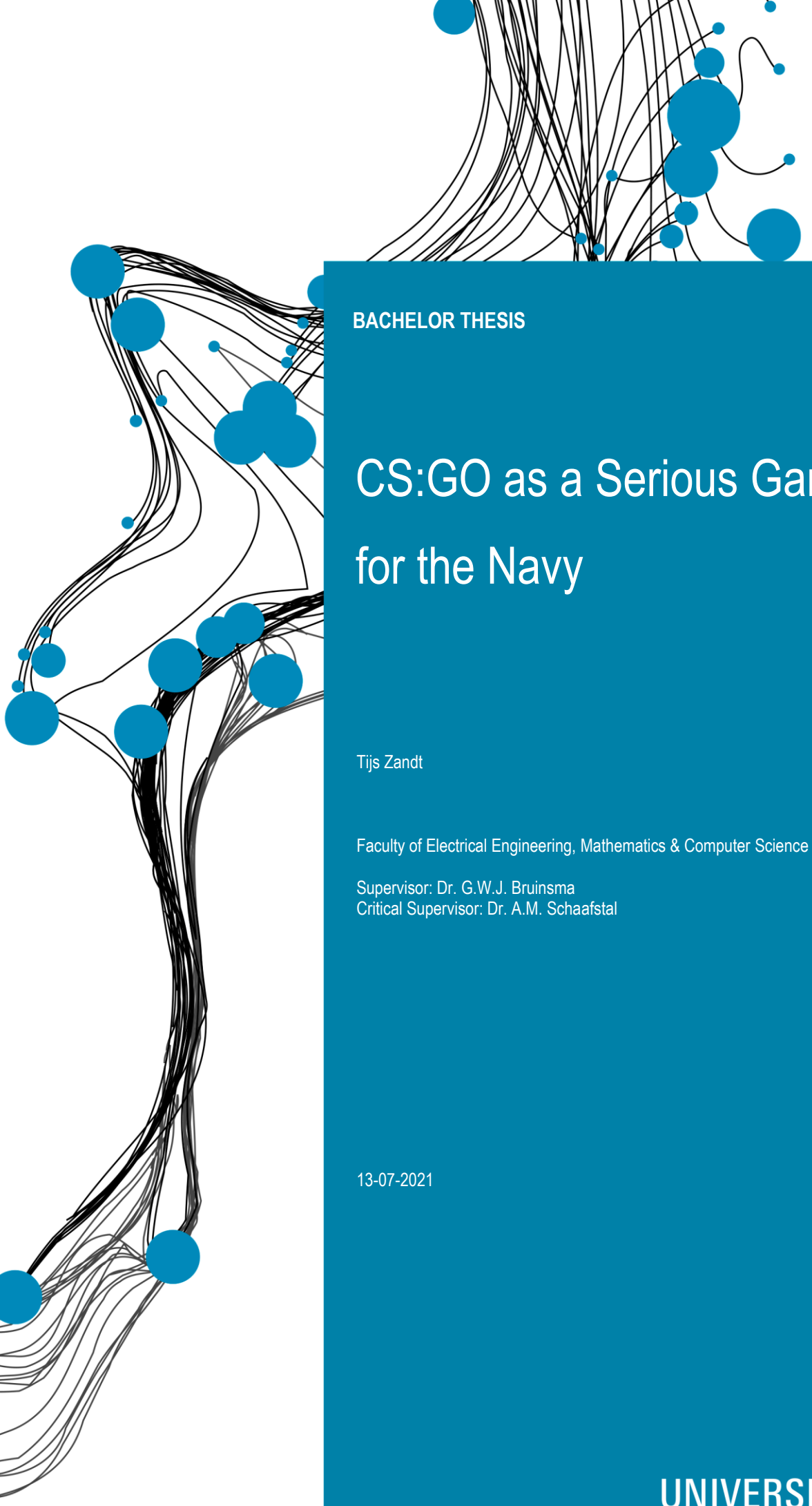

BACHELOR THESIS

CS:GO as a Serious Game for the Navy

Tijs Zandt

Faculty of Electrical Engineering, Mathematics & Computer Science

Supervisor: Dr. G.W.J. Bruinsma
Critical Supervisor: Dr. A.M. Schaafstal

13-07-2021

UNIVERSITY OF TWENTE.

Abstract

Teamwork is an important skill and is crucial for the Royal Netherlands Navy (RNLN). The RNLN uses the Crew Resource Management (CRM) model to train teamwork. The CRM model describes seven team-based competencies: decision-making, assertiveness/responsiveness, communication, leadership, adaptability/flexibility, and situational awareness. Currently, these team-based competencies are trained using traditional methods, such as classroom-type settings, workshop-based settings, simulations and team-reviews. A promising field to train these competencies is through the use of videogames, especially through the modification of existing games. The RNLN has shown interest in using Counter Strike Global Offensive (CS:GO) as a tool to train CRM competencies. However, they do not know how this game can be used to train these competencies.

This research takes a step into answering this question by answering the design question of how an insight can be provided in communication and leadership when people are playing CS:GO, intended for training purposes. Two competencies are picked to limit the scope. These are communication and leadership, since these are crucial for teamwork and enable the other competencies.

A Creative Technology approach is taken to create a tool that uses quantitative data analysis to analyse speech data. This analysis uses Bales Interaction Process Analysis (IPA) model to identify group processes and uses research by Butler et al. to interpret Bales' IPA model for leadership styles. The tool uses manual transcription, since available automatic tools are qualitatively not good enough or are outside the scope of this study. The information that is retrieved from the analysis is outputted on a dashboard to give an insight in how communication and leadership are reflected when people play CS:GO. To verify the tool, communication data during a CS:GO game is used from two sessions. One session with an experienced team and the other with an inexperienced team. The tool is expected to show different communication patterns between the two teams. These different patterns show in the results, indicating that the model can discriminate between teams.

To conclude, the tool can give insight in communication and leadership in CS:GO, outputting information on a dashboard that can be used for training purposes. A validation of the tool needs to be done to assess the correctness of the output. Next to this, there needs to be further research into how the manual transcription of the data can be solved if the tool is to be used in training scenarios. The results of the study show the existence of different communication patterns and leadership styles, however, future work should look into whether there is actually competency development or enhancement. Further future work directions can be looking at the other CRM competencies or looking at other data measuring methods.

Acknowledgement

First and foremost, I would like to thank Dr. Guido Bruinsma for the supervision of the project and the continuous help and feedback. Next to that, I would like to thank Dr. Alma Schaafstal for the critical supervision of the project. I would also like to thank the Esports Team Twente and the CS:GO Esports team for their help and resources. Furthermore, I would like to thank Wiren Vroon and the Royal Netherlands Navy for providing this project, their enthusiastic feedback and continuous support. Lastly, I would like to thank my friends, family and girlfriend for their big support, with a special thanks going out to Niels Bos, helping me through the toughest times.

Table of contents

List of figures and tables

Tables:

Figures

Chapter 1

The ability to work together in a team is one of the most imperative skills in organisations [1]. It enables better decision-making, improved problem-solving techniques and the faster and more efficient accomplishment of tasks. An organisation where teamwork is a crucial skill is the Royal Netherlands Navy (RNLN). The RNLN makes use of Crew Resource Management (CRM) as a framework for training and education of teamwork competencies. The CRM framework describes 'The Seven Skills', also known as 'CRM-softskills'. These include decision making, assertiveness/responsiveness, mission analysis, communication, leadership, adaptability/flexibility and situational awareness [2].

Currently, the RNLN uses traditional methods to train teamwork competencies, such as theoretically focused sessions, practical assignments, and the use of simulations. Now, the RNLN has shown interest in the use of Esports to train team-based competencies. This is because desired competencies of potential future navy personnel is showing a shift where digital Esports skills are becoming more prominent, with skills such as technical learning, problem solving and the ability to learn [3][4]. Recruiting new employees that possess these skills is important to remain future proof. Secondly, Esports can serve as a novel (and perhaps more effective and time- and cost-reducing) way to train and educate existing employees in a similar manner as traditional (simulated) training missions and interpersonal competencies.

Team-based competencies are of great importance in Esports and teamwork is crucial for good performance. Therefore, the use of existing Esports to train team-based competencies can be explored. The use of modified existing videogames can be very effective and can provide a high level learning activity, according to Reng et al. [5]. The RNLN has shown a specific interest in Counter Strike Global Offensive (CS:GO), a first person shooter game. CS:GO is a game that is already played by a lot of people within the RNLN and is therefore an interesting game to be used as an educational tool.

This research will take a step in exploring how CS:GO can be used as a training tool for the RNLN to train CRM competencies. This will be done by answering the design question on how an insight in communication and leadership can be provided when people play CS:GO, intended for training purposes. Two competencies are used to limit the scope of the study. These two competencies are communication and leadership, two of the most important ones from the CRM model. Communication enables the other competencies that work through verbal communication. Leadership provides the teamwork structure in which the competencies are used. To answer this research question, a tool will be built that can measure these competencies when people are playing the game. The tool uses automatic data measuring techniques to eliminate subjective bias and provide a more objective and normalized method of measuring communication and leadership. Using data analysis and results from the tool, the training possibilities for these competencies can be evaluated and the design question can be answered.

A concise literature review is presented in chapter 2. There will be a look at the teamwork skill and the competencies in the CRM model. Team-based competencies in videogames will be explored and a more in depth analysis of the communication and leadership competency will be provided. The chapter will conclude with a description of the design goal. Chapter 3 will describe the methods and techniques used in the study. The chapters after that will follow the design process of the Creative Technology Method, as described by Mader & Eggink [6], consisting of an ideation phase, a specification phase, a realisation phase and an evaluation phase. The research will conclude with answering the design question and making suggestions for potential further research.

Chapter 2

This chapter will present a literature review to broaden the knowledge on five topics. These are teamwork, the teamwork model used by the RNLN, team based skills in videogames, the competencies that will be focussed on in this research and the game CS:GO. After this, the design goal of the study is discussed together with the methods that will be applied.

2.1 Teamwork

The ability to work in a team is very important for the performance of teams [7][8]. This has become apparent in many different working domains, for example in healthcare organizations [9], product design [10] and (extreme) military situations [11]. Teamwork is difficult to define, because it is a very broad, dynamic and multidimensional construct, formed from a set of interrelated competencies [12]. Cannon-Bowers et al. [13] tried to describe it in terms of different dimensions, which are adaptability, shared situational awareness, performance monitoring and feedback, leadership, interpersonal relations, coordination, communication and decision-making. However, the dimensions and competencies that describe teamwork are often highly dependent on the context, the team itself and the task to perform. All of this makes it difficult to pinpoint the elements that teamwork consists of. The following section will explore different group competencies that impact teamwork and training methods that can train for these competencies.

Different models and studies highlight group competencies that impact teamwork. Bucic et al. [14] presented findings on the fact that leadership style has a great impact on team learning performance, a predictor for team performance [15]. Dechurch et al. [16] highlighted the importance of team cognition as a driver for team performance. Still, the degree of impact of the different skills is dependent on the situation, regarding for example domain, group size, time pressure, mission objective. An effort by King et al. [17] to integrate teamwork into practice presented four dimensions of teamwork, being leadership, situation monitoring, mutual support and communication.

These wide range of competencies that impact teamwork also gives the opportunity for a wide range of teamwork training interventions. McEwan et al. [18] define four categories of teamwork interventions. The first is by providing education in a classroom-type setting, this is a more theoretical approach where learning methods like lectures, group-based projects or in-class sessions can be applied. The second category is using interactive workshop-style formats. This is a very common approach where there is often a course approach where people work in teams on short or longer term projects, learning to work in teams through gaining experience [19][20]. The third category is using simulation training. This can be used for experiencing realistic scenarios and focusing on interpersonal communication and coordination. It is important for simulations to have a high fidelity level, which is the level of realism that is presented to the user [21]. This can be measured in the dimension of functional characteristics, being the stimuli and informational options of the simulation, and physical characteristics, being the visual and spatial characteristics. The final category is using team-reviews during real-life scenarios. This requires good briefings, monitoring of actions during the scenario to be able to have a quality evaluation. The use of the different interventions is often highly field specific, where medical trainees are placed in representative, multidisciplinary environments [23], teamwork training in sports has seen suggestions for an evidence-informed intervention [22].

Another interesting educational tool that could be used are videogames, since the use of videogames as an educational tool has the possibility to be significantly more effective than nongame-based learning [24]. Van Delden et al. [25] showed the possibility for videogames to also emphasize learning, mapping videogames on a goal-oriented to entertainment and board game to computer-mediated game model. They also emphasize how videogames as educational tools do not have to be created with the sole purpose of education. Off the shelf videogames can also be used if

applied correctly in an instructional setting. This is in accordance with Reng et al. [5], who showed that videogames as educational tools can be used on many different layers. They introduced a layered model describing eight levels of game-oriented learning activities. The model describes layers such as gamification, roleplay and purposive game development, but also describes the possibility of modifying existing videogames. The use of videogames as educational tools touches on the first three layers of Miller's [26] pyramid, aiming for knowledge transmission, interpretation of the knowledge and demonstrating the learned behavior. With that, there is a great potential of using entertainment videogames for learning purposes.

To conclude, the ability to work in a team and the ability for a team to effectively work together are important skills to master, also in the context of the RNLN. Teamwork captures many different individual and team-based competencies, such as leadership, communication and coordination. There are many methods to train these skills, such as lectures, group projects and in-class exercises. One of these methods is through the use of videogames, acting on the third level of Miller's [26] model. Especially when focusing on the fifth layer of Reng et al.'s [5] model, being the method of modifying existing videogames, there is potential for using videogames as a training tool for teamwork.

2.2 CRM competencies

The RNLN uses the CRM model as a framework in teamwork education and training. This model describes different interpersonal competencies to give an insight into the human factors of working together in a team [2] and helps to specify competencies that are used in the field of the RNLN. The model is aimed to provide a framework for the training of skills and competencies on a team level, to make a team more effective, efficient and increase safety.

The CRM model can be compared with other teamwork competencies models. In Table 1, a mapping can be found between the CRM model and two other models. The first one is a model by Stevens & Champion [27], which describes five knowledge, skills and ability requirements for teamwork. It is not field specific as is the second model, which is a teamwork competency model for healthcare practice [28]. When comparing the three models a couple of connections can be made. All of the three models state communication as one of the competencies. Next to that the healthcare teamwork competencies model [28] and the CRM model [2] both state leadership as one of the competencies. The following section describes the seven softskills of the CRM model, being decision-making, assertiveness, communication, leadership, adaptability, and situational awareness. An overview of the definitions of the different CRM competencies can be found in Table 2.

The first competency is decision-making, which is the skill to come to an optimal decision based on the available information. It is divided into two levels, the rational level which focuses on the ability to search for information, alternatives and consequences, and the emotional level which focuses on the motivation to choose an option and to run this option. According to O'Connor et al. [29], situation assessment, generating and considering one or more response options, selecting and implementing an option and outcome review describe the four main components of decision-making.

Assertiveness is the second competency, describing the extent to which someone is able to stand up for him- or herself within a group. It is a balance between being receptive and open, which next to being able to stand up for one's rights, also facilitates assertive behavior in others. [30] Many studies highlight the positive correlation between assertiveness and communication effectiveness inside of teams, all together making it an important softskill to have.

Next is mission analysis, which is the ability to use all of the available information and resources to carry out a successful mission. It starts with the correct organisation and planning of the

mission, followed by monitoring and guiding the actual mission, closing with a well performed reflection on everything that happened.

The fourth competency is communication, which describes the exchange of information between two or more people, either verbal or non-verbal. Communication is a critical skill and a facilitator of good teamwork, enabling other competencies, such as leadership and assertiveness. It can be subdivided into four different components that can be used to assess the communication, being the 'What' needs to be communicated, 'How' needs to be communicated, 'Why' needs to be communicated and to 'Who' needs to be communicated. [29]

The following competency is leadership, which is the ability to influence one or more people. In a broader perspective it is the coordination of a team and the members of the team, assigning tasks, planning and organising and providing a positive and motivational atmosphere [31].

The sixth competency is adaptability, which is the capability to adjust the course of the mission when the situation asks for it. The importance and training of adaptability is often talked about in the context of digital skills and the rapid changing scene of technological advancements [32], but is just as important in the general working environment.

Last is situational awareness, which is the ability to be aware of all the things that happen during a mission in and outside of the team and also being able to recognize situations that call for action. It is a skill that improves performance in complex real-world tasks [33] and is important in the working environment.

The CRM model provides specific competencies for the Navy that are not found in other teamwork competency models, such as situational awareness and mission analysis. However, there are also competencies that overlap, such as communication and leadership. Leadership is important in many domains. Communication is also crucial and is a competency that enables other teamwork competencies.

Crew Resource Management [2]	**Steven & Champion [27]**	**Teamwork competencies in healthcare [28]**
Decision-making	Problem Solving	Shared Understanding
Leadership	Conflict Resolution	Team Leadership
Mission Analysis	Goal Setting and Performance Management	Team Support
Communication	Communication	Communication
Assertiveness	Planning and Task Coordination	
Adaptability		
Situational Awareness		

Table 1: A mapping of three different teamwork competency models

Skill	Description
Decision-making	Ability to come to a decision based on the available information.
Assertiveness	The extent to which someone is able to stand up for him- or herself within a group.
Mission Analysis	The ability to use all of the available information and resources to carry out a successful mission.
Communication	The exchange of information between two or more people.
Leadership	The ability to influence one or more people.
Adaptability	The capability to adjust the course of the mission when the situation asks for it.
Situational Awareness	The ability to be aware of all the things that happen during a mission in and outside of the team.

