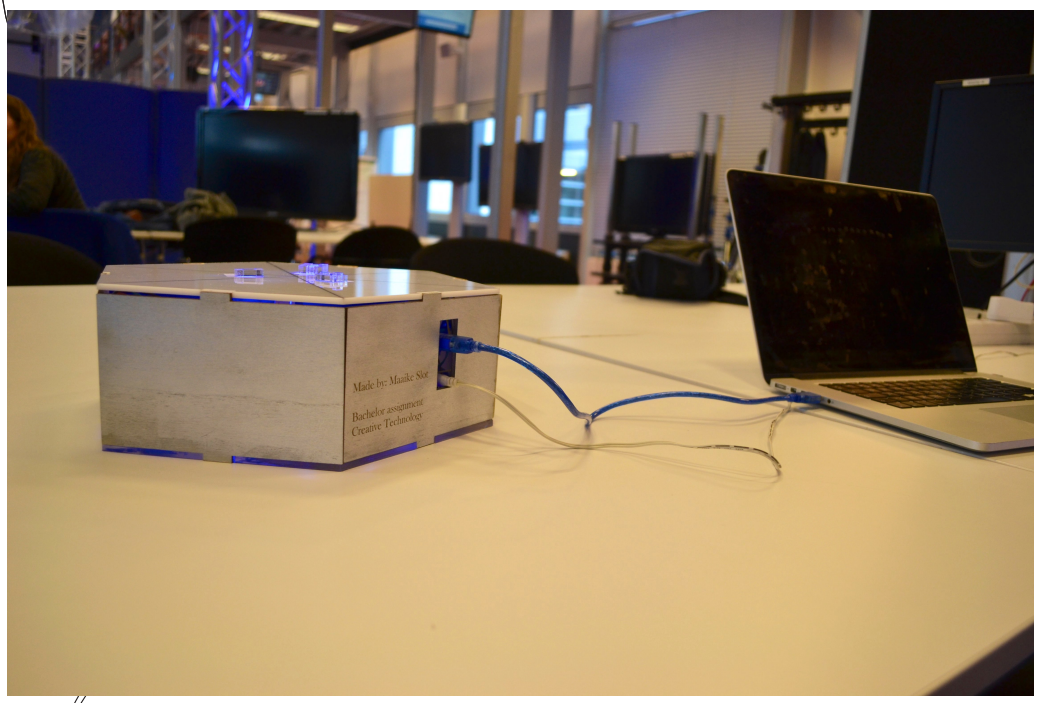
The SocioMetricVis

Giving Feedback During a Brainstorm Session



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Abstract

The goal of this thesis is to describe the designing and prototyping process of a visualisation made to give feedback on the behaviour and collaboration of team members in a brainstorm session, with the use of data collected from the Sociometric Badges. The visualisation should be easy to use and user-friendly. A background research and a state of the art research are done. Current visualisations make use of screens to visualize the data, these screens can be very obtrusive. All the other visualisations found also show data about the amount of speaking and the interaction. There are no current visualisations for brainstorming. Concept design sketches are drawn and a user test is done to find out what the users would prefer. Users preferred adding different colors to show a different value. The visualisation will consist out of a bar per user that shows the amount of speaking and interruptions per user over time. Another user test is done to see how the users react to the movement of the visualisation. Users overall react positively to the visualisation and its movements. Users stated that the change in colour was not clear enough. Small improvements are done and a final prototype is made. With these final improvements the design goal has been accomplished.

Acknowledgement

I would like to thank everybody who contributed to this thesis and who helped making this visualisation possible. I would like to thank some people in special:

- Khiet & Elze for all the tremendous help, creative ideas, feedback and critical remarks.
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Chapter 1 - Introduction

Scientists are very interested in how the dynamic of groups work [1]. Group collaboration and behaviour however, are very difficult to measure. This costs a lot of time to research and analyse. The researcher has to observe a lot of factors and has to rely on surveys of test groups. These observations and surveys will not always give sufficient information. A solution was invented to make this research easier, it is called the Sociometric Badge [1]. The Sociometric Badge contains sensors to measure group interaction. The research group of the department of Psychology of Conflict, Risk and Safety (PCRS) at the University of Twente recently purchased the Sociometric Badge. They want to use the Sociometric Badges not only for research but also in practice. PCRS is looking for a team member interaction visualisation made out of the data collected by the Sociometric Badges.

For this graduation project a visualisation of team member interaction during a brainstorm session will be made. The visualisation should contribute to the group behaviour and team member interaction. Adding extra screens can have a negative influence on the group interaction. Therefore the visualisation will be made tangible. The idea of tangible design is to integrate the visualisation into its surroundings by hiding the electronics. The choice was made to focus on team member interaction in a brainstorm session because during a brainstorm session a lot of team member interaction is required. Team members have to work together to find the best and most efficient solution for their problem.

The Sociometric Badge has advanced sensing, processing and feedback capabilities. It contains sensors which are able to measure and analyse interaction patterns, physical distance, engagement in a conversation, interruptions, speaking time and pitch. With these measurements a visualisation will be made to give feedback on the brainstorm session and to improve the team member interaction. This will be done by showing the team members information about their own measurements from the badge. The setting of this brainstorm will be static, therefore no movement measurements are needed.

The visualisation can be used for further research on group interaction and the effect of giving sociometric feedback to a group. This research might lead to more knowledge about group interaction and with that knowledge, more understanding of the human behaviour. For example, research can be done to see if the group interaction improves and the brainstorm gets more effective with the use of the visualisation. The visualisation will not only be used for research on brainstorming, but it can also be used by the brainstorming group themselves. It might improve their group behaviour during a brainstorm session, which might lead to a more effective brainstorm with better results.

The goal of my graduation project is to design and build a visualisation of the Sociometric Badges that gives feedback on the behaviour and collaboration of the team members in a brainstorm session. The visualisation needs to be friendly and easy to understand. Research will be done to find out what factors will be the best to show to the users. After this information is gathered and analyse, the visualisation will be designed and build. During the design process user tests will be done to evaluate what choices the users prefer. To reach the goal of building an effective, friendly and easy to use visualisation two sub questions will be answered.

The first sub question will be: *What are important factors of a brainstorm session, which can be measured with the Sociometric Badges?* The Sociometric Badge is capable of measuring various data. It is important to know which data is relevant for the visualisation.

It is very important to design the visualisation in such a way that it will have the most impact on the user. During the design process very important decisions will be made. These design choices will be explained based on research and user tests. The second sub question will be: *How can the visualisation be designed to give user-friendly and easy to understand feedback on the brainstorm session to the user?*

This thesis will start by explaining the method and techniques that are used. This is followed by the different phases of the design process. The thesis ends with an evaluation, conclusion and future work section.

Chapter 2 - Methods and Techniques

It is very important to design the visualisation in such a way that it will be the most user-friendly and easy to understand for the user. During the design process, important decisions will be made that have an effect on the design and the user. By explaining how the visualisation will be designed, a part of the second sub question will be answered: *How can the visualisation be designed to give user-friendly and easy to understand feedback on the brainstorm session to the user?* At first the Creative Technology Design process will be explained.

2.1 - The Creative Technology Design Process

The Creative Technology Design Process has been designed for the bachelor program Creative Technology at the University of Twente. This design process is divided into four phases [2]. This thesis will follow the four phases of the Creative Technology Design Process. Figure 1 shows a schematic view of the Creative Technology Design process. How the visualisation will be designed will be described below.

