belly, an eye/facial tracker, and a tilt measurement. The first two sensors will be located on the body using electrodes. These electrodes will be connected to a computer which will be located near the chair. This computer could be a Raspberry Pi and or Arduino. The electrodes are connected through wires since this will give the best measuring outcome. *See figure 17.*

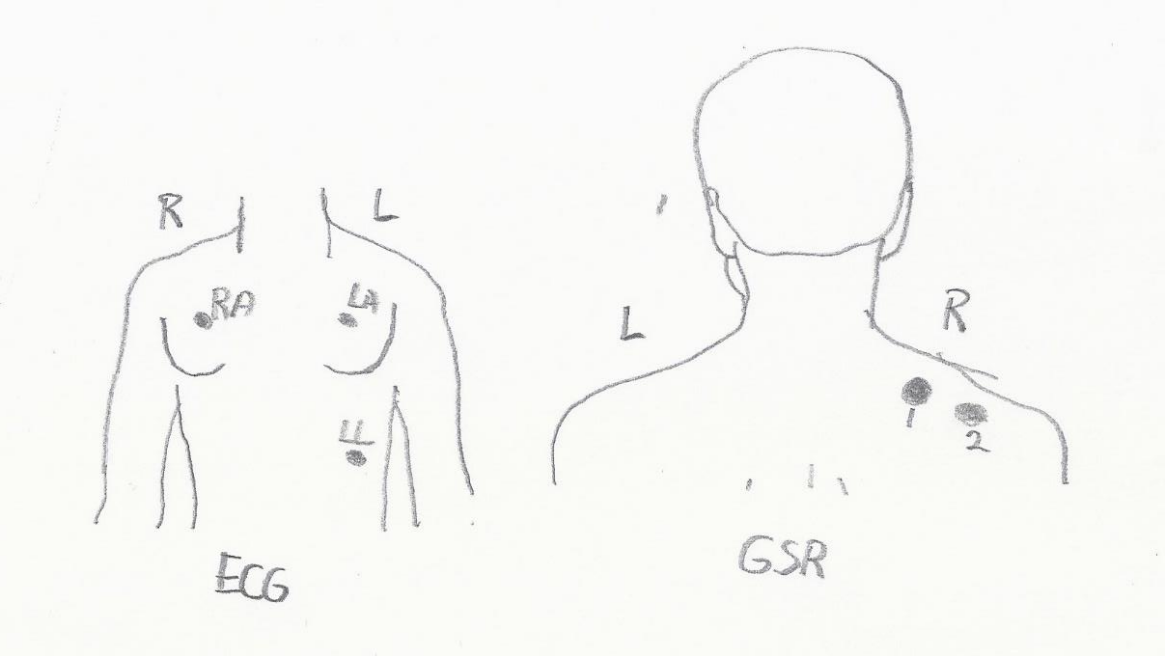

Figure 4.2, Drawing of placement of electrodes for ECG and GSR

It is to be said that the electrodes used for the ECG measurements are placed through the three-electrode system (Cadogan, 2019). The electrodes placed for the GSR measurement have been placed on the shoulders. This is a valid way to measure GSR according to Roth et al (2012) and van Dooren & de Vries (2012). The electrodes can be put in place without the initial use of wires. The wires can be attached later so the gamer can attach and detach him/herself at any given time. The eye/facial tracker will be located near the screen. The data will be collected through a webcam which will be aimed at the gamer. The tilt measurement will be conducted via the controller. The controller will be connected to the same computer as the heartbeat sensor and GSR. This will also be done via cable since this will provide the least amount of delay during gameplay. For the whole setup, *see figure 18.*

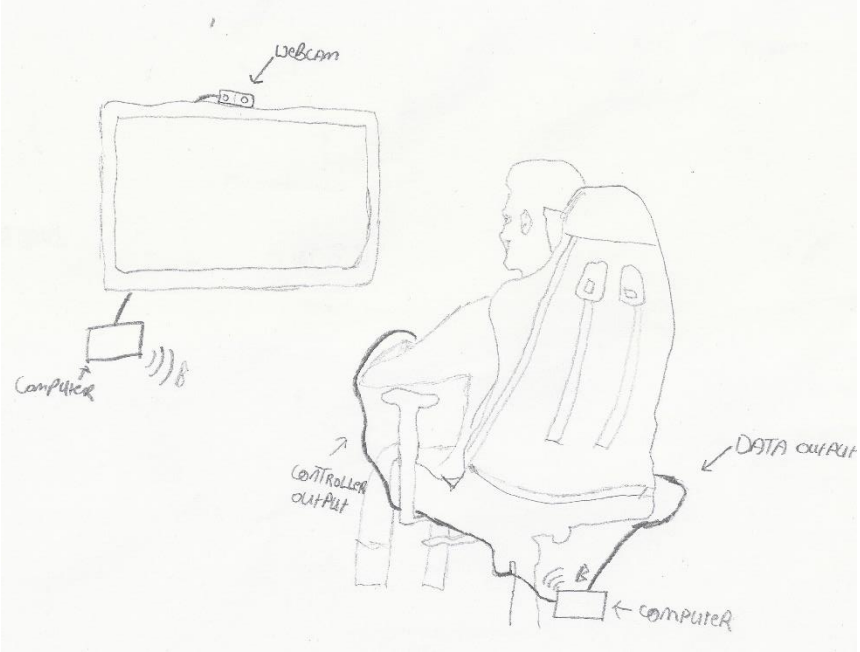

Figure 4.3, Drawing to illustrate a potential setup

Since the webcam can be placed far away from the gamer (where the other measurements are being conducted), two ways of getting webcam data from the screen to the other measurements have been made. The first is by letting a wire from the computer run to the webcam to have an immediate connection. The second method makes use of a second computer that is linked through Bluetooth with the other computer. The last option will combine the data at one of two computers and give an output. For this ideation, the second option has been chosen since it gives more mobility and less intrusiveness during the gameplay. However, in the project it will take too much time to build this setup. Therefore, all the sensors will be connected to one single computer. This is done to create a proof of concept. This proof of concept will be sufficient to show that the measuring method works and that it is possible to create the final design.

The controller, with which tilt measurements will be conducted, will be connected to the computer via a wire. It will use a standard micro-usb to usb cable. To note, is that with the use of this cable, it might provide an issue while conducting measurements during tournaments. With this controller-computer connection, it is also possible to download emulators/cheats which will improve one's performance in an unfair manner. Therefore, there must be looked at a way to prevent issues with competitive organisations with the use of this device.

The reason for not picking other measurement methods within the first design is because those would be more intrusive or expensive. The fNIRS and EEG measurements would require headgear which will be expensive and or intrusive. The PPG will most likely be located around the wrist. Since an eSporter uses its hands and wrists the most, this was not

an option. Breath measurements were taken out since it would give somewhat of the same outcome as heart rate measurements, only less precise, and cortisol measurements are not a real thing when it comes to real time measurements.

For the feedback device, two designs will be made in the first design iteration. The first of these two designs will be an on-screen feature which will be visible for both the coach and the eSporter during gameplay, and the second will be a visualisation that can be made for just the coach. The on-screen feature will consist of four bar charts. These bars will all show the four different measurements conducted by the sensors. If one of the sensors measures higher stress levels, the designated bar will become bigger. In addition, when perceived stress is higher, the bars will turn red and if the perceived stress is low, the bars will be green. To indicate which bars will show which feature, there will be names given to them underneath the bar, *see figure 19.*

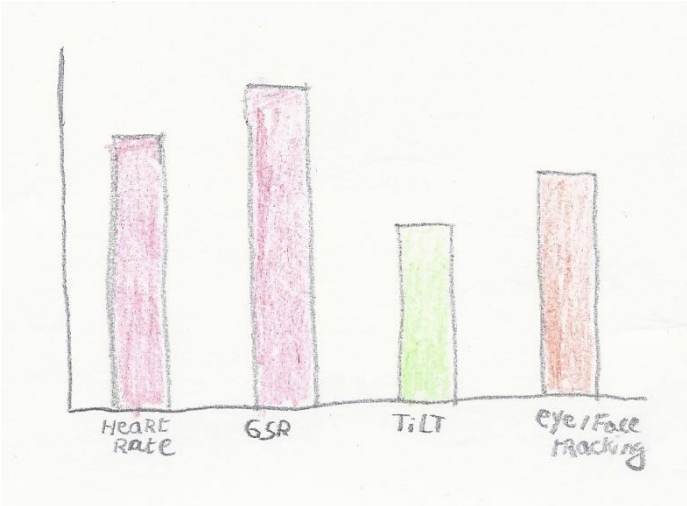

Figure 4.4, Drawing of a potential bar chart

This feedback method would come with a small description which the players and coaches will receive to understand the feedback. The bar chart can be placed anywhere on the screen; however, preference lies at the bottom, *see figure 20.*

Figure 4.5, Placement of the graphical feedback on screen

For the second design, there is an idea to let the feedback come to the eSporter trough a coach. The feedback of the eSporters stress levels would be provided via a tablet or other display which can be held by the coach. The display would show a line graph. This line graph will show all four measures just as the other design does. In addition, with this feedback, it is possible to use the data for an extended period. Since the coaches are not playing themselves, it is possible for them to check up on earlier obtained data. This might give the coaches more insight into what the player is experiencing. The four different measures will all get their respective colour coding. When the lines of the measures go up, stress is being perceived by the sensor. To use this style of feedback without help from a nonplayer would be hard since line graphs cannot be interpreted within small periods of time, *see figure 21.*

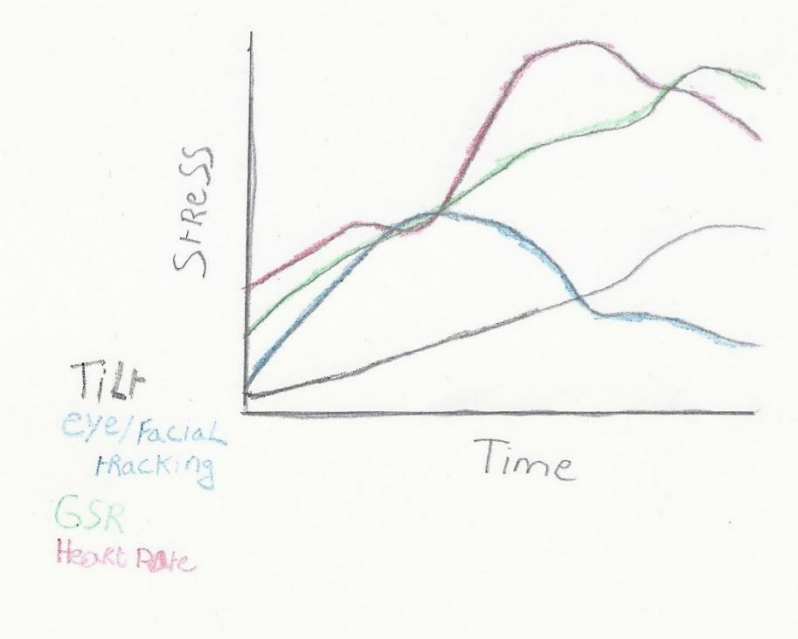

Figure 4.6, Drawing of a potential line graph

To say, this feedback will have to make use of an additional screen which is controlled by the coach. It is also possible to add extra features to this feedback method to make it more complicated but practical. A coach might want to zoom in on specific points in time, so a zoom in function can be added. A coach might want to translate the data into other types of visualisations or maybe even numerical feedback. This will be possible with the use of this feedback method.

The reason for not picking other feedback methods is because it is thought that these methods have a slight advantage over other feedback. In the first method, a stress meter is used in combination with on screen feedback and colour feedback. In the second method, line graph feedback is used in combination with coaching feedback.

4.3 First semi-structured interview

Now that the first design iteration is complete, feedback from the stakeholders must be provided. Since a lot of different people are involved in the project, it will be hard to conduct interviews with all of them. Therefore, a semi-structured interview (chapter 3.4) is done with just the eSporters of FC Twente. The eSporters of FC Twente -there are three- have been chosen since they are the actual end-users and their requirements have high priority to almost all stakeholders. From the given answers, improvements for the idea can be generated, which will lead to a second or final design iteration. *See appendix B.*

INTERVIEW OUTCOME

From the interview, a few things were made clear. The first and most notable was that all eSporters do not think that feedback given to them directly on the playing screen is useful. It was said that this feedback will possibly distract them or give them extra stress. In addition, one noted that due to the concentration while playing, it is possible that he would not use the indicator, therefore rendering it useless. The feedback given in the form of a line graph with all factors being separated was a good idea in their opinion. The eSporters stated that it is an easy and familiar way of displaying information. In addition, the eSporters said that if the data will become too simple, it will not be possible to extract much useful information from the feedback.

The eSporters were enthusiastic about the feedback method provided to the coach. To add, it would be especially useful during eDivisie matches since at those matches, the players only focus on the game and nothing else. The coaches could use the feedback to get the eSporter out of their focus if they are stressing too much, therefore improving their mental state for the better. However, it was noted by one of the eSporters that this way of feedback would be hard to use during training, since they would do so alone at home. Therefore, the feedback should be usable at home. This requirement will also be added to the requirement list. This can be done with for example a light that changes colour or a small addition to the second screen which is easy to interpret. In addition, one noted that it might be useful to add a small and simple stress indicator to both feedback designs. This simpler indicator would create a quick way to see one's stress status.

The eSporters indicated that when using the second design, it could be possible to add extra features to the stress indication. These features could be indicators of why the stress occurred, like goal related activities. One even noted that he would like to see who has ball possession on which part of the playing field. He said that this feature might be able to indicate where he could improve in performance.

For the measurement method, the eSporters agreed with the idea. They did state some tips which could make it easier to use. For the webcam part of the sensor, there were no remarks since it should not disturb the eSporters at all. The wire which would obtain the controller output could use some improvement since it might distract the eSporters. It was stated that the wire could touch their hands and therefore distract them. To counter this, two stated that if the part of the wire that was closest to the controller is made hard/not flexible, the wire should not be able to touch their hands. The fact that the controller would be attached to the chair is no issue for the eSporters.

The most tips/improvements could be made with the electrodes. It is to say that all eSporters thought that the electrodes will not bother them during gaming. However, they also stated that the connection of the device should be made as easy as possible. An idea should be generated with which it is possible to confirm that the electrodes are placed correctly and with which it is easy to connect these electrodes to the computer located underneath the chair.

4.4 Second ideation cycle

Within this ideation phase, the concept will not drastically change in comparison to the first phase. It will only add upon the first ideation. The choice has been made to continue with only one feedback style. This style will be the line graph placed upon the extra display. The other feedback method has been discarded because eSporters thought that it would not be the best possible solution. In this ideation phase and the next, not the whole concept will be repeated and described. The new ideation phases will only describe changes made to the existing concept.

The first thing that should be added to the initial design of the measuring device is a way to make sure that the wire does not touch the hands. The problem of the controller touching the hand can be solved with the use of a hardened cable or cable hardener. This will make sure that the part of the cable closest to the controller does not immediately go down due to gravity. For this design, the option of a cable hardener will be picked since this can easily be made with the use of a 3d printer. The hardener will be detachable and attachable since it will make it easier to store the cable.

The second change that is made to the concept is the setup of the electrodes. The eSporters told that it would be better if the electrode placement could be done easier. To do so, two additional options have been thought of. First, since there will be made use of a second display for the feedback, it is possible to add extra information on this screen. To make sure that the users know where to place the electrodes, two pictures will be shown in small with information about the electrodes. These images will be clickable so that when needed, they can be enlarged, and when not needed, they do not bother the user. With this clickability comes another addition since there will be a need of an interactive screen instead of a simple display. Since a mouse would cause extra hardware for the product, a touchscreen will be used. The second addition will be an easy way to attach the electrodes to the computer. This will be done with the use of a plug which in one instant connects all wires of the lose electrodes to the computer. This will be useful since the user is then able to easily connect and disconnect himself from the installation without taking of all the electrodes or unplugging all electrodes apart from one another.

Lastly, there is one feature that should be added to the second feedback method. This is a manner to use the feedback at home/without additional help from others. This feature has been requested by one of the eSporters since it would be hard to use a line graph and play a game at the same time. To do so, there will be an extra easier visualisation which indicates stress placed on the second screen. This visualisation will be a stress meter. This stress meter will work as a speed meter like in a car. When the stress levels go up, so does the stress meter. In addition, the colour of the stress meter will change identically. When the stress is high, the meter will turn red, when the stress is low, it will turn green. It will not show separate readings as the line graph does, and after the game is done, one can use the line graph to look back at stressful moments during the game. In the interviews, it was noted that the eSporters would like to see additional information besides the stress data to clarify the stressors. Specific moments named by the eSporters included ball possession, ball position and shooting position. These factors can be implemented in the feedback; however, it does not lie within the scope of the project. Therefore, the display is designed such that there is still a small space left to display crucial information, *see figure 22.*

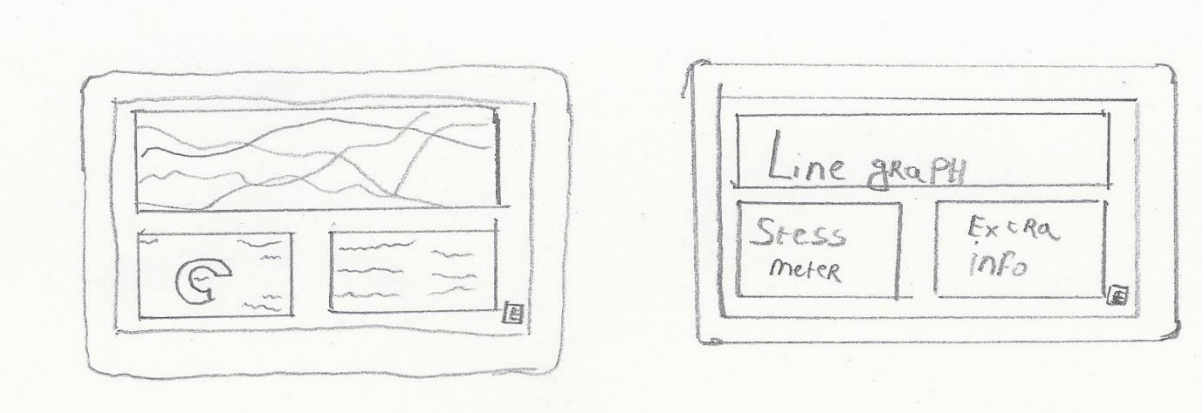

Figure 4.7, Design of the feedback display

In the initial design, the display is connected wireless to the computer placed near the gaming chair. However, in the prototype created in this project, the screen will be connected with wires to the one available computer. This again will be a proof of concept created to show that the idea works. In addition to the extra visuals, a stand will be made to put the feedback display on. This will make sure that the extra display can be put next to the playing screen and is therefore visible. This display stand does not have to be big and can be 3d printed.

4.5 Second semi-structured interview

With the given answers in this interview session, improvements for the idea can be generated, which will lead to a third or final design iteration. *See appendix C.*

INTERVIEW OUTCOME

From the interview, a couple of things were noted. It is to say that all the eSporters liked the idea. Nothing that was presented had a downside at this point in the project. One did note that there might be a downside within the idea, however it might only come forward if it were to be user tested.

One of the interviewees talked about the display. He noted that when the display is used at home, one can sit quite far away from the actual gaming screen. Since the display will be put next to the gaming screen during a game of Fifa, it was noted that the screen should not be too small. It was noted that the display should be around tablet size. In addition, one told that it would be nice if the display stand would be customisable. Since the stand will be made with the use of 3d printing, it is possible to do so. Another of the interviewees said that it might be useful to make the stand in such a way that the angle of the display could be adjusted. This was said because the sun might get annoying while gaming. Since this issue is uncommon, and the stand would get complicated to build and design, this request will not be added to the design. Another statement was made about the cable hardener. One of the interviewees noted that the extra piece of plastic should not become to big or heavy since this might impair the performance of the eSporters.

The interviewees also had an idea to improve the feedback device in a way that was not yet considered. This idea goes beyond the scope of the project so it will not get included in all further phases of this paper except for the final ideation phase. During the interviews, the use of an interface came forward. This interface would become a way in which one can easily guide him/herself through all the different types of data. One noted that it would be nice to be able to, for example, have different tabs which could guide one to different kinds of information. One tab could be about current measurements (which was seen in the second ideation phase), another could be a storage to watch back stress levels from previous played games and another could be about a sum up of these played games and show stress average stresses over all these games etc.

4.6 Final ideation cycle

This ideation phase will not drastically change any of the ideas generated in previous ideation phases. It will only add upon the previous ideations and add some extra details to them. This phase of the chapter will not repeat the complete description as these have been provided in previous phases.

In addition to the design of the second ideation phase, a couple restrictions are being added to the idea. The screen will get a size indication so that it is known how big it should be. The size of the display must be as big as an average tablet. The cable hardener will be made relatively small and light weight. If this cannot be done, the hardener must be redesigned or not used at all.

The interviewees said that there might be a need for an interface which is able to let the user guide through the data much more efficient and logically, *see figure 23.*

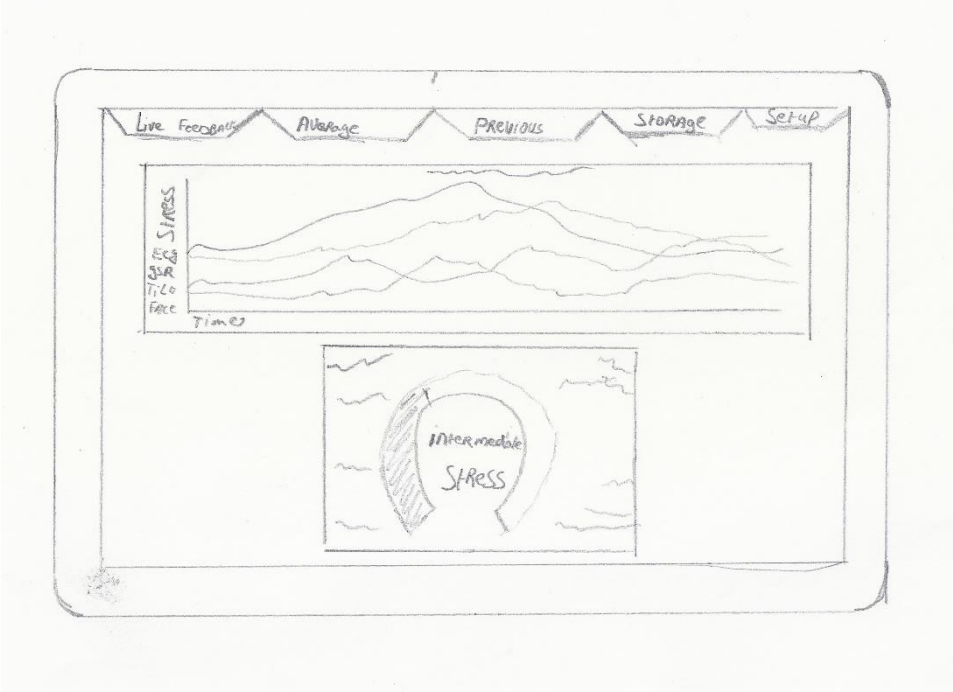

Figure 4.8, Display design with interface

Since this interface is not in the scope of the project, it will not be created. Therefore, the display will only contain the stress meter and the line graph. These two features will be placed on top of each other in order to create perfect visibility for both of the features, *see figure 24.* It is to say that in the prototype version, the visualisations are not interactive via touchscreen and will only display live measurements.

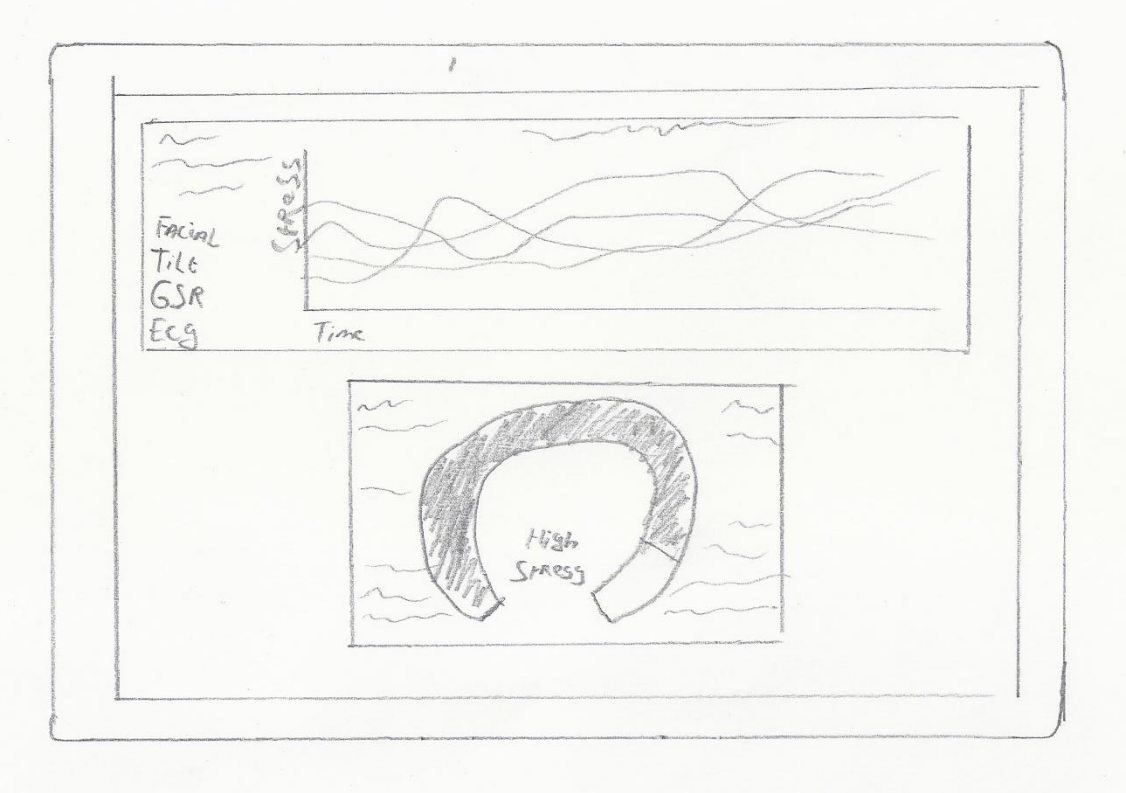

Figure 4.9, Display design without interface (prototype version)

4.7 Prototype design

Based on the findings from the stakeholder analysis, brainstorm and interviews, a prototype concept has been designed. This concept can be divided into three sections: the measuring equipment, the data processing computer, and the feedback method.

Measuring equipment

The data will be collected with the use of four sensors: ECG sensor, GSR sensor, tilt sensor and facial sensor. The ECG sensor could be made with electrodes. These electrodes would be placed by using the three-lead placement method. The GSR sensor could also be made with electrodes. The electrodes would be placed on the shoulders as seen in figure 17. The electrodes from both the ECG and GSR would be tied together to form one place where all the electrode wires towards the computer. The tilt sensor could be made by using controller output. The controller output would be extracted by a cable which will be hardened at the closest point near the controller. The facial sensor would be a webcam. This webcam could be placed in front of the user and thereby measure stress from the face or eyes.

Data processing

The data will be inputted and outputted by the computer, *see figure 25.* The input is provided by the four sensors which have been named above. The output will be provided to a screen as can be seen below. The computer will be a Raspberry Pi and Arduino which will be placed near the chair in which the user is sitting.

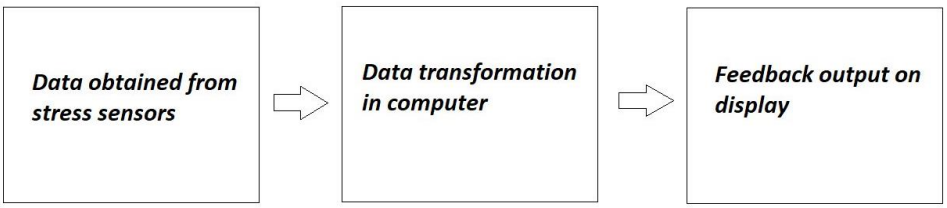

Figure 4.10, Data process

Feedback method

The feedback would be provided by a display. This display is connected to the computer via a cable. The display would contain two visualisations: the first would be a line graph, and the second would be a stress meter (chapter 2.4). The whole design of the visualisations is displayed in *figure 24.* The display itself will not be tablet sized since the prototype would not have additional value in this stage of the project.