Table 2: The Seven softskills described in the CRM model [2]

2.3 Team-based competencies in video games

Videogames have been proven to be effective as educational tools and when using videogames as educational tools, learners are often longer engaged in the learning activity when compared to nongame-based learning [24]. Individual skills can be enhanced through casual play, such as reaction time [34][35][36], memory [37][38] and information processing [39][40][41]. Some researchers even suggest casual play enhances the ability to learn [42][43][44]. Next to these individual skills, the enhancement of team-based competencies can also be found in many videogames, because it is important to work together, cooperate and communicate. Three important team-based competencies that are enhanced through videogame play will be discussed.

The first team-based competency that can be found in videogames is teamwork. Badatala et al. [45] suggested that when being able to play a videogame cooperatively, this can support teamwork. This is in accordance with findings by Qiu et al [46], suggesting that playing virtual team-based games has a positive effect on teamwork in the real world.

The second important competency found in videogames is communication. Barr [47] highlights the potential that videogames can have in the development of communication skills. He suggests that videogames not only work as an instrument to develop communication skills, but also create an interaction stimulating environment. Bailey et al. [48] showed similar findings of videogames stimulating communication, showing high instances of discussion and communication among students playing videogames.

The last competency found that is enhanced through videogame play is leadership. Lisk et al. [49] presented findings on leadership in multiplayer online environments, showing the presence of distributed team leadership. Similar findings by Nuangjumnong [50] also showed the presence of leadership in multiplayer online games and the findings show that videogame playing can be used for leadership development. This positive impact on leadership skills was also found by Rubtcova et al. [51], having a similar conclusion that videogame play can develop leadership skills.

Next to these team-based competencies that can be enhanced through videogame playing, playing videogames can also increase team effectiveness. Badatala et al. [45] suggested that

videogames can improve team effectiveness when played cooperatively. Keith et al. [52] took it a step further and compared team videogame play with traditional team-building activities and showed a higher productivity increase in the group that played the videogame.

All in all, videogame do not only enhance individual competencies, but can also aid in developing and improving team-based competencies, such as teamwork, communication and leadership. A factor that should be further explored is how much time people need to play videogames to actually improve certain competencies. This could be an interesting direction for further research.

2.4 Communication and Leadership

Section 2.2 showed three models and the comparison of the different teamwork competencies. Two competencies showed overlap between the models, being communication and leadership. Leadership is an important competency in a team and is important in many domains. Communication is also crucial and enables other competencies. Section 2.3 showed the potential of videogames for the development and enhancement of communication and leadership. For these reasons and to limit the scope of the study considering time and resource constraints, there will be a focus on communication and leadership. The next section will go further in-depth into these two competencies.

Communication is one of the most important skills in a team. Better communication not only increases team effectiveness, but is also a pre-emptive measure for mistakes [53]. It consists of a couple of components, these are the ability to send information concise and clear, the ability to include context and goal during the communication, the ability to listen and receive information and lastly the ability to recognize and address the obstacles to good communication [29]. In the past, different measurement techniques for communication have been used. Van Dalen et al. [54] validated a tool that used a scoring manual to manually score the communication skills of students, focussing more on the process of communication, rather than the contents of the communication. Duffy et al. [55] also provided evidence on the fact that the use of checklists is a method that is effective and showed that this method is most frequently used. This is in accordance with a study by Rehim et al. [56] who presented findings on different communication skill assessment tools in the critical care industry. They showed that all tools used an observational method together with scoring systems.

Leadership is also very important in a team. It is the act of influencing individuals or a group, the coordination of activities and stimulation of team members [2]. According to Morgeson et al. [57], leadership is focused on team need satisfaction, with the ultimate goal of improving team effectiveness (the capacity of a team to accomplish their goals and objectives). Different styles of leadership can also have an effect on the team and different styles should be used based on the situation that the leadership occurs in [14]. Lewin et al. [58] set out three different leadership styles, being autocratic, democratic and laissez-faire. Autocratic leaders provide clear expectations, democratic leaders offer guidance and allow input from the group, laissez-faire leadership offers little guidance and has the group make the decisions. Bass et al. [59] distinguished two different styles of leadership similar to the autocratic and democratic leadership styles. These are transformational and transactional. Transformational leadership is similar to democratic leadership and is a style that is focused on working together with the team to identify needed change and vision through motivation and inspiration. Transactional leadership is similar to autocratic leadership and is more managerial focused, based on supervision with the goal for group performance. Vera et al. [60] later added the ambidextrous leadership style to the two leadership styles. Ambidextrous uses multiple approaches at leadership. There are a scarce amount of quantitative measures that have been explored to measure leadership. There has been a look at social signal processing [61] and audio expressions [62]. More specific research by Wang et al. [63] presented a system with which leadership can be detected in broadcast conversations of multiple people.

Ultimately, there are a lot of methods to train communication and leadership competencies, however, not a lot of studies have focused on quantitative measurement techniques to measure these competencies. This is an area that would be interesting to further explore.

2.5 CS:GO

There are many team-based games that have the potential for team-based competency development. A sub-category of these games is called Esports. Wagner [64] defines Esports as 'An area of sport activities in which people develop and train mental or physical abilities in the use of information and communication technologies.'. Esports can be individual, but are often team-based.

There are many different types of Esports. Besombes [65] mapped different Esports disciplines, examples are racing videogames, strategy videogames and card videogames. Another type of Esports are shooting videogames, subdivided into battle royale videogames, third person videogames and first person videogames. One of the videogames that fits into the first person tactical category is CS:GO, a team-based game. CS:GO is currently one of the most popular Esports titles, having almost 700,000 average daily players in January to March 2021 [66]. Next to that, it also has a large viewing audience, reaching 100,000 viewers per day on average on Twitch in the months January to March 2021 [67]. CS:GO is also played by a lot of people within the RNLN, and the RNLN has therefore shown a specific interest in the use of CS:GO to train team-based competencies. CG:GO provides an environment where the correct use of the different CRM competencies is crucial. The main gamemode of CS:GO is a team-based situation where two teams of five compete in a best of 30. Using guns, utility items and armor, players have to manage different game elements in order to win. Especially good communication and leadership are crucial for good performance.

A model by Reng et al. [5] describes different levels of game enhanced learning, defining four lower levels and four higher levels. From the lowest to the highest, these levels are using stand-alone analogue or digital games as teachers, using games as a facilitator of learning activities, exploiting gamification, motivating students through roleplay, modifying existing games, fundamental game development, creating games while enhance learning in a desired topic and the development of purposive games. When considering the model by Reng et al. [5], CS:GO can act on the fifth level of the model, being the modification of existing games. Next to this, the game can act on the third level of Miller's [26] model, where people can show their skills and that they know how the competencies work and how they can be applied. The game could be adjusted to act as a training tool for teamwork competencies, since it already incorporates a lot of these elements naturally. These skill elements in videogames are commonly divided into two terms, micro and macro gameplay. Micro gameplay has everything to do with small-scale individual decisions and activities. In CS:GO, this can be controlling recoil, aiming for headshots or throwing a smoke grenade at the correct angle. Then, there is macro gameplay, which refers to higher level elements, such as strategic considerations, resource management and map awareness. While micro gameplay often comes down to muscle memory, macro gameplay is closely connected to team competenties. It is important to communicate, make correct decisions based on the available information and much more.

To summarize, CS:GO is a popular team-based game that has the potential for adjustment to act as a training tool for teamwork competencies. Therefore in this study, there will be a focus on CS:GO. The RNLN have shown an interest in the use of this game for the training of team-based competencies. It is a popular game that shows many team-based elements, having great potential for use as an educational tool for the training of team-based competencies.

2.6 Design goal

This section will elaborate on the design question, that asks how an insight can be created for communication and leadership when people are playing CS:GO, intended for training purposes. It then defines the first functional requirements from the context. Lastly, it will introduce the research method that will be used in the remainder of the research.

The RNLN wants to know how CS:GO can be used as a training tool for the training of CRM competencies. In this research, a step is made into answering this question by answering the design question on To answer this question, a tool will be built that outputs information. From the context, three functional requirements emerge for the tool:

- The tool should give an insight in the communication and leadership competency.
- The tool should measure in the context of the game CS:GO.
- The tool should give information that is relevant for competency training purposes.

To create this tool, the remainder of the research will be structured based on the Creative Technology approach by Mader et al. [11]. This study presents an approach with four phases, being the ideation, specification, realisation and evaluation phase. These will be explained more in-depth in the next chapter.

Chapter 3 - Methods and Techniques

In this chapter, the methods and techniques are described that will be used in the process of the research. First, the design process that is used during the research is explained. After this, the methods and techniques that are used during the different phases are discussed.

3.1 Creative Technology approach

A Creative Technology approach presented by Mader et al. [6] is used to structure the research. This approach can be seen in Figure 1 and describes four phases of a design method, consisting of the ideation phase, the specification phase, the realisation phase and the evaluation phase.

The ideation phase describes the process of coming up with an envisioned solution to answer the research question. It uses methods such as stakeholder analysis, divergence and convergence techniques, interviews and more to address different design questions. The result of the ideation phase is a more elaborated project idea, in combination with design requirements.

Building on the output of the previous phase, the specification phase uses short feedback and evaluation loops to explore and further define the concept from the ideation phase. Using a prototype-like building approach, the different concepts are created, tested and evaluated. Based on the evaluation of the concepts, new concepts are formed and evaluated. The specification phase is finalized with a final prototype and design specifications that can be used in the realisation phase.

The realisation phase uses the finalized prototype and takes the next step to add data and start the functional testing. In this way, there can be a verification of the tool. With this, further steps can be made in realizing the prototype.

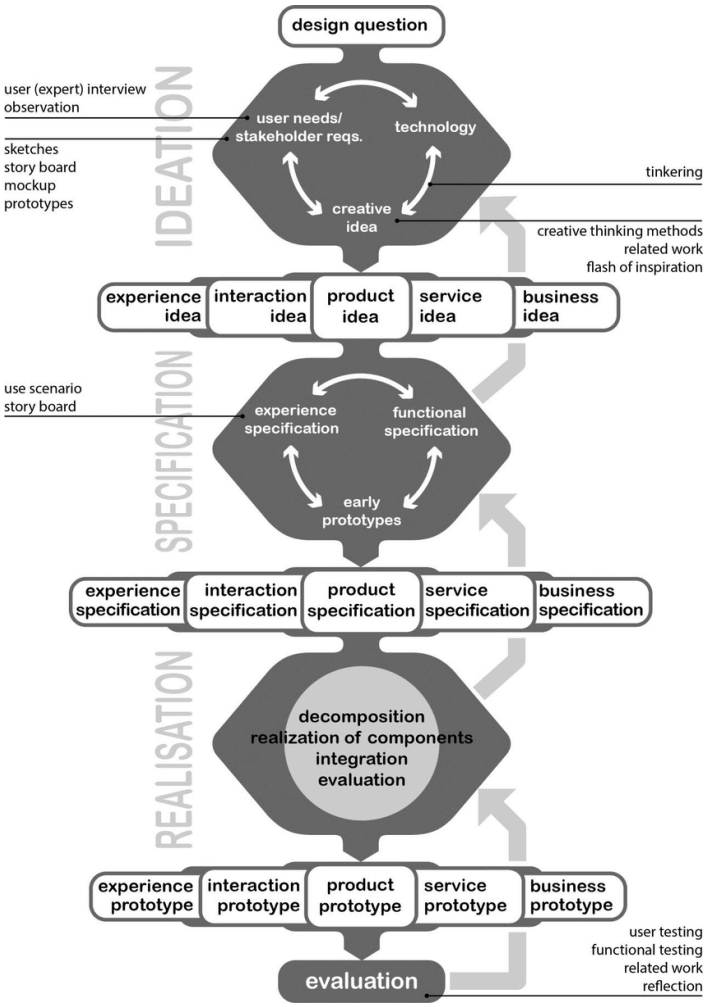

Figure 1: The Creative Technology approach

The last phase is the evaluation phase where the final result is evaluated to see whether all the original requirements that were formed in the ideation phase are met. The steps and design choices are evaluated and a set up is made for the future work recommendations.

3.2 Chapter 4: Ideation phase

The ideation phase consists of four elements. The first being the stakeholder analysis, then the acquisition of relevant information, thirdly the requirement analysis to form the design requirements and lastly the concept generation. The methods and techniques for these elements will be described in the following sections.

3.2.1 Stakeholder analysis

A stakeholder analysis is performed to identify the potential stakeholders in the project. The different stakeholders that have an interest and a say in the project can be mapped. The stakeholders will be identified through brainstorming and an analysis will be performed using a power-interest matrix [68]. This is a matrix that maps the interest of a stakeholder, which is the importance of the project to the stakeholder, to the power of a stakeholder, which is the influence that a stakeholder has in enabling the achievement of the project's objective.

3.2.3 Acquisition of relevant information

After the stakeholder analysis, the relevant data measurement methods that can be used in the project need to be discussed to find how the tool that will measure communication and leadership can be formed. With the use of divergent techniques, such as brainstorming and freewriting, ideas for different methods and tools are identified. Then, using a convergence technique where the pro's and con's for each idea are discussed, the different ideas are put together. The best method is picked and is further explored to see how this method can be used for the measurement of the communication and leadership competency. The information found is used in the requirement analysis and concept creation section.

3.2.3 Requirement analysis

To be able to define the design requirements of the tool, a requirement analysis is used. This requirement analysis consists of a couple of steps. The first step is to identify the requirements of the key stakeholders. This will be done through semi-structured and unstructured interviews with the stakeholders. The methods and techniques for the interviews will be elaborated in the next section. The requirements will be structured using the user story format that is also used in Scrum [69]. This format describes the requirement from the perspective of the stakeholder. It is written as follows: *As ... we want ... in order to.* Next to the requirements of the key stakeholders, the requirements that have resulted from the acquisition of relevant information are also taken into account.

After identifying all the requirements, they are all grouped together. The requirements described in previous chapters and sections are also taken into account. The requirements will then be categorized based on two types [70]:

- *Functional requirements*
  Describe the system's functionality. It defines what a system must and must not do.
- *Non-functional requirements*
  Describe the system's properties and constraints. It specifies how the system should perform its functions.

These categorized requirements provide guidance and an evaluation model for the concept.

3.2.4 Interviews

To get information, ideas, feedback and more generally an insight into the perspective of other people on the project, interviews are conducted throughout the research project. Only qualitative interviews will be used, since quantitative interviews are not relevant to the project. The interviews conducted are done in a semi-structured or unstructured format, this provides freedom, the option for discussion and it enables an open conversation. These interviews will take place with the relevant stakeholders, CRM experts and CS:GO experts.

3.2.5 Concept formation

Divergence and convergence techniques are used together with brainstorming techniques to form the concept. The concept formation will be done based on the requirements from the requirement analysis

and the relevant information found. This result will provide a more elaborated idea for the concept that is expanded upon in the specification phase.

3.3 Chapter 5: Specification phase

The specification phase will incorporate a prototype building approach with the goal of creating a prototype that can be used in the realisation phase. Based on the concept defined in section 4.4, a first prototype is constructed. This prototype is built in Python [71], a high-level programming language. Python is a general-use programming language, offering easy use of modules and packages. The prototype is split up in three parts, each built, tested and analysed on its own, after which the parts are merged and the full prototype is evaluated. The prototype consists of the speech to text part, the Bales model implementation part and the dashboard construction part. All parts are evaluated, which leads to an improved prototype and adjusted design specifications.

3.3.1 Speech to text

Two speech to text toolkits, Kaldi Open Source and the Google Cloud Speech API, will be compared. The goal of the toolkit is to be used in the part of the tool that transcribes speech files, so the text can be analysed using Bales' model. First there will be a short exploration on what the toolkits are and how they can be used. Then, the toolkits will be compared based on two aspects:

- *How easy is the toolkit to use?*
  This aspect measures how easy the toolkit is to set up before it can be used and it measures how easy the use of the tool is to accomplish set goals.
- *What is the transcription performance of the toolkit?*
  This aspect measures how well the toolkit performs at transcribing voice clips. This will be done by testing the toolkit with three voice clips. Two of these voice clips will be retrieved from the Open Speech Repository [72], an audio repository for the use in speech recognition and speech quality areas. The audio files consist of the recordings of ten Harvard sentences [72] each. Harvard sentences are a collection of standardized sentences intended for voice over testing and speech recognition testing. These files have a clear pronunciation of words. The third clip is retrieved from the communication while a person was playing CS:GO. This last voice clip is intended to explore how the results are different when the pronunciation is less clear and jargon is used. All of the voice clips will contain a single speaker.

3.3.2 Bales

The Bales Interaction Process Analysis (IPA) [74] will be used in the tool to analyse the transcribed text to get an insight into how communication and leadership are reflected when people play CS:GO. The different steps of how the analysis will be done will be discussed and the implementation into the tool is explained. The model will be implemented with the use of the following libraries and databases:

- *Wordnet [75]*
  Wordnet is a lexical database of English words where similar words are grouped together into synsets, based on conceptual-semantic and lexical relations.
- *SentiWordNet 3.0 [76]*
  SentiWordNet 3.0 is a lexical resource for the classification of words based on their sentiment score. It is a database that is a result of the automatic annotation of the Wordnet database.