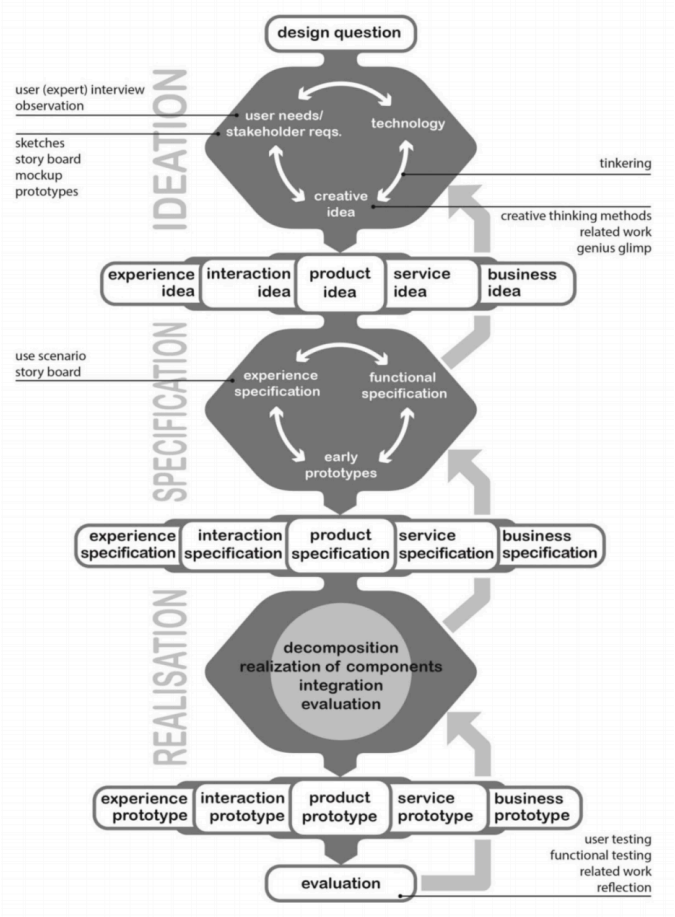


Figure 1: The Creative Technology Design Process [2].

2.1.1 - Ideation Phase

The first phase is the ideation phase. The ideation phase starts by gaining as much information as possible about the project and the origin of the design question. This is done through background research on Sociometric Badges, brainstorming, giving feedback, tangible design and all the aspects that are linked to the project. Furthermore, a State of the Art research is done. After doing research, a clear research question will be defined. In the ideation phase, the design space is explored and ideas for the visualisation are described. The end products of the ideation phase are different product concepts. The ideation phase can be found in Chapter 3.

2.1.2 - Specification Phase

The second phase is the specification phase. It builds upon the output of the Ideation phase and reflects on the produced product concepts. A large number of prototypes are developed, this is called fast prototyping. The prototypes will be evaluated and the gained feedback is applied to the design. A user test is conducted to test the functionalities and the effect of the functionalities on the user and the user experience. The different prototypes are discarded, developed or merged into a new prototype. After a short evaluation of the new prototype and the functional specifications, a prototype of the final design will be developed. The specification phase can be found in Chapter 4.

2.1.3 - Realisation Phase

In the third phase, the realisation phase, the functional specifications defined in the specification phase will develop into a functional architecture. This functional architecture is leading in designing the visualisation. The architecture will be translated into system components. For each of this components, different possibilities are explored and the most feasible solution will be implemented into the design. During the implementation, functional testing will be done to answer the question: Does the component fulfill the functional requirements? During the functional testing, testing will be done on the integrations of the sub systems. A user test will be done to evaluate if the expectations are fulfilled. Adjustments are made to the prototype according to the evaluation and the final prototype will be finished. The deliverable of the realisation phase is a fully working prototype of the visualisation. The realisation phase can be found in Chapter 5.

2.1.4 - Evaluation Phase

The final phase of the Creative Technology Design process is the Evaluation phase. First, an evaluation on the functional and user requirements is conducted. Each requirement will be checked to see if it is integrated into the visualisation. By evaluation these requirements the design goal can be evaluated. The evaluation phase concludes by an future work section. The goals of the evaluation phase is to reflect and answer the design goal and sub questions. The evaluation phase can be found in Chapter 6.

2.2 - Planning

To make sure every phase will be handled with enough time a planning is made. The full planning can be found in appendix 1. Table 1 shows the simple planning of the phases. With the use of this planning the design process will be explained and structured.

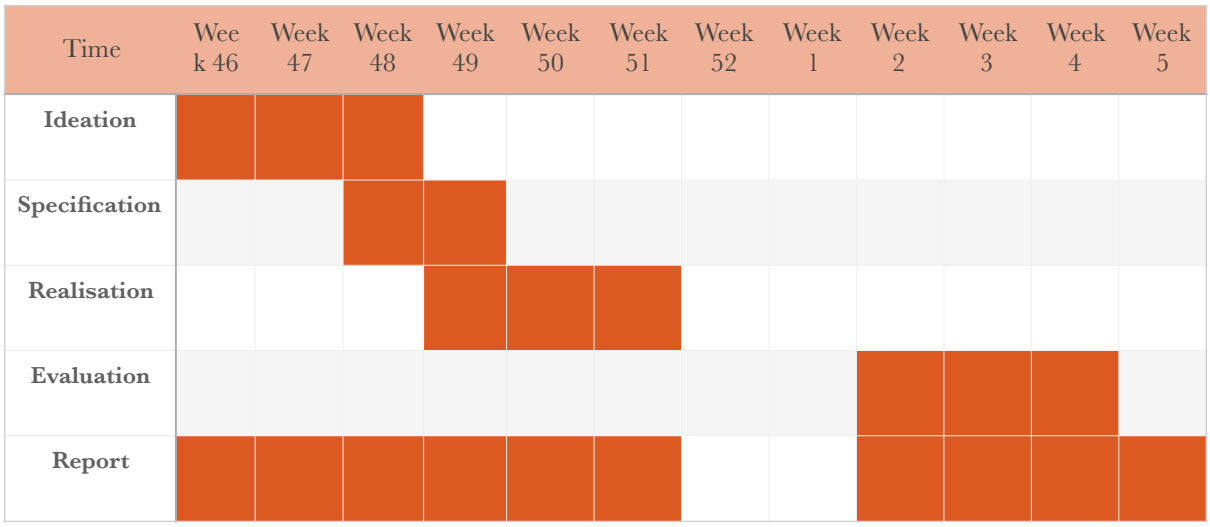


Table 1: Planning of the different phases

2.3 - User Tests

To make sure the visualisation is made to give user-friendly and easy to understand feedback on the brainstorm session, multiple user tests are done. What user test are done and which prototypes follow from this are described in table 2. The user tests are described into more detail later on.

Phase and Step	Activity	Description
Ideation Step 1	Background research and Brainstorming	First ideas for the concepts will be created.
Ideation Step 2	First concept drawings	First concepts will be drawn.
Ideation Step 3	Expert review	This is a review with the supervisor, designer and client. In this review feedback will be given and some concepts will be thrown away.
Specification Step 4	User scenarios & requirements	These scenarios and requirements give insight in what the needs and requirements are from the user.
Specification Step 5	Rapid prototyping	Multiple concepts will be drawn.
Specification Step 6	User test 1: User interpretation & Adding light intensity or colour	The concept drawings of the design will be showed to the 6 users. The users will be interviewed on the usability and user friendliness. They will also be asked if adding light intensity of coloured light will add something to the design.

Phase and Step	Activity	Description
Specification Step 7	Functional requirements	These requirements define what the must haves are for the final prototype.
Realisation Step 8	Prototype 1.0 with mechanism	This prototype is the first physical version the visualisation.
Realisation Step 9	Expert review	This is a review with the supervisor, designer and client. In this review feedback will be given to improve prototype 1.
Realisation Step 10	Prototype 2.0	This prototype contains all the adjustments that where needed after prototype 1.0.
Realisation Step 11	User test 2: Reaction on Design and Movement	This user test will ask the user to look at the visualisation and the users will be asked afterwards about their opinion of the moving visualisation. Is it user-friendly and how do the users react to the moving visualisation?
Realisation Step 12	Prototype 3.0	This prototype has the feedback of user test 2 incorporated .

Table 2: An overview of the user tests, evaluations and prototypes.

Chapter 3 - Ideation Phase

As described in Chapter 2 - Method and Techniques, the ideation phase starts by gaining as much information as possible about the research field of the graduation project. Therefore a background research is done in Chapter 3.1. In Chapter 3.2 a State of the Art research is done. This will give information about development in the field of research and visualisation that have already been made with the use of Sociometric Badges. This section will answer the question: *How can a visualisation of the Sociometric badge and look-a-likes inform participants about their behaviour and collaboration in a brainstorm session?* Chapter 3.3 will be a concluding paragraph describing all the choices and concept drawings that have been made based on the gathered information in the background research and the State of the Art.