4.8 IPACT analysis

The IPACT analysis is conducted to obtain a better insight in the potential user and what they will do with the system (chapter 3.5).

Intention
The prototype will be made to measure stress from the user and convert this into tangible feedback. This feedback will give insight into the stress of the user and could be used to improve the users gaming performance.

People
John is 20 years old and an eSporter at one of the eDivisie clubs. He plays Fifa during the weekends, in the evening and during the eDivisie. He uses the system to improve on his performance and to know when he should relax more. He is not that technical but does know how to use basic equipment like computers and consoles. He uses the developed product only if he knows that he going to have a big session playing Fifa, during scheduled training sessions or during eDivisie. If John uses the system, he uses all the sensors and sometimes interacts with the feedback. During eDivisie he does not use the feedback himself since he is too focused on playing the game. At home, he does take time to look at his stress levels since at home he is more relaxed and is focussing on improving.

Dennis is 29 years old and a trainer at one of the eDivisie clubs. He plays Fifa for fun and analysis gameplay of his trainees. Dennis will use the system to gain insight into his trainee's stress levels and improve his performance. He will use the system when he is training his eSporter during the eDivisie and at scheduled training sessions. If Dennis is using the device, he will be handling the feedback display only. He does not interact with the sensor while the device is working; however, Dennis will interact with the sensors if they are being set-up.

(user) Activities
eSporters want to use the device while gaming. This is done when the eSporter sits down in a chair. The device will thus be used when the user is sitting in a chair. The body will not move much while gaming, or to better phrase it, the body will not move drastically. However, the user will most likely want to stretch his/her legs. The device will thus be required to not break when the user is standing up. While gaming, the user might also want to take a break. At this point, the device will be disconnected. These must thus be an easy method with which the device can be connected and disconnected. In addition, the user might move the chair. The device must thus be made such that the user cannot destroy it when moving the chair.

Context
eSporters game in an indoor environment which at least consist of a chair, table and tv screen. This physical context of an indoor environment can include a bedroom, gaming room, tv studio, stage, hall and even a cinema on rare occasions. The social context of the use of this device is training with their trainer or training with other eSporters in their team.

Technology
The prototype device will use electrodes, a webcam and controller output for data gathering. This data will be stored and processed by a Raspberry Pi and Arduino. The Raspberry Pi will also function as output device and will send the created feedback straight to the attached display. The electrodes will send data to the Raspberry in the form of electrical intensity/numbers. The controller output will send data to the Raspberry in the form of ones and zeros linked to the pressed button and the webcam will send video images which will be evaluated and processed.

This project will make use of three libraries to help process and obtain data. For the webcam, that will be used is the OpenCV library. This library will be used to help acquire data from the webcam. The Inputs pip will be used to obtain controller output, and the Plotly pip will be used to create the visualisations. As said, the computer that will be used is a Raspberry Pi. The programming language that will be used is Python. Python is a coding language which is well supported by the Raspberry Pi and has its own coding platform pre-installed which is named Thonny.

Python

"Python is an object-oriented programming language that allows for manipulation of high-level data structures and is a popular tool for rapid prototyping and development" (Python.org, 2020). Within Python, there are lots of libraries open for use. Some of these libraries are made by the creators of Phyton themselves or by the community. The Inputs pip, Plotly pip and OpenCV are the main libraries used within this project. The inputs library is a pip which is used to obtain and manipulate output from any controller, keyboard and or mouse. It can be used to determine which exact buttons have been pressed and at which time. The OpenCV library must be used with some support libraries. These libraries are the Imutils and Keras library. Together, these libraries extract, refine and output video images to use them for measurements. The Plotly pip is used to create the visualisations. This pip has several different functions but for this project, the offline function will be used since it is the simplest of them all. The data acquired by the sensors will be inputted into arrays which the Plotly pip will transform into a visualisation. The Plotly pip can be combined with the Dash pip to create complex online visualisations; this might be useful in the future. It is to say that there are more methods to creating a data visualisation with Python. One might for example want to use the Matplotlib library or convert the data into a CSV file and then input it into a visualisation.

Raspberry Pi

The Raspberry Pi is a small computer, which is capable of almost everything a normal computer can but with low processing power. In this project, the Raspberry Pi 3 is going to be used. This Pi has four USB ports, one HDMI port, one ethernet port and one micro-USB port. The Raspberry Pi is a product made for small computer driven projects. The device is easy to use because it is created to be used by novice and professional engineers. In addition, the Raspberry Pi can be easily connected to an Arduino via simple serial communication (raspberrypi.org, 2020).

Arduino

Arduino, much like the Raspberry Pi, is a small computer. Where Raspberry Pi is capable of a lot of actions, the Arduino is specialized in physical computing of sensor and actuator equipment. In this project, the Arduino Uno will be used. This version of the Arduino is the most common version and has thirteen digital pins and five analog input pins. The Arduino is created for prototype systems. It can be used for end systems, however it does not have the best processing power and will need multiple computers to make bigger projects work. (Arduino.cc, 2020)

4.9 Ideation requirements

This section states the requirements found in the stakeholder analysis and interviews. This list of requirements is in an early state and will not yet be subjected to a requirement analysis. The requirements might change in the specification and realization phase.

From stakeholder analysis

1. Low calibration time – The calibration time should not take longer than 30 seconds
2. Low cost – The system should not cost more than 1000 dollar
3. Easy to set-up
4. Not intrusive
5. Easy understandable feedback during gameplay – Expert knowledge should not be needed to understand the feedback
6. No distractive feedback
7. No detailed feedback during gameplay
8. Easy to transport
9. No sound measurements – No use of sound measurements
10. Detailed feedback during the game for coaching purpose
11. Visuals for media purpose
12. No Fifa specific data
13. Detailed data accessible after a game of Fifa

Brainstorm

14. Wireless connection
    a. Between two computers
    b. Between the display and computer

From the first interview

15. No on-screen feedback
16. Usable live feedback at home
17. Detailed feedback used for coaching purposes and simple feedback for eSporters usage
18. Extra features to indicate stress related moments
    a. Goal related activities
    b. Ball possession
    c. Ball position on the field
    d. Fouls
19. Not letting the controller output wire distract the user
20. Easy way to connect and disconnect electrodes from the body and or computer

From the second interview

21. Display should be tablet size
22. Cable hardener to prevent concentration problems created by wiring
23. Customizable display stand
24. Changeable angle of the stand
25. An interface which could guide through different sections
    a. Previous played games and that feedback
    b. Average feedback throughout the week
    c. Live feedback
    d. Information about the system

4.10 Ideation conclusion

A stakeholder analysis, brainstorm session, interviews and IPACT analysis were used to help find an answer on the following sub-questions.

“How can insight in stress levels be obtained?”

“How can stress levels be translated into informative feedback?”

In the ideation, it was found that the eSporters and coaches have the most to say about the future of the project, even though they are not the most influential. The eSporters wanted to have a device which was not intrusive and could provide non-distractive feedback. The ideation showed that insight in stress levels can be obtained with the use of an ECG, GSR, tilt, and facial sensor, but it is not yet known how these devices would work together. The stress levels can be translated into feedback with the use of a second screen, but the mechanics need further investigation. Both the technical aspect of the measurement and feedback device will be elaborated on in the specification and realisation.

5. Specification

This chapter will be the specification of the project. In this specification, a FICS analysis will be conducted. This analysis will be performed to gain more insight into the usage of the system, from the systems point of view. To get familiar with the data processing of the device, a cognitive walkthrough will then be done. The cognitive walkthrough will be followed by an activity diagram. This activity diagram will show the interaction between the user and the system. The specification will end with a finalized version of the requirements. The requirements will be subjected to the MoSCoW prioritization and will be divided into functional and non-functional requirements. The specification will help answer two research questions:

"How can insight in stress levels be obtained?"

"How can stress levels be translated into informative feedback?"

5.1 FICS analysis

The FICS analysis is used to gain a better understanding of the use of the system from the systems point of view, see section 3.7. The analysis is split into the sub-sections belonging to FICS: function and event, interaction and usability, content and structure, and style and aesthetics.

Function and events

In this project, the prototype will have four main functions.

1. Sensing the data. This includes the four sensors which will sense bodily reaction to stress and transmit this data to the computer.
2. Translating the sensed data into tangible information. This includes the transformation of webcam images, controller output, GSR and ECG electrical current into data which represents the actual change in stress.
3. Translating the tangible information into numbers which can be used in a visualisation. This step will transform the data about changes in stress into numbers which can be used into visualisations.
4. Creating the visualisation. This step will change the numerical values into visualisations which can be used as feedback.

Interaction and usability

The prototype which will have two types of interaction. The first interaction is passive. This is the interaction when the user uses the system while gaming and sensing his/her stress level. The second interaction is active. This is the interaction done while using the feedback. This interaction requires the user to actively look at and take in the feedback to understand what is happening. Another part of the active interaction is the set-up of the system because the user has to set-up the prototype to make it work. The active interaction with the prototype is described in the activity diagram. In addition, electrical schemes will be added to clarify how to setup the system.

Content and structure

The system will output feedback about the user's stress levels. This feedback is displayed on a tablet sized screen and will consist of data acquired by the sensors.

Style and aesthetics
Since the system should not be intrusive, it is made such that the user has no feelings towards the device. The prototype must not cause any stress within the user since it will only cause the measured data to be untrue. The interaction with the device does not give the user a choice to what it should do, there is only one correct way to interact with the system. This will contribute to the feelings towards the device since it is not possible for the device to do something the user does not want it to do.
The user will not interact with the programming software used for the system. There will thus be no aesthetics for this part.

5.2 Cognitive walkthrough

Image 26, 27, 28, and 29 are used to illustrate the data flow of all four data types. The visualizations will start at with raw data and end with the data needed for a visualisation. The data does not represent actual measurements but is a mock-up. Since the GSR and ECG data would be acquired with the use a pre-made boards, the data processing will not go into full detail. The data will be converted into feedback with the use of the Plotly pip. This pip allows the user to convert arrays into any kind of simple graphical visualisation. The data transformed into the feedback must thus be in the form of an array.

GSR cognitive walkthrough

Before the GSR can start processing data, a small calibration will be needed to find out if the “stress levels” at the starting point are high or low. The sensor board that will be used is the Grove- GSR sensor (retrieved from: https://wiki.seeedstudio.com/Grove-GSR_Sensor/, 2020). The cognitive walkthrough of the GSR data can be seen in *figure 26.* The GSR is used on the shoulder. This sensor makes use of two electrodes of which one is the emitter and the other the receiver. The first electrodes will send an electrical signal to the skin. The skin conducts this signal towards the other electrode, which will receive the signal and sends it back to the computer. The stronger the signal, the higher the stress. The board itself produces a numerical value. The numerical value will be converted into a stress value. This value will be turned into the visualizations.

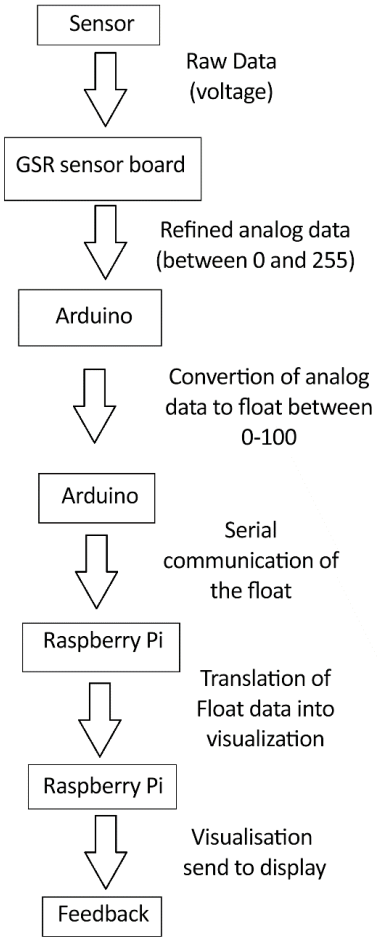

Figure 5.1, GSR walkthrough

ECG cognitive walkthrough

Before the ECG can start processing data, a small calibration will be needed to start recognizing a pattern within the heartbeat. The sensor board that will be used is the AD8232 Heart Rate monitor (retrieved from: https://learn.sparkfun.com/tutorials/ad8232-heart-rate-monitor-hookup-guide/all, 2020). The cognitive walkthrough of the ECG data can be seen in *figure 27.* The ECG sensor, as said, makes use of electrical signals near the heart. In the measurement method used in this project, there are three electrodes since it makes use of the three-lead measurement method. Two of the electrodes are placed near the heart at the chest, and the third electrode is placed on the left or right side of the belly. The upper two electrodes are the actual measurement electrodes of this set. These two are the electrodes that will catch the signal send from the brain to the heart. The third electrode is placed as a way of cancelling noise in the other two electrodes and is called the reference electrode. Since the third electrode does not measure heart rate, it will only measure electrical noise generated in the body and by the environment. By using this electrical noise from the third electrode, it is possible to clean the signal received by the other electrodes (Francis, 2016). This will leave the computer with a (almost) noise free ECG signal which can be used to extract information as heartrate and HRV. The board itself will output numerical values which, if plotted, will show an ECG graph. From the numerical values, the BPM and time intervals will have to be calculated. From the BPM and time intervals, a stress value will be created. This stress value will be converted
into the visualization.

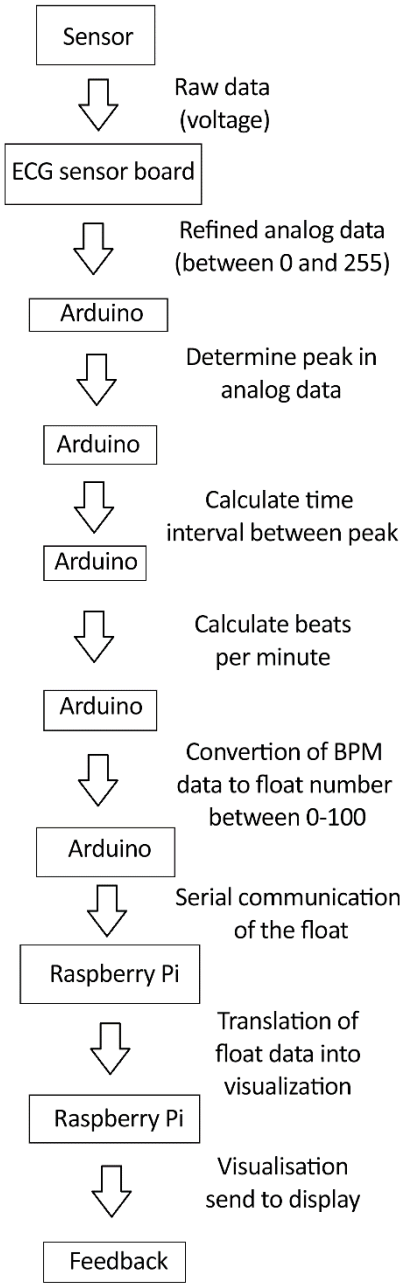

Figure 5.2, ECG walkthrough

Controller cognitive walkthrough

The cognitive walkthrough of the controller data can be seen in *figure 28.* The library that will be used is the inputs pip (inputs library). The tilt sensor will be a measure from the controller. This sensor will look at what buttons are pressed at what time and transforms this data into a measure of stress. For this sensor, the trigger buttons and joysticks will be ignored since these are pressed of higher amounts of time. Therefore, they will not be valid data sources in this sensor. There will be looked at the amount of other presses on buttons. These buttons include the A/cross, B/circle, Y/triangle, X/square, UP, DOWN, LEFT, RIGHT, TL/L1 and TR/R1. In Fifa, these buttons are used to perform actions which might be needed in a split second. Therefore, the buttons named earlier will be useable to detect stress unlike the other action buttons, which are pressed more often and with more finesse. The more a button is pressed in x amount of time, the higher the stress. The times a button is pressed in the x amount of time, will be converted into a stress value. The stress value will be converted into the visualisation.

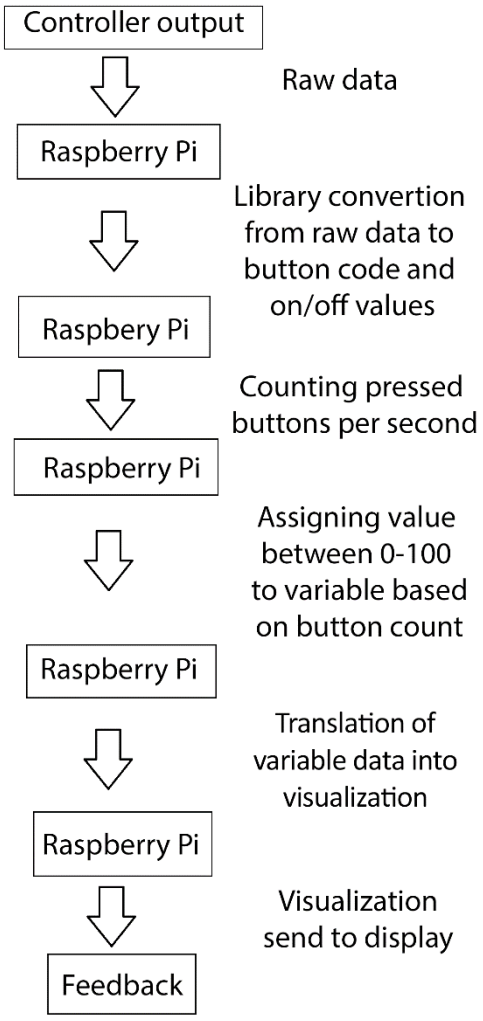

Figure 5.3, Controller walkthrough

Facial expression cognitive walkthrough

The cognitive walkthrough of the controller data can be seen in *figure 29.* The library that will be used are OpenCV, Imutils and Keras. The facial sensor will measure changes in facial expression. The sensor will start of by looking at the players face and cross reference this with images from a data base. This database will contain labelled images in which emotions are shown. The program will give a percentage to which degree the expressed measured face fits a certain emotion and will assign a stress value. The stress value will be based on the emotion percentages. The higher the emotion percentages, the higher the stress value will be. This value will be converted into the visualisation.

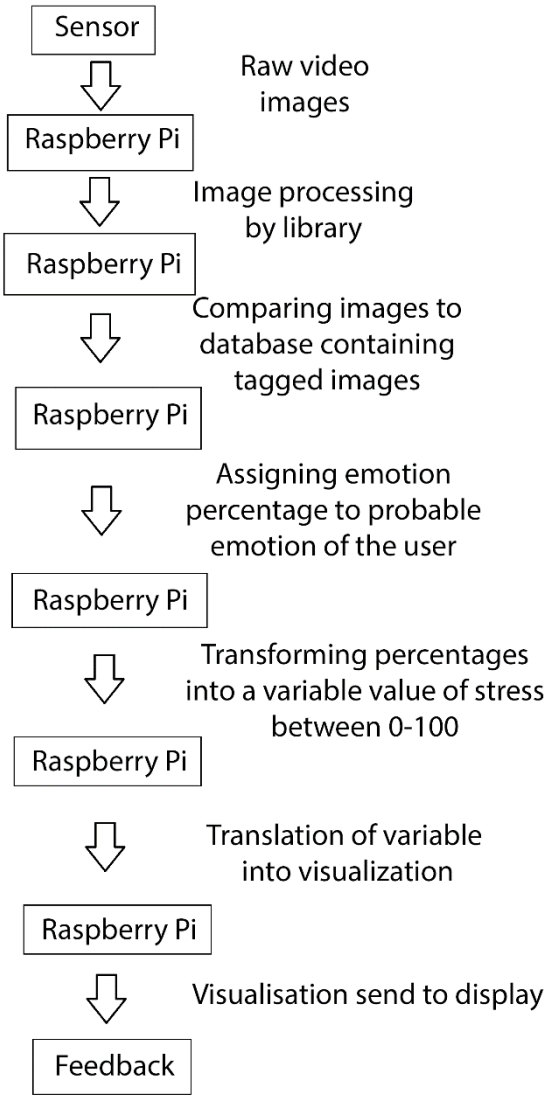

Figure 5.4, Facial expression walkthrough

5.3 Activity diagram

The activity diagram shown in *figure 30,* will describe the interaction with the prototype as it is described in the final design phase of the ideation. As said in the ideation, the final product should be more elaborate since there are much more functions needed or wanted to make the system as good as possible. Due to time management, the system is reduced to key components and interactions which are shown below. The diagram shows major interactions done by the user and the response of the system to these interactions. These steps will provide a better understanding about the dynamics between the user and the system.

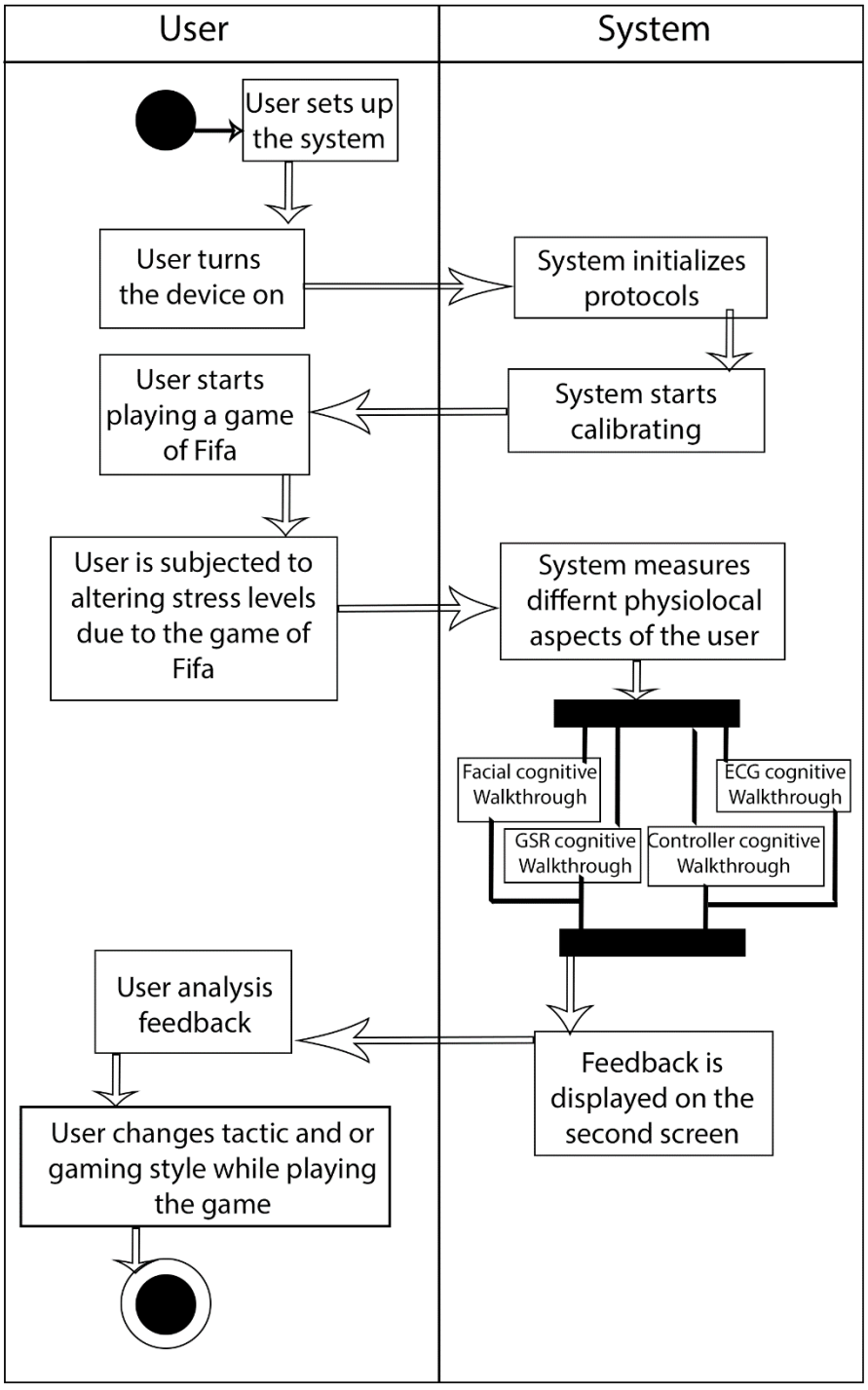

Figure 5.5, Activity diagram

The parallel functions refer to the steps performed in the cognitive walkthrough. In the parallel activity of the system, it performs all the calculations and transform the raw data into the refined feedback. For the setup of the four sensors and computers, the following details are needed. The Raspberry pi needs to be attached to a power source via the micro-USB port. The Arduino is connected to the Raspberry Pi with the computer to Arduino cable (which is part of almost every Arduino set). This connection will charge the Arduino and take care of the serial communication. The webcam and controller input are both connected to the Raspberry Pi via USB. The GSR sensor is connected to the Arduino with the use of three cables, *see figure 31.* The electrodes are connected to the board with the use of the top right connectors.

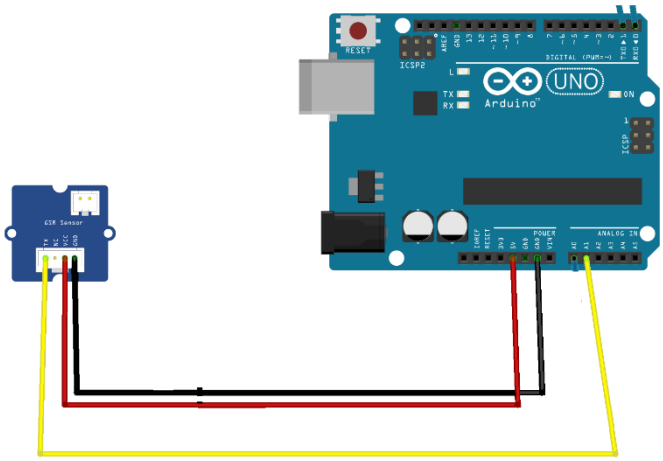

Figure 5.6, GSR sensor hook-up

Since the picture is not perfectly readable, a small explanation will be given. The yellow cable is connected to an analog input pin on the Arduino and to the TX pin on the board. The red wire is connected to the 5v pin on the Arduino and to the VCC pin on the board. The black cable is connected to the GND on the Arduino and to the GND on the board.

The ECG sensor is connected to the Arduino with the use of five cables, *figure 32.* The electrodes can be connected in two different ways. The first way is shown in the figure. It uses three separate electrode cables. The second is with the use of the jack. This requires a fitting set of electrodes that can be used with the board itself.

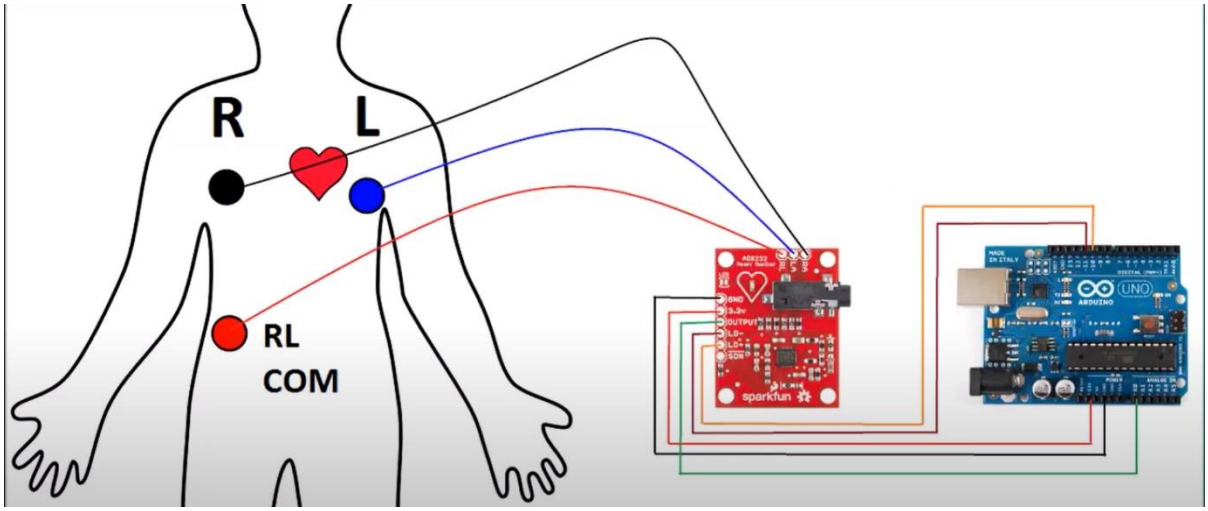

Figure 5.7, ECG sensor hook-up

5.4 Requirements

This section states the requirements found in the stakeholder analysis, interviews and specification. This list of requirements will first contain a priority segment as described in section 3.6. The functional and non-functional requirements will be indicated with the use of functional or non-functional stated behind the requirement. These requirements will later be used in the evaluation to see whether, the system meets the requirements.