3.3.3 Dashboard

Based on the concept formation of the tool output in the ideation phase, a dashboard will be created. This will be done in two steps. First, there is determined how the different statistics and information that the dashboard needs to display (determined in the ideation phase) can be retrieved from the data.

In the second step, the actual dashboard is built. This step will also build upon the concept dashboard that has been formed in section 4.4.1 of the ideation phase. The dashboard will be built using Dash [77], an open source Python framework to build analytic applications. To plot the different statistics that are shown on the dashboard, Plotly Express [78] is used, a Python module built to create complete figures at once.

3.3.4 Evaluation

The first prototype will be evaluated using the requirements from section 4.3 of the ideation phase. For each requirement, there is discussion to what extent the first prototype meets that requirement. If the requirement is not met, there will be a look at why this is the case and what can be done to change the prototype to meet the requirement. There is taken a look at whether some design requirements need to be adjusted. Next to that, a setup is made for an improved prototype.

3.4 Chapter 6: Realisation phase

The realisation phase consists of two sections, the collection and preparation of data and the testing of the prototype with the collected data. The testing is done in order to verify the tool. A verification is a check on whether the model functions as it is supposed to, but does not look at the correctness of the data when comparing the results to real-life. The collection of the data will be done during two individual sessions, one with a professional CS:GO team and one with an inexperienced team. The data is prepared using manual transcription and after that, the transcripted data is used with the prototype to gather results of the analysis.

3.4.1 Data collection

The data collection will be performed in two separate sessions. The first session is with players that are experienced in CS:GO, professionals playing in national tournaments. The second session is performed with inexperienced players with less than 20 hours played. The purpose of having data on experienced and inexperienced players is that the data can be compared to see if the output of the tool is different. The expectation is that the communication patterns and leadership patterns are different for the two teams. If this is the case, this can serve as an indication for the verification of the tool.

The experienced team will be recruited through the Esports Team Twente. They have a professional CS:GO team, with all experienced players. The inexperienced players will be recruited through personal contacts. All participants will have access to an information sheet (see Appendix A) and will have to fill out a consent form (see Appendix B). The information sheet, consent form and the session in itself have all been approved by the EEMCS/CIS Ethics Committee.

The session setup will consist of five players playing a single game of CS:GO. The players can play from home and will communicate via Discord [79], a messaging and VoIP application. The speech of the players can be recorded with the use of a channel recording bot, called Craig [80]. The CraigBot can output the recordings as individual audio files for each player. The players will play an online game on one of the random maps that are in rotation. The players are matched to players of their own skill level through the use of MMR. MMR is short for Match-Making Rating and is an integrated score in the game that determines a player's skill-level. By winning, MMR increases, by losing, MMR decreases. The performance of the players in-game is irrelevant for the data collection, therefore no other measures for the matchmaking will be used.

3.4.2 Data transcription

To be able to analyse the data with Bales IPA, the speech data needs to be transcribed. This transcription will be done manually. The following procedure will be used for the transcription.

In the program, the speech data is separated into small audio chunks. This is done based on the silence between speech segments, creating chunks where every chunk is one sentence that is spoken. Each audio chunk is played and the transcription of what is said is inputted into the program. If the audio chunk is unclear and cannot be transcribed, 'Error' is inputted into the program. These 'Error' messages can be filtered out later in the analysis. 'Error' messages can for example be a cough, a sneeze or a word that is not clearly pronunciated.

3.4.3 Testing the prototype

The data from the transcription phase is inputted into the program. This outputs the different statistics on the dashboard. Two verifications will be done:

- Verification of the dashboard
  It will be verified whether the dashboard output is visually as expected. Are the graphs shown correctly? Is the layout as expected? With this, the output of the tool is verified.
- Verification of the tool
  By comparing the two different dashboards from the two data collection sessions, a verification can be done on whether the tool functions as expected.

3.5 Chapter 7: Evaluation phase

The evaluation phase will evaluate the final prototype. This will be done in three sections. First, there will be an evaluation of the verification of the tool. This will look at the verification that was done in the previous chapter. After that, there will be an evaluation on the validation of the tool. Lastly, there will be an assessment to what extent the functional design requirements formed during the ideation phase have been met. This will be done by looking at and evaluating every design requirement.

Chapter 4 - Ideation

In this chapter, the concept for a tool is formed that can give an insight into how communication and leadership is reflected when people play CS:GO. Before this tool can be created, the design requirements for the concept need to be constructed. From chapter two, three functional requirements have already emerged. These are that the tool should give an insight in the communication and leadership competency, the tool should measure in the context of the game CS:GO and the tool should give information that is relevant for competency training purposes. Other requirements can be identified from the stakeholders and from the acquisition of relevant information.

Therefore a stakeholder analysis will first be performed with the purpose of identifying the relevant stakeholders and to analyze the needs of those stakeholders to be able to develop a quality tool. After that, there will be an acquisition of relevant information where two questions are answered. These questions are important to narrow down the options, such as the use of technology that can be used for the formation of the tool. The first question is which data measuring technique will be used for the tool. The second question builds upon the first, where it is explored how communication and leadership can be measured with the data measuring method that resulted from the first question. After this acquisition of relevant information, a requirement analysis is performed to identify the key requirements for the tool based on the stakeholders and the relevant information. Using all of the relevant information gathered, the design specifications are formed and concepts for the tool are constructed.

4.1 Stakeholder analysis

The stakeholder analysis is performed to identify the potential stakeholders and to be able to identify the stakeholder requirements in section 4.3. In Figure 2, the stakeholders are presented on a power-interest matrix, which visualizes their perspective on the project. The power level describes the influence a stakeholder has on the implementation of the project; stakeholders with high power are often the decision makers. The interest level describes the amount of interest the stakeholder has in the successful completion of the project. The following stakeholders were identified.

The Royal Netherlands Navy is one of the project providers and is interested in the use of Esports in their professional training. It is important for them that training and training tools are backed up with academic research. Therefore, their interest level in the project is high. Their power level is also high, because they play a large role in the implementation and use of the finished research.

The University of Twente plays a role as project provider and supervisor. The university facilitates the project and plays a role in giving feedback and assessment of the research. Their interest also is high, because of the connection with the navy. The university plays an important role in the future prospects of the project, where they can facilitate related future research.

The navy instructors serve as potential end-users. Their goal is to train new marines as best as possible and prepare them for their career. Their interest is relatively low, since they do not necessarily need the project. However, if it would be implemented successfully, they could gain a lot of positive value out of it. Their power level is a little bit below average, since the project is in such early development that they do not play a large role in the decision making process.

The navy trainees serve as potential end-users. Their goal is to learn and be educated for their future careers. Trainees could be interested if the concept would enhance learning and do this in an enjoyable way. Their power level on the project is minimal, since they are not decision makers in the development and implementation process.

The Esports Team Twente is interested in the project, since it can play a role in starting up future projects and future Esport research. They therefore have a medium-high interest in the project.

Since they do not make decisions within the project, but can provide resources, their power level is medium-low.

W. Vroon is a potential distributor of the results of the project within the Royal Netherlands Navy. Vroon has an interest in pushing Esports to a higher level within the organisation so it can be implemented in different ways. Vroon has a very high interest level in the project, because it can be used for his intended goals. He has a medium power level, because his efforts can play a large role within the implementation of the project.

Future students are not immediately related to the project, but can reap the rewards of a well completed project, providing potential future work directions. They have a medium low interest in the project, because they are not immediately involved in it, this also gives them a low power level.

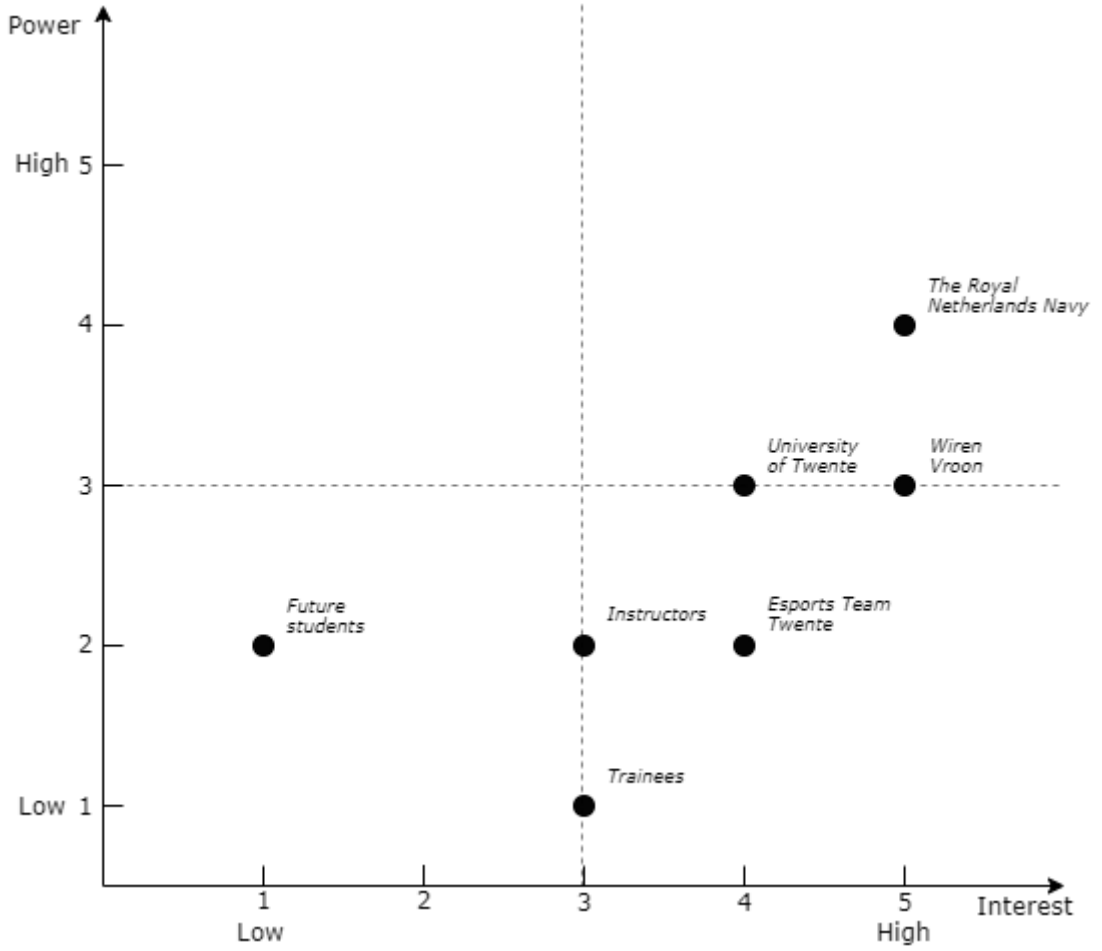

Figure 2: Power-interest matrix of the stakeholders

4.2 Acquisition of relevant information

In this section, relevant information on data measuring methods and their implementation that can be used for the tool are discussed. First, different data measuring methods that can be used to measure data when people play CS:GO will be explored. The use of these different data measuring methods for measuring communication and leadership will be discussed, next to the ease of implementation, ease of use and data quality. From this analysis, a single data measuring method for the tool is chosen based on the pro's and con's. After that, the method of measuring communication and leadership with the use of this data measuring method is explored.

4.2.1 Automatic data measuring methods

There are different automatic data measuring methods available when people are playing CS:GO. The following section will discuss these different data measuring methods and their pro's and con's. The pro's and con's are summarized in Table 3.

- *In-game data tracking*

  In-game data tracking is the tracking of game-related data of the players. There can be many things in CS:GO, such as the amount of kills, the amount of gold over time, the player's positions on the map, etc. There are a few opportunities when using in-game data tracking. It provides the opportunity for tracking gameplay activity and gives the possibility of creating behavioral profiles of the different players [81]. Next to that, it allows for the assessment and analysis of player performance. There are also some disadvantages to in-game data tracking.

  The presentation of behavioral profiles is difficult, since the interpretation of the profiles asks for a lot of context. Next to that, when looking at communication and leadership, in-game data does not provide a direct measure for these competencies. It could be used in the interpretation and assessment of leadership calls, to analyse whether certain calls were performed correctly or whether they were good calls. However, as a single data measuring method, it does not provide an impression on how communication and leadership are reflected when people play CS:GO.

- *Observation [82][83]*

  Observation is a qualitative data measuring method. It allows for the observation in a natural environment where an expert can observe, track and interpret the different activities that happen when people play CS:GO. The expert can give immediate feedback to the players. Communication and leadership are competencies that can very well be measured using observation. The verbal and non-verbal communication, the facial expressions, the body language of people and other relevant factors can all be observed. There are however a couple of disadvantages of using observation as a method. The first is that there is a high potential for a subjective bias. Every individual interprets the incoming data differently, which can result in subjective results. Secondly, it is difficult to quantify the data. The person that does the observation needs to take in a lot of data. Writing down and collecting every piece of incoming data is a large task and is often not possible. Therefore it is difficult to quantify the gathered data. Lastly, because of the need for experts and people that do the observation, it is often only possible to get small sample sizes of data.

- *Recording speech*

  The recording of speech is a method that is very easy when people are playing CS:GO. Players use headphones and microphones to communicate and therefore the only missing piece is a recording device. These are widely available, often integrated in many communication programs, such as Discord and Skype. The software programs that can do this are cheap or available for free and have well developed technology, providing recordings of good quality. Speech recordings provide measures for communication, since the communication when people are playing CS:GO proceeds through spoken words. Leadership can also be analysed with the use of speech recordings, since the calls that a leader does also proceed through spoken words. A disadvantage of recording speech is that the data cannot immediately be analysed, because it has to be transcribed to text first. This also means that there has to be none to a minimal amount of noise in the data to be able to transcribe the speech recordings.

- *Recording facial expression*

  Facial expressions can be recorded with the use of a camera. The recordings allow for a

detailed analysis of facial expressions [84]. These non-verbal expressions can be used to analyse communication, giving information on an individual's emotions. Since there is often access to cameras through the use of webcams when people are playing CS:GO, recordings of facial expressions are relatively easy to collect. However, it is difficult to code the movements that happen in the face. Therefore, the interpretation and analysation of the data can be very difficult, compared to other data measurement methods. Next to that, many outside factors can influence the quality of the results, such as the influence of light, the camera quality and head movements.

- *Eye tracking*
  Eye tracking is the tracking of the movement of the eyes [85]. This allows for the analysis of what and where a person is looking at on the screen. This could be very interesting when trying to measure for situational awareness, however, communication and leadership cannot be measured using this method. Next to this, eye tracking has a lot of disadvantages, such as the fact that it does not work on everyone, it requires considerable time and financial resources, and it requires calibration every time it is used.

Data measurement method	Pro's	Con's
In-game data tracking [81]	- Possibility for behavioral profiles on gameplay activity - Allows observation of performance	- Presenting analyzed behavioral data is difficult - No direct connection to communication and leadership
Observation [82][83]	- Allows observation in natural environment - Provides immediate interpretation of results	- High potential for subjective bias - Difficult to quantify data - Small sample sizes of data
Recording speech	- Easy to collect data - Technology to record widely available	- Needs to be transcribed to text to be analysed - Noise needs to be low to none
Recording facial expression [84]	- Allows for detailed analysis of facial expressions and emotions - Easy access to required technology	- Difficult to code the movements - Many outside factors can influence results
Eye tracking [85]	- Allows for the analysis of what a person looks at	- Eye tracking does not work on everyone - Requires considerable time and financial resources - Requires calibration - No connection to communication and leadership

Table 3: Data data measuring methods and their pro's and con's

Considering the pro's and con's of the different data measuring methods, two data measurement methods stand out for the measurement of communication and leadership when people play CS:GO.

These are the method of observation and the method of recording speech. However, for this study, one method is superior. The study aims at providing an insight into communication and leadership through the use of a tool. Using this tool, it is aimed at providing an objective, or at least normalized analysis of the data. Since the method of observation has a high potential of subjective bias, the tool becomes subjective as well. Therefore, the method that will be used for this project is the method of recording speech, because this method allows for the automatic collection of data. The data allows for the analysis of both of the competencies. Next to that, the technology required is widely and easily available, which makes the accumulation of data easy and convenient. The disadvantage is that in order to analyse the data, the speech recordings have to be transcribed. However, all of the methods require complex analysis tools and multiple steps before interpretation of the data is possible. Therefore, speech data is considered the best option and will be used for this project.

4.2.2 Speech data

The method of data measurement has been chosen to be the recording of speech. To be able to use this method, the question is raised how speech recordings can be used to measure communication and leadership. This will be answered by taking a look at different quantitative measures and interpretation of these measures for communication and after that for leadership.

There are many ways to measure communication, however, these are often linked to the content of what is communicated in the context that is communicated in. Yet this is not necessarily needed to measure communication of a team when they are playing CS:GO. For example, Van Dalen et al. [54] focused on how questions were asked, instead of what was asked. This was done using a scoring system to score a person on different items such as providing information, dealing with emotions or eliciting information. These represent categories of the intent of what someone is saying, instead of what that person is actually communicating. Other quantitative measures can also be used to measure communication, for example the number of words or sentences per unit time, percentage of words or sentences and filler words per second [86].