3.1. - Background Research

Background research has been done to gain more knowledge about social interaction, social sensing, the Sociometric Badges, brainstorming, feedback and tangible design. The goal of this section is to give more information to answer the first sub question: *What are important factors of a brainstorm session, which can be measured with the Sociometric Badges?*

3.1.1 - Social Interaction and Social Sensing

Mast et al., states that any verbal or nonverbal behaviour directed towards one or many interaction partners is called "Social Interaction". Getting insights in social interaction behaviour is very important to improve our understanding of human psychology because much of human behaviour occurs in a social setting [3]. Social sensing allows for verbal and nonverbal interaction behaviour to be measured by social sensors, such as the Sociometric Badge. The possibility that any behaviour can be measured everywhere, is connected to inventions in the computational data processing. These new inventions make it possible to measure behavioural cues without the need of a user giving input. This concept is called ubiquitous computing [3]. The concept of ubiquitous computing has for example been used in the invention of Reality Mining. It uses the signal of mobile phones to study the interaction and movement of individuals and organizations. Unfortunately, this concept has a lot of privacy issues, is not very accurate and therefore not the ideal method to analyse and collect data about social interaction [4].

With the use of social sensing and social sensors, a new way of measuring social interaction has been made possible. One of the first social sensors that have been made was the Sociometer [5], which learned social interactions from sensor data and used infrared transceivers, a microphone and two accelerometers to model the dynamics of a social network. After the Sociometer the Uberbadge was developed. It was invented and made by Paradiso and Pentland in 2008 [6]. This social sensor has been used to identify social interaction patterns at a conference by linking the badges to bookmarks set at stands [6].

3.1.2 - The Sociometric Badge

The Sociometer and the Uberbadge evolved into the Sociometric Badge, a device capable of automatically capturing social interaction behaviour. The invention of the Sociometric Badges started at MIT Media Lab by a research group that is called the Human Dynamics Group [7]. The goal was to design a new platform to reveal group dynamics and patterns. This new sensor-based technique origins from the need of researchers to measure bigger organizations, which means more people and gain more data without needing more observers and a large amount of surveys [7].

The Sociometric Badge is not only capable of measuring interaction, it can also analyse the data, which can be exported into an excel file. The excel file contains one tab that is the most interesting for my visualisation, t_speech_profile [8]. In this file the following values are given:

- P1 speaking: this shows when the user is speaking;
- Overlap: the amount of seconds spoken while somebody else is speaking;
- Listening: the amount of seconds which the use is silent while somebody else is speaking;
- Silent: the amount of seconds which somebody is silent and nobody is speaking;
- Total_speaking: the total amount of seconds spoken in total;
- Total_silent: the total amount of seconds silence.

The values total_speaking and overlap are very interesting because they give information over a period of time. The overlap can show the amount of interruptions of the user and the total speaking time can show if the user, compared to other users, has talked too much or too little.
This data is not always easy to understand, especially not for every psychologist who wants to work with this data. Research shows that it is very important to give feedback to the user to keep them committed to wearing the Sociometric Badge when measurements are done over a longer period of time [7]. The excel file which contains the data of the badges does not provide conclusions about the measurements. The data is very raw and needs to be translated into something visual in order to give understandable feedback and to keep the user interested.

3.1.3 - Brainstorming and Feedback

As stated before in the introduction, the visualisation will give feedback in a brainstorm setting. During a brainstorm session, a lot of social and group interaction is required. By doing a literature study, additional information can be found on important factors of a brainstorm session and insights can be gained in what feedback is important to give to the team members during a brainstorm. Osborn [9] did research on brainstorming and defined four basic rules for brainstorming:

- Think of as many ideas as possible
- Encourage each other to think of as free and creative ideas as possible
- Build upon the ideas that are previously thought of
- Combine different ideas into new ones

Paulus and Dzindolet [10] added another set of rules to the basic rules to make brainstorming more efficient. He stated that group members should not tell stories or explain the ideas with too much detail and group members who are not talking enough should be stimulated to give more input. Following these set rules will help the creativity of the team members.

Besides Paulus and Dzindolet [10] and Osborn [9], Thompson [11] did research on how to improve creativity in organizational work groups. She defined that there are four major threats to team creativity:

- S*ocial loafing* - wondering off, stop participating because members perceive their own contributions to be unidentifiable and dispensable.
- *Conformity* - based on the principle that every human desires to be liked and accepted by others, particularly in a group.
- *Production blocking*- if a person is in a flow and is not interrupted, the brainstorm group cannot speak at the same time. They have to wait for their turns to speak. Consequently, people may forget their ideas or decide during the waiting period not to present theirs.
- *Downward Norm setting* - The level of performance is often compared to the person who is the most unproductive. This does not contribute to the performance of the team. The least productive member of the team is often more influential in determining overall team performance than the high performers.

The defined rules for brainstorming and the major threats to team creativity are important to keep in mind while choosing what feedback the user will get from the visualisation. The given information will try to influence the team members to not show behaviour that is threatening to the creativity and the brainstorming rules. Very often users are not aware of their own behavior. When a user is presented with this data, the user will realise that it needs to change his/her behaviour. If this behaviour is not shown, the group collaboration and productivity will probably improve [11].

How the feedback affects people's behaviour during their interaction remains to be investigated. The feedback can be used for training and to increase self-awareness, which can lead to personal development. Behavioural feedback can affect how we experience ourselves, as we sometimes make assumptions about our own behaviour based on our view of ourselves. The study on automated instant feedback is still new [7]. Unfortunately, the Sociometric Badge is not capable of showing automated instant feedback but the visualisation for the project will be made so that it could be used for automated instant feedback.

The Sociometric badges will be used to measure a static brainstorm session with 6 team members. Research by Remmerswaal [12][13] showed that the number of participants for a brainstorm session should be less than 8 and more than 5. Therefore the amount of 6 participants is chosen.

3.1.4 - Tangible Design

The visualisation that will be made for this graduation project will be physical. This is a choice based on the idea that a screen can be obtrusive and will not add something to the interaction of the users. The simplest example is the current way students participate in a lecture. When looking at the students from the lecturer's perspective, only people behind screens can be seen. This does not add anything to the interaction between the teacher and students, because students only look at their screen to make notes. Similar to this example is the way people currently have meetings. Everybody has a laptop in front of them, this can be very obstructive for the interaction in the group and the communication will be interrupted by the usage of the computer while discussing things. The

visualisation will be something that can be put on the table without attracting too much attention. It will be a tangible design, which means that the visualisation will interact with digital information through the physical environment. The idea of tangible design is to input computer interfaces into "the real world"[14].

Tangible design can be distinguished into three different views. The first view is the data-centered view. This can be characterized by using physical representation and manipulation of digital data, offering interactive coupling of physical artifacts with "computationally mediated digital information". Then there is the Expressive-Movement-centered view, which is characterized to aim beyond form and appearance and focused on designing the interaction itself. The focus lies on what interaction does and how it can be designed in order to achieve the best interaction. The third view is the Space-centered view. This view is characterized by arts and architecture and is focused on the ultimate use of physically embedded systems within real spaces. This view tries to trigger a reaction from the user [14]. This data centered view will be the view that is used for the visualisation. The purpose of using the data centered view is to make the visualisation more attractive and less obtrusive to the user.

3.2 - State of the Art

By looking at literature of the Sociometric Badge as well as current thinking in the research field of social sensors used to improve group behaviour, we will get more insight in how the Sociometric Badge is already used and can be used in the future to give feedback to groups. The development and design choices made for competitors and predecessors can help with developing the visualisation, which uses data from a brainstorm session. The main research question of this state of the art research will be: *How can a visualisation of the Sociometric badge and look-a-likes inform participants about their behaviour and collaboration in a brainstorm session?*

3.2.1 - Humanyze

The Sociometric Badge is bought from Sociometric Solutions by the company Humanyze. They developed a program for the badge and offer the complete service from badge to feedback system. The badge platform, as they call it provides all the information for both the individual and management through visualisation and dashboards. An example is given in figure 2. This way they can keep track of the dynamics if the dynamics change after implementing new things, which team collaborates most often and what the most effective spaces are within the company [15].
The Humanyze Badge Platform is a very commercial use of the Sociometric Badges. This is a very closed platform, which only shows the results without showing how they are calculated or analyzed.