Must have

- The whole device is to be setup in three minutes (functional)
- The electrodes must be able to be setup in two minutes (functional)
- The device must keep the focus of the user while playing a game of Fifa (non-functional)
- The feedback must keep the focus of the user while playing a game of Fifa (non-functional)
- The setup must obtain data about stress without the use of sound measurements (functional)
- The feedback must be displayed on a different screen as on which Fifa is being played (functional)
- The controller output wire must keep the focus of the user while playing a game of Fifa (non-functional)
- The device must keep the user relaxed so it does not cause stress generative feelings (non-functional)

Should have

- Low calibration time – The calibration time should not take longer than 30 seconds (functional)
- Easy understandable feedback – Expert knowledge should not be needed to understand the feedback (non-functional)
- The feedback must be simple during gameplay (non-functional)
- The device should be able to fit inside a backpack, bigger display screens and consoles not included (functional)
- The device should be setup without the use of a manual after using it for five times (non-functional)
- Detailed feedback during the game for coaching purpose (non-functional)
- Usable live feedback at home (non-functional)
- Detailed feedback used for coaching purposes and simple feedback for eSporters usage (non-functional)
- Easy way to connect and disconnect electrodes from the body and or computer (functional)
- Display should be tablet size (functional)
    - The feedback should be readable from two meters distance (functional)
- The device should start measuring when powered (functional)
- The device should be soldered instead of breadboarded to prevent misreading (if wired connection is needed) (functional)

Could have

- Low cost – The system should not cost over a thousand dollar (functional)
- The device could include visuals for media purpose (functional)
- Wireless connection between the computers and/or displays(functional)
- Customizable display stand (functional)
- Changeable angle of the stand (functional)

Won't have

- Detailed data accessible after a game of Fifa (non-functional)
- Extra features to indicate stress related moments (non-functional)
    - Goal related activities
    - Ball possession
    - Ball position on the field
    - Fouls
- An interface which could guide through different sections (non-functional)
    - Previous played games and that feedback
    - Average feedback throughout the week
    - Live feedback
    - Information about the system
    - Etc.
- Display stand (non-functional)
- Cable hardener (non-functional)
- The device should not use data specific to Fifa for stress measurements (functional)

5.5 Considerations for the realisation

In this section of the specification, the realisation outline will be explained. The outline is provided because the realisation will be different from what the expectation might be. Within the realisation, not the whole prototype will be built. This is done since not all needed equipment is available. In addition, some components of the prototype are common and easy to create, therefore it will not be posing a problem in the validation of the project. The measurement outcome of the components which will not be created, will be replaced with other sensoric equipment which can measure the same data. This will provide a valid replacement for the missing components since the replacement devices will provide the same information as the prototype would.

Prototype device

The parts of the measuring device prototype that will be created are the controller output sensor, the facial stress sensor, and the feedback display. The other two sensors (GSR and ECG) have been left out since it was not possible to create these sensors with the available equipment. These two sensors will thus be replaced by another sensor which will be explained later in this section. The feedback display will provide feedback about tilt and facial stress and thus contain two lines in the line graph. This line graph will be made after the measurements and not live. The live feedback will not be used within the prototype since it will not have any value in this prototype. In addition, the actual stress meter will not be added. This decision is made because the feedback is easy to create, but it will consume a lot of time. If the line graph can be realised, it is safe to say that the stress meter can be realised. The 3d models for the cable hardener and display stand will also not be realised. These objects will not be created because the use of a 3d printer is limited during corona. It

will not be possible to recreate an object if it is not perfect within the first printing session, thus these features can not be achieved.

Data acquisition

The data acquisition of the four sensors will, as said, be done different. The facial and tilt sensor will be acquired as described earlier in this chapter. The ECG and GSR sensors will be replaced, and thus the data acquisition will be different. To replace the ECG and GSR measurements, an Empatica e4 wristband will be used. The Empatica makes use of its own API which shows the measurements in the form of a line graph. The Empatica will therefore create an almost perfect replica of the data that would be acquired using a fully completed prototype. The data measured by the Empatica will also be used to evaluate the validity of the prototype within the evaluation. In figure 33, the outcome of an Empatica measurement can be found.

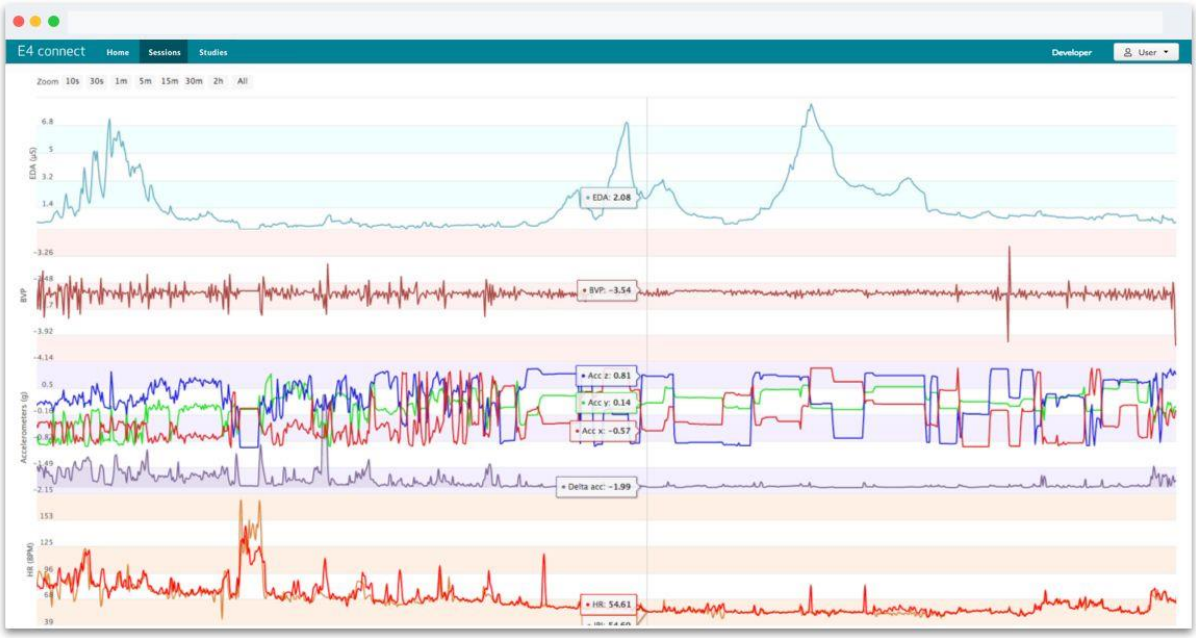

Figure 5.8, Empatica API

Stress measurements

The measurements will be conducted with the use of the Empatica and the prototype device containing the tilt and facial sensor. The measurements will be conducted as follows. At first, both devices will be turned on, which triggers both sensing protocols. Then, a game of fifa will be started. The Empatica has an easy method of marking time locations by pressing the button on the watch. The start of the game will be indicated with three presses, the breaks will be indicated with two presses and a goal will be indicated with one press. These indicators can be cross referenced with the data obtained from the prototype. Now, the data can be analysed by looking at the events and the states of the stress levels. This process will be repeated ten times to have enough data to draw conclusions from. It is to say that in the evaluation, the whole idea will be evaluated and not only the generated functions of the realisation. See section 6.1 for a better explanation of the use of the hardware.

5.6 Specification conclusion

A FICS analysis, cognitive walkthrough and activity diagram were used to help find answers to the following sub-questions.

“How can insight in stress levels be obtained?”

“How can stress levels be translated into informative feedback?”

From the FICS analysis, the basic functions of the prototype have been determined. The FICS gave extra insight in the interaction with the system and how everything should be working. The cognitive walkthrough added an extra layer to the FICS, by showing how the system itself should be working to create feedback from measured values. In the end, the activity diagram helped by explaining all the interaction the user has with the system and vice versa.

6. Realisation

Within this section of the report, the process of development of the prototype is described. The first part of the realisation will contain a section of how the hardware has been setup by the creator, the second part of the realisations will contain a description of how the software is setup, and the last part will give a prediction of the on the works of the prototype.

6.1 Hardware decomposition and use

As stated in section 5.4 of the paper, the prototype version will be simplified due to time reasons. The hardware will now consist of a raspberry pi, which will run the facial sensor and tilt sensor, and the Empatica E4 wristband, which will run the GSR (around the wrist) and heartbeat sensor (around the wrist).

The Pi that is being used is the Raspberry Pi 3B+. The Raspberry has four different connections attached to it, one is the micro-USB connection for power, one is the HDMI connection for a display, and the other two are USB connections. These USB connections consist of a webcam and controller. The webcam is placed on top of the screen which is used to play Fifa on. The Empatica will be used as described in section 2.3 It is placed around the left wrist of the user. Within the prototype, only heartrate and GSR data will be used. A picture of the completed setup can be seen in *figure 34.*

Figure 6.1, the complete setup

Most of the hardware will function without input or actions obtained from the user. However, the Raspberry Pi and Empatica need to be activated before they will conduct measurements. For the Empatica, there are two actions that will be used during the measurements. The first will be the action of starting the measurements. When holding the button for two seconds on the Empatica, it will start measuring. If the measurement started, it will flash a red light. The second action performed is to indicate moments within the measurement. When the button is pressed less then a second, it will put a marker within the measurement graph. This action will be performed when the game starts, when a goal is scored or when a break is indicated within the game. At the start of the game, three markers will be placed; in a break, two markers will be placed; and when a goal is scored, one marker will be placed. The Raspberry Pi data will also have such a marker.

At the same time of the start of the Empatica measurement, the python script for the Raspberry Pi should be fired. This can be done via the run script button and/or the command prompt. When one wants to run the script without the use of the command prompt, the Thonny program is to be used. Thonny is pre-installed on the Raspian software. If the Fifa

game is finished, the Empatica is to be turned off in the same way as it is turned on. This will create a graph for its measured factors. The Raspberry Pi script will have a pre-set timer which will end the program at the set time. The timer is set on 20 minutes. The 20-minute mark has been chosen based on maximum Fifa game times and the amount of times a break might called by the tester.

By using the devices as described above, the time markers of the Empatica and Raspberry data will be aligned. Therefore, during the evaluation of the data, it will be easier to compare data and time marks of measured high stress values.

Setup steps:

- Connect Pi to power outlet via micro-USB port
- Connect webcam and controller to Pi via USB port
- Connect second screen to Pi via HDMI port
- Turn on power
- Start measuring by activating software

6.2 Software decomposition

This part of the realisation will consist of three parts. The first part will describe the software of the controller measurement and feedback, the second part will describe the software of the video measurements and feedback and the last part will describe the two pieces of software combined. The Empatica software will be left out of this chapter since this is a fixed feature. The Empatica software is there to be used and not to be altered and understand.

6.2.1 Controller software

The controller software is built around the Inputs pip. As said, the Inputs pip can obtain data coming from a controller will it be Xbox or Playstation. Within the program, the buttons are measured with the use of the gamepad library and event. When a button is pressed, a variable (button_pressed) will be triggered which will add a number to its own value. After a time interval, which is stated as the variable “interval”, the program will transform the amount of button presses into a stress value. This is done by using a multiplier to gain data that fits the other data in magnitude. This stress value will be appended to an array known as “data”. The “measuringtime” array will contain timestamps of the measured stress values. Both arrays will fill until the program is complete. When the running time of the program is done (running time is indicated as a number by the variable “aofmin” and transformed into actual minutes by “programrun”), the “data” and “measuringtime” array will be inputted into a graph. The program uses Plotly offline to make sure there is not internet lag. For the whole code, *see appendix D*, for a simplified breakdown of the code, *see figure 35.*

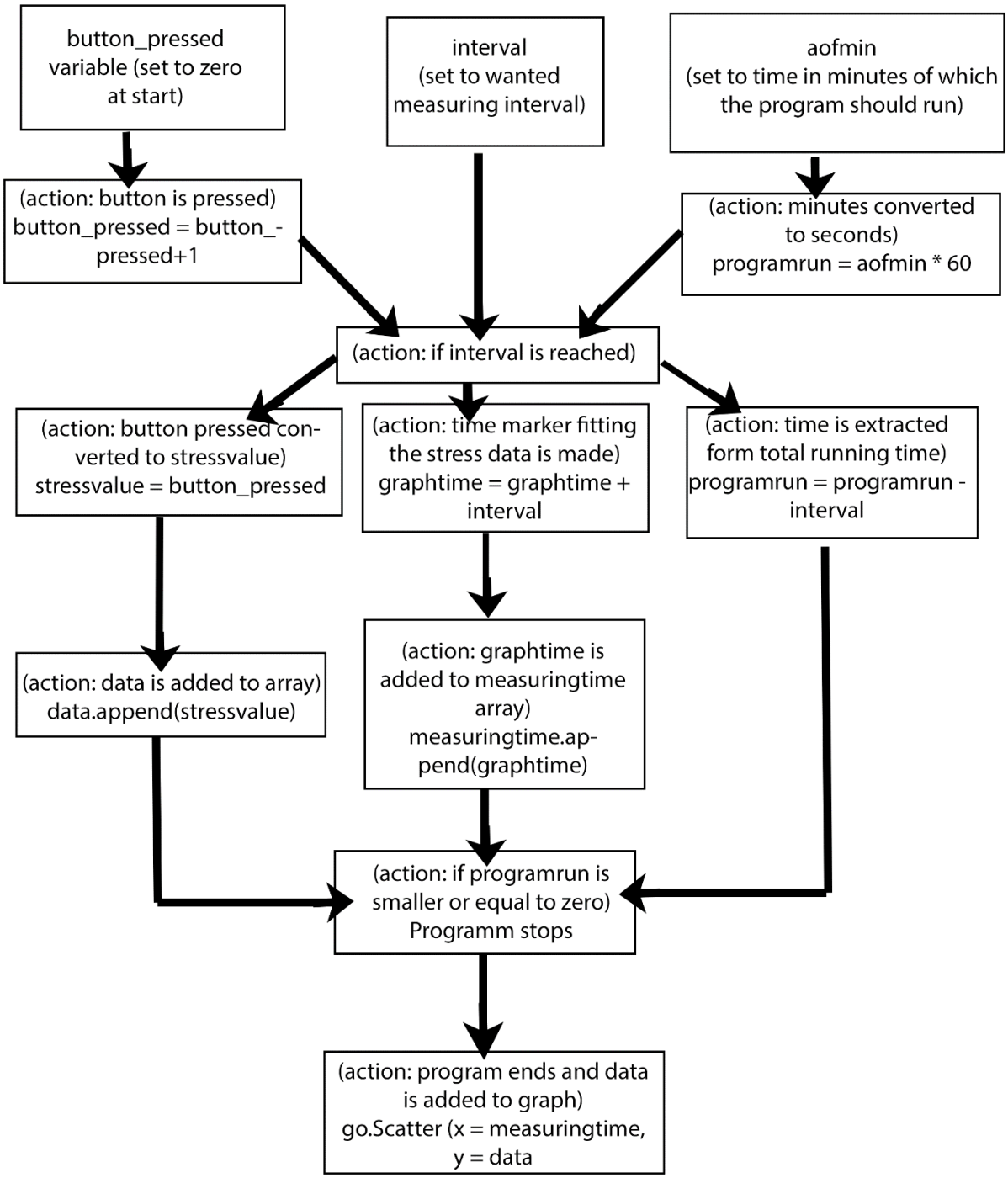

Figure 6.2, Simplified breakdown of code steps

6.2.2 Video software

The video software that is used is taken from Github. This is done to prevent time issues since writing a complete working program would cost to much time. The code is taken from creator Geek-Ubaid and is called Stress Detection. The code itself uses many libraries which are used to import and process video data, calculate vectors and positions, and create graphical output (feedback). The software starts off with defining three functions, eye_brow_distance, emotion_finder and normalize value. These functions will later be used in the main part to extract the actual data from the image collected by the camera.

Functions
The eye_brow_distance function does as the name describes, it locates the distance between the eyebrows. The emotion_finder function is used to determine whether the user is stressed or not. This is done by comparing the images coming from the camera with labelled images. These labelled images are based on the emotions that could be shown by the user. The images obtained by the camera will then be given a percentage to what emotions are shown. The most prominent emotion will define the inputted image and based on that emotion, the label stress or no stress is applied. This label has nothing to do with the perceived stress percentage given to the user. The normalize_values function is used to create a label for the perceived stress. The label can consist of “high stress” and “low stress” however, it acts independent from the emotion_finder function. There might thus be a moment in which the emotion_finder might indicate “no stress”, but the normalize_values function will indicate high stress. This might happen since the emotion finder is based on the complete image, and compares it to other images, and the normalize values function is based on changes in eyebrows (which is a stress indicator).

The main program
The program starts off with a couple of commands that start the detection of the face, start predicting face shape, load in the database for emotion recognition, and capture the live facial data. Then, it is followed by a while loop that keeps running as long as there is video data or the user presses “q” on the keyboard. The frames coming from the camera are being resized to fit with the format. Then, the left and right eyebrows are being located with the function “(lBegin, lEnd) = face_utils.FACIAL_LANDMARKS_IDXS[“right_eyebrow”]” and “(rBegin, rEnd) = face_utils.FACIAL_LANDMARKS_IDXS[“left_eyebrow”]”. Now, the actual stress detection will begin. The detection will start of by determining the emotion with the emotion_finder function. Then, this emotion is displayed in the frame that is perceived by the camera (this part can be turned off since it might not be useful). Then, the data of the eyebrows and shape of the face is inputted into variables that will be used to draw a contour onto the picture which is displayed by the program. Then, the distance between the eyebrows is calculated with the eye_brow_distance function, just as the stress level and stress label is calculated by the normalize_values function. This data is also added to video perceived by the camera. Then, with the command “cv2.imshow(“Frame”, frame)”, the actual created image is displayed on the screen. If the while loop is broken, the video images are being scraped from the screen, and a graph with the outputted stress levels over time is played. For the whole code, see appendix E**,** for a simplified breakdown of the main part of the code, *see figure 36.*

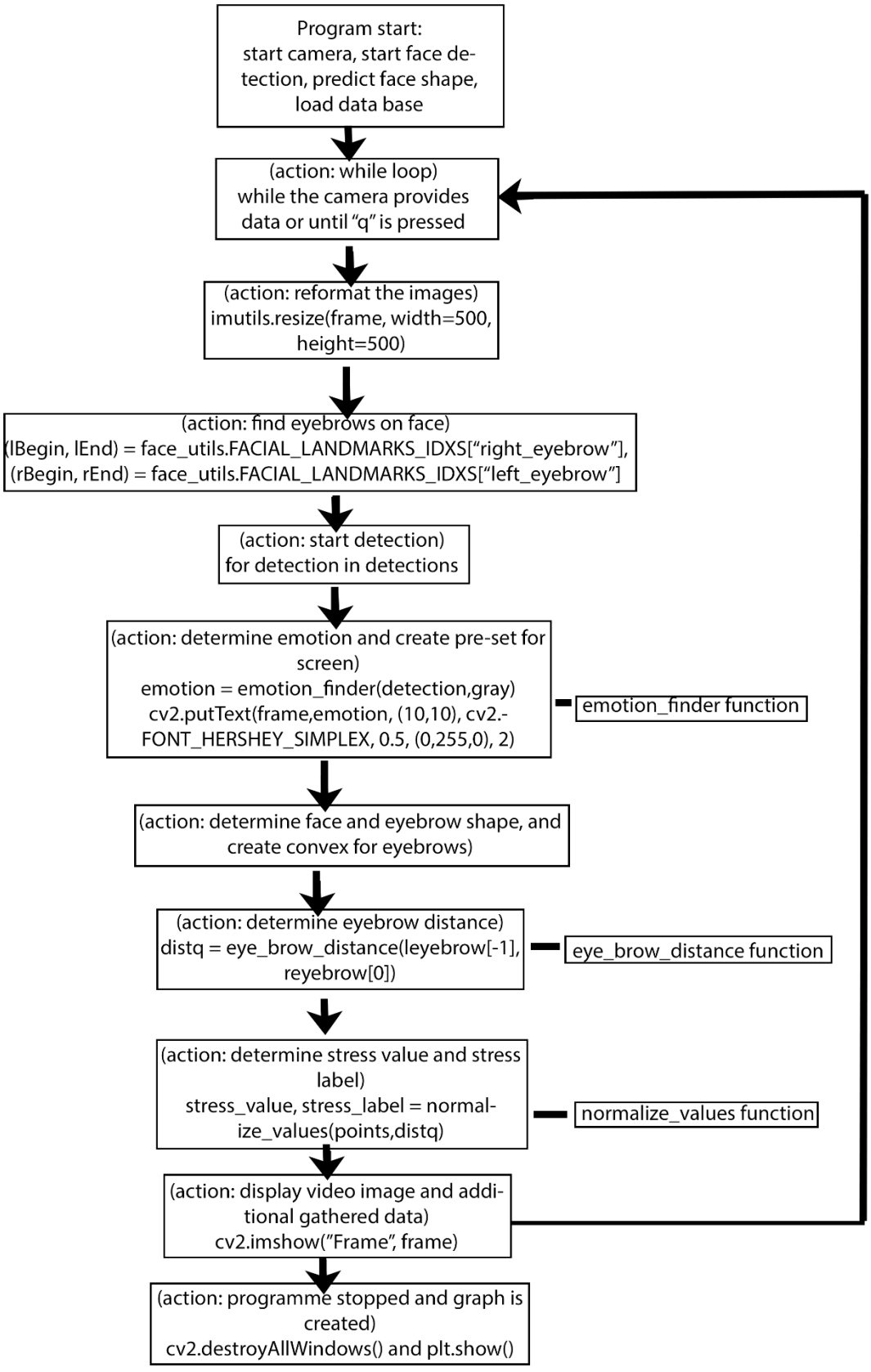

Figure 6.3, Simplified breakdown of video program

6.2.3 Complete software

To run both software programs at the same time or convert them into one program proves a challenge. Due to the two separate while loops used in both programs, it is not possible to convert the programs together into one entity. It is however possible to run both programs at the same time. This has to be done with the use of the command prompt by entering the command “parallel ::: “python script1.py” “python script2.py””. There are other options to create a parallel run of both scripts and these can be found and tried with the use of the following forum: https://stackoverflow.com/questions/28549641/run-multiple-python-scripts-concurrently#:~:text=You%20can%20run%20multiple%20instances,then%20run%20your%20client%20code.

6.3 Output

The output of the system is not as planned. During the realisation, the video software did not work. This issue occurred within the download of the OpenCV library. The Raspberry Pi’s memory did not handle the amount of data that was needed to download OpenCV. This problem is one that can be solved given a bit more time; however, this project has a limited time span. That is why it could not get fixed.

The software will output one single graph. This graph consists of the data obtained from the controller. This data can be used within the evaluation phase of this project to see whether the data is related to stress. The graphs created from the controller output can be labelled. In the future, every test that will be conducted will give the graph a time and date stamp. This is done to determine which data set is being used.

7. Evaluation

Within this section there will be looked at the performance of the created idea and prototype. At first, measurements will be conducted as is described in the specification. These measurements will be used to create insight into the functionality of a possible future product. Next, a functionality test will be conducted to see whether the project met its demands as specified in the functional requirements. After the functionality test, a user test will be conducted to see if the probable end-user is content with the results. Later, there will be a general discussion about the whole project and in the end, the evaluation will be concluded. This conclusion is supported by a new and final requirement list. This section will provide an answer to all the sub questions:

"How can insight in stress levels be obtained?"

"How do stress levels alter in Fifa eSporters during a game of Fifa?"

"How can stress levels be translated into informative feedback?"

7.1 Feasibility testing

The feasibility testing will be conducted as explained in section 3.10. The chosen teams will be FC Barcelona vs Real Madrid in which the tester will play as FC Barcelona. The tactics cannot be changed before and during the game; however, within the game, substitutions can be made if wanted. The output provided is as discussed in section 6.3. This data will be accompanied by data obtained by the Empatica E4 wristband. The Empatica and the prototype sensor devices will be started at the same time, which will cause both measurements to align. In addition, the controller measurement setup will receive a function which allows the user to place markers -in the data file- while playing the game. These markers will be placed at the beginning and end of a game (as with the Empatica). This function will make it easier to align the obtained data. The data sets of the Empatica and the prototype are labelled with time and date to make sure that data sets are not mixed up. With both data sets (visualisations) conclusions can be drawn to what extend the final prototype and prototype idea are useful and realistic. In section 5.5, the marker function of the Empatica is explained. For this test, we will hardcode a function in the controller output to make sure the data is easily comparable, *see appendix F*.

Within *appendix F*, an extra set of comments is placed alongside the data. These comments explain what happened during the game and what was experienced. It also provides some explanation about weird points within the measurements. In addition, every measurement will receive a small description about the measured data, a general conclusion per day, and a general conclusion of all the measurements. The general conclusion can also be found in this section. It will answer three main questions about the test. What is the influence of difficulty on the stress levels, what is the influence of time -at which the game is played- on the stress levels, and what are specific moments that generate stress?

Feasibility test conclusion and discussion

In general, it is hard to draw detailed conclusions from the obtained data. However, there are conclusions that can be named based on the data. It is found that in later stages of a game measured stress levels go up. Within games that are one sided -with many goals on one side- the gamer tends to become more annoyed than usual. This feature also causes the tilt levels to rise more near goal related events due to button mashing.

The influence of difficulty on stress levels is not determined. There is no real pattern found between the different difficulties and the stress levels. This might have happened due to the low stakes of the game. There is nothing to gain from winning or losing, thus it might have happened that the test subject did not care about the difficulty.

There is a sign of stress changes in correlation with the time on which a game is played. It is found that the earliest played game is the least stress generative in comparison to the other two games. This is found independent from the difficulty at which the game is played. There are two explanations for the phenomena. The first is the fact that in the morning, the user is rested. Therefore, he will have the most concentration and perform at his best. The second option rests in the physical state of the tester. In the morning, the user is still starting his day. That is why it could be that the physical aspects of the measurements were lower since those aspects were not fully turned on yet. This must be investigated in further research.

Within the data, there is one specific moment of which can be said to generate stress. This moment is a goal related moment. Within the data, almost all the spiking elevations in stress levels, which have been found, are related to a goal or an event near the goal (in distance). It can thus be concluded that near goal events are a cause of spikes in stress levels.

A curious finding which was not accounted for was that the accelerometer -which was included into the Empactica E4- was also a good indicator for tilt. People tend to move during a game when they get mad, happy, or something changes within their behaviour. This is almost perfectly indicated in the accelerometer sections of the Empatica measurements. The accelerometer measurements are shown in the purple colours within the Empatica measurement graphs in *appendix F*.

7.2 Functionality testing

The functionality test will be as described in section 3.10. The requirements used within this test are coming from section 5.4. The checklist will be performed based on the idea presented in section 4.7, 5.2 and 5.3 and not on the eventual prototype. This is done to validate a working idea and not the prototype since the prototype is not built to meet the requirements. The requirement list which will be evaluated will be answered with a simple yes or no. If a requirement is not met, an extra explanation will be added why this is not performed. In this section, the requirements will also receive a number so that in a later stage, they can be referred. This functionality test will only contain functional requirements, the non-functional requirements will be evaluated in the usability test.