For leadership skills, leadership detection provides a lot of quantitative measures and predictors. These measures can be used to show how leadership is reflected when people play CS:GO. Naim et al. [87] describes common approaches such as lexical features and speech-related measurements such as speed of speech, pitch, the amount of speech and emotion analyses. Wang et al. [63] also presents similar predictors for leadership, such as number of statements per unit time, percentage of sentences out of the total interaction, percentage out of all positive and negative responses and more.

Quantitative measures provide data, but need to be interpreted in the context, before they have meaning. Therefore, there needs to be taken a look at models that measure for group processes, since these allow for the interpretation of communication and leadership. An important model that needs to be considered is Bales Interaction Process Analysis (IPA) model [74]. This is a method to study the communication processes that occur between people. The model uses a system of categories where the statements that people make are categorized during observation. The system of categories is presented in Figure 3, where each section is also divided into 4 parts, positive reactions, attempted answers, questions and negative reactions. These in turn are subdivided into the positive social-emotional area, the neutral task area and the negative social-emotional area. This categorization of group interactions gives a profile for each individual. This profile can be analysed and interpreted.

Bales IPA analyses the communication and categorizes the statements of what is said. However, to be able to do this, the audio files need to be transcribed to text. In the next chapter, different automatic speech to text methods will be experimented with.

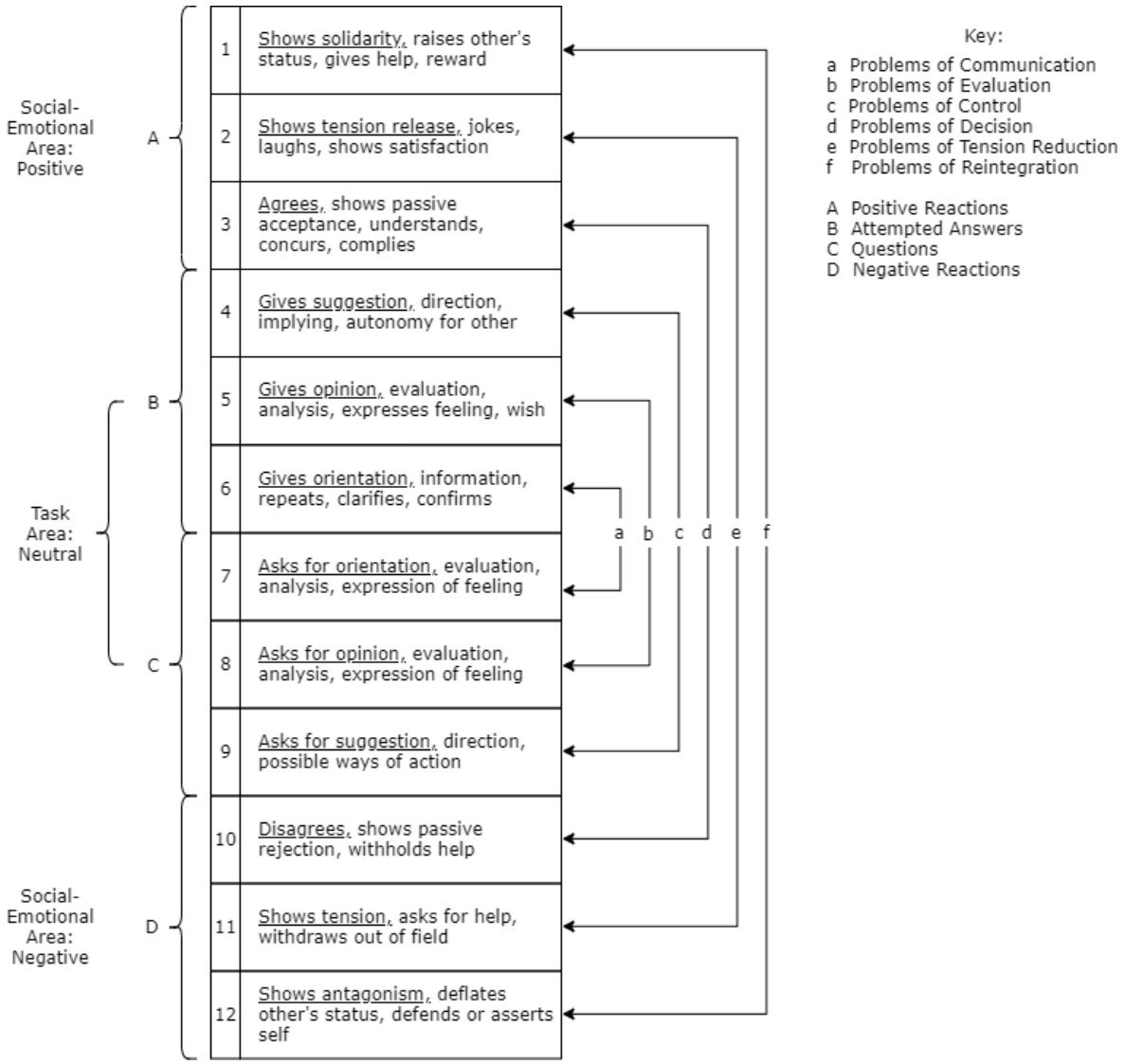

Figure 3: The system of categories used in observation in Bales Interaction Process Analysis

4.3 Requirement analysis

Now, a requirement analysis will be performed. First, the requirements from previous chapters will be discussed. Secondly, the requirements of the stakeholders will be identified. After that, the requirements for the relevant information will be discussed. The stakeholder requirements will be done, as described in section 3.2.3, using the user story format which is also used in Scrum [69]. After this, the requirements will be categorized into two categories. These are functional and non-functional requirements.

The following requirements were identified in previous chapters.

- *The tool should give an insight in the communication and leadership competency.*

This requirement directly relates to the design question, focussing on giving information on two specific competencies, being communication and leadership.

- *The tool should measure in the context of the game CS:GO.*

The tool is meant to be used when people play CS:GO, this is the context in which it will be used.

- *The tool should give information that is relevant for competency training purposes.*

The tool is meant to be used during training sessions, therefore, the output information should be relevant in training scenarios.

The following requirements were identified through semi-structured and unstructured interviews with the stakeholders.

- *As an instructor, I want the tool to work automatically without having to put in a lot of work to get results so I can focus on the students and the training.*

When using the tool, the user should not have to put in a lot of work to get results. The tool should be able to receive data in audio form and output the results of the analysis without needed interference from the user. (This is assuming the tool was set up correctly and the input data is in the correct format)

- *As an instructor, I want the tool to be easy to use, so I can use it without needing external assistance.*

The tool should be easy to use with little explanation. No big knowledge gap to let the tool function should be present.

- *As the Royal Netherlands Navy, we want the tool to provide practically relevant information, so the information should be directly applicable to our training situations.*

The results of the tool should contain relevant, understandable information that can be easily interpreted in practical situations. Where possible, the data should be automatically interpreted using academic background research instead of showing raw data.

- *As the University of Twente, we want data to be securely and anonymously processed and stored during research to protect research participants.*

The tool should process data anonymously and use and store no demographic data about the player. Next to that, the data should be safely stored and without reference to the players from which the data is from. Lastly, before players use the tool, players should give informed consent for the recording and processing of their speech data.

The following requirements are results of the acquisition of relevant information.

- *The tool gives an insight into how communication and leadership are reflected in the game, showing the instructor and/or player the output of the analysis.*

The goal of the tool is to provide insight into how communication and leadership are reflected when people are playing CS:GO.

- *The tool should have audio speech data as an input.*

The tool should have an input of audio files, one for each player. This audio file should be in a consistent format. This format will be discussed in the next chapter.

- *The tool focuses on interaction instead of content through the use of Bales IPA for analysis of the data.*

The tool has a focus of analyzing the interaction and group processes, rather than the content of the communication. This is done through the use of Bales IPA [74].

In Table 4, the different requirements can be found with their source and categorized based on the type of requirement.

Requirements	Source
Functional requirements	
The tool gives an insight in communication and leadership competency.	Chapter 2
The tool measures in the context of the game CS:GO.	Chapter 2

The tool gives information that is relevant for competency training purposes.	Chapter 2
The tool outputs practically relevant information.	The Royal Netherlands Navy
The tool should have audio speech data as an input.	Acquisition of information
The tool uses Bales IPA for analysis of the data.	Acquisition of information
The tool should work automatically.	Instructors
Data should be securely and anonymously processed and stored.	University of Twente
The output of the tool is visually pleasing to use as promotional content.	W. Vroon
The documentation and structure of the code should be easily accessible.	Future students
Non-functional requirements	
The tool gives an insight in how communication and leadership are reflected in the game.	Acquisition of information
Little to no knowledge gap to use the tool.	Instructors
The research provides future work directions.	The Esports Team Twente

Table 4: The requirements, categorized into functional and non-functional

4.4 The concept

In this section, a concept idea will be formed based on the previously defined requirements. This will consist of a general outline of the idea, followed with a broader elaboration of an idea for the output of the tool. This concept idea will be expanded upon in the next chapter where, with the use of prototyping, the concept is defined further.

The concept idea will be a tool that gives an insight in how communication and leadership are reflected when people are playing CS:GO. For this, speech recordings will be used as an input for the tool. The speech recordings will be analysed with the use of Bales IPA [74], which will result in an output of information that is practically relevant. This information can be outputted and show the information and different statistics.

4.4.1 Tool output

The tool output needs to present information on how communication and leadership are reflected when people play CS:GO. For this, there first needs to be discussion on how communication and leadership can be presented, and which statistics are interesting to present. After this the method of presentation needs to be discussed.

For communication, there can be presented how much communication there is per person. This can be in terms of sentences/words per unit time or sentences/words as a percentage of the total. Using Bales IPA [74], it can be presented how the communication takes place. Is a person giving a lot

of information, is a person asking for suggestions, etc. Another interesting representation of communication could be the percentage of negative and positive statements that an individual makes.

For leadership, the Bales IPA analysis needs to be interpreted to find the types of leadership that occur when people play CS:GO. As discussed in Chapter 2 section 2.4, there are different types of leadership. Bass et al. [59] defined transformational leadership, transactional leadership, while Lewin et al. [58] also defined a leadership style called laissez-faire leadership. Transformational and transactional leadership present a leadership model where a single person leads the group and makes decisions while laissez-faire leadership allows all group members to make decisions. Laissez-faire is similar to shared leadership where influence is distributed throughout the team, identified by Pearce et al. [88]. So a first analysis of the data would be to identify whether there is shared leadership or whether there is not. Wang et al. [89] presented features of leaders that can be used for leadership detection. These are lexical cues, the quantity of verbal contributions and the participation in agreements and disagreements. Leaders have a larger quantity of verbal contributions and a larger participation in agreements and disagreements than other group members. If the analysis does not show shared leadership, but a single leader, there can be another analysis to determine what type of leadership this person has. A study by Butler et al. [90] identified different leadership dimensions from the results of Bales IPA. They suggested four leadership styles through looking at the correlations between the different Bales categories. These styles are:

- *Task-oriented positive leadership*
  This leadership style incorporates lots of suggestions, opinions and orientation next to agreeing a lot.
- *Leadership uncertainty factor*
  This leadership style incorporates a lot of agreement, asking for orientation, tension and tension-release.
- *Self-oriented negative leadership*
  This leadership style incorporates a lot of disagreement, tension and showing antagonism.
- *Rejection of leadership*
  This leadership style incorporates solidarity, asking for orientation, tension and showing antagonism.

These styles can be used to find the potential leadership style of the group leader.

Now that the different statistics and information that can be used to present communication and leadership have been discussed, the actual presentation of the data can be explored. To present the data, a dashboard can be used. A dashboard is a broad term that describes an interface that presents different key indicators and information relevant to a specific goal. A dashboard can visualize the different statistics and data analysis results, next to this, it can easily be updated and downloaded in different formats. In Figure 4, a sketch of a concept dashboard is presented. This dashboard presents four different elements:

1. *Bales Interaction Process Analysis Profile*
   This graph shows the different Bales IPA profiles of the different players from whom the speech data is analyzed. This is presented with a line graph.
2. *Leadership style information*
   This element presents data on the leadership style. It presents whether there is shared leadership or whether a certain player is identified as the group leader. If the latter is the case, the identified style of that group leader is also presented. This is presented in text format.
3. *Percentage of words said*
   This element presents the percentage of words said by every person. This is visualized using a pie chart.

4. *Amount of positive and negative responses*
   This element shows the amount of positive and negative responses of each individual player. This is visualized using a bar chart.

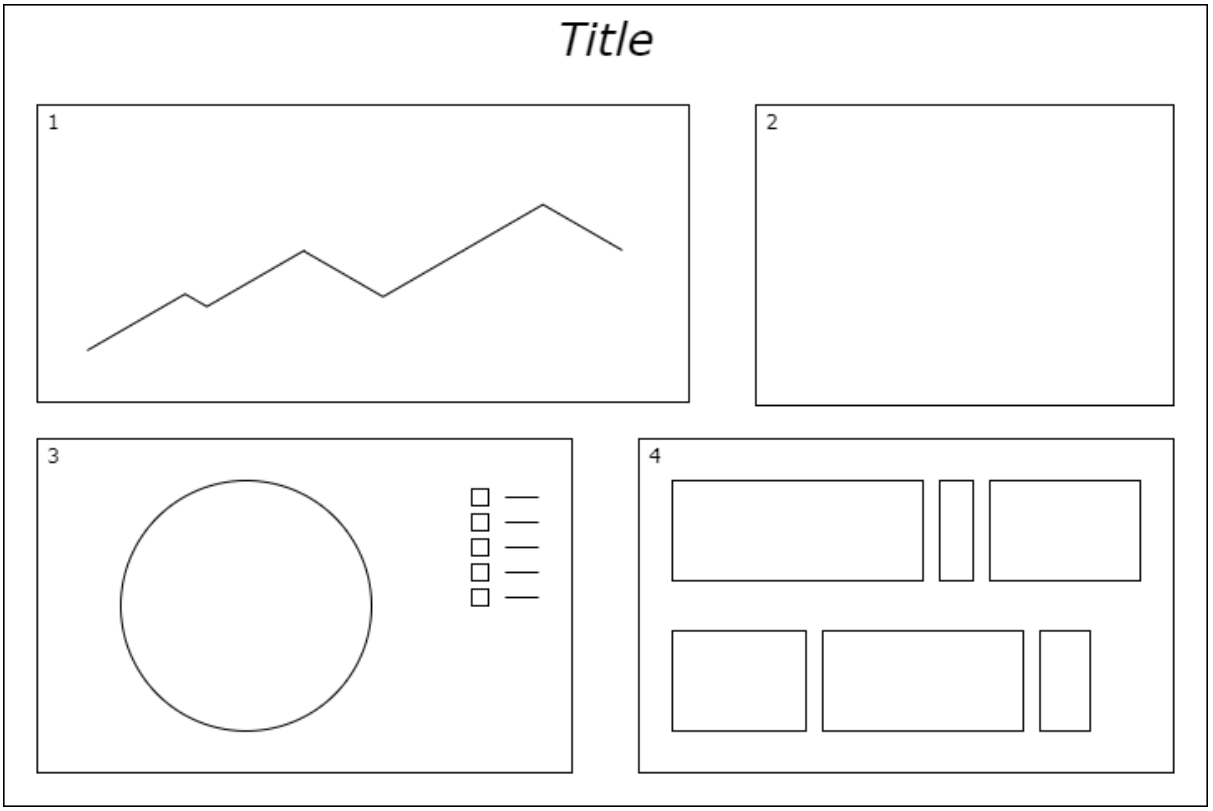

Figure 4: Sketch of the layout of the tool output dashboard

4.4.2 Tool structure

In Figure 5, the construct of the idea is visualised. The inputs are individual audio files of the speech data that has been recorded. To be able to analyse the data using Bales IPA [74], the speech data has to be transcribed to text. The prototypes in the next section will explore different speech recognition tools such as Kaldi and Python Libraries. After transcription, the text is analysed and data is outputted on a dashboard.

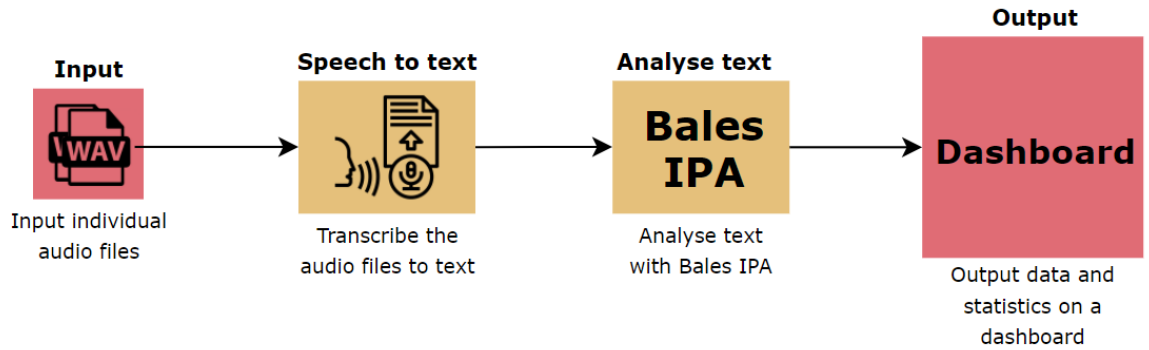

Figure 5: The structure of the tool

Chapter 5 - Specification

Based on the concept idea formed during the ideation phase, a prototype will be built. This chapter will present the coding loop of the tool. This explains the structure of the program and the changes that it goes through based on the concepts that are tested and tried. First, the concept formed in section 4.4 is expanded by prototyping the different elements that the prototype consists of. After that, there is an evaluation of the prototype resulting in a second prototype. The chapter is concluded with a revision of the design requirements.