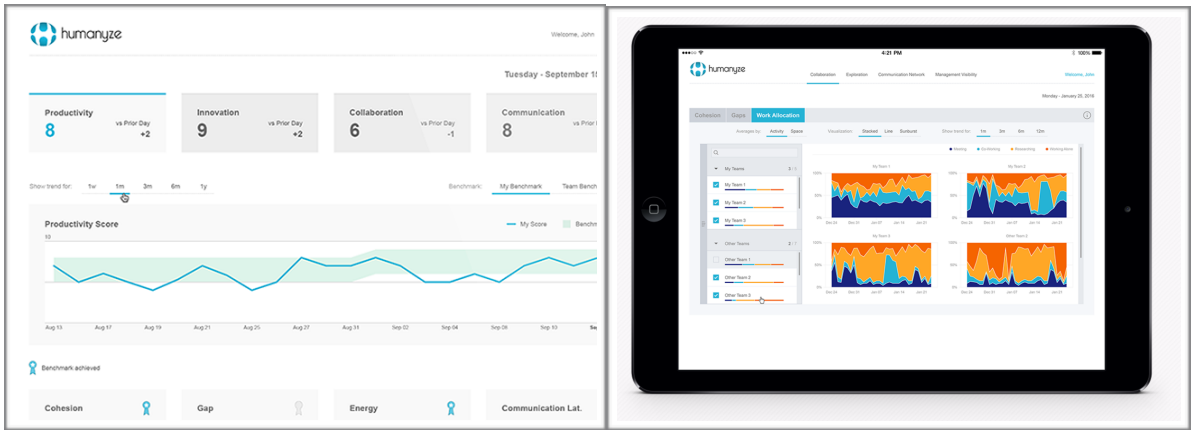


Figure 2: The Humanyze Badge Platform [15].

3.2.2 - Meeting Mediator

The "Meeting Mediator" is a real-time portable system that can detect social interaction and gives feedback to the user to improve the interaction within a group. It consists of a Sociometric Badge and cellphones for displaying meeting status. This is shown in figure 3.

Figure 3: Four subjects participate in brain- storming and problem-solving meetings wearing Sociometric Badges [16].

The Meeting Mediator motivates speech and interactivity by showing the absolute amount of talking per user. The Meeting Mediator also tests if giving feedback to the user about their behaviour will change the dynamic of the meeting and the behaviour of the user [16].

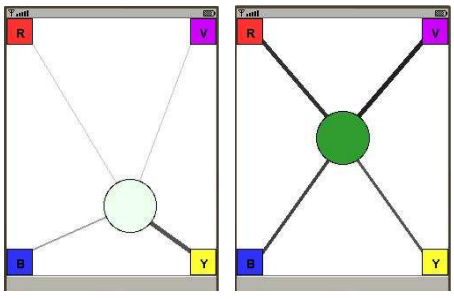


Figure 4: The visualisation on the phone of the Meeting Mediator [16].

Figure 4 shows the visualisation, which is visible on the phone. The circle colour denotes group interactivity level, circle position denotes balance in participation and the line thickness denotes speaking time [16].

3.2.3 - Second Messenger

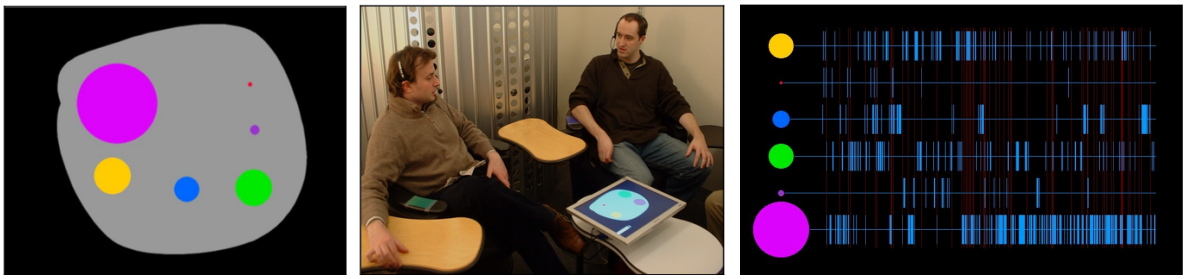


Figure 5: The visualisation of the data on the screen(left), the setting(middle) and the playback visualisation shown afterwards (right) [17].

There are also look-a-likes of the Sociometric Badge. Second messenger is a simple version of a sociometric feedback system. The idea is to limit social factors, which can prevent the user from realizing their potential. The platform provides feedback to groups by means of a visual display of participation levels and turn-taking patterns during face-to-face meetings or afterwards in the form of a visual replay. Unlike the Sociometric Badge, Second Messenger only uses noise-cancelling microphones to measure speaking patterns. The different coloured circles represent different users and the size of the circle reflects the participation of the person. This can be seen in figure 5. The researchers tested how they could make the visualisation as unobtrusive as possible, test users reported that they did not think that the visualisation was distracting and would use it again [17].

3.2.4 - Ubiquitous Meeting Facilitator

Figure 6: The UMF when in use [18].

There are also feedback systems, which contain the same sensors and electronics as the Sociometric Badge. The "Ubiquitous Meeting Facilitator" (UMF) for example, monitors the level of participation, detects turn-taking, various types of interruptions and gives feedback back to the individual and the group on a shared display. The setup of the UMF is shown in figure 6. The UMF uses humor and a not too personal representation of the data.

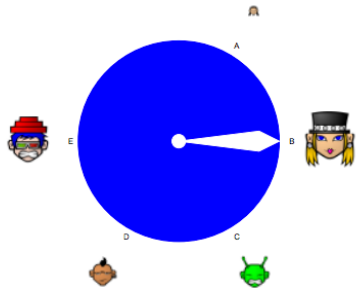


Figure 7: The visualisation of the UMF [18].

The visualisation shows a clock, which has a maximum of 12 users. Each avatar represents a user. The avatar has different types of faces: normal, talking, laughter and frown. The size of the avatar is relative to the moving average. As shown in figure 7, the hand of the clock points to the user who is speaking and when talking, the avatar will show talking or laughter. A frown face show if someone successfully interrupts someone else. Finally, the avatar can also get a hat on its head, this shows that serious or offensive behaviour is shown by this user for example always interrupting. Technically the UMF is ahead of the Sociometric Badge because it is able to distinguish speech from laughter. This can be used to determine if the user interrupts someone or is laughing friendly [18].

3.2.5 - Conclusion State of the Art

The main research question was: *How can a visualisation of the Sociometric Badge and look-a-likes inform participant about their behaviour and collaboration in a brainstorm session?* The Meeting Mediator, The Humanyze platform, The Ubiquitous Meeting Facilitator and Second messenger all show a visualisation, which gives feedback about team member interaction. The Second Messenger shows the speaking time, whereas the Meeting Mediator both show the speaking time and the interactivity of the users. These two visualisations show that visualizing the measurement of a sociometric sensor works. They also show that the visualisation of the data has an effect on the user. It is interesting to see if this can be improved to make the visualisation even more interesting and user-friendly.

The different systems show how the Sociometric Badges can be used to visualize data. The UMF, for example, uses humor in combination with advanced technology. This is something that the other systems do not use. The visualisations are all screen-based. Some visualisations use mobile phones for every user, while others use one screen for all users. These screens can be obtrusive and be distracting for the users. All the described visualisations give immediate feedback, except the Humanyze platform. This platform is designed for analyzation of the data after a certain period of time. The collected data can be viewed at any moment. This way the change in data can be viewed live.

The visualisation will be used in a brainstorm session. This is a field of research different from the described visualisations. The new visualisation will be new research and development in the field of brainstorming and sociometric feedback. With the use of tangible design, it will deviate even more from the visualisations that were already made. With this new sociometric visualisation new research can be conducted, users are triggered to collaborate more efficiently and users are able to have a more productive brainstorm session.

3.3 - Conclusions of Ideation Phase

3.3.1 - Choices bases on Background Research and State of the Art

During the background research, an answer has been found for the first subquestion. The first subquestion was: *What are important factors of a brainstorm session, which can be measured with the Sociometric Badges?* The most important factor of a brainstorm session, which all the found factors have in common, is the idea that everybody has the same speaking time and the same opportunities to share their ideas.