Table 5, Functional requirement list and check

Number	Requirement	Checklist
	Must have	
1	The whole device is to be setup in three minutes	X
2	The electrodes must be able to be setup in two minutes	X
3	The setup must obtain data about stress without the use of sound measurements	X
4	The feedback must be displayed on a different screen as on which Fifa is being played	X
	Should have	
5	Low calibration time – The calibration time should not take longer than 30 seconds	X
6	The device should be able to fit inside a backpack, bigger display screens and consoles not included	X
7	The device should not use data specific to Fifa for stress measurements	X
8	Easy way to connect and disconnect electrodes from the body and or computer	X
9	Display should be tablet size	
10	The feedback should be readable from two meters distance	X
11	The device should start measuring when powered	

12	The device should be soldered instead of breadboarded to prevent misreading (if wired connection is needed)	X
	Could have	
13	Low cost – The system should not cost thousands of dollars	X
14	The device could include visuals for media purpose	
15	Wireless connection between computers and/or displays	
16	Customizable display stand	
17	Changeable angle of the stand	

Requirement number 9 is not completed within the initial prototype idea since the tablet would not have additional value in a prototyping environment. To convey the message of feedback a screen was used (also in the usability evaluation). It is predicted that this will not influence the outcome of the eventual project.

Requirement number 11 is not completed since this feature should make testing harder within a prototype. When one needs to constantly turn off and, on the power, to test a prototype, it would cost time. This time waste is not necessary thus the prototype will measure with the use of the start script button in Thonny.

Requirement number 14 is not completed since media purposes were not considered within this prototype. The prototype does create visualisations; however, the method of outputting these visualisations for media purposes has not been thought of.

Requirement number 15, 16 and 17 are not completed since these could not be realised yet. The wireless connection could not be realised since the hardware was not available. The display stand (features) has/have not been realised since the display itself has not been turned into a tablet that could make use of such a stand.

In general, the requirements that have not been met within the prototype idea are features that could later be added without foreseen problems. These features do not mess with data streams or software pieces. It is thus not be problematic that these features have been excluded.

7.3 Usability testing

The usability test will be performed as described in section 3.10. The requirements used within this test are coming from section 5.4. The interviews and interview outcomes can be found in appendix G. The interviews are used to see if the requirements have been met. The interviewees are the eSporters of FC Twente. These people are all male and vary in age from 17 – 21-year-old. The conclusions about the different requirements are being drawn from the performed interviews. Within the interview, the interviewees rate their agreement of the requirement with the prototype in a 5-point scale. With this rating, the requirements will be stated as “met” or “failed”. If any of the eSporters gives a rating below three, the requirement fails. If any requirement receives a rating of three, there will be looked at the explanation. If a decision for the “met” or “failed” needs an extra explanation, this will also be included in the section below. In this section, the requirements will also receive a number so that in a later stage, they can be referred. This usability test will only contain non-functional requirements.

Must have

1. The device must keep the focus of the user while playing a game of Fifa

   This requirement has been met. However, one eSporter stated that he will want to test the device before he can give a true answer.

2. The feedback must keep the focus of the user while playing a game of Fifa (non-functional)

   This requirement has been met. Since most of the eSporters already use a second screen. They will therefore not be distracted by the feedback.

3. The controller output wire must keep the focus of the user while playing a game of Fifa (non-functional)

   This requirement has been met. The eSporters already use a cable sometimes to charge their controller.

4. The device must keep the user relaxed, so it does not cause stress generative feelings (non-functional)

   This requirement has been met. However, one eSporter noted that he will probably have the relaxed feeling towards the device after getting used to it.

Should have

5. Easy understandable feedback – Expert knowledge should not be needed to understand the feedback (non-functional)

   This requirement has been met. No real explenation was given about this statement. The eSporters must think it is basic knowledge to be able to handle line graphs.

6. The feedback must be simple during gameplay (non-functional)

   This requirement has been met. However, one eSporter stated that he will want to test the device before he can give a true answer.

7. The device should be setup without the use of a manual after using it for five times (non-functional)

   This requirement has been met. The eSporters thought that the steps involved in the setup were not that hard. In addition, they stated that there were not that many steps.

8. Detailed feedback during the game for coaching purpose (non-functional)

   This requirement has been met. However, one eSporter stated that he will want to test the device before he can give a true answer.

9. Usable live feedback at home (non-functional)

   This requirement has been met. However, one eSporter stated that he will want to test the device before he can give a true answer.

10. Detailed feedback used for coaching purposes and simple feedback for eSporters usage (non-functional)

    This requirement has been met. However, one eSporter stated that he will want to test the device before he can give a true answer.

Within this user evaluation, all eSporters were content with the usability of the prototype. There was one of them that stated that he will have to test the prototype before he could give a true answer. However, he also noted that it looked ok for what he knows at this point. From the interview, three new requirements were found that have not been taken into consideration before. These requirements will not be evaluated any more, but they will be features that have to be looked at in later studies.

One of the eSporters stated that the colours of the line graphs (and the prototype in general) should be readable. He also noted that colour-blind people must use the device. This statement adds the following requirement:

Must have

"The device must be usable for colour-blind users."

The same eSporter also noted that there must be an indication of what is normal within the feedback. This normal value should give an indication to what degree one is too relaxed or too stressed. This statement adds the following requirement.

Should have

"The device should show a normal stress value."

Another eSporter stated that his cats also walk around on his desk. The cats could push over an extra screen placed on his desk. This statement adds the following requirement

Should have

"The device should be able to withstand a fall from at least 1 meter high."

7.4 Project discussion

This section of the evaluation will describe problems and or other difficulties that were experienced during the project. It will give explanations for why these things happened or have been done the way they have been done, and it will sometimes show a better course of action that could have been taken.

7.4.1 General

One change that could have been made lies within the planning. At the start of the project, the aim was to create a full working prototype with all the necessary sensors. This proved not to be possible. The information that had to be gathered to be fully aware of the possibilities and methods took way more time than expected. This shifted the outcome of the project drastically. If the aim of the project would have been more towards validating and gathering information, it could have been possible that there was more reasoning behind the made choses, and the same amount of physical components could have been made.

Within the evaluation, it was found that an accelerometer was also a good way of measuring stress in the form of Tilt. This type of tilt sensor could proof to enable more detailed feedback; however, it would not have changed to outcome of this project in major ways. In an earlier stage of the project, an accelerometer was not found to be related to stress. After quick research, there was no article found in which the accelerometer was indicated as an indicator of stress within humans. On the other hand, there are articles that talk about the accelerometer as a stress measurement within animals. It is thus needed to verify this indicator of stress.

To create a perfectly working facial sensor, more time was needed then is given for this project. Within the project, the facial sensor is used as a standard idea which can be easily implemented. However, to have a perfect working facial measurement sensor, it must be more detailed. For example, there must be thought of the many facial expressions and not just the eyebrows. This perfectly working sensor should also incorporate the feature to make it work on a user with glasses. The better working sensor would not change the outcome of the research. However, it would be able to provide a more detailed visualisation.

The prototype is capable of measuring stress levels. However, to make it usable in a consumer form, the prototype must be personalized. Before stress levels can be called high or low for a user, there must be looked at normal stress levels during the user's life. Within the project, this was not considered when designing and creating the prototype.

7.4.2 Ideation

During the ideation, it might have been better to include a bit more expert input. This design is based on the input of the three Fifa eSporters of FC Twente. If more input were obtained, it could have been possible to create more requirements and specifications for our prototype. This would have improved the project since it would allow the project to be versatile and problem focused. It is to say that the project as it is, is performing as was expected at its start. However, with the extra input, it could have obtained one or two extra details that could have added value.

7.4.3 Realisation

Due to Corona, acquiring hardware was difficult and cost time. That is why, for example, it was not possible to realize an ECG with different equipment than stated in the specification section. It would have been great if the full prototype could have been realised.

The realised project could have used the help of an expert in the field of stress and programming. This project is a simplistic version created for the use data validation (do button presses go up during stressful events as a goal etc.). It would have been better if the prototype were created to withstand harder user tests. This could have been achieved by someone with more experience and prior knowledge of python and Raspberry Pi. Another method that would let one achieve this feature is to perform a wider research on these subjects. This wider research would allow the creator to have a better understanding of what is happening in a shorter amount of time.

For the creation of the feedback (data visualisation), another, method could have been used. This method would have let us input the data into a csv file, which would later be converted to a visualisation. This would give better insight into the feedback and data. In addition, it would make it easier to locate specific data points. This has not been done during this project since this method was discovered after the program was finished as it is. Therefore, it was not time efficient to create another program that would essentially do the same.

As the visualisation is now, the x-axis displays its time in seconds. It is preferred that this is converted into minutes or real time data. This has not been done due to time difficulties.

The measuring interval for the controller should be determined in a better way. When testing the prototype, the interval is set on 4 seconds. These intervals have been chosen based on previous tests. However, it is not said that this interval is the best way to see whether one is pressing in one-time span. It might even be better to create a formula for this measurement, to replace the interval. This might provide the user with a more fluent graph. This feature has not been performed for this project since the outcome would remain the same and there was no time to do so. If the interval would not have proven to be optimal, it does not harm the

outcome of the project. The only difference would be a more nuanced feedback visualisation.

7.5 Final requirement iteration

This section states the requirements found in the stakeholder analysis, interviews, specification, and evaluation. This list of requirements will first contain a priority segment as described in section 5.4. The added requirements in comparison to section 5.4 are added in **BOLD**.

Must have

- The whole device is to be setup in three minutes (functional)
- The electrodes must be able to be setup in two minutes (functional)
- The device must keep the focus of the user while playing a game of Fifa (non-functional)
- The feedback must keep the focus of the user while playing a game of Fifa (non-functional)
- The setup must obtain data about stress without the use of sound measurements (functional)
- The feedback must be displayed on a different screen as on which Fifa is being played (functional)
- The controller output wire must keep the focus of the user while playing a game of Fifa (non-functional)
- The device must keep the user relaxed so it does not cause stress generative feelings (non-functional)
- **The device must be usable for colour-blind users (non-functional)**

Should have

- Low calibration time – The calibration time should not take longer than 30 seconds (functional)
- Easy understandable feedback – Expert knowledge should not be needed to understand the feedback (non-functional)
- The feedback must be simple during gameplay (non-functional)
- The device should be able to fit inside a backpack, bigger display screens and consoles not included (functional)
- The device should be setup without the use of a manual after using it for five times (non-functional)
- Detailed feedback during the game for coaching purpose (non-functional)
- The device should not use data specific to Fifa for stress measurements (functional)
- Usable live feedback at home (non-functional)
- Detailed feedback used for coaching purposes and simple feedback for eSporters usage (non-functional)
- Easy way to connect and disconnect electrodes from the body and or computer (functional)
- Display should be tablet size (functional)
    - The feedback should be readable from two meters distance (functional)
- The device should start measuring when powered (functional)
- The device should be soldered instead of breadboarded to prevent misreading (if wired connection is needed) (functional)

- **The device should show a normal stress value (functional)**
- **The device should be able to withstand a fall from at least 1 meter high. (functional)**

Could have

- Low cost – The system should not cost thousands of dollars (functional)
- The device could include visuals for media purpose (functional)
- Wireless connection between the computers and/or displays(functional)
- Customizable display stand (functional)
- Changeable angle of the stand (functional)

Won't have

- Detailed data accessible after a game of Fifa (non-functional)
- Extra features to indicate stress related moments (non-functional)
    - Goal related activities
    - Ball possession
    - Ball position on the field
    - Fouls
- An interface which could guide through different sections (non-functional)
    - Previous played games and that feedback
    - Average feedback throughout the week
    - Live feedback
    - Information about the system
    - Etc.
- Display stand (non-functional)
- Cable hardener (non-functional)

7.6 Evaluation discussion and conclusion

Due to corona, the usability test has not been conducted in a conventional method. For this reason, the usability test might not be as perfect as it should be. The users will answer the requirements based on their knowledge and feelings; however, these ideas and feelings about a section of the prototype might not be true. This misguided perception is created since they did not fully experience the prototype. Therefore, it can be said that the usability test is not perfectly true to reality. The functionality testing and feasibility testing did go according to plan. Combining all the results, provided answers to the sub-questions:

"How can insight in stress levels be obtained?"

"How do stress levels alter in Fifa eSporters during a game of Fifa?"

"How can stress levels be translated into informative feedback?"

The answers can be found in the conclusion of the project. This conclusion will also contain a section with recommendations for future work.

8. Conclusion

To conclude this project, the answers to the sub-research and main-research questions need to be answered. First, the three sub-research questions will be answered. The answers to the questions are obtained from the chapters State-of-the-art, Ideation, Specification, Realization and Evaluation. When all the sub-research questions are answered, it will be possible to answer the main-research question. By answering the main-RQ, the project goal will be reached, and the project is concluded. After the conclusion, a small section will be provided which contains recommendations for future work.

8.1 Research answers

Sub-RQ: *"How can insight in stress levels be obtained?"*

Insight in stress levels can be obtained with the use of different methods and tools. In the eSports context, measurements via ECG, GSR, tilt and facials sensor are the most feasible methods. While ECG and GSR are of the shelf measurements to measure stress, tilt and facial expressions are not. Controller output, and accelerometer information could provide information as excessive movements and "button bashing" are positively correlated with tilt and stressful situations. Changes in facial expression can be used to indicate stress while gaming. In the prototype -due to practical and time constraints- only ECG, GSR and controller input are incorporated. With regard to accelerometer and facial expression use in the esports domain it can be concluded that these methods are valuable, but their practical use should be explored further.

Sub-RQ: *"How do stress levels alter in Fifa eSporters during a game of Fifa?"*

Stress levels alter in Fifa eSporters during a game of Fifa in short bursts and over longer time spans. The short bursts of stress are generated by events that occur close -in distance- to a goal. During a full game of Fifa, measured stress levels have a higher general level near the end of the game in comparison to the beginning. From the measurements, it can not be concluded if the difficulty of a game influences the perceived stress levels. This might have happened due to the low stakes of winning or losing a game when conducting the tests.

Sub-RQ: *"How can stress levels be translated into informative feedback?"*

Stress levels can be translated into various forms of feedback. In the eSports context, the feedback must not be intrusive and or distractive. A data visualisation is a good fit as feedback for eSporters if the data visualisation is not displayed on the display which also displays the Fifa game. The two options -which are most promising- are the combination of a line graph and curved bar graph. Other data visualisations can also be used if these visualisations are compatible with the type of data, the representation of the data and the interpretation of the data.

Main-RQ: *"In what manner can insight in stress levels be obtained in Fifa eSporters during a game of Fifa and how can this be translated into informative feedback?"*

Insight in stress levels can be obtained with the use of an ECG, GSR, facial and tilt sensor. These sensors combined will provide data which can be converted into a data visualisation. This data visualisation can function as feedback for the user to provide the information about his or her stress levels. Within this project, a working prototype has been generated and successfully implemented to support these findings.

8.2 Future possibilities and work

This section of the conclusion discusses findings within the project that could add or improve the project but could not have been realised within the given time span.

8.2.1 Improvements

Facial sensor -improve and glasses

The used facial sensor within the project did not properly work in the end. However, if it did, it should have worked good enough to conduct first trial tests since the prototype code had already been tested and used by other creators. For a finished product, the facial sensor should obtain more features to measure. In addition, it should also be made such that it works if a user is wearing glasses. This would make the sensor much more versatile in use. The sensor should also be made less dependent on general databases. This could be achieved by personalising a database for users or measure solely on the inputted images from the webcam. An improved type of stress sensor via camera would not only benefit this project, but also other projects. There is not one piece of general software and or hardware available, that can be used as a good facial stress meter. By creating one, it would benefit not only the project, but also other people who want to make use of a stress sensor with facial camera.

8.2.2 Additions and future studies

Accelerometer

Within the feasibility test of section 7.1, it was found that an accelerometer can be used as a potential tilt sensor. This possibility should be researched for future use since it might have applications which other sensors might not have. Since there is nothing known about the use of this sensor for measuring stress, the application of it would not only benefit this project. If an accelerometer proofs to be a valid stress sensor, it would benefit other scientists as well.

Interface implementation and csv-file use

Before creating a full-on product of the project, an interface must be created. This interface can be designed as described in the Ideation phase of the project. Since the design idea for an interface has not been specified and realised, there must be done research on how to do so. It might be useful to create the visualisations with the use of csv-files instead of arrays. The csv-files are a more reliable option since these can be stored and used in later projects and functions.

Study on relations between the game and stress

Since it was hard to draw conclusions from the stress measurements, a data analysis study must be conducted. This study would allow the users to draw extra meaningful conclusions from the data which can be used for training purposes. In a later stage, it might be possible to expand this study. It might be possible to determine what types of stressors are solely depend on the game “Fifa”. In the future, this could proof useful when applying the device on other games since these might contain other types of stressors.

Future applications of the project

For the implementation of this product, extra studies should be conducted within three different fields. For the training aspect of the device, a study on training schedules and training styles should be done. One should efficiently be able to conduct measurements and convert those measurements into a way of training. The second study should be conducted on the use of the device during tournament matches. An efficient way to see different stress levels and device a plan to counter much be created. If not done, it could happen that the user is not obtaining a benefit from the use of the product. At last, there must be a study on the media purpose of the device. In the future, visualisations can be made with the data obtained by the sensors of the project. These visualisations can be used for media purposes

during livestream; however, there must first be looked at the form of the visualisations and if they will add value to a stream or not.

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Appendices

Appendix A: Thought process of stakeholder analysis

eDivisie clubs

The eDivisie clubs are the ones who want to use this product to improve the performance of their eSporters. The power of the clubs will be big and so is their interest. This is all because they are an overarching domain for the eSporters and coaches. However, the clubs will mostly listen to the requirements of their own eSporters and coaches. Therefore, most of the power of the eSporters and coaches will indirectly be increased through the clubs.

The clubs themselves will not use the system to a degree in which the coaches and eSporters will. However, they might use it. To have a system which can measure stress and show this system is a good way to attract sponsors. Therefore, it could be possible that the clubs will have a test setup for quick use. To do so, it is wanted to have a system which would not require a lot of time to calibrate. It is to say that this requirement does not outweigh the demands of their eSporters and coaches.

For the feedback mechanism, it should be clear. The feedback does not need to be that precise since the club will not use it to improve performance themselves. However, the feedback must indicate when someone had a hard time or did something tricky.

The clubs will probably use the system in a room especially made for its purpose and will not move it that much. Therefore, there is no real demand in size limit and or type of equipment used. It is to say that the clubs do not want a high cost system, thus this must be considered.

Preferences

- The needs of the eSporters and coaches are high priority for this stakeholder
- Low calibration time needed
- Not that precise feedback but it must be truthful
- No size or equipment limit
- Low cost

Team Gullit

Much like the eDivisie clubs, Team Gullit is a stakeholder who wants to use the project to improve the performance of their eSporters. The difference between Team Gullit and eDivisie clubs is that Team Gullit is a company that specialises in improving gamers and their performance and the eDivisie clubs are teams which play in a national competition. Both stakeholders have their own respective eSporters, but the aim of Team Gullit is simply to improve performance and eDivisie clubs aim to win the eDivisie. The power of Team Gullit will be big and so will their interest. However, Team Gullit will mostly listen to the requirements of their own eSporters and coaches. Therefore, most of the power of the eSporters and coaches will indirectly be increased through Team Gullit. In this case, the power of the coaches will increase more than that of the eSporters since Team Gullit's secret lies in the competence of their coaches. In addition, the interest of Team Gullit in the project is less than that of the eDivisie clubs since they said that at this point in time they do not need or want to work with electronic aid.

The requirements of Team Gullit are the same as the requirements of the eDivisie clubs. Team Gullit will not use the system to a degree in which the coaches and eSporters will. However, they will use it for promotion. To have a system which can measure stress and show this system is a good way to attract sponsors and show all the effort they put in to training their eSporters. It is possible that Team Gullit will have a test setup to demonstrate what they are doing. To do so, it is wanted to have a system which would not require a lot of time to calibrate. It is to say that this requirement does not outweigh the demands of their eSporters and coaches.

For the feedback mechanism, it should be clear. The feedback does not need to be that precise since the club will not use it to improve performance themselves. However, the feedback must indicate when someone had a hard time or did something tricky, for them to show that the system works.

Team Gullit will probably use the system in a room especially made for its purpose and will not move it that much. Therefore, there is no real demand in size limit and or type of equipment used. It is to say that the clubs do not want a high cost system, thus this must be considered.

Preferences

- The needs of the eSporters and coaches are high priority for this stakeholder
- Low calibration time needed
- Not that precise feedback but it must be truthful
- No size or equipment limit
- Low cost

eSporters

The eSporters will be the main users of the end-product of the project, since they are the ones on whom the measurements will be conducted. eSporters themselves will not have great power to influence the project, but they do have an interested in it.

With the use of the product, the eSporters will want to get better at Fifa. In addition, it is also fun for them to see what they are experiencing during a game. The eSporter will be the one who will setup the device together with the coaches. Therefore, it will be key to listen to this stakeholder when it comes to handling the device.

The eSporters will also be involved in the usage of the feedback system. For them, it must have the same requirements as named earlier. The eSporters might not have any technical knowledge of the used equipment. Thus, the device must be easy to handle or come with a small description which is easy to understand. The device must not be distractive, because it might compromise their concentration and or performance. In addition, it would be useful if the feedback would be easily and quickly understandable while gaming. Furthermore, it will be hard for eSporters to constantly check the feedback during a game. Therefore, it is not needed for them to have detailed feedback since they do not notice it.

The eSporters might use the system on multiple locations; at home, at the club and during the eDivision. Therefore, it is needed for the system to be compact and easy to setup since they will use it at many different locations. The environment itself will consist of basic equipment and a changing “background”. While playing the game, there will always be a chair, screen, and console available. Furthermore, the setting around them (the background) will always change. It would thus be useful if the product will make use of the already available equipment. However, it is not a must since an extra computer can be placed in the environment without interrupting with other equipment. The device will, as said, also be used in a competitive setting. In this setting, it is likely that there will be an audience who can generate noise. Therefore, a stress measurement using sound is not useful.

Preferences

- Easy to setup
- Not intrusive
- Short calibration time
- Feedback easy and quick to understand
- Not distractive
- Not too much detail during game, indicate large stress moments
- Easy to transport
- No sound measurement

eSporter coaches

The coaches will be involved into the use of the system. They are the ones that make use of the data it measures and will help with setting up the system. The coaches themselves are not that powerful to influence the project. However, they do have a big interest in the project, since it is their job to improve eSporters their performance.

The coaches will interact with the system by helping to set it up. The coaches most likely do not have knowledge about the sensoric technology which will be used. Therefore, it is wanted that the device is easy to setup or comes with a manual. In addition, the coaches will want the system to not impair their players performance. The system must thus not be intrusive or distractive. The coach will likely want a system which can conduct perfect measurements. Therefore, the system should use the best possible methods to measure stress.

For the coaches, an elaborate type of feedback is wanted. The coaches will want to have the most and best quality data they can obtain. This could also influence the type of feedback. For the coach, the feedback must be clear and detailed. It should be able to show detailed stress levels which might not be needed for the eSporters themselves.

The usage of the system for the coaches will be on the same places as for the eSporter: at home, at the club and during the eDivisie. Therefore, it is needed for the system to be compact and easy to setup since they will use to it at many different locations. The environment itself will consist of basic equipment and a changing “background”. While playing the game, there will always be a chair, screen, and console available. Furthermore, the setting around them (the background) will always change. It would thus be useful if the product will make use of the already available equipment. However, it is not a must since an extra computer can be placed in the environment without interrupting with other equipment.

It is to be said that the system will be used in different ways by the coach, in comparison to the eSporter. At home, the coach will want to be able to check up on data from played matches to come up with strategies to counter the stress. The feedback must thus always be accessible for the coach. During the matches, which will be observed by the coach, played on the club and eDivisie, the coach will want live feedback on the players stress levels. The feedback does not need to be detailed; however, it is useful. The device will, as said, also be used in a competitive setting. In this setting, it is likely that there will be an audience who can generate noise. Therefore, a stress measurement using sound is not useful.

Preferences:

- Easy to setup
- Not intrusive
- Detailed measurements possible
- Easy to transport
- Detailed feedback which is accessible after the games
- Detailed or none detailed live feedback
- No sound measurement

University of Twente/Guido Bruinsma

The University is the organisation which initially started the project. Guido Bruinsma is the one most invested in the project. He has initiated the research on eSports and started to build an eSports research branch within the University. This project will be one of the building blocks of the research and falls under his supervision. In addition, the University controls the time boundaries in which the project is conducted. With that said, Guido/the University is a powerful stakeholder and has a high interest factor.

The University does not have the kind of interest in the project as the other stakeholders do. The University wants to obtain knowledge from the research that is

conducted. Therefore, there are no requirements coming from this stakeholder that will influence the product. However, the methodology and execution of the project is one that needs to be truthful. This is a requirement from the University, for it is an insurance that the research conducted is reliable and can be build upon.

Preference:

- Truthful reasoning and information

Media organisations

The stakeholder “media organisations” is a group consisting of multiple companies like Bundle and the eDivisie. They will not benefit from the project immediately, however with some further research it is possible to create visual information about the eSporters which can entertain the viewers. The interest of the media organisations in the project would be high, however they do not have much power. This is since they are not directly involved in the project.

The media organisations would use the product for entertainment purposes. However, this will only happen if the eSporters and coaches see benefit in using these devices. Therefore, it can be said that the interest of eSporters and coach will also interest the media organisations. In addition, media organisations will most likely not want a high prized system since the cost might not weigh up against the gain.

The feedback is an important factor for the media organisations. The priority for the stakeholder will be, creating cool visuals to show to their audience. Therefore, the feedback should have a visualisation to show to the audience during the gameplay. If this demand is not obtainable since the media organisations are not the main stakeholder and user of the final product. It would be nice to provide feedback which is easily translatable into a visualisation for these stakeholders.

If the device would be used by the media organisations, it will be used in a competitive setting. In this setting, it is likely that there will be an audience who can generate noise. Therefore, a stress measurement using sound is not useful.

Preferences:

- eSporter’s and coach’s needs are important
- No high costs
- Need visualisation
- Easy convertible feedback
- No sound measurements

Other games

This stakeholder will get a different approach to its description since it has one requirement. The other games are potential stakeholders since they will probably be able to use the product from the project for their own gamers. The only requirement is that the measurements and feedback will not use Fifa specific data.