5.1 First prototype

The first prototype is based on the concept formed in section 4.4. The concept is elaborated upon in the following sections, where each section will go over a part of the prototype. The different components of the prototype are broken down and the techniques explored for those components are discussed. First, there is a look at the speech to text component that will serve as a bridge between the speech data input and the input of the Bales IPA. It is important to know what the output of the speech to text component is and can be, to be able to correctly implement Bales IPA, which is the second part that is looked at. Lastly, there will be a look at the design and implementation of the dashboard. This is done last, because the structure of the output from the Bales IPA plays a large role in the implementation of the dashboard.

5.1.1 Speech to text

The speech-to-text function of the tool has the goal to transcribe the audio files into text for the input in the Bales IPA. Two free of charge toolkits for speech-to-text that have been explored will be discussed. These will be evaluated based on two aspects. The first aspect is how easy the tool is to use. This is in terms of how easy it is to set up the tool and also on how easy the tool is to accomplish set goals. The second aspect is what the transcription performance is of the tool. This will be done by testing the toolkits using three audio files. From these three, two are retrieved from the Open Speech Repository [72]. This is a repository that contains audio files with each being the recording of ten Harvard sentences [73]. Harvard sentences are a collection of different standardized sentences that can be used for speech recognition testing and voice-over testing. The third clip is intended to explore how the results of the toolkits are different when jargon is used and when the pronunciation is less clear. This third audio file is retrieved from the communication while someone was playing CS:GO.

The toolkits that will be explored are Kaldi and the Google Cloud Speech API. Kaldi [91] is an open-source toolkit for speech recognition. It is a speech recognition toolkit with the intended use of speech recognition research. The second tool is the use of the SpeechRecognition library for Python [92]. This library supports different engines such as the Google Cloud Speech API.

Kaldi provides a Python wrapper [91] and can be used to create simple automatic speech recognition systems using speech data. Kaldi provides some example scripts, but documentation and tutorials on how to set up and use Kaldi are very scarce. During the installation and set up, a lot of problems were encountered. First of all, Kaldi is originally built for Linux and the Windows support is not very extensive. This in itself created a high entry knowledge threshold. The application and use of the toolkit appeared to be very difficult and required a lot of knowledge to create a speech recognition system. These setup difficulties were problematic within the time constraints of the study. Next to that, the speech recognition systems that can be built using Kaldi need to be trained with a lot of data in order for them to work properly. This means that the model can work for an individual if it is trained for this specific person, however, this does not mean that the model then also works for other people. This is because every individual pronounces words differently, has different intonations and different speech volumes.

The Google Speech API is much easier to set up and use. Python provides a speech recognition library [92] that is supported by the Google Speech API. To test the quality and functionality of the library, the API will be tested with speech samples. The first speech sample is a sample that is used to train speech recognition systems, consisting of ten sentences. In the sample, the following is said:

"A king ruled the state in the early days. The ship was torn apart on the sharp reef. Sickness kept him home the third week. The white rose shimmered in the hot sun. The lazy cow lay in the cool grass. Lift the square stone over the fence. The rope will bind the seven books at once. Hop over the fence and plunge in. The friendly gang left the drug store. Mesh wire keeps chicks inside."

When using the Python speech recognition library, together with the Google Speech API, the program gives the following result for the transcription:

"the King's Road estate and early days the ship was torn apart on a sharp relief sickness kept him home the third week the White Rose shimmer in the hot sun The Lazy Cow Lane the cool grass Leicester Square stone over the fence the Rubble by the seven books at once over the fence and plunge in the friendly game left the drugstore mesh wire keeps chicks inside"

This transcription is close to what is originally said. There are in total about 12 words out of 69 that are wrong or missing. One thing that stands out however is that the transcription cannot separate the different sentences. This sample had a very clear pronunciation, something that is not always the case when recording speech data. The same results appear for the second audio file where the following ten sentences are said:

"A pencil with black lead writes best. Coax a young calf to drink from a bucket. Schools for ladies teach charm and grace. The lamp shone with a steady green flame. They took the axe and the saw to the forest. The ancient coin was quite dull and worn. The shaky barn fell with a loud crash. Jazz and swing fans like fast music. Rake the rubbish up and then burn it. Slash the gold cloth into fine ribbons."

This sample is transcribed by the Google Speech API to:

"a pencil with black rights best coax a young calf to drink from a bucket schools for ladies teach charm and Grace the lamp shown with a steady green flame they took the X and the sort of the forest the ancient coin was quite a doll and worn the shaky bar and fell with a loud crash jazz and swing fans like festmusik break the rubbish up and then burn it states the gold cloth into fine ribbon"

This sample has about 12 out of 79 words that are wrong or missing.
To compare these results to the results of a more representative audio file for when people are playing CS:GO, the third test uses a sample from an individual that plays CS:GO and communicates to his/her teammates. The following is said in the sample:

"We could actually go mid to B right now, like we could just smoke. One mid, he saw me. Left side corner, I am throwing a smoke right now. I am flashing the corner deep, just go, just go."

The program produces the following with this speech sample:

“just actually going to be right now I could just smoke one mate it's my smoke now the corner deep”

When comparing these results to what is originally said, it can be seen that it is far from what has actually been said. There are some similar words, but the sentences are completely different, even skipping over certain words. Next to that, the different sentences that existed in the original sample have completely disappeared.

Now that both of the speech to text toolkits have been explored, it has become clear that both of these options are not usable for the project. The Kaldi Open Source toolkit is too difficult to implement within the scope of this project, because it requires a lot of pre-knowledge to be used. Next to this, the models that can be built need a lot of ‘training’ to work, which would be impractical for a training scenario. The Python Speech Recognition toolkit together with the Google Speech API is easy to implement, but needs very clear speech files in order to work. When using a voice communication sample from a CS:GO player, which is representative of the data that will be used as an input for the tool, the toolkit cannot transcribe the text well. Next to this, the different sentences are indistinguishable from each other, which is a crucial part of the Bales IPA, where sentences are categorized. Because of these results, a different solution for the speech-to-text part of the tool needs to be found. This solution is to use manual transcription of the data. With this, the design requirement that states that the tool should work automatically needs to be adjusted. Section 5.2, will elaborate on the implications and solutions of these findings.

5.1.2 Bales

To be able to get an insight into how communication and leadership are reflected when people play CS:GO, Bales IPA [74] will be performed with the output from the speech-to-text part. The following section will describe the process of this analysis. This will be done in four steps, in the order of the different steps on how the program is structured. This structure of the Bales IPA in the tool is presented in Figure 6.

The first step is to take a sentence from the input list. The input list is the output list generated in the speech-to-text part of the tool. It consists of the different sentences that people say to each other when they play the game. In Bales IPA, not every sentence is processed at the same time, but every single sentence is individually categorized in the model as presented in Figure 3.

The second step is to tag the words in the sentence with a grammatical tag, which is needed in a future step. The tagging is done using Wordnet [75], a lexical database of English words. Wordnet groups similar words together into synsets, based on conceptual-semantic and lexical relations. The program searches in the database for the words and links the correct grammatical tag to them.

After the tagging, the next step is to analyse all of the words in order to get a sentiment score for the sentence. This is a score that interprets whether the sentence is positive, negative or neutral. This is used for the subdivision of the sentences into these three categories, before they are categorized into one of the twelve categories of the Bales IPA model. Bales IPA model divides the twelve categories into four subgroups, being positive reactions, attempted answers, questions and negative reactions. With the subdivision using the sentiment score, the sentences can be connected to one of these four subgroups. To get the sentiment score of a sentence, the first step is to break the sentence down into single words, analysing them one for one. Each word is processed to identify the meaning of the word in the context, which is important for two reasons. Every word should be in ‘standard’ conjugation format, for example verbs should be in their present tense. Secondly, the meaning of the word needs to be identified, because a word can have multiple meanings. This identification of meaning of the word is also done with the use of Wordnet, where the different definitions of the word are compared with the grammatical tag and the context of the word in the sentence. This disambiguation step is useful for the actual sentiment analysis of the word. The

sentiment analysis is based on SentiWordNet 3.0 [76], a lexical resource for the classification of words based on their sentiment score. SentiWordNet is a database, resulting from the automatic annotation of the Wordnet database. Each word has three numerical scores, the positive score, the negative score and the objective score. These indicate how positive, negative or neutral a word is. Using this database, the words in the sentence are rated. Adding these scores together results in a final sentiment score for the whole sentence.

Having scored the sentence with a sentiment score, the last step can be performed. This is the categorization of the sentences into the model of Bales IPA, done in two steps. The first step is to determine the sub category in which the sentence belongs. As mentioned earlier, these sub categories consist of positive reactions, attempted answers, questions and negative reactions. First, there is checked whether the sentence is a question, if so, it is put in the question category. If this is not the case, there will be a look at the sentiment score of the sentence. If positive, it is put in the positive reactions category, if negative, it is put in the negative reactions category and lastly if it is neutral, it is put into the attempted answers category. Now that the sentence has been sorted into one of the four categories, it is one to the last step. The words in the sentence are associated with the different categories in the sub category. Word lists are used of frequently used words in those specific categories. Based on the associations with the categories, it is determined in which category the sentence belongs. Uncertainties are settled with the rule that a category more distant from the middle should be favored over a category closer to the middle [74].

The analysis is done for all of the sentences in the speech file. For every individual, the amount of sentences in each category is stored and updated in each loop. After the program is finished with the analysis, the data can be used for the output of the tool.

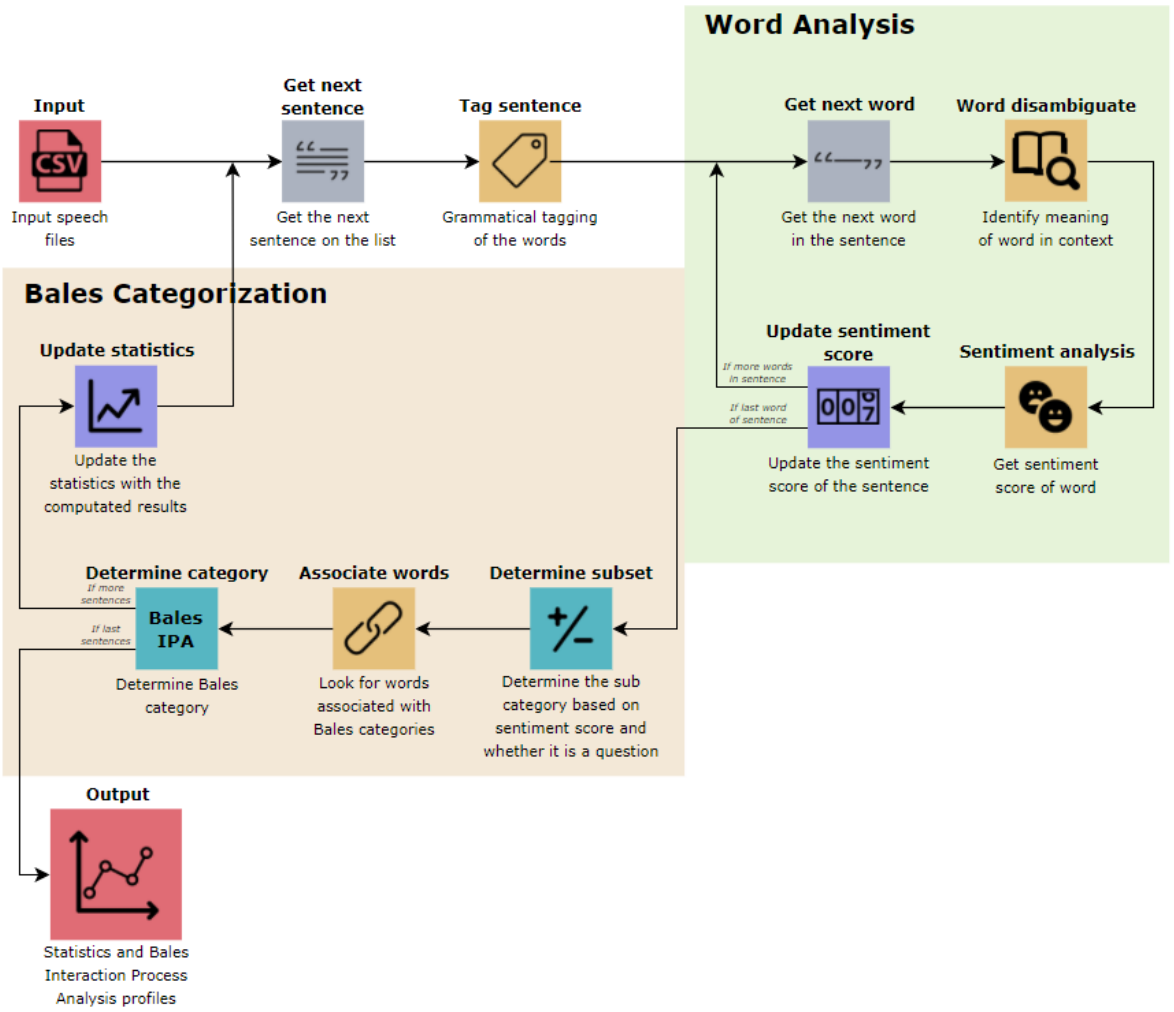

Figure 6: The program structure of the Bales Interaction Process Analysis element

5.1.3 Dashboard

This section will describe how the dashboard is created. It consists of four different elements, as described in section 4.4.1. These are the Bales IPA profile graph, the section that gives information on the leadership style, the percentage of words said and the amount of positive and negative responses of each individual.For each of these parts, there will be described how these can be retrieved from the data, after that, there is an elaboration on how the actual dashboard is formed.

The first section is the Bales IPA profile graph. This graph can immediately be extracted from the results of the Bales IPA. It visualizes the scores that every individual has in each category with the use of a line graph.

The second section is the information on the leadership style. This section needs to be subdivided into two parts. First, there needs to be determined whether there is a leader and if so who that leader is, or whether there is shared leadership. Then, if there is a leader, there can be an analysis on what type of leader this person is. According to Wang et al. [89], to determine who the leader is, there can be looked at who has the largest quantity of verbal contributions and the largest participation in agreements and disagreements. This can be retrieved from the data outputted from Bales IPA by looking at which person has said the most words and participated most in agreements and disagreements, both categories in the Bales IPA model. Then, for this person, there can be looked at what percentage of the total he or she said, agreed and disagreed. When analysing five players, the closer these percentages are to 20%, the more probable it is that there is shared leadership. The further

away from 20%, the more probable it is that this person is the individual leader of the group. To determine what type of leader the most probable leader is, the research by Butler et al. [90] can be used. As explained in section 4.4.1, they define four different leadership styles through looking at the correlation between the different Bales categories. By looking at which categories the leader scored more than other categories, the research by Butler et al. [90] can be used to give a suggestion of the leadership type.

The third section is the percentage of words said. To get this information, a counter can be added in the Bales IPA part of the tool. The Bales IPA analyses every word of every sentence and with that can count the number of words for each individual. This can be plotted in percentages out of the total in a pie chart.

The fourth and final section is the amount of positive and negative responses that each individual has made. A counter can also be integrated into the Bales IPA. Every sentence is scored with a negative, neutral or positive score using a sentiment analysis. Everytime a sentence is scored, the counter can be updated by adding a point in one of the three categories for each individual. The information gathered can be plotted in a stacked bar graph.

The dashboard in itself can be built with the use of Dash [77], a framework for analytic applications that can be used in Python. The different graphs can be plotted through the use of Plotly Express [78]. Using CSS, a coding language to build a layout and do visual styling, the dashboard can be designed. In Figure 7, a prototype of the dashboard with the styling and the different elements of the dashboard is shown.