All the important factors reflect on the fact that everybody needs the chance to share their ideas. The Sociometric Badge is capable of measuring the speaking time and the amount of interruptions. These two values can give feedback on the idea that everybody has to have the same time to share their ideas and should be able to share their ideas without being interrupted. The speaking time and the amount of interruptions are measured over time.

To avoid the critical point of downward norm setting, the values that will be shown in the visualisation will not be absolute and the values will be shown over time to not put too much stress on the absolute amounts of speaking and interruptions.

Unfortunately, the Sociometric Badge is not capable of sending real-time data. The background research on brainstorming and feedback in chapter 3.1.3 showed that it is important to give feedback to the user to keep the user interested. Therefore the visualisation will give feedback during the break of the brainstorm session. The Sociometric Badge collects data every second. Showing all these seconds after the brainstorm might take too long. Therefore the visualisation will show a fastened replay version of the collected data over time. This will be different from the visualisations that are described in the State of the Art section, which show live feedback of the interaction. Showing a replay is a temporary solution to solve the problem of not having real-time data. This proof of concept will show the collected data during a break in the brainstorm session. Ultimately the visualisation would give feedback during the brainstorm itself.

According to Roe [19], not showing direct live information might be a good thing. Roe [19] argues that time is underestimated when doing research about behaviour. He thinks that researchers have the tendency to reason in terms of "what is", rather than 'what happens'. This does not imply that it represents the behaviour of the user itself or the dynamics that happen. Roe [19] thinks that researchers need to look at the differences and the "phenomena" that happen during a research. Phenomena can also be translated to events or actions. A phenomenon is not always linked to a direct amount of time. It might be 30 seconds or 6 years. The rough data does not show the impact or change in the behaviour of a person but is more likely to emphasize the differences between people. Without looking at the phenomena, researchers might believe that evidence of these differences is the same as evidence of change within people [19].

The Sociometric Badges are not yet capable of recognizing phenomena. In the case of the Sociometric Badges, phenomena might be one speaking turn of a user or a small discussion of multiple users. By looking at a larger amount of time, instead of a live visualisation of the collected data, hopefully one or more phenomena are shown. The conclusions that are drawn from the visualisation might be more realistic and less harmful when wrongfully interpreted because they reflect a larger amount of time. The variable that will be shown will consist out of the summed up data per 30 seconds, instead of data per second.

As described in the State of the Art section, the described visualisations all use a screen or display to show the visualisation. Which is different from the visualisation that will be made. The visualisation will be designed using the ideation of tangible design. This means that the visualisation will be physical. The purpose of this is to make the visualisation more attractive and less obtrusive to the user.

A tangible design can put a computer interface into the real world. Brainstorming is something that is very "human". By making the visualisation tangible, the visualisation will be more graspable. A screen-based visualisation also can be obtrusive, tangible design helps to avoid this. The most tangible designs make use of a beamer to project things on a table or a visualisation form above. The visualisation will be used for brainstorming and brainstorms are not always conducted in a specific room. To project things onto the table, a whole setup is needed. It will be useful to make the visualisation portable. Therefore the choice was made to not use projection on a table but make a physical visualisation. All these sociometric feedback tools are used for group interaction and research on group meetings. The graduation project will focus on brainstorming, this setting has not been used yet for implementing Sociometric Badges. The decision was made to name the visualisation SocioMetricVis. It is short for sociometric badge and visualisation.

3.3.2 - Concept Drawings

The first sketches are made by looking at different shapes. The idea to make the visualisation in the form a hexagon came from the most efficient number of participants in a brainstorm. This is between the 5 and 8 users [12][13].

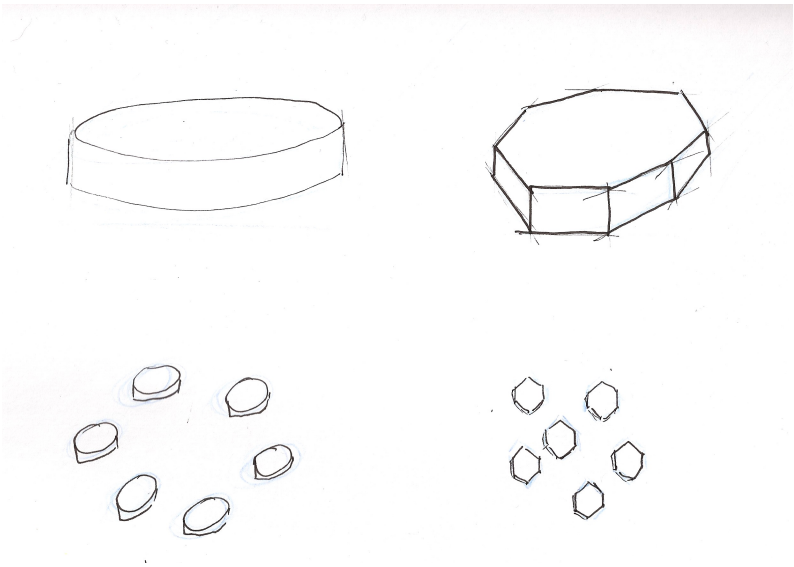


Figure 8: Concepts using Round shapes and a Hexagon shape

Each participant can have its own bar to compare participants. This is inspired by a normal bar chart, which is a good way to visualize data. One big visualisation can be used to show every user or the visualisation can be made modular.

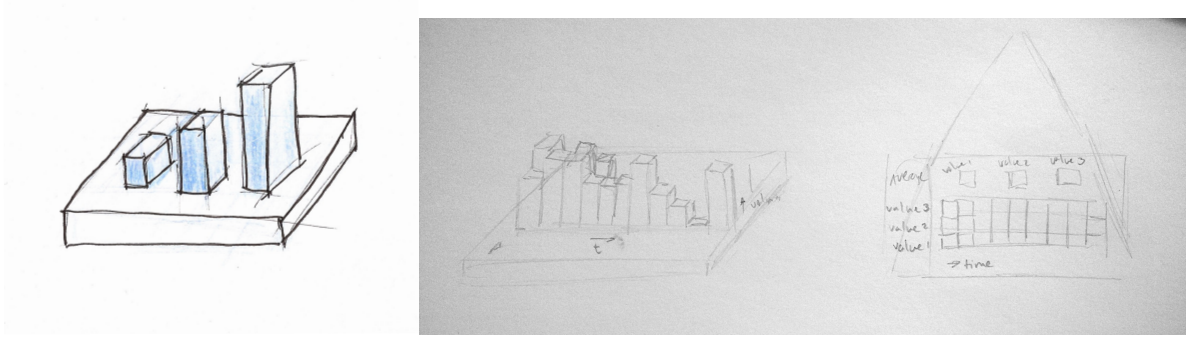


Figure 9: Concepts of square visualisations.

Multiple bars behind each other will be difficult to see and compare. Therefore it might be better to use one bar per user. In one visualisation each participant could have their own partition. In figure 9 and 10, ideas for a visualisation with the shape of a hexagon are drawn.

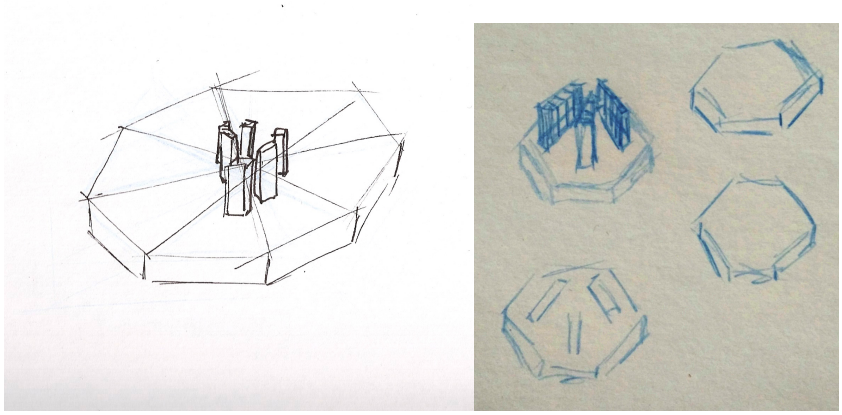


Figure 10: Concepts for displaying bars on hexagons

Chapter 4 - Specification

As explained in chapter 2 - Methods and Techniques, the Specification Phase builds upon the output of the Ideation Phase. First the user case scenarios will be described to predict the users experience and expectations of the visualisation. These user experiences are translated into user requirement. With these user requirement more prototypes are drawn with the use of rapid prototyping. After the rapid prototyping a concept is picked and evaluated by a user test. After the user test the functional requirements are specified and the user requirements might be adjusted. This Specification phase will work in a cyclic way. During the specification phase the prototype idea will be formed and adjusted according to the user case scenarios, rapid prototyping, the user test and the functional requirements. The goal of the Specification phase is to find the user requirements and obtain the best possible functional specification for the envisioned prototype [2].