Preference:

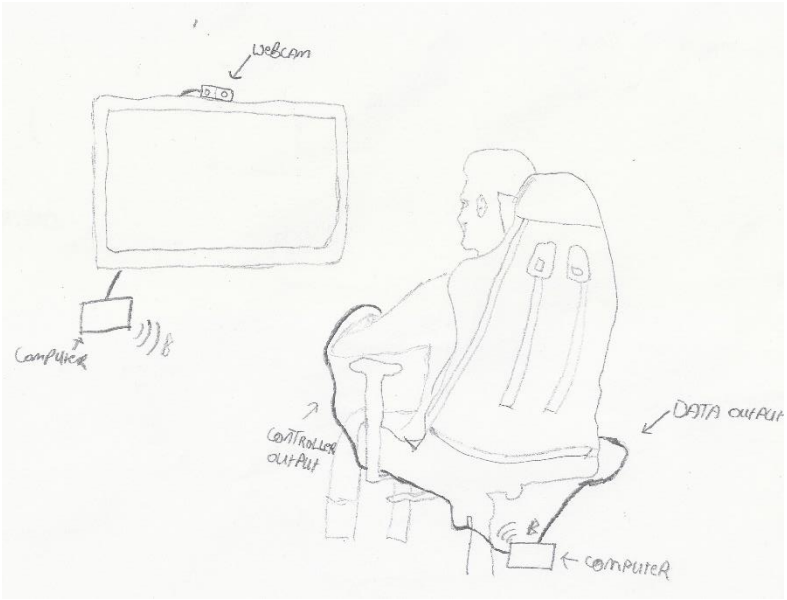
- No Fifa specific data

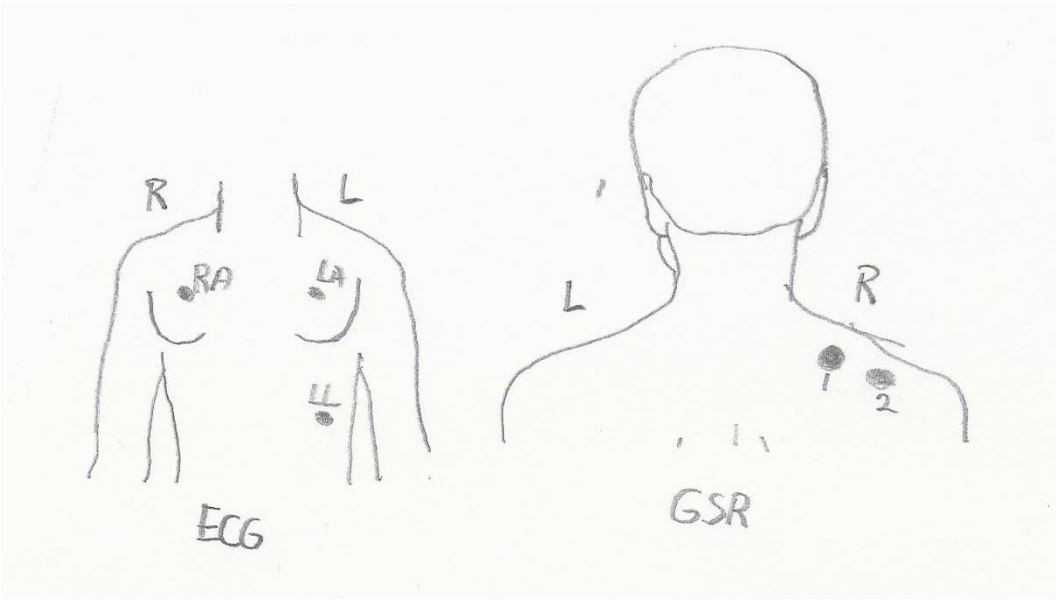
Appendix B: Interview session 1

This interview session will be semi-structured. All the participants will receive an introduction about the design of the stress sensor and two feedback methods. After this introduction, the participants can ask questions to clarify some uncertainties. This will be done to make sure the participants are fully aware of the design. After this is done, the participants are asked if the information they give can be used for study purposes. If agreed, the following questions are to be asked.

1. Do you think this way of measuring would bother an eSporter during gameplay and why?
2. Do you have recommendations to change the measuring methods? (for example: not using electrodes stuck to the body) and why would this improve the device?
3. How would an eSporter like to receive feedback of his/her stress levels?
4. Would a constantly changing bar chart as described earlier distract an eSporter during gameplay, and why?
5. Why would you choose feedback design 1 (Bar Chart on screen) over design 2 (line graph provided to coach)?
6. Why would you choose feedback design 2 (line graph provided to coach) over design 1 (Bar chart on screen)?
7. Are there any other ways with which you want to get insight into your stress during gameplay?
8. Can you come up with improvements for either of these two feedback designs?

The following pictures were used to illustrate the setup, electrode placement and two feedback methods.

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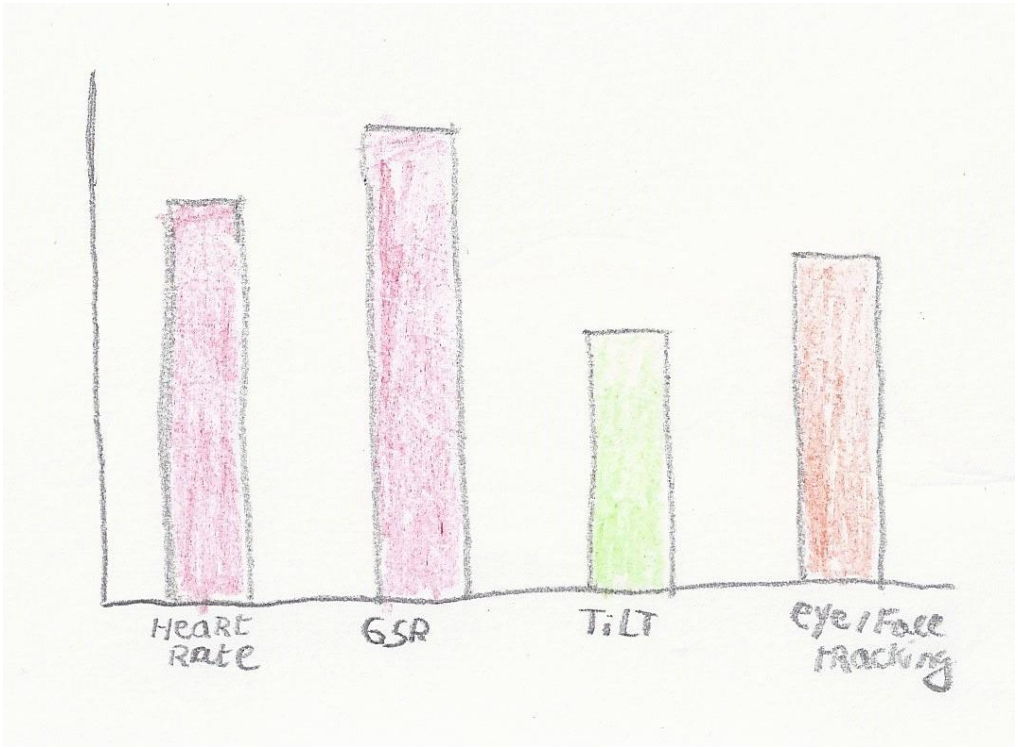
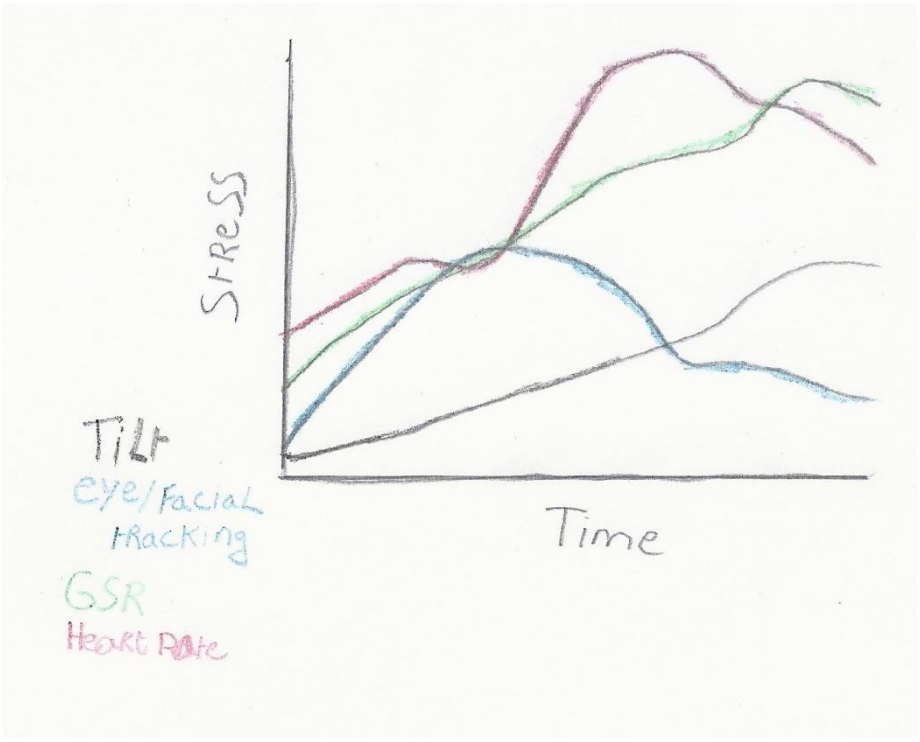
GSR


Heart Rate
GSR
TiLT
Eye/Face tracking



1st JELTE:

Q:

1. Do you think this way of measuring would bother an eSporter during gameplay and why?
2. Do you have recommendations to change the measuring methods? (for example: not using electrodes stuck to the body) and why would this improve the device?
3. How would an eSporter like to receive feedback of his/her stress levels?
    a. Why?
4. Would a constantly changing bar chart as described earlier distract an eSporter during gameplay, and why?
5. Why would you choose feedback design 1 (Bar Chart on screen) over design 2 (line graph provided to coach)?
    a. Why would it annoy you?
6. Why would you choose feedback design 2 (line graph provided to coach) over design 1 (Bar chart on screen)?
    a. What type of features would you like to see?
7. Are there any other ways with which you want to get insight into your stress during gameplay?
8. Can you come up with improvements for either of these two feedback designs?

A:

1. No, I do not think the measuring device will bother me. However, it will need some getting used to.
2. No, I do not. However, I have a small remark. You should watch out with the use of controller output. This might cause some issues with eDivisie since they have a strict policy in not cheating, which can be made possible by letting a wire run in and out of your controller.
3. I would like to get my feedback from someone else.

    a. Since you are concentrated during a game, it is hard to tell yourself to change behaviour. Therefore, it is nice to have someone else say it to you because this has a bigger impact. Brent is a good example. He really needs someone else to tell him to calm down or change tactics.
4. Yes, I think it is possible that it will distract someone. This is because it keeps moving and changing colour. This will grab attention and might influence the performance.
5. I would choose design 1 over 2 because it gives direct insight in my own stress levels, however I would not use it that much since it might annoy me.
    a. It will annoy me since I want to keep getting focused and if I see that I am stressing, this will give me more stress and therefore keep watching the meter to see if it goes down or not.
6. I like this design over design 1 since it will not annoy me as the other one does. It also gives more insight into one's stress levels since it is more elaborate. It is also possible to add other features to this type of feedback, therefore making it even more useful.
    a. I would like to have the indicators of why one is stressing on the screen. This gives a good explanation about what is happening. This includes goals, penalties, possession overtake etc.
7. No, not that I can think of. You could use a sort of light that changes colour; however, this will probably give the same effect as the first design, so I do not think it is useful.
8. Besides the thing I already told you, no. It might however be useful to put a small and simple overall stress indicator on the screen in both design 1 and 2, so that it is easy to see quick stress indications.

2nd BRENT:

Q:

1. Do you think this way of measuring would bother an eSporter during gameplay and why?
    a. How can the wire be improved?
2. Do you have recommendations to change the measuring methods? (for example: not using electrodes stuck to the body) and why would this improve the device?
3. How would an eSporter like to receive feedback of his/her stress levels?
    a. Why?
4. Would a constantly changing bar chart as described earlier distract an eSporter during gameplay, and why?
5. Why would you choose feedback design 1 (Bar Chart on screen) over design 2 (line graph provided to coach)?
6. Why would you choose feedback design 2 (line graph provided to coach) over design 1 (Bar chart on screen)?
7. Are there any other ways with which you want to get insight into your stress during gameplay?
8. Can you come up with improvements for either of these two feedback designs?

A:

1. No, I do not think so. The electrodes will probably not bother me since I am too concentrated during a game. The wire coming out of the controller might only disturb when it touches my hand. This could thus be improved.
    a. You could for example make the wire hard at the beginning, so it is further away from the hands
2. I would make the device as simple as possible because I am not the most technical person. It might be useful to have a manner which makes it easier for us to attach and detach the electrodes-wires from the computer. In addition, the device should be

a plug and play system. Not that we must do additional steps in order to make it work.

3. I prefer to get information from the coach.
    a. I am concentrated during the game and that influences my behaviour and mental state. When the coach tells me to calm down, it works most of the times.
4. It might distract some people. I do not think it will distract me; however, I will not use it. As said before, I am too concentrated while gaming. Therefore, I might only use something like this in the break or after a game.
5. If one uses this, it is a direct method of feedback without “a delay” which, in the other option, is provided by the coach.
6. This way of feedback should be less distractive. In addition, this way of conveying information to the eSporter should work better in my case. It must also be better since this type of feedback can be delivered in more detail and is more insightful then the other.
7. No, not that I can think of right now. If I come up with something, I will let you know.
8. For the bar chart, no. With the line graph on a second screen, it might be possible to add additional data. For example, when there is a goal scored or other factors which might induce high levels of stress.

3rd ENIS:

Q:

1. Do you think this way of measuring would bother an eSporter during gameplay and why?
    a. And do you think the controller cord will bother you?
2. Do you have recommendations to change the measuring methods? (for example: not using electrodes stuck to the body) and why would this improve the device?
3. How would an eSporter like to receive feedback of his/her stress levels?
    a. Why?
4. Would a constantly changing bar chart as described earlier distract an eSporter during gameplay, and why?
5. Why would you choose feedback design 1 (Bar Chart on screen) over design 2 (line graph provided to coach)?
6. Why would you choose feedback design 2 (line graph provided to coach) over design 1 (Bar chart on screen)?
7. Are there any other ways with which you want to get insight into your stress during gameplay?
8. Can you come up with improvements for either of these two feedback designs?
    a. Could it also help to know what the position of the ball is and who is in possession?

A:

1. I do not think the electrodes will bother me. However, I would not like electrodes placed near the fingers.
    a. The controller cord will not bother me since I sometimes play with the controller plugged into the ps4.
2. The simpler the device is, the better. I would not like to struggle setting up the device or must spend a lot of time doing so. I want to add that when using measurements on the controller, it is not wanted to get a delay while gaming.
3. It depends. When gaming at home, it might be good to get direct feedback on the screen, but during the eDivisie it is better to receive feedback from the coach.

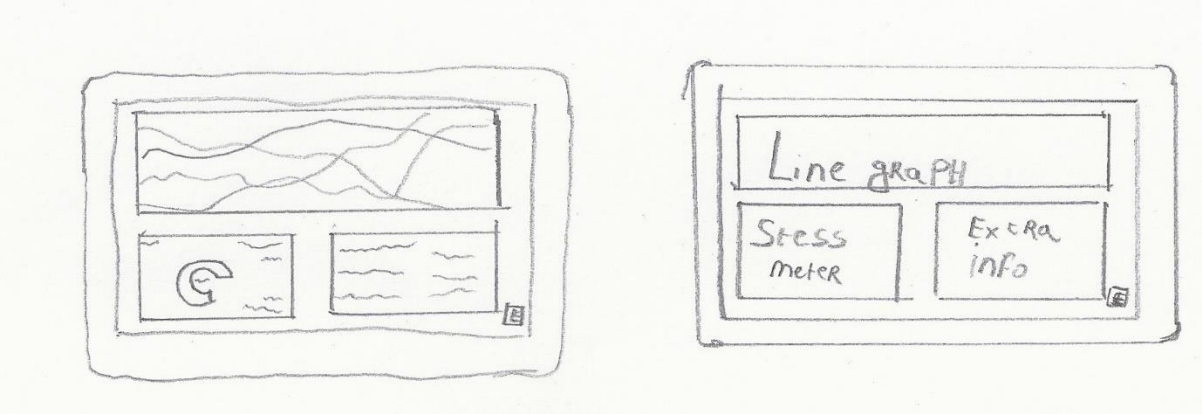
    a. This is because during eDivisie the concentration level is much higher. Therefore, feedback from the coach will be much more useful. When playing at home, I am less focused and therefore use the other feedback more. There is also no coach at home.
4. I think it could distract me. This is because I want to take the info in, but I must focus on the game. This could be fatal during an important game.
5. It gives easy feedback directly to the player. Therefore, I would choose design 1 over design 2.
6. Design 2 would be better during eDivisie. It is much more detailed and precise. If you use design 1, it could become much to easy, which can be useless.
7. No. I cannot think of any way, method two is nice, but it must become useful when playing at home.
8. What would be useful, is if you add information about the position of the ball/in-game data in general to the feedback. Like when I am entering the penalty zone or something and what this does to my stress levels. This knowledge might be able to show me where I can improve in performance during a game.
    a. It would be nice is to show if the ball is on the midfield, at the goal, at left or right side of the field, in the opponents or in my possession and maybe shooting position.

Appendix C: Interview session 2

This interview session will be semi-structured. All the participants will receive an introduction about the design of the stress sensor and the feedback method. After this introduction, the participants can ask questions to clarify some uncertainties and to make sure the participants were fully aware of the design. After this is done, they are to be asked if the information they give can be used for study purposes. If agreed, the following questions are asked.

1. What would be an advantage and disadvantage of haptic feedback?
2. What do you like about the new feedback design?
3. What do you dislike about the new feedback design?
4. What is your opinion about a stand additional to the screen?
5. How would you change the new feedback design?
6. What do you like about the idea of a hardened part on the output cable of the controller?
7. What do you dislike about the idea of a hardened part on the output cable of the controller?
8. Why do you think that the new idea of an additional picture which indicates electrode placement will help you?
9. Why do you think the idea of a plug near the computer for the electrodes would be useful?
10. How would you improve this placement method?

Question 1 is a question to see if the named type of feedback might be useable in the project. In addition, the following picture is shown to illustrate the feedback display.



1st Jelte:

Q:

1. What would be an advantage and disadvantage of haptic feedback?
    a. Do you think that we should try and test the usability of haptic feedback?
2. What do you like about the new feedback design?
3. What do you dislike about the new feedback design?
4. What is your opinion about a stand additional to the screen?
5. How would you change the new feedback design?
6. What do you like about the idea of a hardened part on the output cable of the controller?
7. What do you dislike about the idea of a hardened part on the output cable of the controller?

    a. If the hardened extra part is small and not that heavy?
8. Why do you think that the new idea of an additional picture which indicates electrode placement will help you?
    a. Why?
9. Why do you think the idea of a plug near the computer for the electrodes would be useful?
    a. How is it making the project user friendly?
10. How would you improve this placement method?

A:

1. It would give direct feedback which should be nice, however I think it will get annoying. It might be better when you expect the vibrations, but I would not like it.
    a. No, I am almost certain that it would be annoying and therefore not useful.
2. I think it will be much more versatile in use. This way, you can train with it, during a game if we want to and let it be used by a coach during eDivisie. It will also be much more straight forward this way.
3. I do not dislike anything**; however, it might be useful to add an extra interface layer in on this system. It might for example be useful to have an extra tab in which an overview of all the stress levels of all the played games during the week are displayed. In addition, it might be cool if we can look back at statistics of stress of previous played matches by having them all presented in a list.**
4. The standard is nice, **but it must be Twente personalised.**
5. I would not change it, it is clear. To elaborate on an interface, it could have all the subjects at the top of the screen like current measurements, previous games, average stress etc. this could be a nice way to navigate.
6. I like the idea. It is nice that the parts can be taken apart and be put back on since it makes it easier to use and clean.
7. **If it becomes too heavy or too bulky, it might not be useful but annoying.**
    a. I would use it.
8. Yes, it is nice to have an example if you do not know where to stick the electrodes. However, if you use it often, the extra image will not be necessary anymore.
    a. Because you just know where to place them so it will become useless.
9. It would be useful because it makes the project more user friendly.
    a. It lets the user easily get something to drink at home, but also at the eDivisie, it would not require everyone to have his or her own device. This would however also include that the saved stresses of games need to be tagged for everyone.
10. I think that the placement is good like this. It is easy to attach and user friendly since it does not require one to be constantly attached when he/she is hooked up. However, it is to be noted that there might be an issue with this device, but we might only find out by testing it.

2nd Enis:

Q:

1. What would be an advantage and disadvantage of haptic feedback?
    a. Do you think that we should try and test the usability of haptic feedback?
2. What do you like about the new feedback design?

3. What do you dislike about the new feedback design?
    a. Jelte talked about an interface with which you could navigate through different sources of data like summed up stress over x amount of games etc. Would you like to see this as well?
        i. What data would you want to have presented?
        ii. Last interview, you talked about stress at particular parts of the field, would that be something you like?
4. What is your opinion about a stand additional to the screen?
    a. How do you mean, perfectly visible?
5. How would you change the new feedback design?
    a. Jelte suggested an interface *explanation about this interface*. What do you think about this interface and its functions?
6. What do you like about the idea of a hardened part on the output cable of the controller?
7. What do you dislike about the idea of a hardened part on the output cable of the controller?
8. Why do you think that the new idea of an additional picture which indicates electrode placement will help you?
9. Why do you think the idea of a plug near the computer for the electrodes would be useful?
10. How would you improve this placement method?

A:

1. I would not like the vibrations because it would be distracting and weird. I cannot think of an advantage for this type of feedback.
    a. Yes, testing is always possible, however I do not think it will be useful.
2. I like it because this will provide an easy way of receiving feedback. This will also solve my previous issues about whether it is useful at home.
3. I cannot think of anything that I dislike. I just go with the flow as they say and cannot tell about something I dislike if I do not dislike something. If I dislike something, I will say so.
    a. Yes, that would be nice. It would also make the data much more insightful since it is more detailed and has a good overview.
        i. I do not really know. The stress over multiple games are nice, but I cannot think of anything that would be useful at this moment.
        ii. Yes, that would be nice, then I would know on what aspects I could train in a general sense.
4. **The stand seems nice. Since I do change my distance from the screen it might be useful to be able to adjust the angle of the screen in order to make it perfectly visible.**
    a. Well, when the sun hits the screen in a certain angle in might be useful to be able to get rid of that.
5. I would not change it. It seems fine like this.
    a. This type of interface seems cool, but I do not know about how this will work. If it works like standard known apps it will be fine. The functions seem fine as well, apart from the subjects I told in the last interview; I cannot think of any new data that could be used.
6. The hardened part is a good idea. The addition which makes it attachable and detachable is especially nice. Therefore, if it is not useful or does something unwanted, it is possible to remove it and get it back to standard mode. It will thus not be annoying.
7. I do not dislike it. For the same reason as earlier *see answer 3*
8. It will help me since I am not an expert in placing electrodes on my body. However, after using it for a while I will probably not need the picture anymore.

9. It would be useful since it minimalizes the steps needed to connect and disconnect from the system. This will make the usage much easier.
10. I do not know. I think it is fine like this and we will know more once we can test it because for me it is hard to tell without knowing how it will feel.

3rd Brent:

Q:

1. What would be an advantage and disadvantage of haptic feedback?
    a. Do you think that we should try and test the usability of haptic feedback?
2. What do you like about the new feedback design?
3. What do you dislike about the new feedback design?
    a. This has not been decided yet, but I am aiming at tabled size since one can sit quite far away from a screen, and a small screen would not be able to provide detailed feedback.
4. What is your opinion about a stand additional to the screen?
    a. Do you think that the stand should have a sort of extra function?
5. How would you change the new feedback design?
6. What do you like about the idea of a hardened part on the output cable of the controller?

Brent left for 10 minutes to get and eat his pizza

7. What do you dislike about the idea of a hardened part on the output cable of the controller?
8. Why do you think that the new idea of an additional picture which indicates electrode placement will help you?
9. Why do you think the idea of a plug near the computer for the electrodes would be useful?
10. How would you improve this placement method?

A:

1. It is not nice since it will get you out of focus. I cannot think of an advantage at all.
    a. Testing is always possible. Testing is fun
2. I like it, it gives clear feedback and every aspect has a function. To start off, it will have the right functions.
3. **I do not really dislike anything; however, I do have an additional question. How big will the screen be?**
    a. **Ok, then I think it will be fine, however the screen should not get smaller because otherwise I do not think it will be that useful.**
4. The stand is nice, I do not have an actual opinion on it since it is just a stand.
    a. No, not that I can think of. I also think that it would be harder to make if it could move or something. It should not be that special.
5. I would not change anything. It seems fine as it is right now. I can only tell if I really dislike something but the difference between good and best is hard for me to see.
6. I like it since it solves a mayor issue of mine which is cable touching hand. I find it so annoying.
7. I do not dislike anything at all. I hope to get this asap since I might use it right now.
8. The picture will solve the problem I had with placing the electrodes on a wrong position, however this will be an indication. It will not be a precise method of placement. That said, I do think it will be enough for us to not fuck it up.
9. Yes, the idea would be great. It will make it easier for me to get my food when I am gaming. *joking about his pizza*
10. I do not know; it is same as the question about the feedback improvement. I do not know what the difference is between good and best, so I think it is fine for now.

Appendix D: Controller code

```
from __future__ import print_function

# The python file inputs.py is basically the py that coded everything for the controller
# and this py file I want to retrieve that data
from inputs import get_gamepad

#libraries for plotting
import plotly.offline
import plotly.graph_objects as go

def main():
    #variable for measuring time of interval
    interval = 5

    #time of program running in min
    aofmin = 15   #amount of min
    programrun = aofmin * 60   #convert to sec

    #initialize a one time use variable
    programstart = True #used to initialize a later variable (hardcoded is bad)
    stressvalue = 0 #initialize stress variable

    #multiplier is used to create a stress value
    multiplier = 10 #this varible is used to obtain maching values with the other data

    #setting button pressed, graphtime and data to 0 at start
    button_pressed = 0
    graphtime = 0

    #initializing arrays for data
    measuringtime = [0]
    data = [0]

    while 1:
      #start event
        events = get_gamepad()

        for event in events:

            #very hardcoded way to initialize the starting time
            if programstart == True:
                programstart = False
                program_start = event.timestamp

            # Time buttons pressed gamepad (Playstation terms in the names)
            if event.state == 1 and event.ev_type != "Sync":

                #checking which button is pressed (usefull for future purpose)
                if event.code == 'BTN_SOUTH':
                    button_pressed = button_pressed+1
                    print("pressed")

                if event.code == 'BTN_WEST':
                    button_pressed = button_pressed+1
                    print("pressed")

                if event.code == 'BTN_NORTH':
                    button_pressed = button_pressed+1
```

```
            print("pressed")

        if event.code == 'BTN_EAST':
            button_pressed = button_pressed+1
            print("pressed")

        if event.code == 'BTN_TR':
            button_pressed = button_pressed+1
            print("pressed")

        if event.code == 'BTN_TL':
            button_pressed = button_pressed+1
            print("pressed")

    #checking if interval is reached
    counter = event.timestamp
    if counter - program_start >= interval:

        #computing stress value
        stressvalue = button_pressed * multiplier

        #reseting buttons pressed
        button_pressed = 0

        #resetting program starting time so a new interval can be made
        program_start = program_start + interval

        #creating valuees to add to graph
        graphtime = graphtime + interval

        #adding values to array
        data.append(stressvalue)
        measuringtime.append(graphtime)

        #check what time is left for program
        programrun = programrun - interval
        print(programrun)
        print(data)

    #to kill program if time ran out
    if programrun <= 0:
        break

    #adding arrays to graph
  plotly.offline.plot({"data": [go.Scatter(x = measuringtime, y = data, name = "Controller data")],
                "layout": go.Layout(title="Controller data", xaxis_title = "Time", yaxis_title = "Stress Level")},
                filename = 'controller data.html', image = 'jpeg', image_filename = 'sensor test')
#actual start of the program
if __name__ == '__main__':
  main()
```

Appendix E: Facial measurement code

```
from scipy.spatial import distance as dist
from imutils.video import VideoStream
from imutils import face_utils
import numpy as np
import imutils
import time
import dlib
import cv2
import matplotlib.pyplot as plt
from keras.preprocessing.image import img_to_array
from keras.models import load_model

def eye_brow_distance(leye,reye):
    global points
    distq = dist.euclidean(leye,reye)
    points.append(int(distq))
    return distq

def emotion_finder(faces,frame):
    global emotion_classifier
    EMOTIONS = ["angry" ,"disgust","scared", "happy", "sad", "surprised","neutral"]
    x,y,w,h = face_utils.rect_to_bb(faces)
    frame = frame[y:y+h,x:x+w]
    roi = cv2.resize(frame,(64,64))
    roi = roi.astype("float") / 255.0
    roi = img_to_array(roi)
    roi = np.expand_dims(roi,axis=0)
    preds = emotion_classifier.predict(roi)[0]
    emotion_probability = np.max(preds)
    label = EMOTIONS[preds.argmax()]
    if label in ['scared','sad']:
        label = 'stressed'
    else:
        label = 'not stressed'
    return label

def normalize_values(points,disp):
    normalized_value = abs(disp - np.min(points))/abs(np.max(points) - np.min(points))
    stress_value = np.exp(-(normalized_value))
    print(stress_value)
    if stress_value>=75:
        return stress_value,"High Stress"
    else:
        return stress_value,"low_stress"

detector = dlib.get_frontal_face_detector()
predictor = dlib.shape_predictor("shape_predictor_68_face_landmarks.dat")
emotion_classifier = load_model("_mini_XCEPTION.102-0.66.hdf5", compile=False)
cap = cv2.VideoCapture(0)
points = []
while(True):
    _,frame = cap.read()
    frame = cv2.flip(frame,1)
    frame = imutils.resize(frame, width=500,height=500)


    (lBegin, lEnd) = face_utils.FACIAL_LANDMARKS_IDXS["right_eyebrow"]
    (rBegin, rEnd) = face_utils.FACIAL_LANDMARKS_IDXS["left_eyebrow"]
```