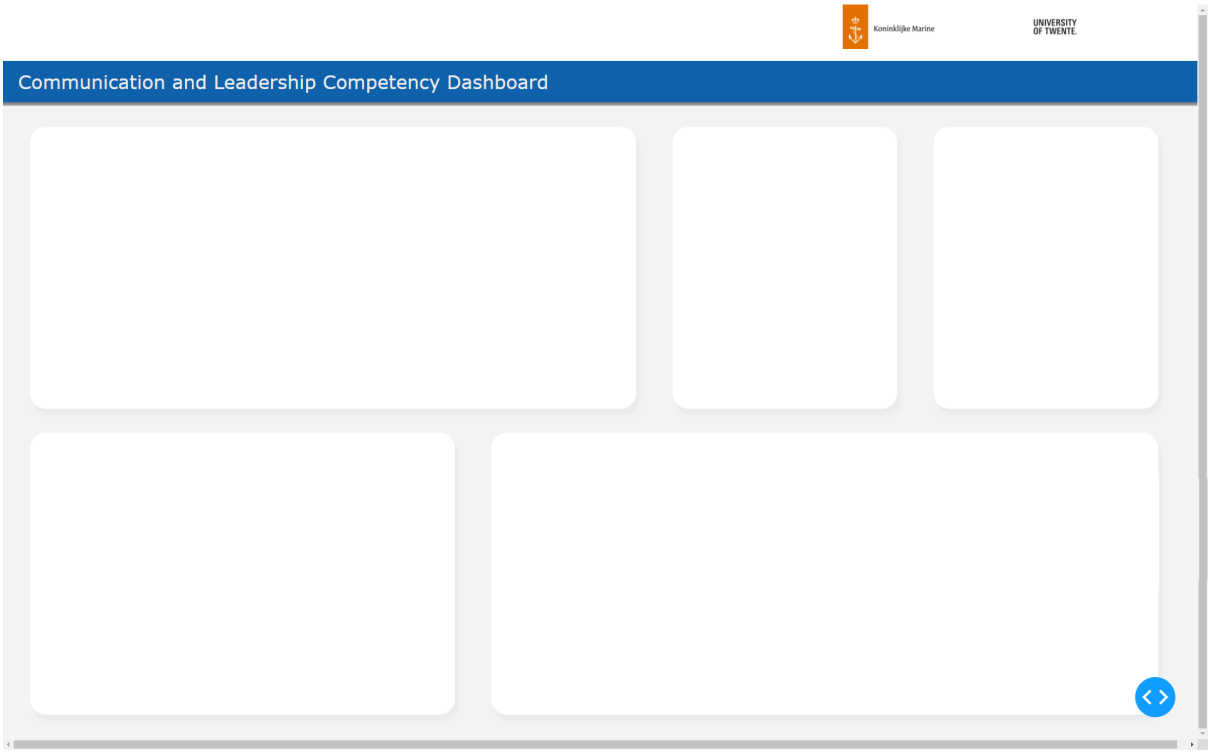

Figure 7: Empty dashboard design

5.2 Evaluation and solutions prototype

This section will evaluate the different parts of the prototype discussed in the previous section with the use of the relevant design requirements from the ones defined in section 4.3. First, there is

discussed whether the relevant design requirements were met. Then, for the design requirements that haven't been met, solutions are proposed.

The tool uses Bales IPA for analysis of the data. This design requirement is met. As described in section 5.1.2, the tool uses Bales IPA to analyse the different sentences that the players say when they are playing the game.

The tool should work automatically. This design requirement has not been met, since the speech-to-text step needs to be done manually.

The tool should have audio speech data as an input. This design requirement has been met, the tool can have .wav files of the individual players as an input.

Data should be securely and anonymously processed and stored. This design requirement has not been met. The tool processes the data of the players, but does not take a specific step in anonymizing the data.

The output of the tool is visually pleasing to use as promotional content. This design requirement is very difficult to assess, since this is very subjective. However, the dashboard does have styling and visual clarity.

The documentation and structure of the code should be easily accessible. This design requirement is also difficult to assess because of its subjectiveness. However, the code is structured properly and adequately commented.

Two design requirements have not been met. These are the automatic working of the tool and the secure and anonymous processing and storing of the data by the tool.

There is not a concrete solution to be able to satisfy the first design requirement, however, the design requirement can be adjusted, together with the addition of a second input method. This second input method can be used to input already transcribed audio files. This allows for the automatic processing of data if there is access to the transcribed data. With this solution, two design requirements are adjusted. '*The tool should work automatically'* becomes, '*The tool should work automatically with the input of a transcribed audio file'*. Next to that, the design requirement *'The tool should have audio speech data as an input.'* becomes, *'The tool should have two input methods, one for audio speech data and one for transcribed audio data.'*.

For the secure and anonymous processing of the data, a step can be added where the names of the files are anonymized to 'Player 1', 'Player 2', etc. This gives the possibility to distinguish between players during the training session and use of the tool, but anonymizes and allows for the secure storage of the player data.

5.3 Second prototype

The second prototype combines the different elements discussed in section 5.1, being the speech-to-text, the Bales API and the construction of the dashboard. Next to this, it incorporates the solutions from the previous section, adding a second input to input already transcribed audio files and adding a step to anonymize the analysed data. The full prototype is shown in Figure 8 below. The code of the full prototype can be found on Github [93].

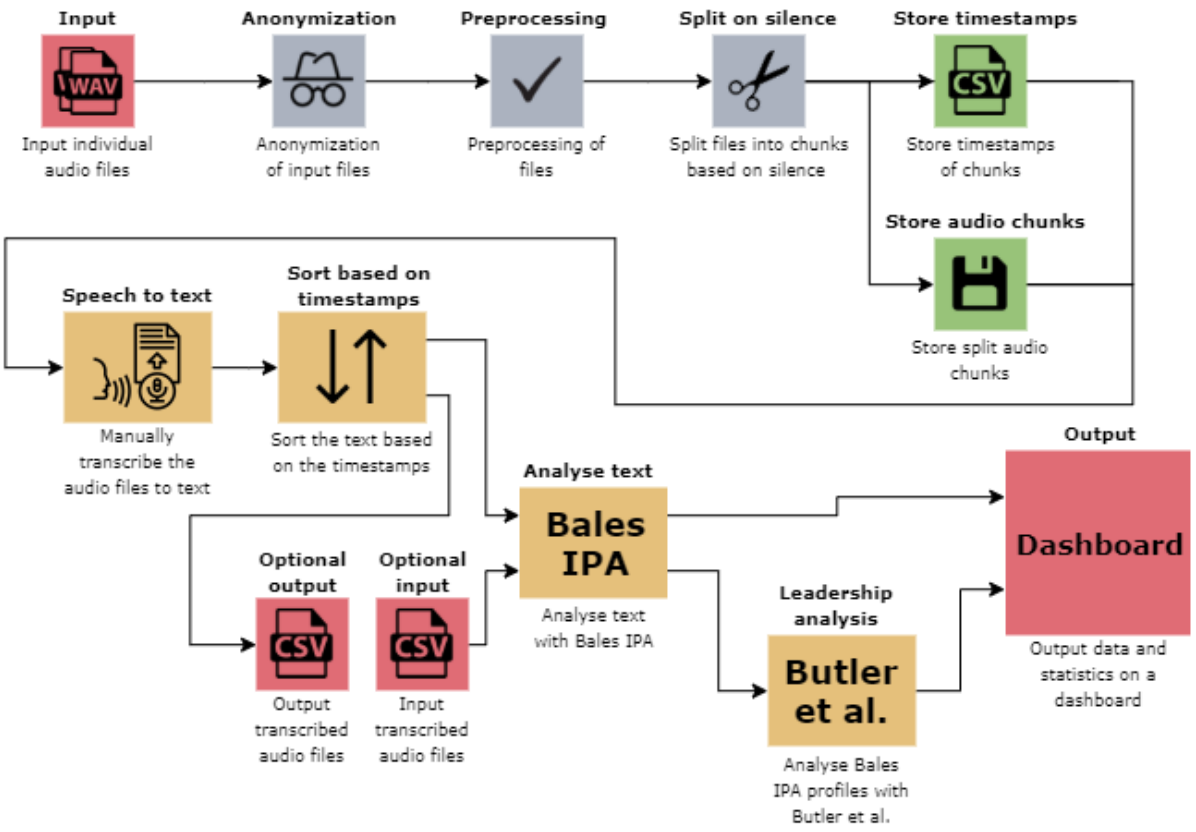

Figure 8: The program structure of the full second prototype

Chapter 6 - Realisation

This chapter will describe the testing of the tool using speech data collected from people playing CS:GO. The goal of this testing is to verify whether the tool functions as intended. First, there will be a short explanation of the data collection method. Then, the data transcription will be described. After that, the data is used with the tool and the output results are presented.

6.1 Data collection

To be able to get results from the tool, speech data is required from people playing CS:GO. With this data, the tool can be tested, verified and further developed. The next section will shortly go over the data collection method and data transcription, a more elaborate description of this can be found in chapter 3 section 3.4.

6.1.1 Collection method

The data is collected during two different sessions, both with different participants. The participants of the first session consist of people from the CS:GO Esports team of the University of Twente. These are experts at the game with lots of hours played and will serve as the experienced team. The second session consists of people with little experience, less than 20 hours played. The players play an online game against people of their own skill, matched based on their CS:GO MMR. MMR stands for Matchmaking Rating and determines your in-game skill level and is used to match people against others of the same skill level. The communication during the game is done through Discord [79], a messaging and VoIP application. Using Craig [80], a channel recording bot, the speech of the players can be recorded. The CraigBot outputs the results of the recording as separate audio files for each player.

6.1.2 Data transcription

The data transcription of the speech data is done manually. The tool processes the audio first and splits these up into chunks, storing the timestamps in the process. Then, each chunk is listened to in order and the transcription is inputted into the tool. If the audio is not clear, it can be repeated as many times as necessary. When the audio is untranscribable, the word ‘Error’ is inputted. This can happen in various cases, for example when a cough, a sniff or cry is picked up by the microphone. The transcribed audio files are stored and can be used for the remainder of the tool.

6.2 Prototype testing

This section will present the results that the tool outputs using the collected data. It will show the complete dashboard and will show the different graphs separately.

6.2.1 Experienced team

The dashboard output with the data of the experienced team is shown in Figure 9. The profiles of the players from Bales IPA are all showing the same shapes, indicating similar communication patterns. As can be seen, the analysis estimates player 1 to be the group leader. This player has communicated the most and participated the most in the positive and negative responses. However, the amount spoken and the participation in negative and positive responses are close to 20%, suggesting possible shared leadership. The estimated leadership of the potential leader is the task-oriented positive leadership style, giving a lot of suggestions and orientation.

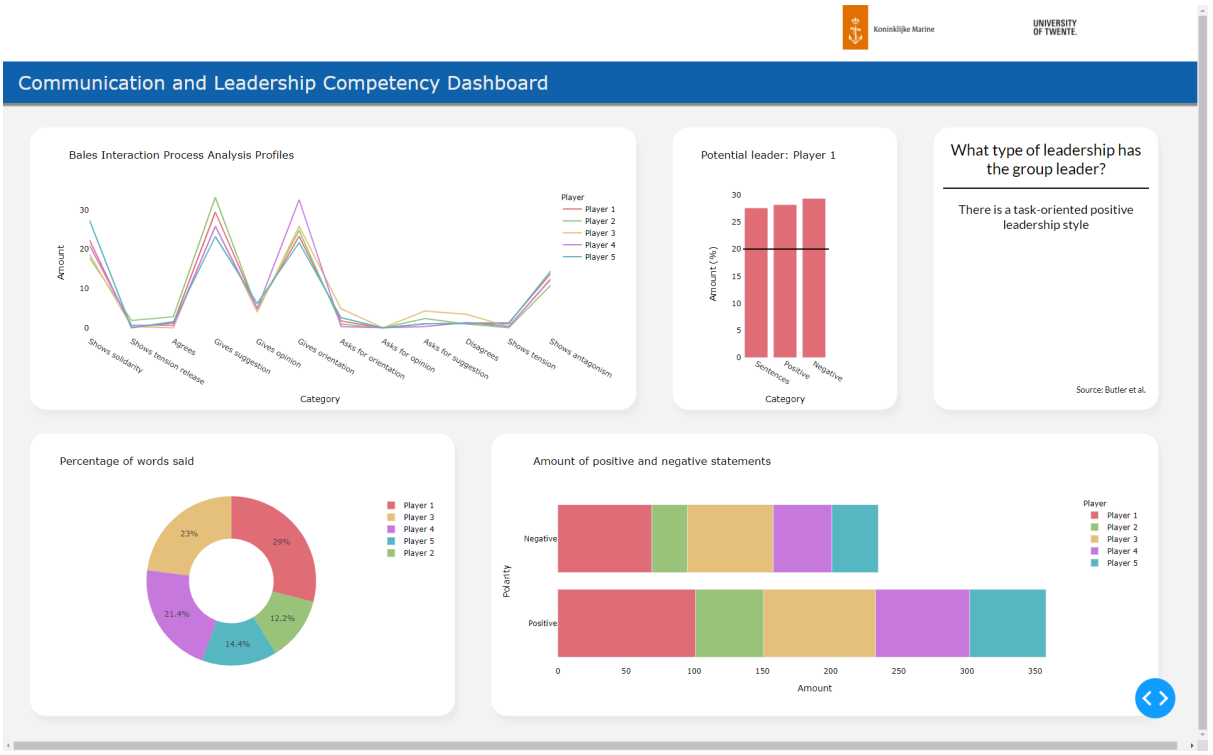

Figure 9: The dashboard output using data from the experienced team

6.2.2 Inexperienced team

The dashboard output with the data of the inexperienced team is shown in Figure 10. In contrast with the Bales IPA profiles of the experienced players, the profiles of the inexperienced players are shaped differently for each player. Two players give a lot of suggestions, while the other three do this less. The analysis estimates player 2 to be the leader. There could still be shared-leadership, however, player 2 communicates the most and participates in almost 30% of the positive and negative responses, suggesting individual leadership. The estimated leadership style is the same as for the experienced team, being task-oriented positive leadership.

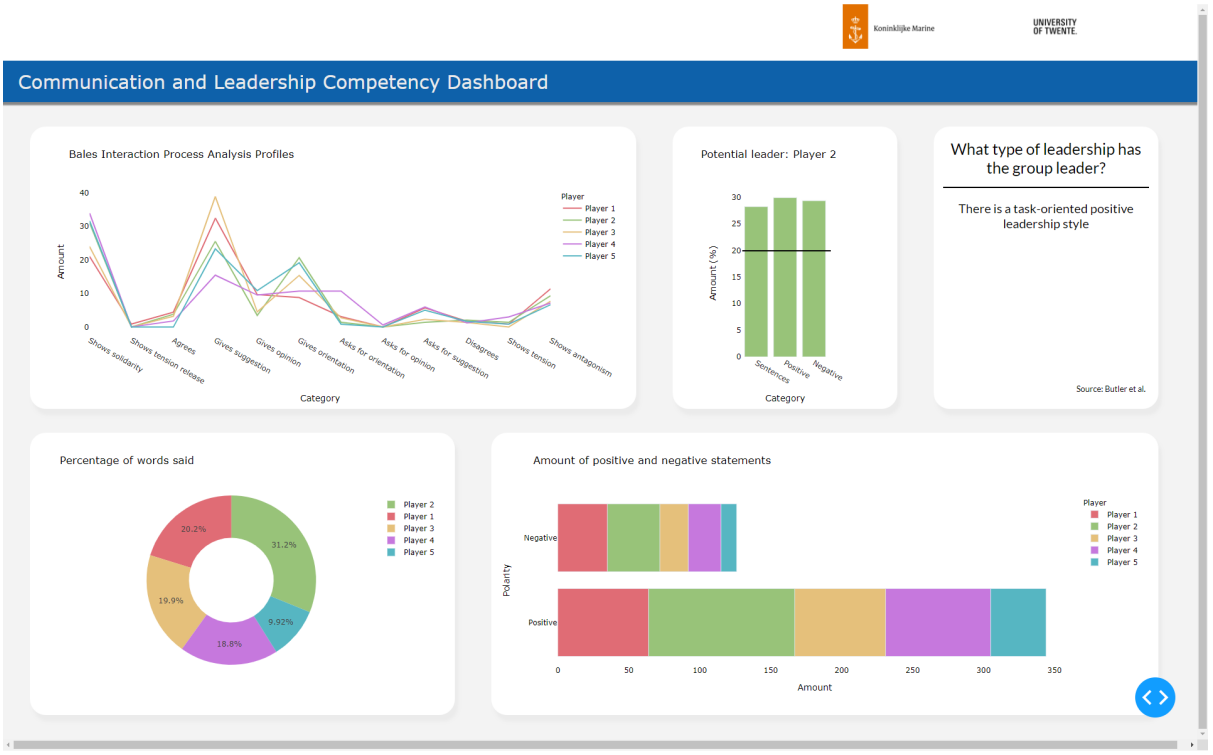

Figure 10: The dashboard output using data from the experienced team

6.3 Verification of the tool

To verify the tool, there needs to be looked at the different communication processes of the two teams. If the tool functions as it is supposed to, it is expected that different communication patterns exist between the two teams. Figure 11 shows the Bales IPA model profiles of the experienced players and and Figure 12 shows the Bales IPA model profiles of the inexperienced players. It can be observed that the inexperienced players show different patterns than the experienced players, indicating a correct functioning of the tool.