4.1 - User case Scenarios

In this section three user case scenarios are described. These scenarios will give more information about the user of the SocioMetricVis and the requirements it needs to have.

4.1.1 - Project Leader Dennis

It is Monday morning and Dennis is going to the university to start with a new course. For this course he needs to make a new product with a group of 6 members. Dennis decided that it would be a good idea to do a brainstorm session to produce as much ideas as possible. Dennis has the habit to speak too much and claim the floor while brainstorming. He decides to use the SocioMetricVis to make sure everybody has enough speaking time and he will get feedback if he speaks too much. He hands a Sociometric Badge to all the other 5 group members and starts by explaining what the visualisation will show. He explains that the SocioMetricVis will show feedback during the break of the brainstorm. Dennis starts the brainstorm by mentioning a couple of his own ideas and the group starts to brainstorm. During the break Dennis collects all the Sociometric Badges again and puts them through the program. He loads the gained Excel file into the system and looks at the visualisation that is moving together with the other members of his group. After the use of the SocioMetricVis with his group, Dennis is no longer afraid of being too dominant during the next brainstorm.

4.1.2 - User and Project Member Kees

Kees is going to a brainstorm session organized by a new group member. He enters the room and sees the SocioMetricVis. He receives a Sociometric Badge from Dennis, his group member, and waits for a small explanation on how the SocioMetricVis will work. He hands his Sociometric Badge back during the break of the brainstorm and watches the visualisation. The SocioMetricVis shows that Kees has been participating less than the other group members and the visualisation also shows that he has tried to interrupt a lot but without success. Kees knows now that he has to speak up more and needs to try to interrupt differently and maybe at other moments. The brainstorm continues and Kees gives more input then before the break. He is glad the rest of the group listened more to him after the break.

4.1.3 - Researcher Scott

Scott is a social scientist. He is working on a research about group behaviour during a brainstorm session and he wants to know if giving feedback has effect on the behaviour of the group members. He bought the Sociometric Badges and the SocioMetricVis together with the University. He has been busy with collecting enough participants to make a research setting. He finally collects 6 participants who are going to be part of a brainstorm. He explains how it will work and gives each test user a Sociometric Badge. Scott starts the recording of the badges and stops the recording for a break. During the break Scott collects the badge data with a program and puts the gained Excel sheet into the program. He first asks the test users about their vision on the brainstorm and shows the feedback afterwards with the user of the SocioMetricVis. After the second half of the brainstorm session he asks the participants again how they thought the brainstorm went. Together with the data from the Sociometric Badge and the data collected from the surveys he draws conclusions for his research. Scott received good results for his research.

4.2 - User requirements

With the background research and the user case scenario's, described in previous chapters, the following user requirements have been found:

- The visualisation must be tangible;
- The visualisation must be portable, so it can change places;
- The visualisation must not be obtrusive or block the sight on other team members;
- The visualisation needs to be easy to use and user-friendly;
- The visualisation must be inviting to use;
- The visualisation must be foolproof and able to withstand touching;
- The visualisation must need as little explanation as possible;
- The user must be able to input the data into the system without complicated steps.

4.3 - Rapid Prototyping

By looking at the different user requirement and the user case scenarios, new concept drawings have been made. Figure 11 show the last concept drawings of the Ideation Phase. The new concepts will be elaborating on these drawings.

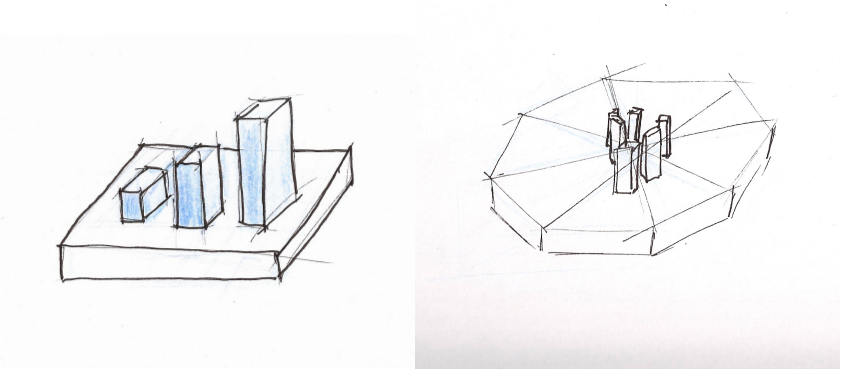


Figure 11: The final concepts from the Ideation Phase.

The hexagon is a very interesting shape to elaborate on. Figure 12 shows a top view on how the bars could be displayed on top of the hexagon. The bars could be round or square and there could be two per user or more per user.

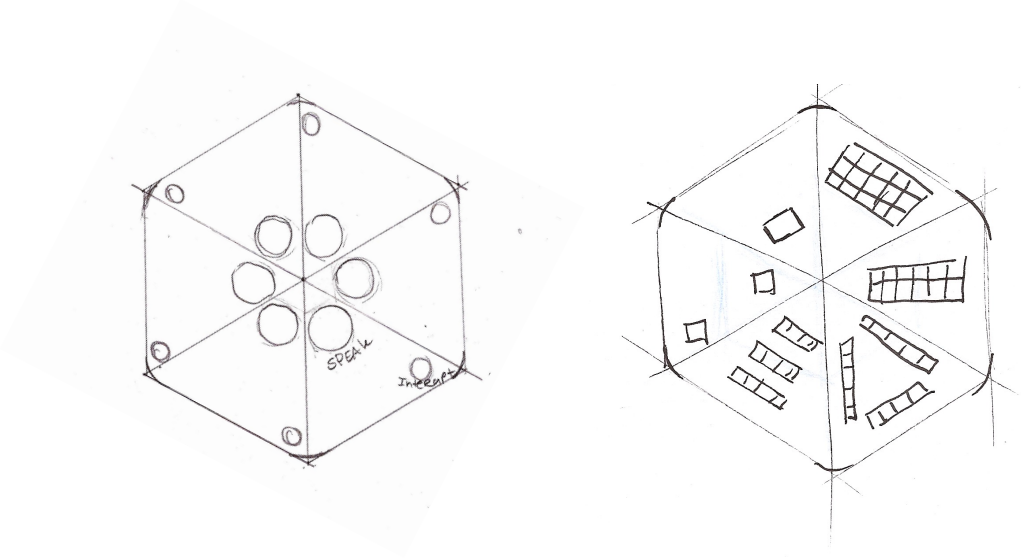


Figure 12: Top view of a hexagon with different bars in it.

It is very difficult to see all the bars if there are more than one per user. Figure 13 shows how the bars could be divided on the hexagon.

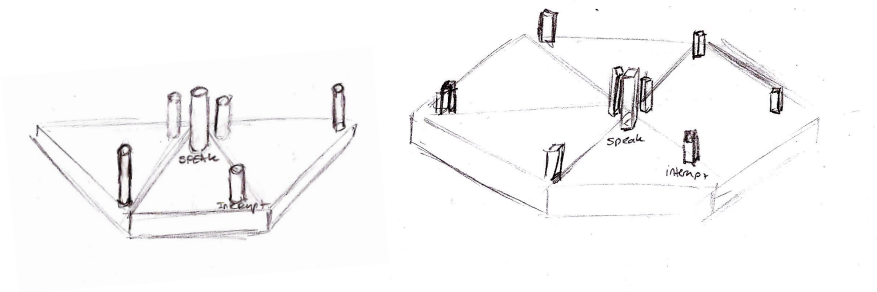


Figure 13: Division of bars on top of a hexagon.

The shape of the bars depend on what is more feasible in designing the mechanism. After elaborating on this the square bars can be moved more easily and give more options for the mechanisms. Figure 14 show how this would look and where the bars could be placed.