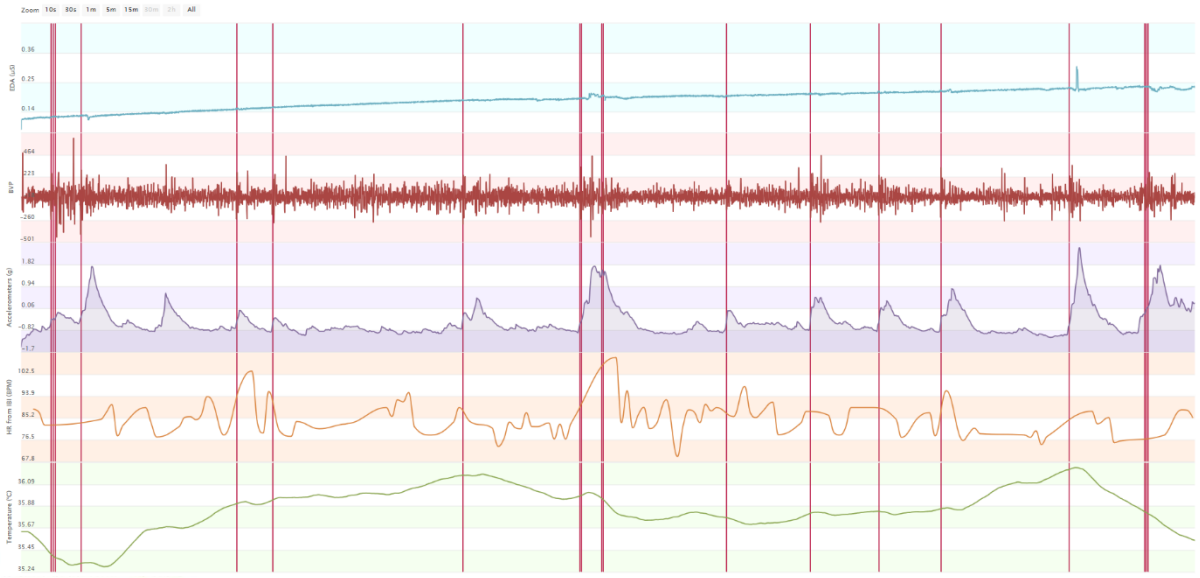
```
    #preprocessing the image
    gray = cv2.cvtColor(frame,cv2.COLOR_BGR2GRAY)

    detections = detector(gray,0)
    for detection in detections:
        emotion = emotion_finder(detection,gray)
        cv2.putText(frame, emotion, (10,10),cv2.FONT_HERSHEY_SIMPLEX, 0.5, (0, 255, 0), 2)
        shape = predictor(frame,detection)
        shape = face_utils.shape_to_np(shape)

        leyebrow = shape[lBegin:lEnd]
        reyebrow = shape[rBegin:rEnd]

        reyebrowhull = cv2.convexHull(reyebrow)
        leyebrowhull = cv2.convexHull(leyebrow)

        cv2.drawContours(frame, [reyebrowhull], -1, (0, 255, 0), 1)
        cv2.drawContours(frame, [leyebrowhull], -1, (0, 255, 0), 1)

        distq = eye_brow_distance(leyebrow[-1],reyebrow[0])
        stress_value,stress_label = normalize_values(points,distq)
        cv2.putText(frame,"stress
level:{}".format(str(int(stress_value*100))),(20,40),cv2.FONT_HERSHEY_SIMPLEX, 0.5, (0, 255, 0), 2)

    cv2.imshow("Frame", frame)

    key = cv2.waitKey(1) & 0xFF
    if key == ord('q'):
        break
cv2.destroyAllWindows()
cap.release()
plt.plot(range(len(points)),points,'ro')
plt.title("Stress Levels")
plt.show()
```

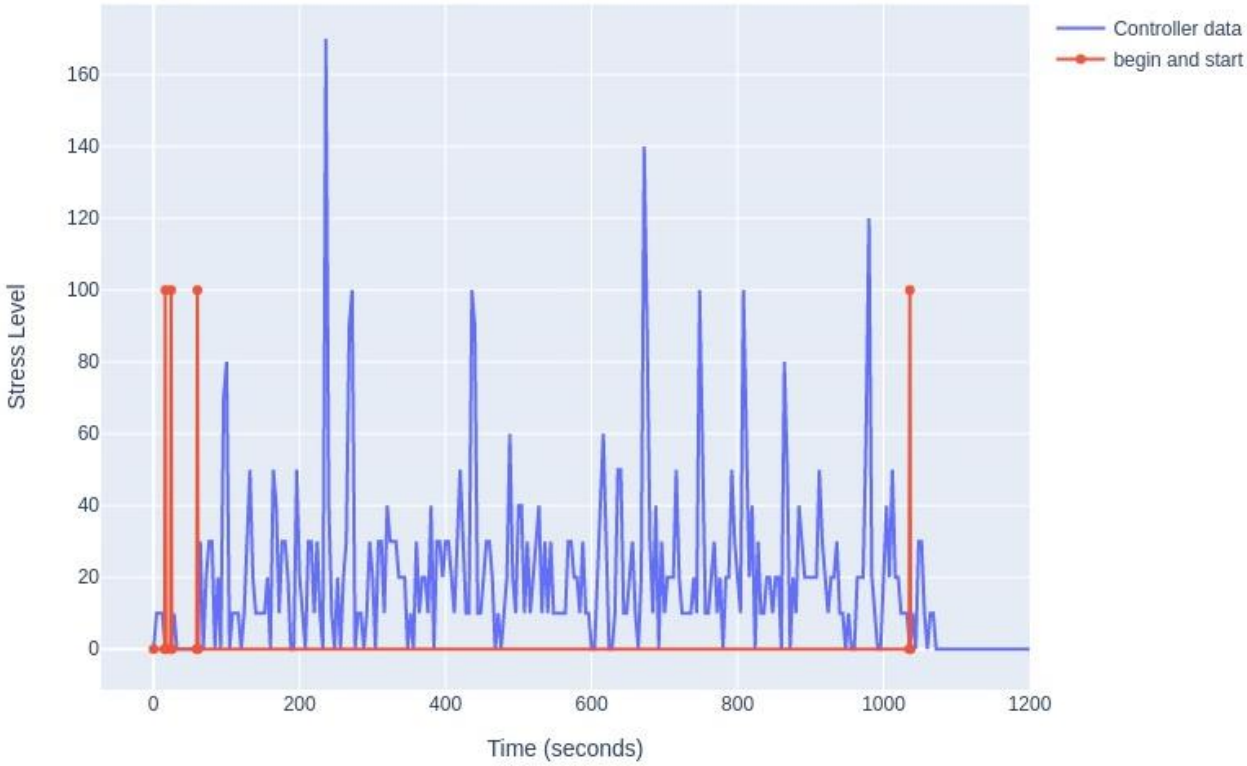
Appendix F: Data section 7.1

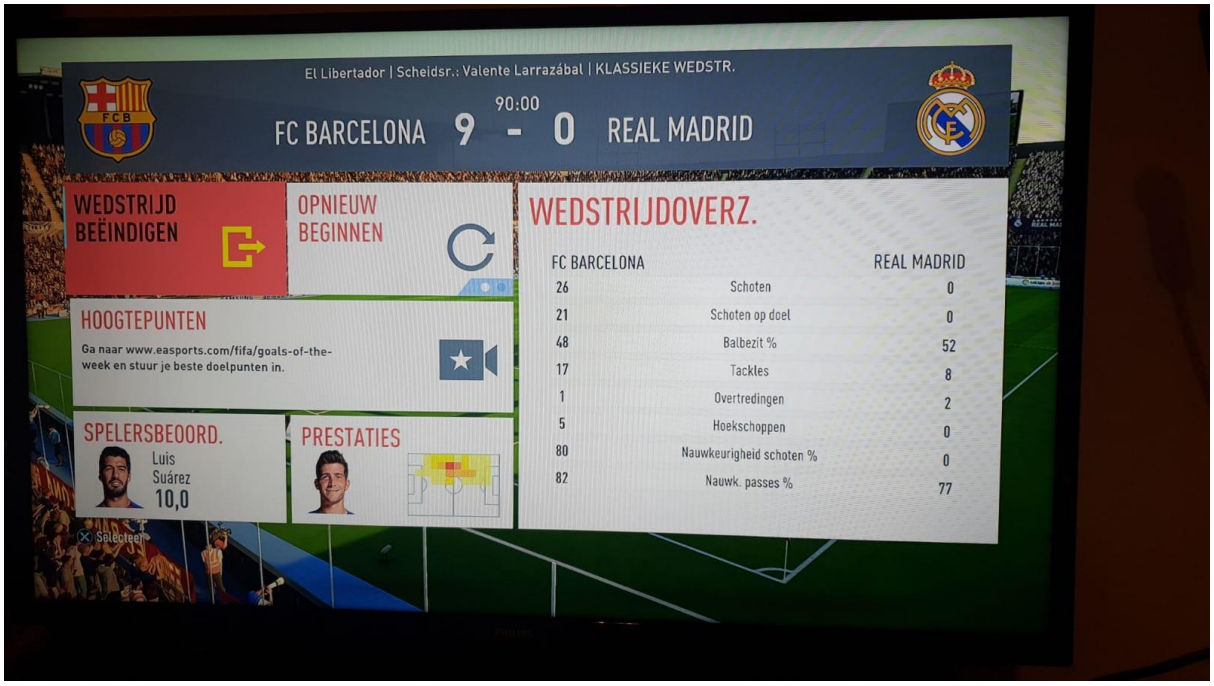
The data from the ECG and GSR are indicated in the colour light blue and orange within every first graph. The GSR data is indicated with light blue, and the ECG data is indicated with orange.

Day 1, 10Am, Difficulty: Amateur

During the measuring session, nothing extraordinary happened. The game went smooth and no difficulties were encountered. At the beginning of the game, the start button for the controller data was pressed three times instead of one. The last click is the actual start of the game.



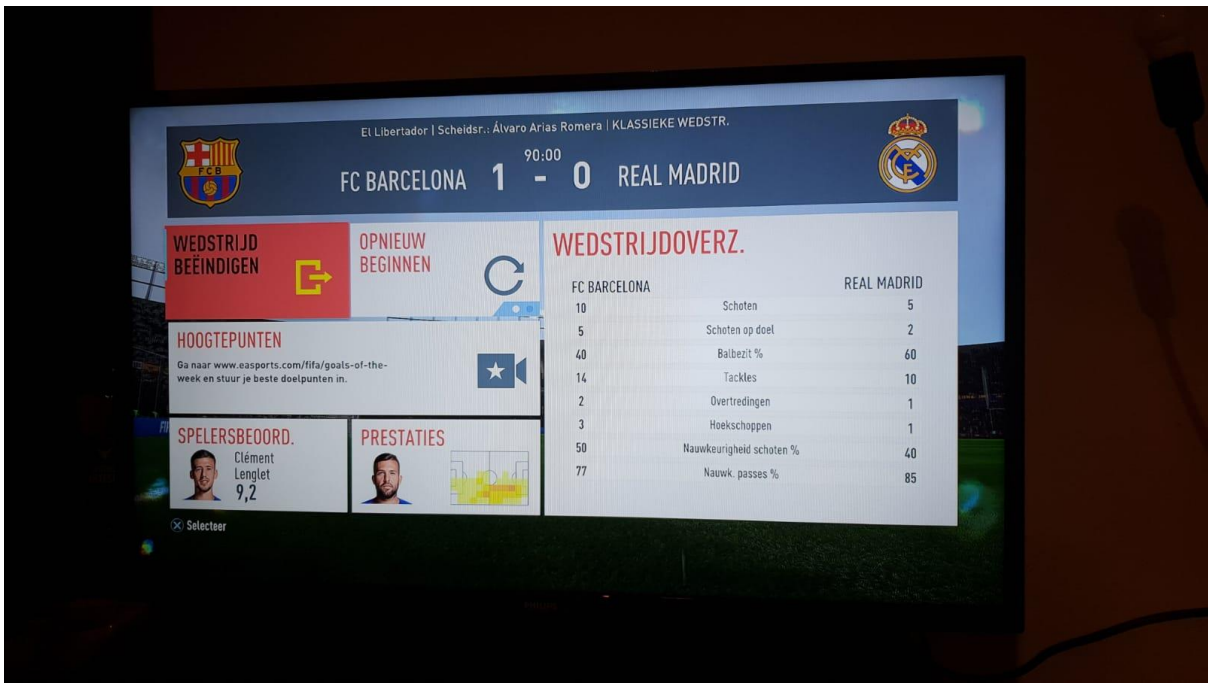


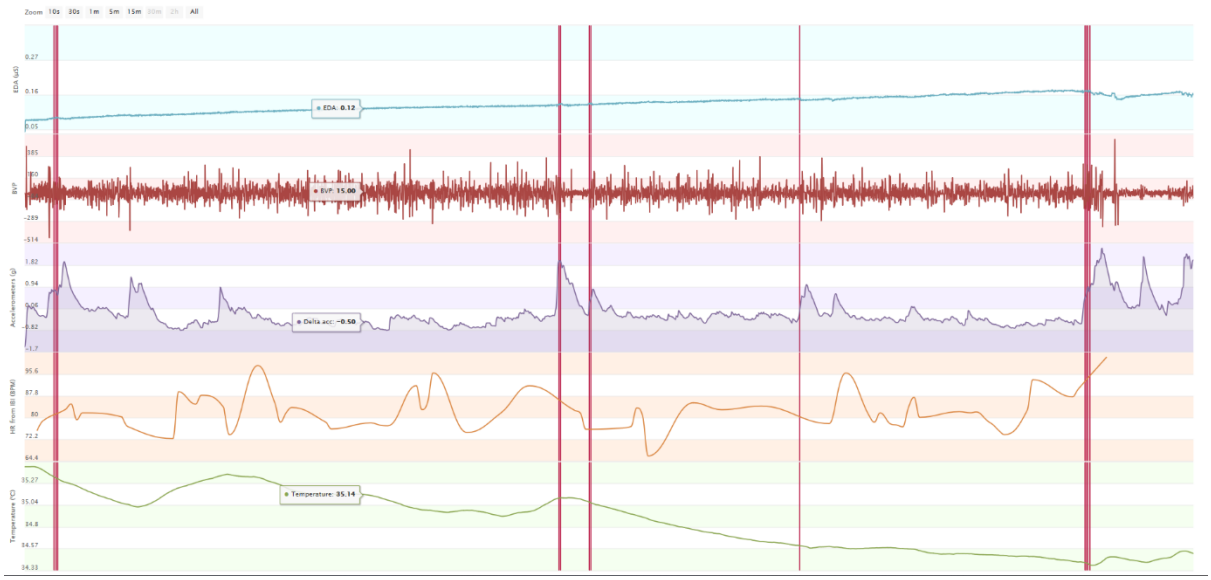


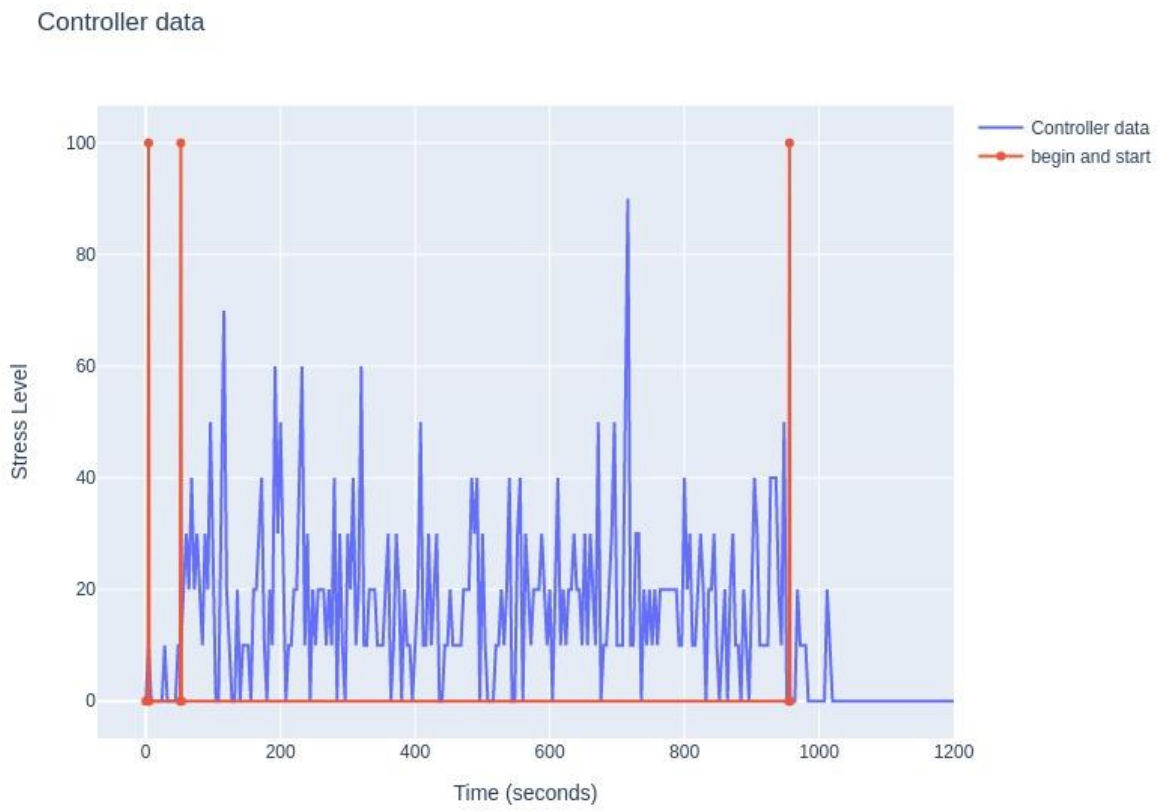
During the game itself, one can tell that stress levels especially rise during goal related moments. This is both true for ECG and Tilt. The GSR data rises as the game continues, indicating that this stress factor does slowly increase during the game. No tilt was perceived in the form of anger during this game.

Day 1, 12Pm, Difficulty: Pro

During the measuring session, nothing extraordinary happened. The game went smooth and no difficulties were encountered. At the beginning of the game, the start button for the controller data was pressed two times instead of one. The last click is the actual start of the game.



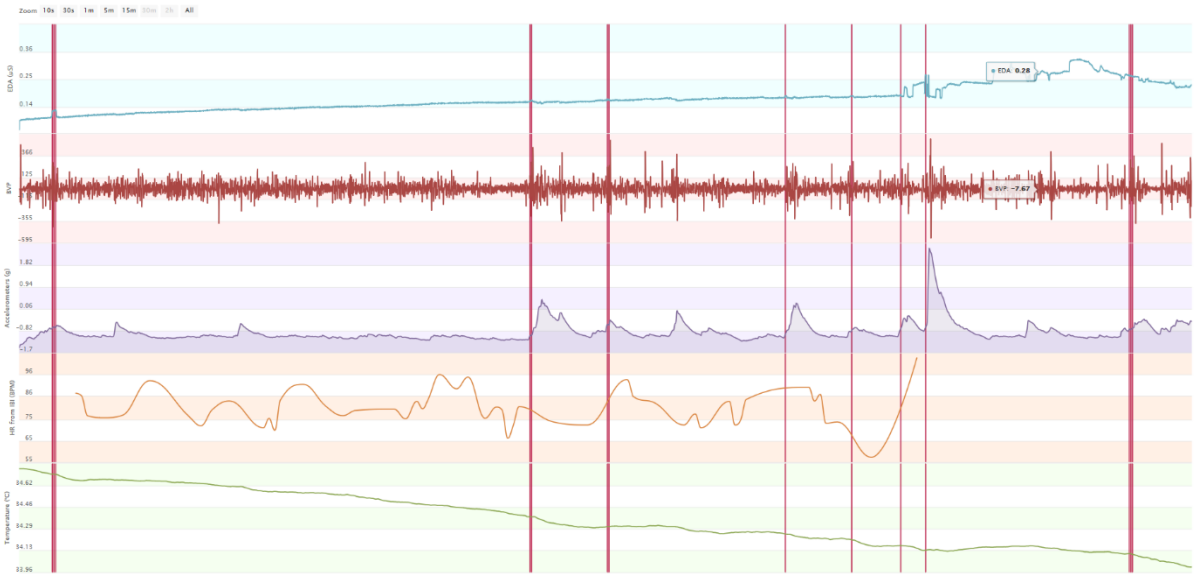


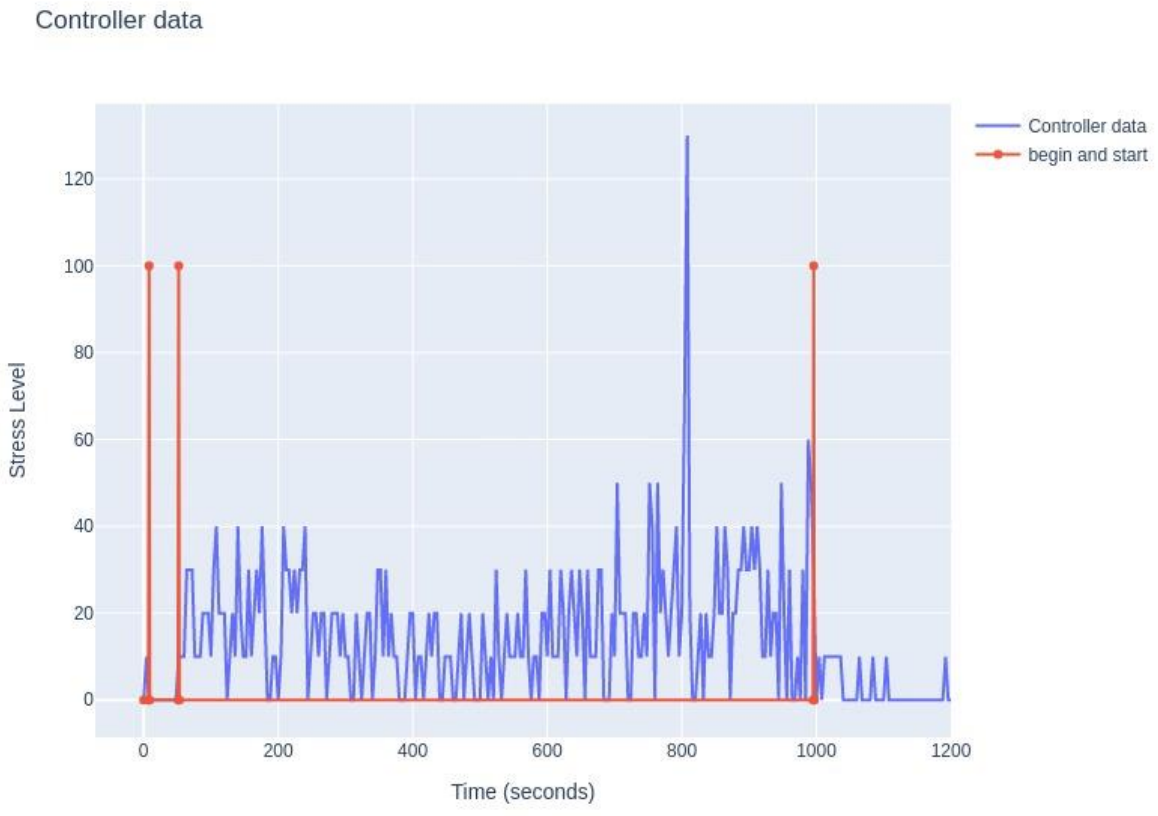


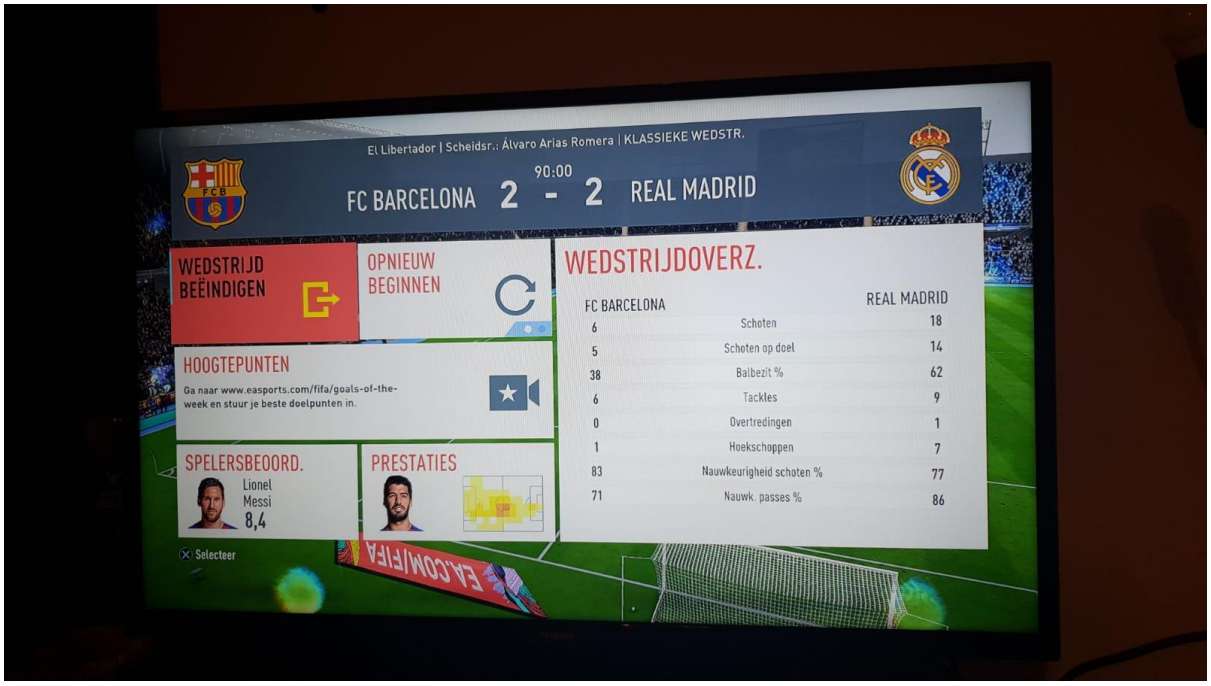
During the game itself, one can tell that stress especially rises during goal related moments. Within the ECG graph, a relaxation can be found after the goal is scored. The GSR data rises as the game continues, indicating that this stress factor does slowly increase during the game. There were small moments in which tilt was perceived in the form of anger. These moments mainly occurred at the start of the game. This can also be seen within the tilt graph since there are high peaks at the start. During the game, stress levels do gradually rise over time.

Day 1, 4Pm, Difficulty: Legendary

During the measuring session, nothing extraordinary happened. The game went smooth and no difficulties were encountered. At the beginning of the game, the start button for the controller data was pressed two times instead of one. The last click is the actual start of the game.