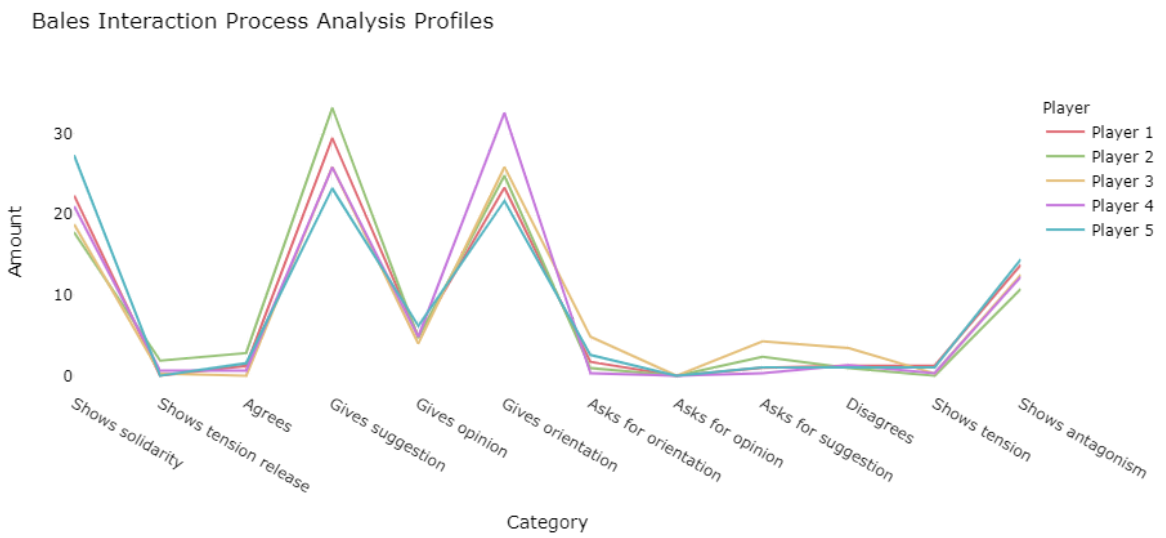

Figure 11: The Bales IPA model profiles from the experienced team

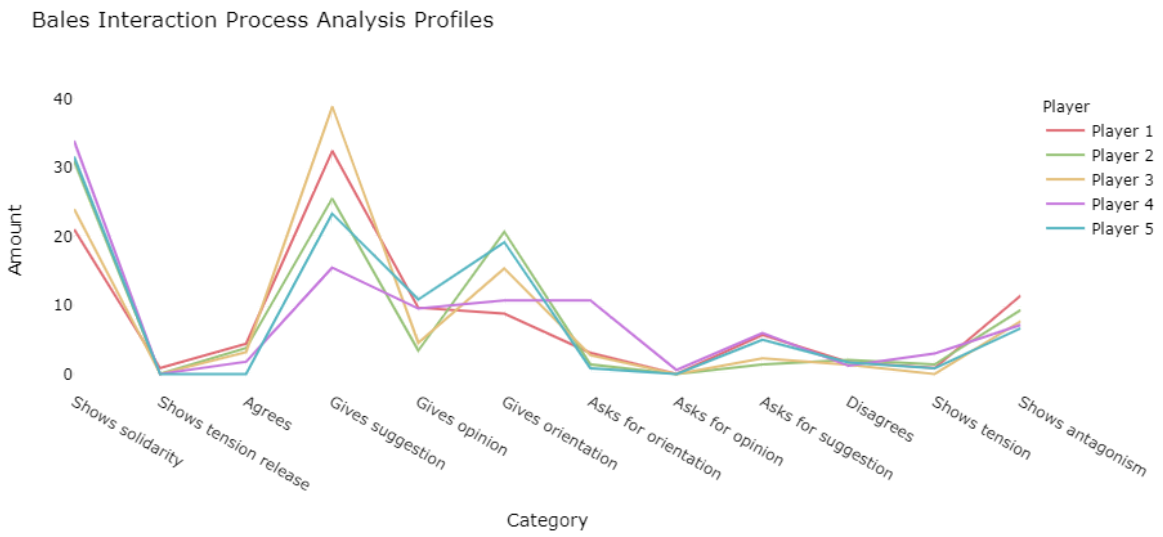

Figure 12: The Bales IPA model profiles from the inexperienced team

Chapter 7 - Evaluation

This chapter will evaluate the tool and the research in three steps. First, there will be an evaluation on the verification of the tool. Second, there will be an evaluation on the validation of the tool and lastly the tool will be evaluated based on the functional requirements defined in chapter 4 section 4.3.

7.1 Verification of the tool

In this research, a tool has been created that can analyse transcribed speech data to reflect how communication and leadership are reflected when people play CS:GO. This is done through the usage of Bales IPA [74]. The tool outputs a dashboard with the results of the analysis and interpretation of the analysis for the leadership competency.

The verification of the tool is a check on whether the model functions as it is supposed to. The verification looks at how the model functions, but does not look at whether the output is correct when comparing the results to real-life. The verification of the tool has been done in section 6.3, by comparing the output of the tool between two datasets. One dataset is from experienced CS:GO players and the other dataset is from inexperienced CS:GO players. As expected, different communication and leadership patterns emerge for both of the teams.

These different communication patterns indicate the correct functioning of the tool. The data displays correctly and the different communication patterns are existing. One limitation is that only two datasets have been used, so there is the potential for a false-positive verification of the tool.

7.2 Validation of the tool

Because of limited resources, the tool has yet to be validated on whether it correctly performs the analysis. The results that the tool puts out look promising and the process of the analysis is substantiated by research. The following section will describe two methods that can be used for validation of the tool.

The first method is through the use of a comparison method. Bales IPA can also be performed manually. An observer listens to the given data and categorizes the statements that the players make. An experienced observer can be used to analyse the same data as the tool has analysed. Then, results of the tool and the categorization by the observer can be compared. It is not expected that the results are exactly the same, but similar results should be observed. Based on the results of the comparison, a conclusion can be made on the validity of the tool.

Another, more complex, validation method is through the use of machine learning. A cross-validation can be used where the model is trained using a dataset. This dataset provides the original data and the categories that the statements in the data belong to. Then, when using another different set of data, the model tries to use pattern recognition and information gained from the original set to analyse the new data. At this moment, the implementation of this cross-validation and model training has not been implemented into the tool, however implementation and usage of this machine learning method can significantly reduce bias and validate the model.

7.3 Requirement evaluation

This section will go over all of the functional requirements individually and discuss to what extent the requirement has been met.

The tool gives an insight in communication and leadership competency.

This requirement has been met. The tool provides information on communication through displaying the Bales IPA profiles of the individuals. Next to that, it visualizes the amount of words that each

player communicates and also the amount of positive and negative responses that each player participates in. An insight in leadership is provided through the use of the research by Butler et al. [90].

The tool measures in the context of the game CS:GO.
This requirement has been met. The tool can process communication data of players playing the game CS:GO.

The tool gives information that is relevant for competency training purposes.
Within the scope of the research, it is not possible to evaluate whether this requirement has been met. The output of the tool displays practical and understandable information, however there has been no test on whether the information displayed is useful in training scenarios.

The tool outputs practically relevant information.
Within the scope of the research, it is difficult to evaluate whether this requirement has been met. The tool outputs information on how the communication took place. For communication competency, the amount spoken, the negative and positive responses and the Bales IPA can be used to evaluate how the team communicates. For leadership, there is an interpretation of how the leadership took place, based on research by Wang et al. [89], and Bass et al. [59]. Then, if there is individual leadership, the leadership style of that person is estimated based on research by Butler et al. [90]. All in all, the tool outputs practically relevant information that can immediately be used in the evaluation and discussion during training. However, research on the interpretation of the Bales IPA in the light of communication and leadership competency is very limited, therefore, there should be more research on this topic. This can help validate the output information of the tool and evaluate whether the tool output is practically relevant.

The tool should have two input methods, one for audio speech and one for transcribed audio data.
The tool has two different inputs. The first one being audio files, the second being the already transcribed speech files. The tool works in both scenarios, however with the first, manual transcription of the audio files is needed. This is because the speech to text tools available for implementation are too difficult with the resources available or qualitatively not good enough. Therefore this requirement is satisfied.

The tool uses Bales IPA for analysis of the data.
The tool does use Bales IPA for the analysis of the data, therefore this requirement is met. The Bales IPA is implemented with the use of different databases and libraries.

The tool should work automatically with the input of a transcribed audio file.
The tool processes the input information fully automatically, when the transcribed audio files are put into the tool. A single button needs to be pressed in order to activate the tool and retrieve the results of the analysis. The only thing that does not work automatically is the transcription of the audio files, but due to the second input for the transcribed audio file, this requirement is met.

Data should be securely and anonymously processed and stored.
This requirement is satisfied. The individual audio files are anonymized through labeling them as Player 1, Player 2, etc. This makes it so during the training, the data can be related to an individual, but if the data were to be stored, it could not be related back to the individual. If, for research or organisational purposes the tool should not anonymize the data, this can very easily be implemented.

The output of the tool is visually pleasing to use as promotional content.
It is difficult to establish whether this requirement has been met, since this is very subjective. However, an effort has been made into making the dashboard visually pleasing, clear and well-structured.

The documentation and structure of the code should be easily accessible.
The code is commented and the structure is clear. This makes the code easily accessible for other people. Next to this, the program structure diagrams presented in chapter 5 also provide guidance and a clear overview on how the program is put together. Therefore, this requirement has been met.

Chapter 8 - Discussion

This chapter will provide a discussion on the research. First, there will be an interpretation of the results. After that, the implications of the results will be discussed. Lastly, the limitations of the tool and of the research will be explored. These limitations can also provide future research directions that will be discussed in chapter 10.

8.1 Interpretation of the results

The results provided an insight in how communication and leadership are reflected when people play CS:GO. With the CS:GO Esports team, it could be seen that the Bales IPA profiles of all the players were very similar, suggesting shared leadership within the team. This was different for the inexperienced players, where a single leader could be identified. These results imply the existence of communication and leadership competency within CS:GO. The tool provides a method to analyse these competencies and give an insight that can be used for training purposes.

8.2 Implications of the results

Gagné's Taxonomy of Learning [94] is a model that describes nine levels of learning. Ascending to the highest level, these are:

> Gaining attention → Identifying objective → Recalling prior learning → Present stimuli → Guiding learning → Eliciting performance → Providing feedback → Assessing performance → Enhancing transfer.

The results have shown that communication and leadership competencies exist when people play CS:GO. When considering the results in the light of Gagné's model, different levels of learning can be touched upon when using CS:GO. The first three levels are important for the preparation of the players, gaining their attention, informing them about the objective of the training and recalling prior learning. Then, CS:GO can be used as a stimulus of the different competencies and the tool can provide feedback on the performance in the context of the competencies.

It is important to set clear training goals and CS:GO can be more or less effective for different training goals. The results show that players come into contact with leadership and communication when playing CS:GO. It is unclear whether the players can actually train or develop these competencies when playing the game, but the results show that the game can be used to introduce the players to these competencies.

8.3 Limitations

In this section the limitations of the tool and the limitations of the research in itself will be discussed.

8.3.1 Limitations of the tool

It is important to note the different limitations of the tool to be able to understand the conditions in which the results can be interpreted.

Manual transcription of the audio files is needed to be able to analyse the data with the use of the tool. This manual transcription costs a lot of time and resources and therefore the tool is not ready to be implemented in training situations.

No validation of the tool has been performed. The analysis process of the tool has been based on valid resources, but the tool has not been validated. This is important to confirm the validity of the results and of the tool.

No front end is provided with the tool. Even though the tool works automatically and only a single button needs to be pressed, there is no user interface that can provide a simple way of navigating and using the tool.

8.3.2 Limitations of the research

There are also limitations to the actual research.

Only a small sample size has been analysed with the tool. This makes it difficult to determine the validity of the results and type II errors could occur if the data would be used to answer hypotheses.

No evidence for the development of communication and leadership competencies has been proven with the tool. The tool has presented results that show the existence of communication and leadership competency when people are playing CS:GO, next to the existence of different leadership styles. However, competency development or enhancement cannot be concluded from the data.

No evidence for transfer of the competencies has been proven with the tool. Even though the existence of communication and leadership competencies have been shown with the results, these results do not show whether these competencies also transfer to real life scenarios.

Only measurements during play have been used. This analyses whether the communication and leadership competencies exist during the gameplay. However, mission analysis and moments before gameplay also inherit these competencies. These moments have not been measured and have not been taken into account in the results.

Chapter 9 - Conclusion

This chapter will focus on answering the design question of how an insight in communication and leadership can be provided when people play CS:GO, intended for training purposes. Next to that, future work is discussed.

9.1 Conclusion

The RNLN has asked the question on how they can use CS:GO as a training tool to train CRM competencies [2]. The aim of this research was to set a step in the direction of answering this question. This was done by looking at the design question of how an insight in communication and leadership can be provided when people play CS:GO, intended for training purposes.

The research has answered this question by creating a tool that can measure communication and leadership competencies by performing a quantitative analysis on speech data. The quantitative analysis uses the Bales IPA model [74] to expose the different communication processes. Next to that, research by Butler et al. [90] is used to interpret the Bales IPA profiles for different leadership styles. The verification and evaluation of the tool suggest that the tool is capable of giving an insight into communication and leadership competency.

Two competencies have been picked from the seven CRM competencies to narrow down the scope of the research. These are communication and leadership, two of the most important competencies of the CRM model. These two competencies show overlap with other team-based competency models. Next to that, communication and leadership enable the other competencies and can therefore give an indication of the other competencies.

To determine the data measuring method for the tool, there needs to be looked at which data can provide information on communication and leadership competency. This can be done through the use of speech data. Information from the speech data can be analysed to get an insight in communication competency. Next to that, since leadership also goes through verbal communication, information on leadership can also be extracted from speech data.

The IPA model by Bales can be used to get an insight in how people communicate. Using the research by Butler. et al [90], the Bales IPA profiles can be interpreted to get an insight into leadership styles that are present. Bales' IPA model categorizes sentences of what people say to create communication profiles. Therefore, the input for the Bales IPA model are text sentences. This requires a step from the speech data, to transcribed speech data. This is done manually, since options for speech to text are qualitatively not good enough or outside the scope of this study.

The tool output consists of a dashboard, displaying the information output from the analysis with Bales IPA model and the analysis based on the research by Butler et al. [90]. It displays the Bales IPA profiles, the potential leader, the estimated leadership style that the potential leader has, the percentage of words said by each individual and the amount of participation in positive and negative responses.

The tool is verified through testing the tool with speech data from two sessions of playing a game of CS:GO. The first data collection session is a session with an experienced CS:GO team, the second with an inexperienced team. It was expected that different communication patterns would emerge for both teams. This was the case, giving an indication that the tool functions as it should. There has however been no validation of the tool, so it is unclear whether the output of the tool is actually correct. This is something that should be addressed in the future.

From the study, it is unclear whether CS:GO can actually be used as a training tool. The study presents results on the different communication processes and leadership styles that are present when people play CS:GO. However, these results do not give information on whether there is actual

competency development or competency enhancement. Next to that, it also gives no proof of potential competency transfer from the game scenario to real life scenarios.

To conclude, the tool can give an insight in how communication and leadership are reflected in CS:GO by performing a quantitative analysis on speech data. The results are promising and show the existence of communication and leadership competency. However, future work must dive further into the actual development and enhancement of these competencies.

9.2 Future work

This research shows promising results for the existence of team-based competencies within CS:GO and the ability to measure these competencies. CS:GO has the potential to serve as a tool that can develop and enhance communication and leadership competencies in people that play the game. However, future work needs to be done to be able proof and further study this potential. Many future research directions can be taken in this field. This chapter will highlight some of these directions.

The first interesting research direction is to validate and further develop the tool that has been created in this study. The tool needs to be validated to assess the correctness of the results. Next to that, there are many further developments, such as creating a solution for the speech-to-text part of the tool, since this now has to be done manually. After this, there can be a look at creating a user interface and looking at how the tool can actually be implemented during a training session. Another direction is to see if the tool can be expanded so that other CRM competencies can also be analysed.

Another important research direction is to see whether there is actually competency development or competency enhancement when people play CS:GO. This development and enhancement can occur short-term, but a more longitudinal study would be more interesting. An important question to answer with this study is whether there is a competency transfer to real life scenarios.

A third more practical research direction could be to develop an actual training within CS:GO and use independent variables to look at how for example in-game skill level, gaming experience, real-life personalities and more have an effect on the outcome of the analysis of the tool. This can be useful in the creation of an actual training, where these independent variables have to be taken into account.

All in all, there are a lot of interesting and important future research directions. There is work needed before CS:GO can actually be implemented as a training tool. The training and training tools need to be developed and competency development in the game and transfer to real life scenarios need to be studied.

Appendix

Appendix A: Information sheet data collection

Information sheet: Play session

1. *What is this project?*

This project aims at researching how CS:GO can be used as a training tool for the Royal Netherlands Navy to train Crew Resource Management Competencies. From the competencies that are found in the game CS:GO, a single competency will be picked. For this competency, the training situation is created to train this chosen competency. The training situation will be tested with end-users, gathering data to measure for this specific competency. Using data analysis, the training situation and training possibilities for this competency can be evaluated and research questions can be answered.

2. *Who is conducting this research?*

I am a Creative Technology student at the University of Twente and this research forms part of my Bachelor Thesis. My supervisor is Bruinsma, Guido, dr. g.bruinsma@utwente.nl.

3. *What does being part of this study mean for me?*

It will involve a practical session in which you will be testing the training tool, together with 5 to 9 other participants. This will consist of playing the game CS:GO which is a first person shooter game. The game does involve shooting opponents using guns but does not involve unpleasant or scary graphical elements. You will play this together in a team and will communicate with each other to work together and beat their opponents. I would like to gather data during this session. This will incorporate screen recording to measure ingame activity, speech recording to record the communication between you and your teammates and it will have eye tracking to record the focus point on the screen of your eyes. Furthermore, I will ask some questions before and after the test and would like to record this interview with your permission using typed or written notes. These questions are targeted to get feedback on the session and the training tool and no personal information will be asked. You can stop the session at any time and you do not need to answer any questions that you do not wish to answer. Sections of the transcript of your interview may be published in the report. Your real name will not be used. Even after having already participated, you have the right to withdraw from the research at any time.