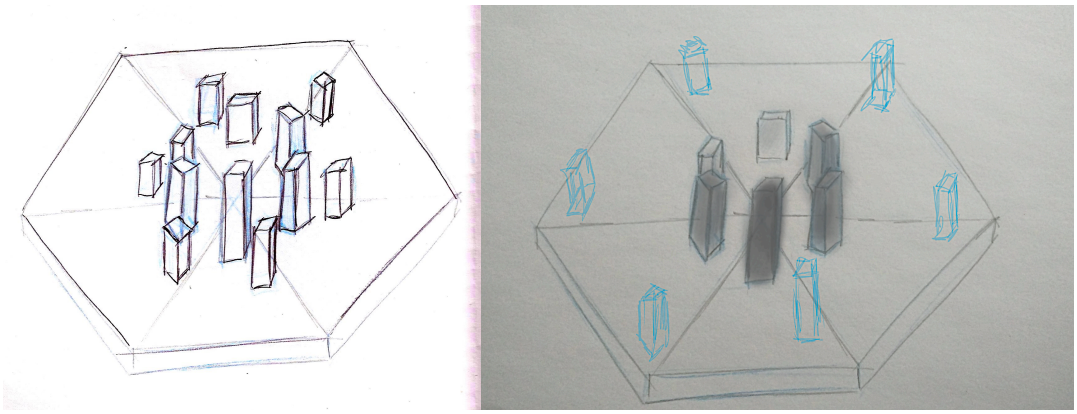


Figure 14: division of square bars on top of a hexagon

The most basic version of the concept drawings is shown in figure 15. The visualisation might be clearer if there is only one bar per user and if the bar might show two values. The second value might be shown with light or colour. This will need to be tested with a user test to see what the user prefers.

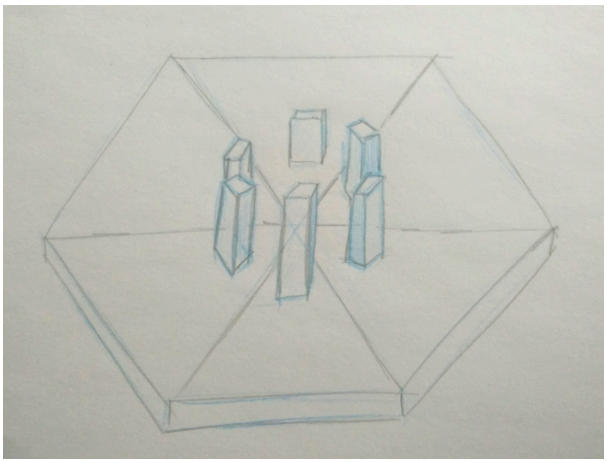


Figure 15: Final rapid prototype

4.4 - User test 1

It is important to test the concept drawings via a user test, to make sure the visualisation is user-friendly and easy to use. During the user test, 6 test users were interviewed. Illustrations were shown to make the explanation clearer. The user test questions and answers can be found in appendix 2. The test users first got a short explanation about the visualisation. The explanation consisted of information about the purpose and setting of the visualisation and information about how the Sociometric Badges work. Every user received the same amount of information. The first part of the interview consisted of open questions. The second part consisted of questions with a Likert-scale from 1 to 5, 1 meaning totally agree to 5 meaning totally disagree.

The first two questions asked the test users what they interpreted from the illustration shown in figure 16 and 17. The first questions were: *Imagine that you are sitting at a table and you get this feedback. What information would you get out of this?* and *Imagine that you are the user at the back. What would you get from this information?* 5/6 users interpreted that the visualisation gave feedback. The test users all agreed that figure 17 showed a value relatively less to the other participants. They stated that: They listened more, did not talk enough, are weak relative to others and gave less input during the brainstorm.

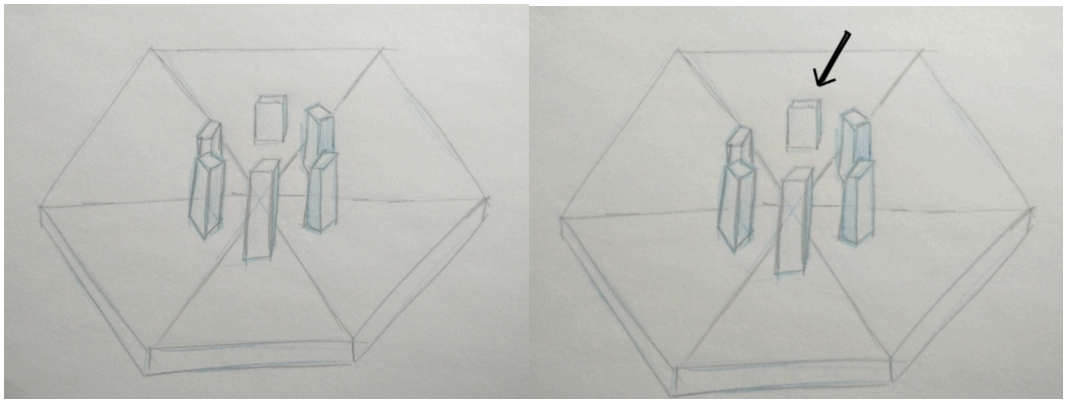


Figure 16 and 17: Picture shown together with interpretation question

The third question was: *Do you think colour will add something to the design and why?* Figure 18 was shown as illustrations. All the users thought that adding colour had advantages. One test user stated that it could be used for coding the users, while 3/6 users stated that they would like the colours to show a value that is different from the value that is represented by the height of the bars. Values that were named were interruptions, aggressiveness, amount of talk and quality.

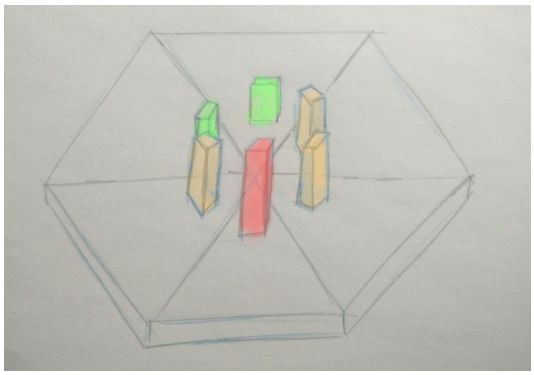


Figure 18: Picture shown together with adding colour question

Question four asked: *What colour should the highest bar be? And the lowest?* 3/6 agreed that the highest bar should be red and 3/6 also agreed that the lowest bar should be green. One user stated that he highest bar could also be blue. A table of answers can be found in appendix 2.

To find out how the test users would interpret colours together with the visualisation, questions about different bars were asked. The first question that was asked was about Figure 18: *Imagine that you are the red bar. What information would you get out of this?* All users associated the red bar with talking too much. The question that was asked about figure 19 was: *Imagine you are the orange bar. What information would you get out of this?* 4/6 users thought that their input was average and one user was satisfied. The remaining user thought that he needed to speak more. The question asked about the red low bar shown in figure 20 was: *Imagine you are the red bar at the back. What information would you get out of this?* 5/6 users thought they were not present enough. One user identified it as taking the least and interrupting a lot.

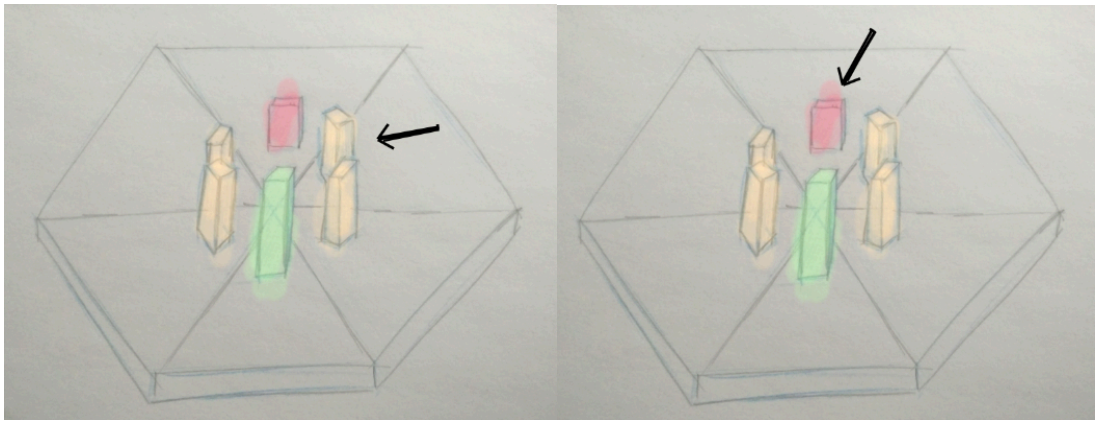


Figure 19 and 20: Picture shown together with association question

The users were the following about adding light intensity to the visualisation: *Do you think that the intensity of light will add something to the design?* Figure 21 was shown as illustration. 5/6 test users thought that light intensity would add something to the visualisation. Out of these five test users, one test user thought it would be very difficult to distinguish and one test user thought it would be more fitting if you would go from black to colour or from white to different colours.