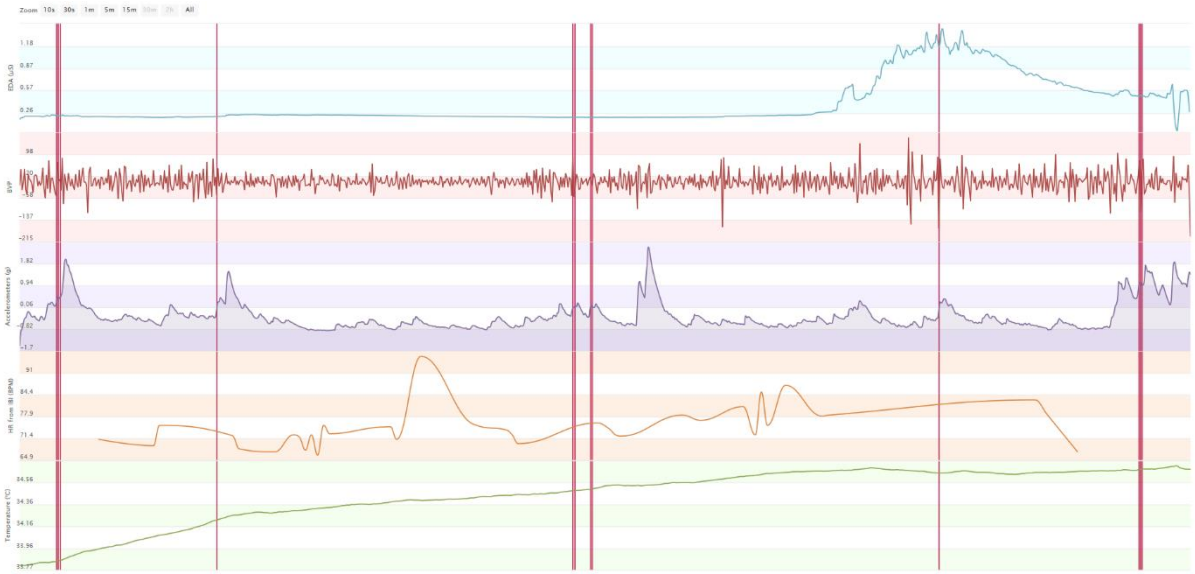
There were moments in which tilt was perceived in the form of anger, especially after the 4th goal was scored. The first goal was scored by the user, the second and third by the AI and the last by the user. The ECG and GSR measurements broke or went out of control after the fourth goal. It is to be said that the data would have been high since the user was perceivably Tilted because the game was tense. This can also be seen in de Tilt measurements because near the end of the game, buttons are pressed more frequent then earlier in the game. Within this session, ECG levels did show elevated levels in comparison to other games. It can thus be said that the difficulty might show elevated stress levels.

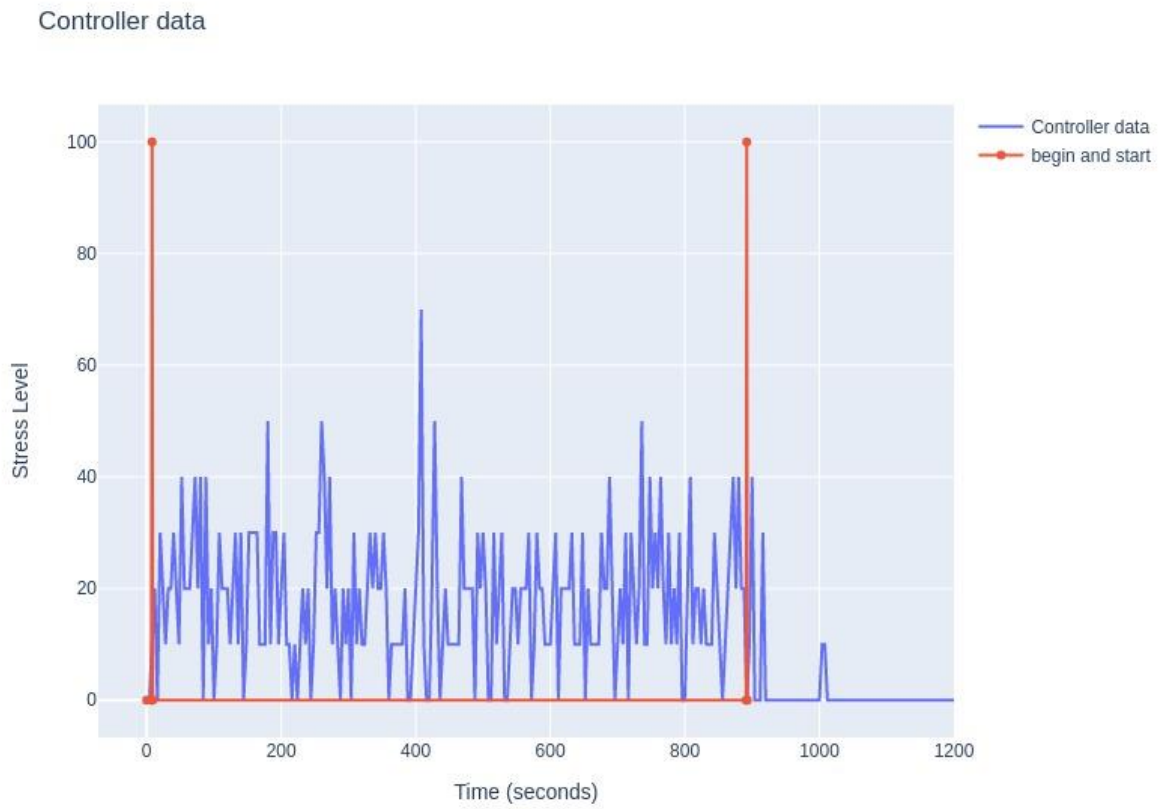
Conclusion day 1

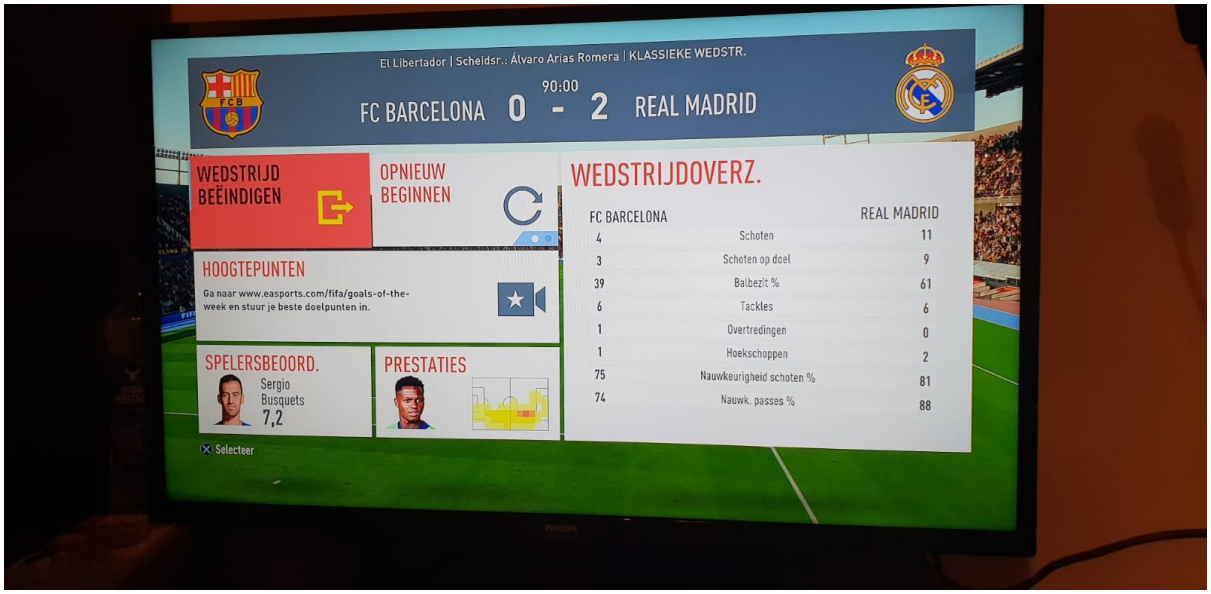
From the ECG and GSR data, it is hard to relate data to events, next to goal related events. Within the controller data, a clear conclusion can be drawn of the general amount of presses: Within the easiest game, the tilt sensor puts out higher data then in the harder games. Within the last game, one can clearly see tilt near the end since the measurements clearly rise at that point. Within the sessions, it is shown that the legendary level has a higher general stress level output. This could happen due to its difficulty, but also due to the time on which is played that day. In addition, it is shown that stress levels over time elevate during the game.

Day 2, 10Am, Difficulty: Legendary

During the measuring session, before the second goal, the user was called. This phone call was important, so he had to multitask by playing Fifa and answer the call. The goal was scored after the call. At the beginning of the game, the start button for the controller data was pressed two times instead of one. The last click is the actual start of the game.



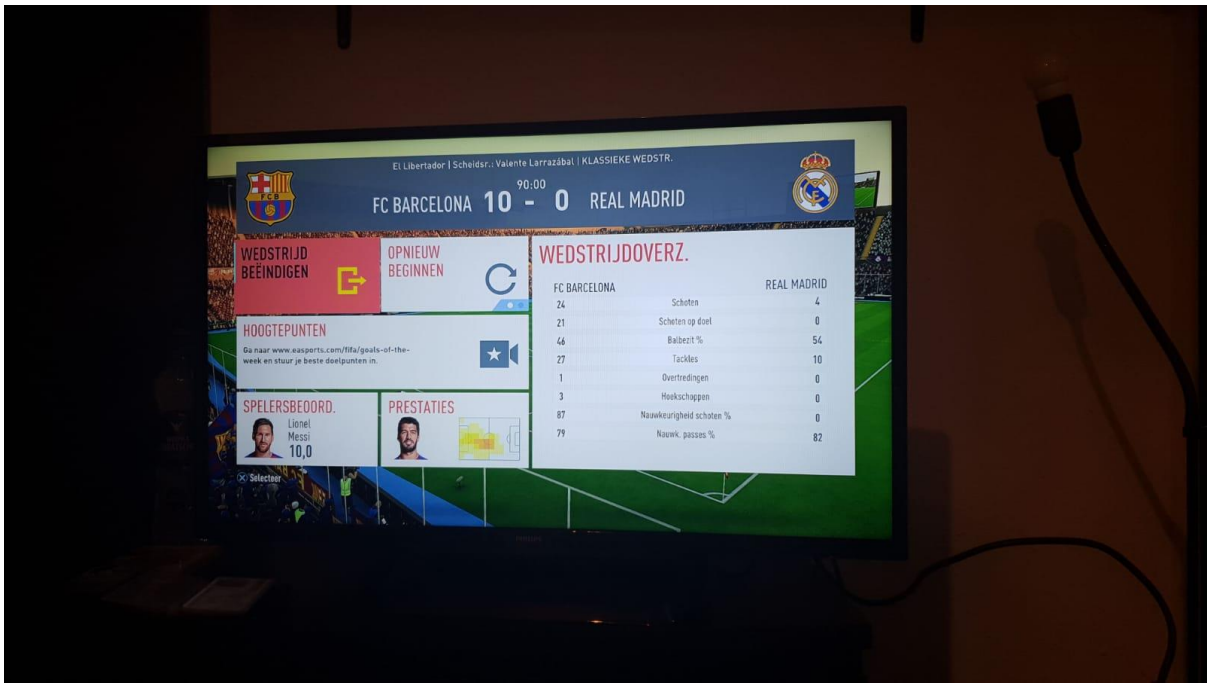


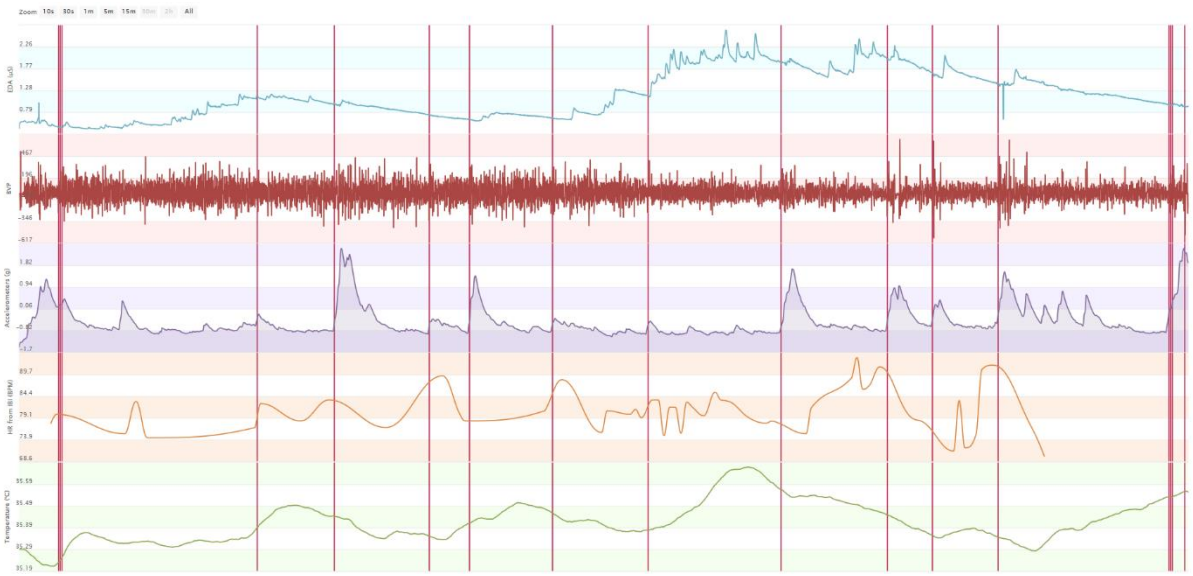


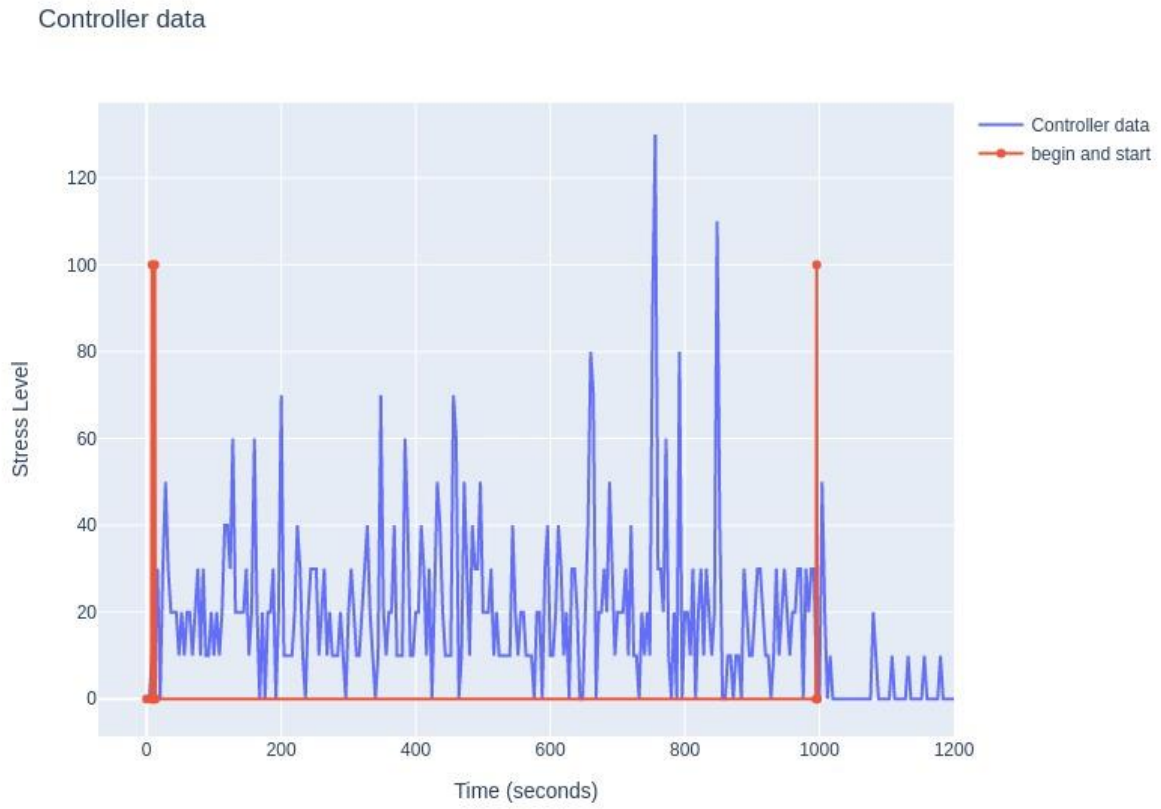
There were small moments in which tilt was perceived in the form of anger. The phone call can be perceived well within the ECG and GSR data. Both measurements indicate a rise which is not peaked but is making the stress rise. Within the ECG and tilt data, there is also a peak perceived that is not marked with a goal. this must indicate a moment in which the ball was clutched in front of the goal. It can be seen in the data that the stress levels do gradually rise during the game.

Day 2, 12Pm, Difficulty: Amateur

During the measuring session, nothing extraordinary happened. The game went smooth and no difficulties were encountered. At the beginning of the game, the start button for the controller data was pressed two times instead of one. The last click is the actual start of the game. The break of the game is not marked because the test-subject forgot to do so. The break was between the 5th and 6th goal.



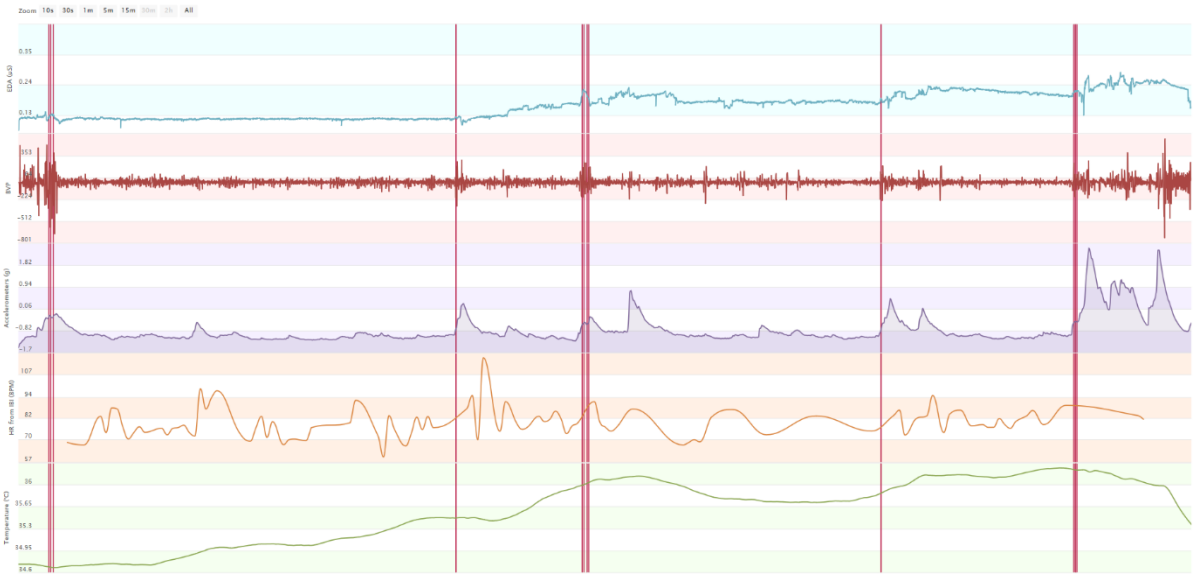


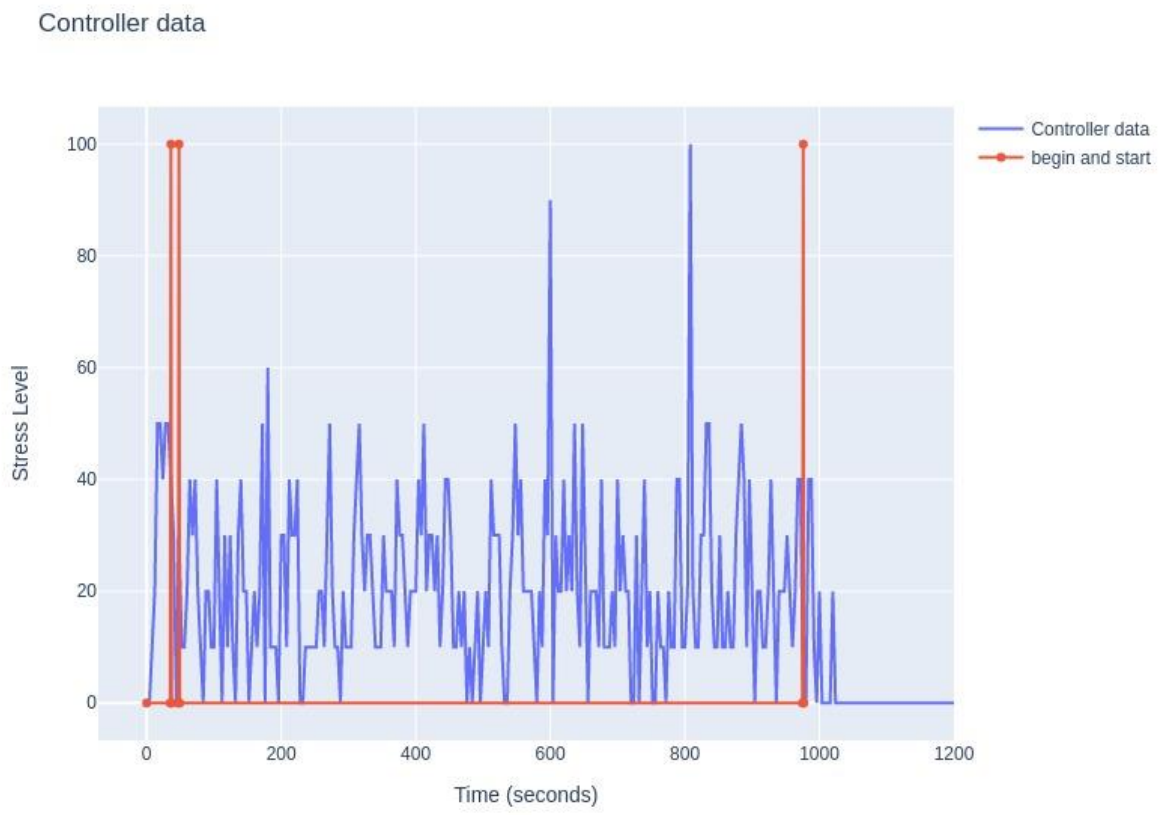


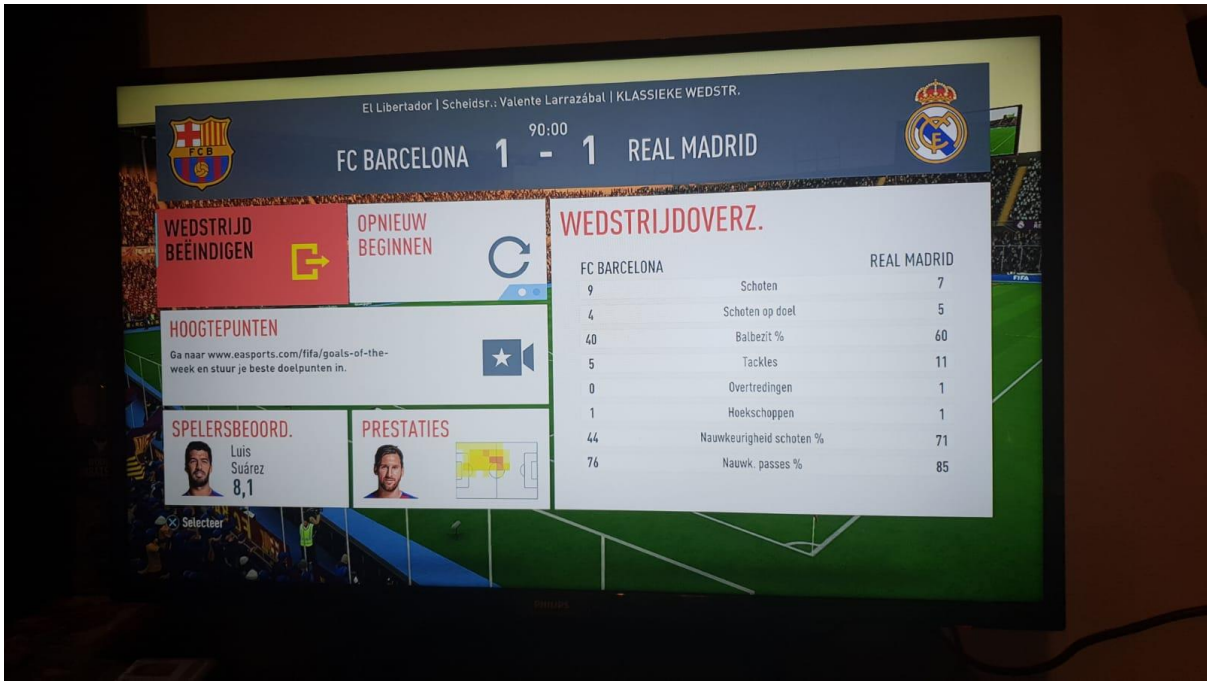
During the game, no tilt was perceived in the form of anger. The measurements show that stress increased during goal related moments in the ECG, GSR and tilt sensors. In this measurement, one can clearly see that the user got bored and therefore stressed after the 6th goal. This could also be seen at his posture since he kept looking away from the screen and was less excited about scoring. The peaks within the tilt sensor also rose significantly near the end since the user wanted to skip the goal videos ASAP. The user was perceivable tired now. This game shows that the user was not in the mood to play Fifa. This is most likely the reason for the elevated stress levels during the game in comparison to the other two days.

Day 2, 4Pm, Difficulty: Pro

During the measuring session, nothing extraordinary happened. The game went smooth and no difficulties were encountered. At the beginning of the game, the start button for the controller data was pressed two times instead of one. The last click is the actual start of the game. The first goal was scored by the AI and the second by the user.







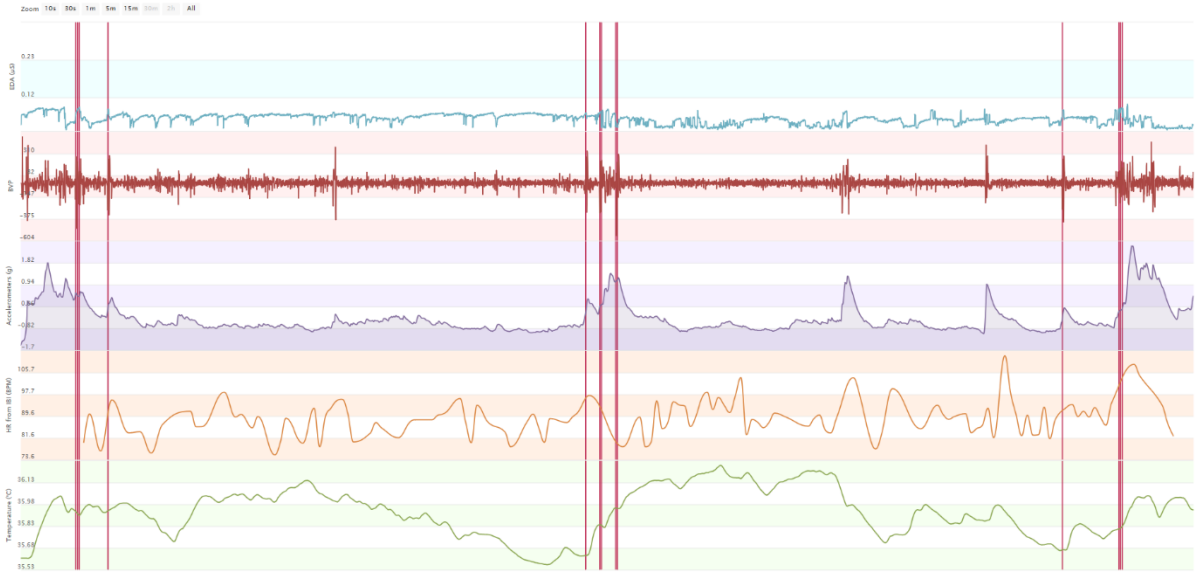
During the game, no tilt was perceived in the form of anger. Within the GSR measurements, one can see that the user perceived stress elevations after the first and second goal. From the ECG and tilt data, it is hard to draw conclusions. This is since there is no clear pattern or correlation between the data types not even within the goal related moments. The reason for this fact must be that the user was tired -which has been confirmed-. During the game, stress levels elevated gradually over time.