4. *Who can I contact for further information?*

For further information about the research or your interview data, please contact:

Tijs Zandt
University of Twente
t.w.a.zandt@student.utwente.nl

If you have concerns/questions about the research you would like to discuss with someone else at the University, please contact:

Ethics Committee Computer & Information Science (EC-CIS)
University of Twente
ethics-create-itech@utwente.nl

5. *What will happen to my interview data?*

The information you provide will be used anonymously for research purposes. Your personal data will be treated in the strictest confidence and will not be disclosed to any unauthorised third parties. The raw data, which is the video and audio data recorded from the sessions, will be deleted after 1 year or as deleted as soon as the thesis is complete. The results of the research will be openly published.

Appendix B: Consent form data collection

Consent form

Consent Form for 'CS:GO as a serious game for the navy?'

YOU WILL BE GIVEN A COPY OF THIS INFORMED CONSENT FORM

Please tick the appropriate boxes	Yes	No
Taking part in the study		
I have read and understood the study information dated [xx/xx/xxxx], or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	□	□
I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	□	□
I understand that taking part in the study involves the capturing of speech data (audio). Furthermore it involves a semi-structured interview to give feedback on my experiences with the training tool, which will be recorded using written/typed notes. The audio and video recordings will be destroyed after completion of the thesis.	□	□
Use of the information in the study		
I understand that information I provide will be used for the report of the bachelor thesis and that this report will be open for people to read.	□	□
I understand that personal information collected about me that can identify me, such as [e.g. my name or where I live], will not be shared beyond the study team.	□	□
I agree that my information can be quoted in research outputs	□	□
I agree to be audio recorded. Yes/no	□	□

Signatures

_____	_____	_____
Name of participant	Signature	Date

I have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

_____	_____	_____
Researcher name	Signature	Date

Study contact details for further information:
Tijs Zandt - t.w.a.zandt@student.utwente.nl

Contact Information for Questions about Your Rights as a Research Participant

If you have questions about your rights as a research participant, or wish to obtain information, ask questions, or discuss any concerns about this study with someone other than the researcher(s), please contact the Ethics Committee Computer & Information Science (EC-CIS) at the University of Twente by ethics-creae-itech@utwente.nl

References

[1] Tripathy, M. (2018). “Building Quality Teamwork to Achieve Excellence in Business Organizations”. International Research Journal of Management, IT & Social Sciences
[2] Maurino, D. E., & Murray, P. S. (2016). “Crew resource management.” Handbook of Aviation Human Factors: Second Edition.
[3] Baptista, R. et al. (2015). “Relationship Between Game Categories and Skills Development: Contributions for Serious Game Design.” ISEP.
[4] Green, C. S., Bavelier, D. (2013). “Learning, attentional control and action videogames.” Curr Biol.
[5] Reng, L., & Schoenau-Fog, H. (2016). “The game enhanced learning model: Mapping game-based learning for educators.” Proceedings of the European Conference on Game-Based Learning, 559–564.
[6] Mader, A., & Eggink, W. (2014). “A design process for Creative Technology.” Proceedings of the 16th International Conference on Engineering and Product Design Education: Design Education and Human Technology Relations.
[7] Cannon-Bowers, J.A. and Salas, E. (1998). “Individualand team decision making under stress: theoretical underpinnings.”
[8] Sundstrom, E., McIntyre, M., Halfhill, T., Richards, H. (2000). “Work groups: from the Hawthorne studies to work teams of the 1990s and beyond.”
[9] Fenech, A., Scerri, C., & Price, D. (2014). “Teamwork in healthcare organisations Teamwork in healthcare organisations”.
[10] Sevier, E. D. (2002). “Biotechnology Education.” 424–426.
[11] Meslec, N., & Soeters, J. (2020). “The role of teamwork on team performance in extreme military environments : an empirical study.” 325–339.
[12] Salas, E., Burke, C. S., & Janis, A. (2000). “Teamwork: emerging principles.” 339–356.
[13] Cannon-Bowers, J.A., Tannenbaum, S.I., Salas, E., Volpe, C.E. (1995). “Defining competencies and establishing team training requirements.”
[14] Bucic, T. (2010). “Effects of leadership style on team learning.”
[15] Robinson, L., Ramburuth, P. (2010). “Effects of Leadership Style on Team Learning”
[16] Dechurch, L. A., & Mesmer-magnus, J. R. (2014). “The Cognitive Underpinnings of Effective Teamwork : A Meta-Analysis The Cognitive Underpinnings of Effective Teamwork.”.
[17] King, H. B., Battles, J., Baker, D. P., Alonso, A. Salas, E. Webster, J., Toomey, L., Salisburt, M. (2008). “TeamSTEPPS™: Team Strategies and Tools to Enhance Performance and Patient Safety”
[18] McEwan, D., Ruissen, G.R., Eys, M. A., Zumbo, B. D., Beauchamp, M. R. (2016). "The Effectiveness of Teamwork Training on Teamwork Behaviors and Team Performance: A Systematic Review and Meta-Analysis of Controlled Interventions"
[19] Morbitzer, K. A., Olsen, A. A., & McLaughlin, J. E. (2020). “A Mapping Review of Teamwork Training and Assessment in Pharmacy Education.” American Journal of Pharmaceutical Education. 8356.
[20] Hernández, J. T., & Ramírez, C. (2008). “Innovation and teamwork training in undergraduate computing engineering education.” Proceedings of 36th European Society for Engineering Education, SEFI Conference on Quality Assessment, Employability and Innovation.
[21] Feinstein, A. H., Cannon, H. M. (2009). “Constructs of simulation evaluation”
[22] McEwan, D., & Beauchamp, M. R. (2020). “Teamwork Training in Sport: A Pilot Intervention Study.” Journal of Applied Sport Psychology. 220–236.
[23] Chakraborti, C., Boonyasai, R. T., Wright, S. M., & Kern, D. E. (2008). “A systematic review of teamwork training interventions in medical student and resident education.” Journal of General Internal Medicine. 846–853.
[24] Zhonggen, Y. (2019). “A Meta-Analysis of Use of Serious Games in Education over a Decade.” International Journal of Computer Games Technology.
[25] Van Delden, R., Spil, T., Bruinsma, G., Vogel, K., Reidsma, D. (2019). “How Serious is Serious Game Design? - Exploring Entertainment-oriented and Goal-oriented Gaming.”
[26] Miller, G.E. (1990). “The assessment of clinical skills/competence/performance.”

[27] Stevens, M. J., & Campion, M. A. (1994). “The Knowledge, Skill, and Ability Requirements for Teamwork: Implications for Human Resource Management.” In Journal of Management (Vol. 20, Issue 2, pp. 503–530).
[28] Olupeliyawa, A., Balasooooriya, C., & Hughes, C. (2009). “A review of the literature on teamwork competencies in healthcare practice and training: Implications for undergraduate medical education.” South East Asian Journal of Medical Education. 61–72.
[29] Flin, R., O’Connor, P. & Crichton, M. (2008). “Safety at the Sharp End: A Guide to Non-Technical Skills”
[30] Anant, Hardeep. (2009). “The Importance and Benefits of Assertiveness Training.” SSRN Electronic Journal.
[31] Salas, E. & Burke, Shawn & Stagl, K.C. (2004). “Developing teams and team leaders: Strategies and principles.” Leader Development for Transforming Organizations: Growing Leaders for Tomorrow. 325-355.
[32] Hess, Kathleen & Littleton, Eliza & Macmillan, Jean & Alliger, George & Titus, Paul. (2001). “Training Adaptability in Digital Skills.”
[33] O'Brien, K. S., O’Hare, D. (2007) “Situational awareness ability and cognitive skills training in a complex real-world task.” Ergonomics.
[34] Dye, M. W. G., Shawn Green, C., Bavelier, D. (2010). “Increasing Speed of Processing With Action videogames.” NIH Public Access.
[35] Shawn Green, C., Sugarman, M. A., Medford, K., Klobusicky, E., & Bavelier, D. (2012). “The effect of action video game experience on task-switching.” Computers in Human Behavior, 984–994.
[36] Cain, M. S., Landau, A. N., & Shimamura, A. P. (2012). “Action video game experience reduces the cost of switching tasks.” Attention, Perception, and Psychophysics.
[37] Blacker, K. J., Curby, K. M., Klobusicky, E., & Chein, J. M. (2014). “Effects of action video game training on visual working memory.” Journal of Experimental Psychology: Human Perception and Performance.
[38] McDermott, A. F., Bavelier, D., & Green, C. S. (2014). “Memory abilities in action video game players.” Computers in Human Behavior. 69–78.
[39] Hilla, Y., von Mankowski, J., Föcker, J., & Sauseng, P. (2020). “Faster Visual Information Processing in Video Gamers Is Associated With EEG Alpha Amplitude Modulation.” Frontiers in Psychology.
[40] Donohue, S. E. (2010). “Video Game Players Show More Precise Multisensory Temporal Processing Abilities.” Attention Perception & Psychophysics.
[41] West, G. L., Stevens, S. A., Pun, C., & Pratt, J. (2008). “Visuospatial experience modulates attentional capture: Evidence from action video game players.” Journal of Vision.
[42] Green, C. S., Bavelier, D. (2013). “Learning, attentional control and action videogames.” Curr Biol.
[43] Spence, I., & Feng, J. (2010). “videogames and Spatial Cognition.” Review of General Psychology.
[44] Bavelier, D., Shawn Green, C., Pouget, A., & Schrater, P. (2012). “Brain plasticity through the life span: Learning to learn and action videogames.” Annual Review of Neuroscience.
[45] Badatala, A., Leddo, J., Islam, A., Patel, K., & Surapaneni, P. (2016). “The effects of playing cooperative and competitive videogames on teamwork and team performance.” International Journal of Humanities and Social Science Research, December 2016, 2455–2070.
[46] Qiu, L., Tay, W. W., Wu, J. (2009). “The Impact of Virtual Teamwork on Real-world Collaboration”
[47] Barr, M. (2017). “Student attitudes to games-based skills development: Learning from video games in higher education”
[48] Bailey, C., Pearson, E., Gkatzidou, S., Green, S. (2006). “Using Video Games to Develop Social, Collaborative and Communication Skills.”
[49] Lisk, T. C., Kaplancali, U. T., & Riggio, R. E. (2012). “Leadership in Multiplayer Online Gaming Environments. Simulation and Gaming.” 133–149.
[50] Nuangjumnong, T. (2016). “The Influences of Online Gaming on Leadership Development”
[51] Rubtcova, M., Pavenkov, O. (2017). “Influence of Digital Video Games on Leadership Skills: Experience of Psychological Research”
[52] Keith, M. J., Anderson, G., Gaskin, J. E., Dean, D. L. (2018). “Team Video Gaming for Team Building: Effects on Team Performance”
[53] Leonard, M., Graham, S., & Bonacum, D. (2004). “The human factor: The critical importance of effective teamwork and communication in providing safe care.” Quality and Safety in Health Care.

[54] Dalen, J. Van, Prince, C. J. A. H., Scherpbier, A. J. J. A., Van Der Vleuten, C. P. M., & Van Dalen, J. (1998). “Assessment - Evaluating Communication Skills.” Advances in Health Sciences Education. 187–195.
[55] Duffy, F. D., Gordon, G. H., Whelan, G., Cole-Kelly, K., & Frankel, R. (2004). “Assessing competence in communication and interpersonal skills: The Kalamazoo II report.” Academic Medicine. 495–507.
[56] Rehim, S. A., DeMoor, S., Olmsted, R., Dent, D. L., & Parker-Raley, J. (2017). “Tools for Assessment of Communication Skills of Hospital Action Teams: A Systematic Review.” Journal of Surgical Education. 341–351. https://doi.org/10.1016/j.jsurg.2016.09.008
[57] Morgeson, F. P., DeRue, D. S., & Karam, E. P. (2010). “Leadership in teams: A functional approach to understanding leadership structures and processes.” In Journal of Management (Vol. 36, Issue 1).
[58] Lewin, K., Lippitt, R., White, K. (1939). “Patterns of aggressive behavior in experimentally created social climates”
[59] Bass, B.M. (1990). “From transactional to transformational leadership: learning to share the vision.” Organ. Dyn. 18(Winter), 19–31
[60] Vera, D. & Crossan, M. (2004), “Strategic leadership and organizational learning.” Academy of Management Review, Vol. 29 No. 2, 222-40.
[61] Vinciarelli, A., & Pentland, A. S. (2015). “New Social Signals in a New Interaction World: The Next Frontier for Social Signal Processing.” IEEE Systems, Man, and Cybernetics Magazine. 10–17.
[62] Zeng, Z., Pantic, M., Roisman, G. I., & Huang, T. S. (2009). “A survey of affect recognition methods: Audio, visual, and spontaneous expressions.” IEEE Transactions on Pattern Analysis and Machine Intelligence. 39–58.
[63] Wang, W., Precoda, K., Hadsell, R., Kira, Z., Richey, C., & Jiva, G. (2012). “Detecting leadership and cohesion in spoken interactions.” ICASSP, IEEE International Conference on Acoustics, Speech and Signal Processing - Proceedings.
[64] Wagner, M. G. (2006) “On the Scientific Relevance of Esports”
[65] Besombes, N. (2019). “Esports & Competitivevideogames by Genre”, Used on 06-07-2021 https://medium.com/@nicolas.besombes/esports-competitive-games-by-genre-61fcaf9c6a8f
[66] Steamcharts. (2021). “Counter-Strike: Global Offensive” Used on 16-04-2021 https://steamcharts.com/app/730
[67] Twitchtracker. (2021). “Counter-Strike: Global Offensive.” Used on 16-04-2021 https://twitchtracker.com/games/32399
[68] Dearden, P., Jones, S., Sartorius, R. (2003) “Tools for Development A handbook for those engaged in development activity”, Department for International Development
[69] Verhelst, F. (2021) “Wat is een User Story”, Agile Scrum Group. Used on 20-06-2021, https://agilescrumgroup.nl/wat-is-een-user-story/
[70] Davis, A. M. (1993) “Software requirements: objects, functions, and states.”, Prentice-Hall, Inc.
[71] Van Rossum, G., Drake, F. L. (2009). “Python 3 Reference Manual.”
[72] Telchemy. (2021). “The Open Speech Repository”. Used on 05-07-2021, http://www.voiptroubleshooter.com/open_speech/
[73] Harvard. (1965). “Harvard Sentences”. Used on 05-07-2021, https://www.cs.columbia.edu/~hgs/audio/harvard.html
[74] Bales, R. F. (1950). “Interaction Process Analysis: A Method for the Study of Small Groups”
[75] Princeton University (2010). “About WordNet.”, WordNet. Princeton University. https://wordnet.princeton.edu/
[76] Baccianella, S., Esuli, A., Sebastiani, F. (2010). “SentiWordNet 3.0: An Enhanced Lexical Resource for Sentiment Analysis and Opinion Mining”
[77] Plotly. (2021). “Dash Python User Guide”. Used on 23-06-2021, https://dash.plotly.com/
[78] Plotly Technologies Inc. Collaborative data science. (2015). “Plotly Express in Python”. Used on 05-07-2021, https://plotly.com/python/plotly-express/
[79] Discord. (2021). “Imagine a place…”. Used on 24-06-2021, https://discord.com/
[80] Yahweasel. (2021). “Craig is the multi-track voice channel recording bot for Discord”. Used on 24-06-2021, https://craig.chat/home/

[81] Powell, R. (2016). “Positive and Negative effects of Game Analytics in the Game Design process: A Grounded Theory Study”.
[82] iEduNote. (2021) “Observation Method of Data Collection: Advantages, Disadvantages, Techniques, Types”. Used on 14-06-2021, https://www.iedunote.com/observation-method-of-data-collection
[83] Communications For Research (CFR). (2021). “Observational Research: Data Collection Advantages and Disadvantages”. Used on 14-06-2021, https://www.cfrinc.net/cfrblog/observational-research-advantages-and-disadvantages
[84] Landowska, A., Wróbel, M., Brodny, G. (2017). “Limitations of Emotion Recognition from Facial Expressions in e-Learning Context”
[85] Khachatryan, H., Rihn, A. L. (2017). “Eye-tracking Methodology and Applications in Consumer Research
[86] Naim, I., Tanveer, I., Gildea, D., Hoque, E. (2015). “Automated Prediction and Analysis of Job Interview Performance: The Role of What You Say and How You Say It”
[87] Berg, M. (2016). “Automated observation of competency-related behavior in serious gaming”, Master Thesis
[88] Pearce, C., Sims, H. P. (2002). “Vertical Versus Shared Leadership as Predictors of the Effectiveness of Change Management Teams: An Examination of Aversive, Directive, Transactional, Transformational, and Empowering Leader Behaviors”
[89] Wang, W., Precoda, K., Hadsell, R., Kira, Z., Richey, C., Jiva, G. (2012). “Detecting Leadership and Cohesion in Spoken Interactions”
[90] Butler, R. P., Cureton, E. E. (1973). “Factor Analysis of Small Group Leadership Behavior”
[91] Kaldi (2021). “About the Kaldi project”. Used on 15-06-2021, https://kaldi-asr.org/doc/about.html
[92] Zhang, A. (2017). Speech Recognition (Version 3.8) [Software]. Available from https://github.com/Uberi/speech_recognition#readme
[93] Zandt, T. (2021). “CompetencyAnalysisTool”, Github Repository, https://github.com/Tijzz/ComptencyAnalysisTool.git
[94] Gagné, R. M. (1965). “The Conditions of Learning and Theoretical Instruction”