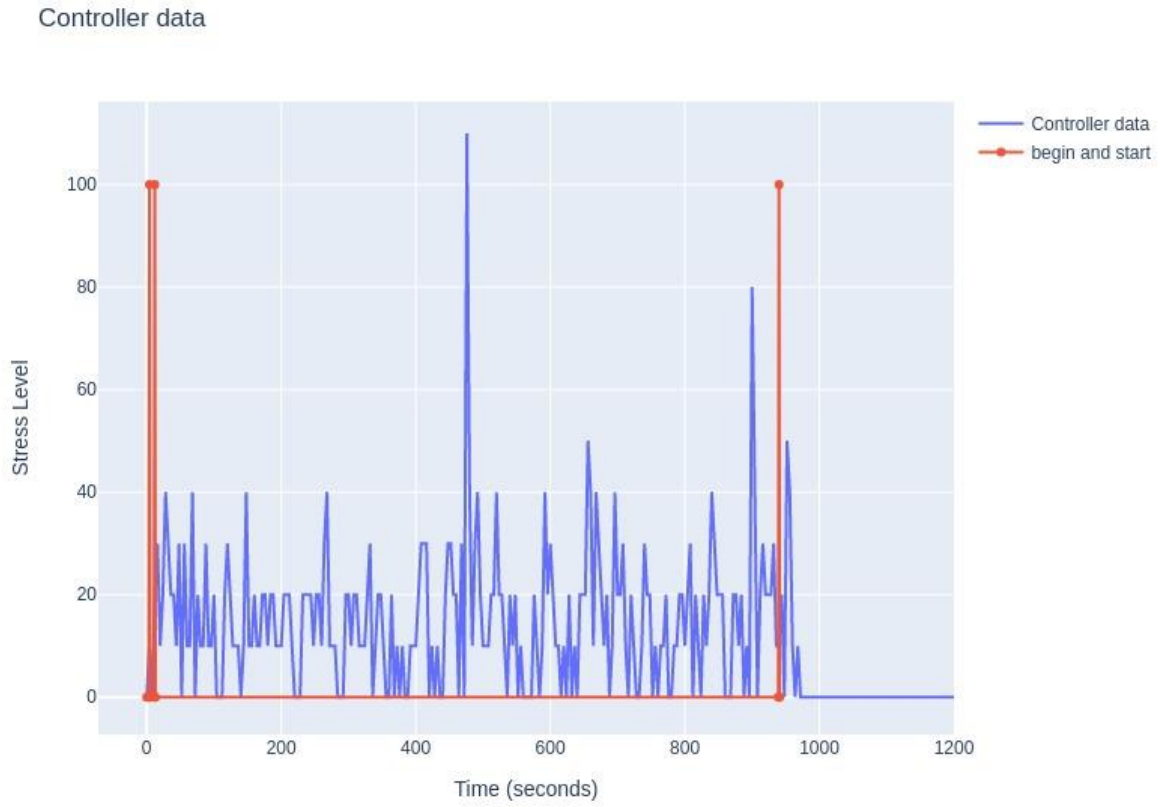
Conclusion day 2

This day showed data which was way harder to track then the data from day one. The data did not really show correlation besides increases in stress near goal related events. It is seen that the general stress levels are higher if the game is played later during the day. The probable reason for the weird data is that the user was perceivable more tired than the day before. It must be that tired gamers are not fully concentrated and focused on their game. Therefore, the gamer does not show behaviour which is fitting to the situation they find themselves in.

Day 3, 10Am, Difficulty: Pro

During the measuring session, nothing extraordinary happened. After the game, the user did forget to store the game outcome. The game ended in a 2-1 victory for the user. The user scored the first two goals and the AI the last goal. During the game, the user had more ball possession and much more scoring changes compared to the AI. At the beginning of the game, the start button for the controller data was pressed two times instead of one. The last click is the actual start of the game.

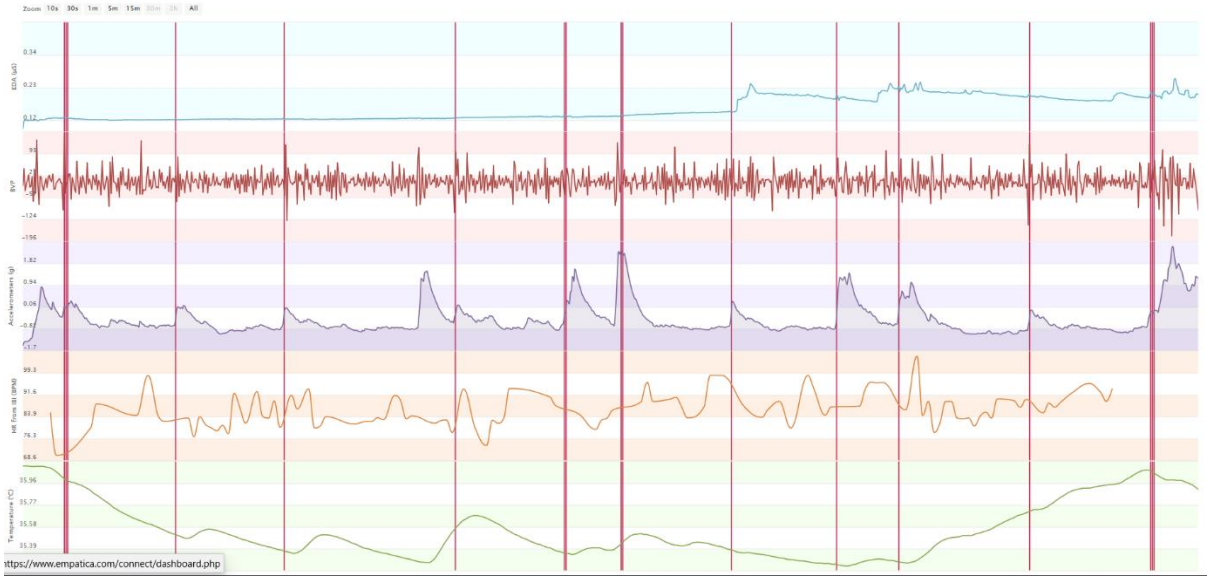


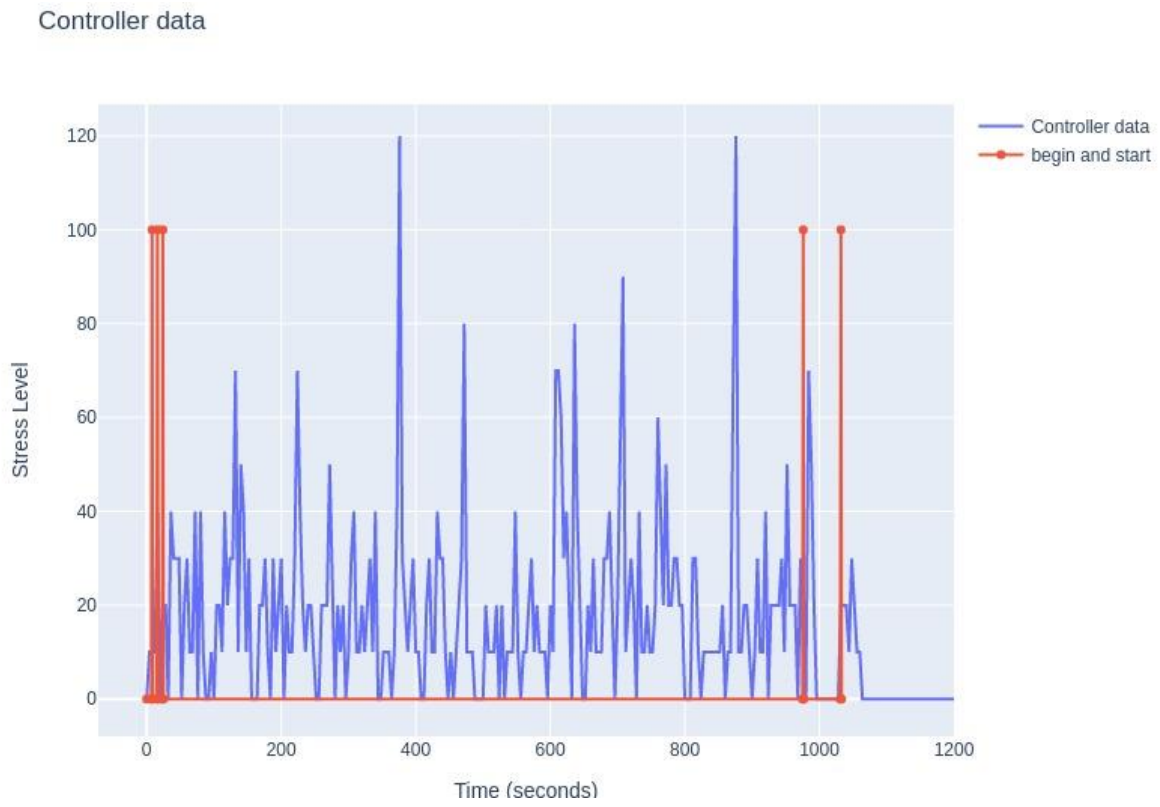


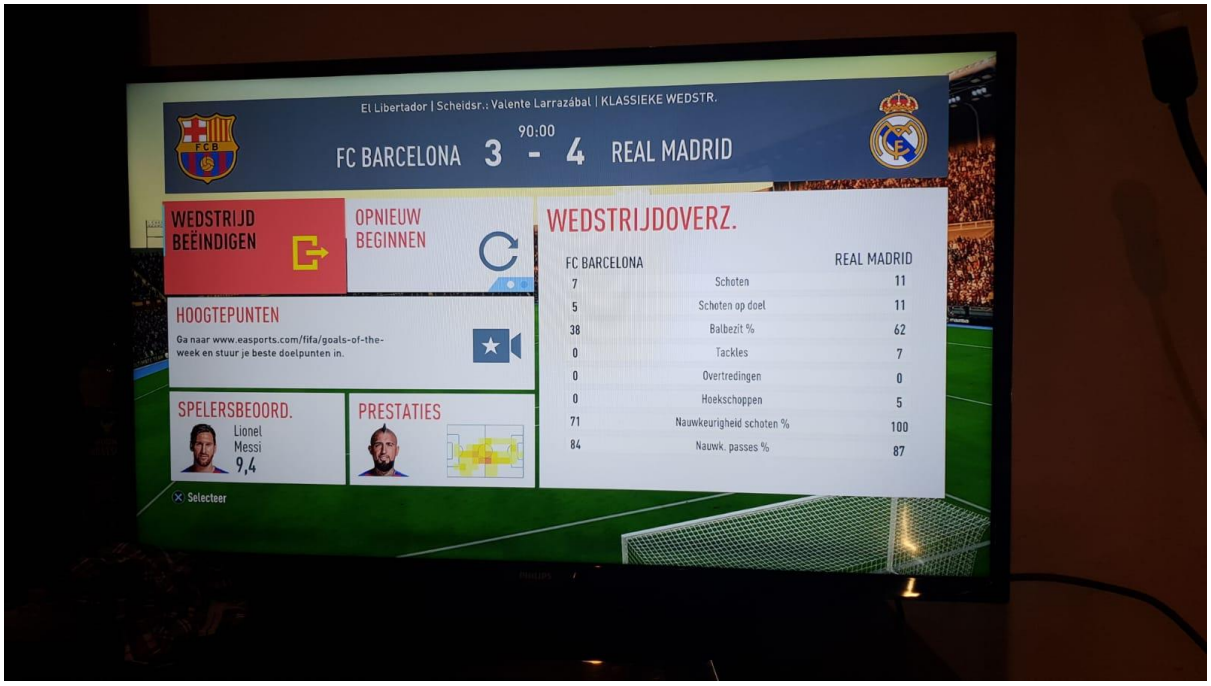
There were small moments in which tilt was perceived in the form of anger. This game can overall be a game with lots of stress changes concluded from the ECG data. Within the tilt measurements, it is safe to say that the amount of button presses is low. The GSR data is steady. During the game, stress was constant, which means that it did not go up or down.

Day 3, 12Pm, Difficulty: Legendary

During the measuring session, nothing extraordinary happened. The game went smooth and no difficulties were encountered. At the beginning of the game, the start button for the controller data was pressed three times instead of one. The last click is the actual start of the game.



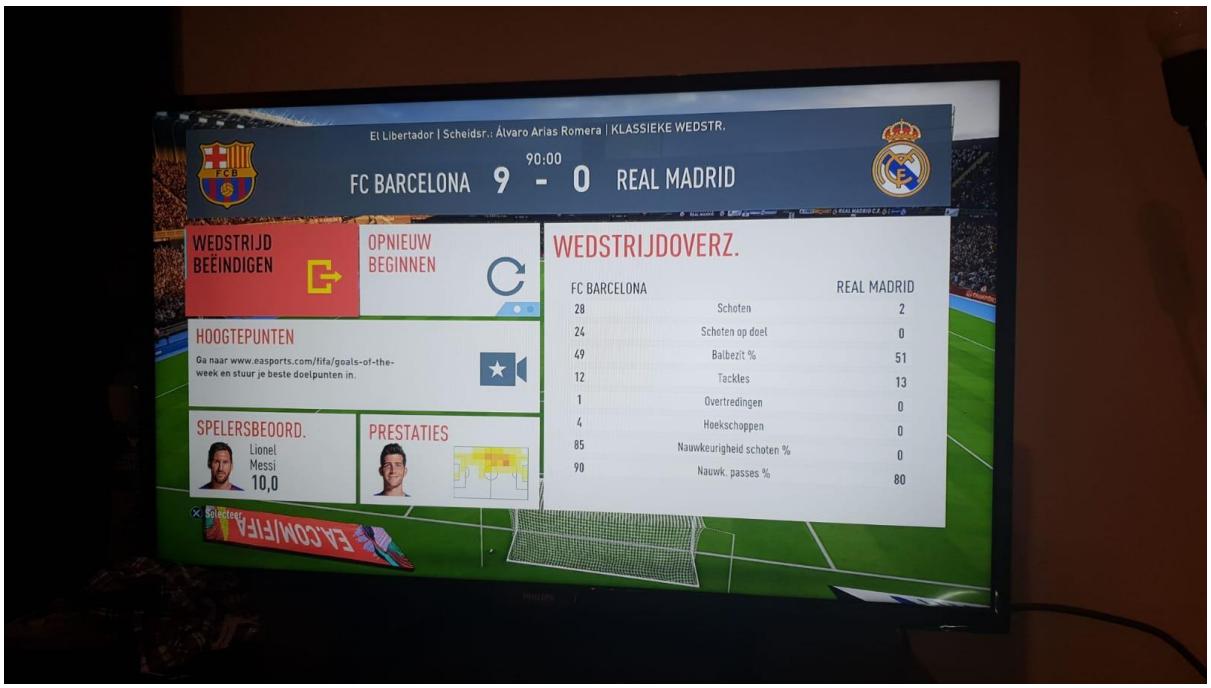


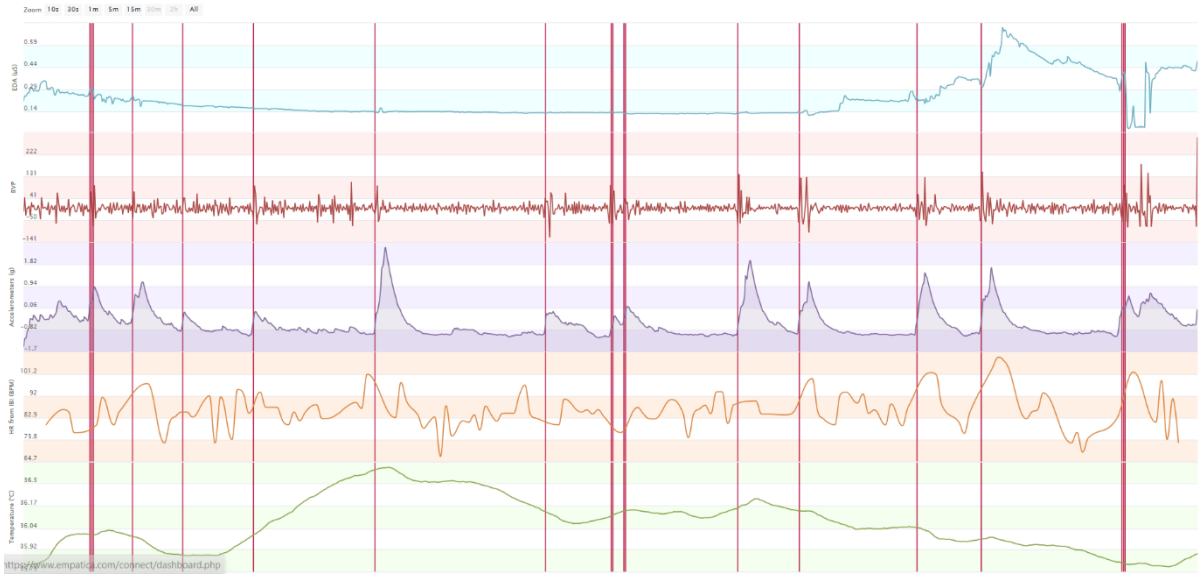


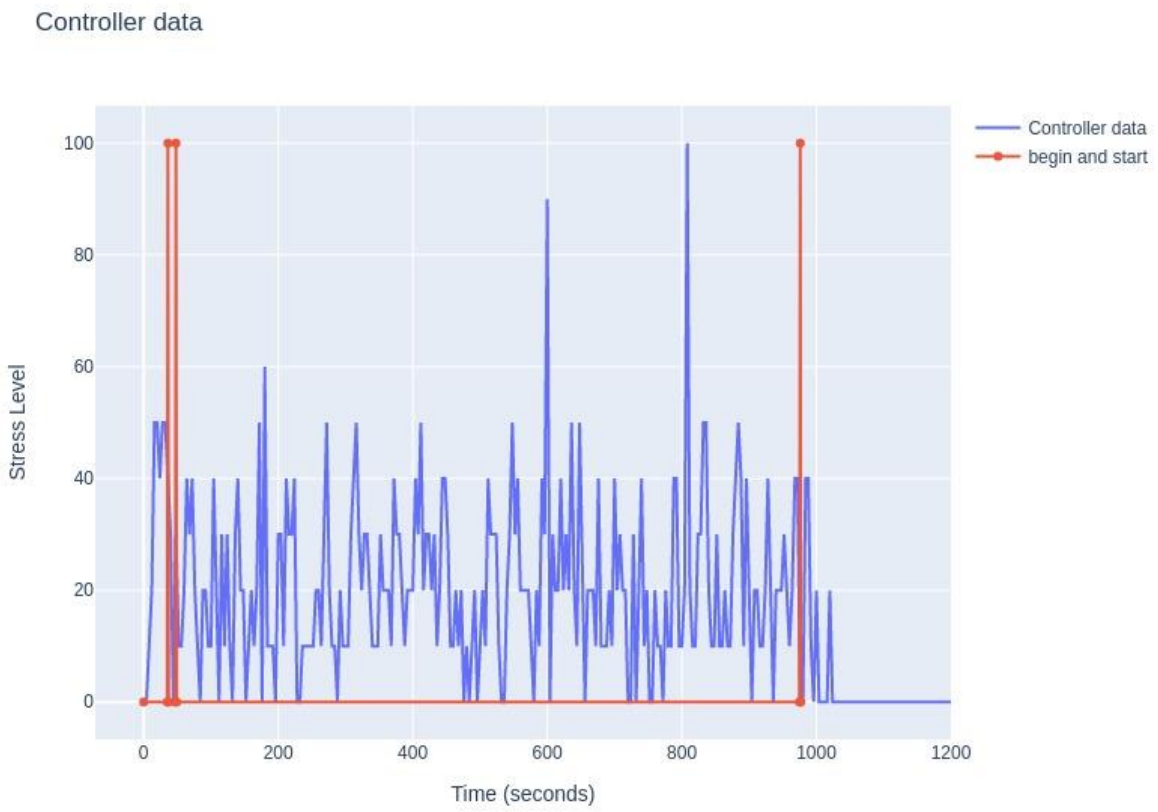
During the game, no tilt was perceived in the form of anger. At the end of the game, stress was perceived higher than in the beginning of the game by the GSR sensor. The ECG and tilt sensor both show no weird data correlations except for the once shown near goal related events. Over time, the stress levels gradually went up. The stress levels itself were higher in general than the game earlier that day.

Day 3, 4Pm, Difficulty: Amateur

During the measuring session, nothing extraordinary happened. The game went smooth and no difficulties were encountered. At the beginning of the game, the start button for the controller data was pressed two times instead of one. The last click is the actual start of the game.







During the game, no tilt was perceived in the form of anger. The data from the ECG, GSR and tilt sensors all show that higher stress is perceived near the end of the game. Furthermore, no real conclusions, besides elevated stress levels near goal related events,

can be found. Stress levels over time did not change much except for the peak near the end. The general stress level is higher than the game played earlier that day.

Conclusion day 3

Within this day, it is also seen that stress elevates during goal related moments. The last measurement of the day also showed indications that in later stages of a game, stress levels grow higher. During the games, stress levels did gradually rise. The game played in the morning did have a significant lower stress level average.

General conclusion

In general, it is hard to draw detailed conclusions from the obtained data. However, there are conclusions that can be named based on the data. It is found that in later stages of a game measured stress levels go up. Within games that are one sided -with many goals on one side- the gamer tends to become more annoyed than usual. This feature also causes the tilt levels to rise more near goal related events due to button mashing.

The influence of difficulty on stress levels is not determined. There is no real pattern found between the different difficulties and the stress levels. This might have happened due to the low stakes of the game. There is nothing to gain from winning or losing, thus it might have happened that the test subject did not care about the difficulty.

There is a sign of stress changes in correlation with the time on which a game is played. It is found that the earliest played game is the least stress generative in comparison to the other two games. This is found independent from the difficulty at which the game is played. There are two explanations for the phenomena. The first is the fact that in the morning, the user is rested. Therefore, he will have the most concentration and perform at his best. The second option rests in the physical state of the tester. In the morning, the user is still starting his day. That is why it could be that the physical aspects of the measurements were lower since those aspects were not fully turned on yet. This must be investigated in further research.

Within the data, there is one specific moment of which can be said to generate stress. This moment is a goal related moment. Within the data, almost all the spiking elevations in stress levels, which have been found, are related to a goal or an event near the goal (in distance). It can thus be concluded that near goal events are a cause of spikes in stress levels.

A curious finding which was not accounted for was that the accelerometer -which was included into the Empactica E4- was also a good indicator for tilt. People tend to move during a game when they get mad, happy, or something changes within their behaviour. This is almost perfectly indicated in the accelerometer sections of the Empatica measurements. The accelerometer measurements are shown in the purple colours.

Appendix G: Interview session evaluation:

This interview session will be semi-structured. All the participants will get an introduction about the session. This introduction will contain a small explanation of the ongoing of the interview, additional information about the project and what the goal is of the interview. In addition, the interviewees will obtain an informative video about the use of the product which should have been seen before the interview session. After this introduction, the participants were able to ask questions to clarify some uncertainties and to make sure the participants were fully aware. After this is done, the participants are asked if the information they gave could be used for study purposes. If agreed, the following statements are to be presented.

Must have

11. The device must keep the focus of the user while playing a game of Fifa (non-functional)
12. The feedback must keep the focus of the user while playing a game of Fifa (non-functional)
13. The controller output wire must keep the focus of the user while playing a game of Fifa (non-functional)
14. The device must keep the user relaxed, so it does not cause stress generative feelings (non-functional)

Should have

15. Easy understandable feedback – Expert knowledge should not be needed to understand the feedback (non-functional)
16. The feedback must be simple during gameplay (non-functional)
17. The device should be setup without the use of a manual after using it for five times (non-functional)
18. Detailed feedback during the game for coaching purpose (non-functional)
19. Usable live feedback at home (non-functional)
20. Detailed feedback used for coaching purposes and simple feedback for eSporters usage (non-functional)

Within this interview session, every statement will start an open discussion. These statements can be elaborated on, on own initiative by the interviewee and interviewer. When the discussion about a statement has ended, a 5-point question will be asked in which the participant must rate to what degree the idea supports the statement.

1st Jelte:

Must have

1. The device must keep the focus of the user while playing a game of Fifa (non-functional)
    a. I think that it will be fine, but I will have to get used to playing this way.
    b. 5

2. The feedback must keep the focus of the user while playing a game of Fifa (non-functional)

a. It will not bother me. I already play with a second screen and if it will bother, you can also place it outside your field of view.
b. 5

3. The controller output wire must keep the focus of the user while playing a game of Fifa (non-functional)
    a. I do not think that it will bother me since I already use the cable to charge my controller sometimes.
    b. 5

4. The device must keep the user relaxed, so it does not cause stress generative feelings (non-functional)
    a. It might generate stress in the beginning because you need to get used to the feedback. Later it will probably not generate stress.
    b. 3

Should have

5. Easy understandable feedback – Expert knowledge should not be needed to understand the feedback (non-functional)
    a. Feedback is easy to understand.
    b. 5

6. The feedback must be simple during gameplay (non-functional)
    a. The feedback is simple enough; however, take note of the line colours since the purple and blue lines are already hard to separate.
    b. 5

7. The device should be setup without the use of a manual after using it for five times (non-functional)
    a. Yes, that will easy. The setup did not seem that hard to realise.
    b. 5

8. Detailed feedback during the game for coaching purpose (non-functional)
    a. It is fine, but the stress meter is crucial to get a general overview since we are no stress experts ourselves.
    b. 4

9. Usable live feedback at home (non-functional)
    a. This will be easily doable.
    b. 5

10. Detailed feedback used for coaching purposes and simple feedback for eSporters usage (non-functional)

a. This question is basically a mix of previous questions. I think the prototype will suffice.
b. 5

2nd Enis:

Must have

1. The device must keep the focus of the user while playing a game of Fifa (non-functional)
    a. I am not sure; I will have to test it before I can really answer this question
    b. 3

2. The feedback must keep the focus of the user while playing a game of Fifa (non-functional)
    a. The feedback will not bother me since I am already used to moving images next to the screen
    b. 5

3. The controller output wire must keep the focus of the user while playing a game of Fifa (non-functional)
    a. The wire will not bother me since I am too focused.
    b. 4

4. The device must keep the user relaxed, so it does not cause stress generative feelings (non-functional)
    a. I will probably not get extra stress from the device
    b. 5

Should have

5. Easy understandable feedback – Expert knowledge should not be needed to understand the feedback (non-functional)
    a. I think the feedback is understandable, but simpler is always better.
    b. 5

6. The feedback must be simple during gameplay (non-functional)
    a. I do not know if the feedback is simple enough during gameplay since I have not used it yet.
    b. 3

7. The device should be setup without the use of a manual after using it for five times (non-functional)
    a. Yes, this will be easily doable since five times is a lot of tries and the steps are not that hard to follow, they are self-explanatory.
    b. 5

8. Detailed feedback during the game for coaching purpose (non-functional)
    a. I do not know since I have not used the device before, but I think it will be fine.
    b. 3

9. Usable live feedback at home (non-functional)
    a. Same answer as earlier
    b. 3

10. Detailed feedback used for coaching purposes and simple feedback for eSporters usage (non-functional)
    a. Same answer as earlier
    b. 3

3rd Brent:

Must have

1. The device must keep the focus of the user while playing a game of Fifa (non-functional)
    a. At Weekend league my focus is not that high any way. I do not think the device will change my focus.
    b. 4

2. The feedback must keep the focus of the user while playing a game of Fifa (non-functional)
    a. Question from Brent: Will there be any sound from the feedback?
        i. Answer: No

        Then, the feedback will probably not distract me
    b. 4

3. The controller output wire must keep the focus of the user while playing a game of Fifa (non-functional)
    a. With the hardener, it will not bother me. Without it, I do not know.
    b. 4

4. The device must keep the user relaxed, so it does not cause stress generative feelings (non-functional)
    a. I do not think that this will generate stress. However, I will have to get used to the device and make sure I do not wreck it because I get mad.
    b. 5

Should have

5. Easy understandable feedback – Expert knowledge should not be needed to understand the feedback (non-functional)

    a. The feedback is understandable. I want to note that it would be nice if there would be a zoom function to enlarge some parts of the data visualisation.
    b. 5

6. The feedback must be simple during gameplay (non-functional)
    a. Feedback is simple enough; I will be able to use it during gameplay but I am not sure if I will.
    b. 4

7. The device should be setup without the use of a manual after using it for five times (non-functional)
    a. This will easily be doable
    b. 5

8. Detailed feedback during the game for coaching purpose (non-functional)
    a. Details are fine, the prototype idea is the best idea I have seen so far (with the stress meter and line graph)
    b. 4

9. Usable live feedback at home (non-functional)
    a. Will be usable at home; however, I need to watch out that my cats will not push a second screen over and destroy it.
    b. 4

10. Detailed feedback used for coaching purposes and simple feedback for eSporters usage (non-functional)
    a. Yes, both are included so I think it is fine!
    b. 4