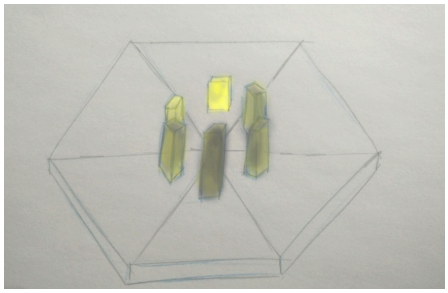


Figure 21: Picture shown together with light intensity question

To find out what scale the intensity of light needs, the test users were asked: *Which bar should be the lightest and which bar should be the darkest?* 3/6 test users said that the darkest bar should be the person who speaks the least. One user said that the person with the clearest and best ideas should be the most light. One user said that the lowest bar should be the lightest. The illustrations that were shown are in figure 22 and figure 23.

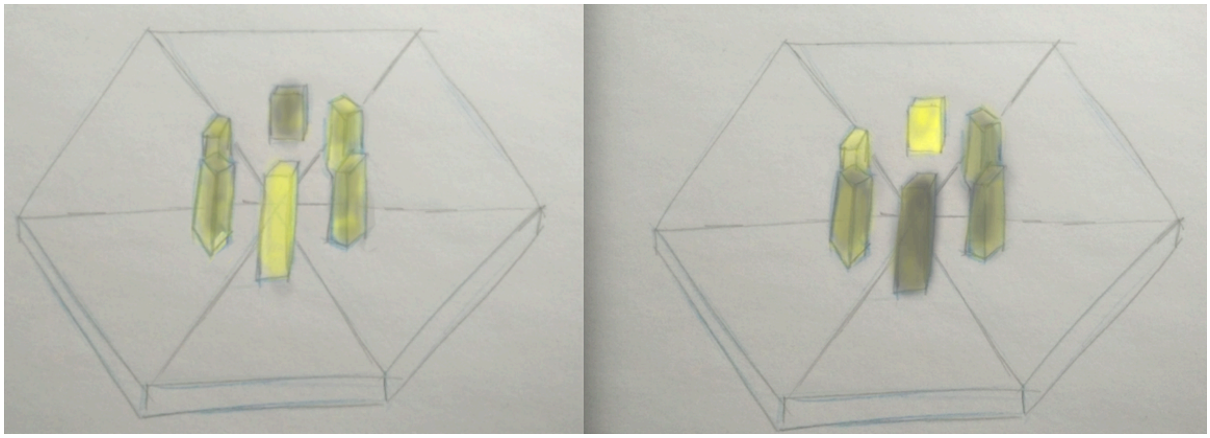


Figure 22 and 23: Picture shown together with light interpretation question

After the open questions 10, quick questions were asked that needed to be ranked from 1-5, totally agree to totally disagree. The overall answers to the questions were moderate. The users gave an average of 3 to the questions: *I would like to use this feedback tool while brainstorming* The questions that had noteworthy answers are described below. The other question including their average can be found in appendix 2.

Test users all disagreed to the question: *I need to learn a lot of things before I can use the feedback tool* This is shown in figure 24. 3/6 users said that more information and learning was not necessary to understand the feedback tool. One user stated that it was absolutely necessary. In contrast to the previous question, all users replied that the visualisation is not complex to the question: *I think the feedback tool is unnecessarily complex.*

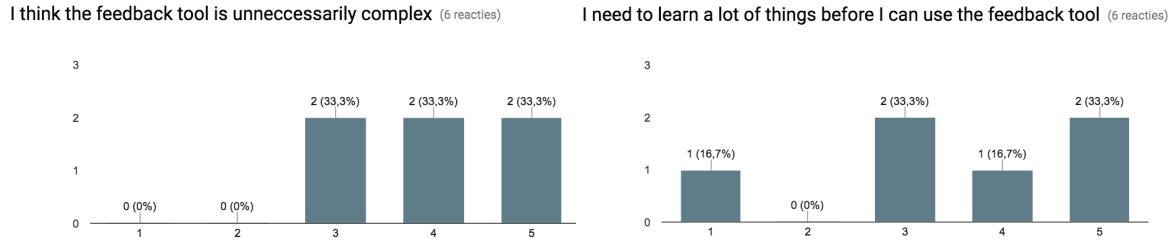


Figure 24: Answers to question if visualisation is difficult, 1(agree) - 5(disagree).

Another question, which had a noteworthy answer was the question: *I can imagine that most people would learn to understand this system very quickly.* This can be seen in Figure 25. 5/6 users said that it would be easy for other users, while one test user stated that is would be very difficult for others too. This can be the same user who stated that he or she needs to learn a lot of things before using the visualisation.

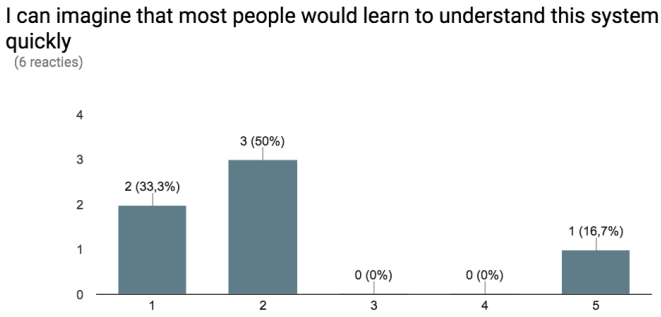


Figure 25: Answer to the question about difficulty for other users, 1(agree) - 5(disagree).

The same goes for the questions: *I think the feedback tool will be easy to understand.* and *I think that I would need the support of a technical person to be able to use this feedback tool.* This is shown in figure 26. One user thought the visualisation would not be easy to understand. 2/6 users thought that they needed help from a technical person to be able to use this visualisation. This means that one user either changed its mind about the usability or misunderstood the question.

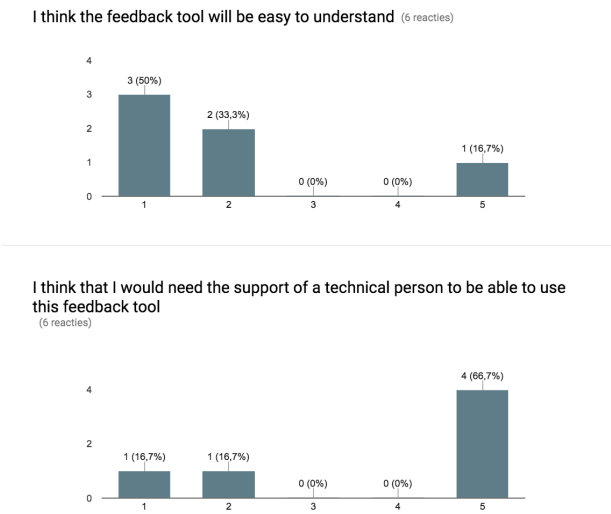


Figure 26: Bar charts showing most noteworthy answers of the user test, 1(agree) - 5(disagree).

Finally, the test users were asked to fill the sentence: *I think the feedback tool needs to show this information…* They stated that they liked to see: A legend, more relative values, quality, the amount of speaking and the aggressiveness of the discussion. Furthermore, they suggested that the hexagon had a lot of free space and that it could be used more efficiently by adding colour or differing in size. One test user said that the quiet person can have deep thoughts but might not talk much. He questioned if everybody should have even time to speak.

To conclude, in this user test users were asked: If they understood the visualisation, if adding light would add something, if adding light intensity might add something and how easy the visualisation would be to use. The overall user understood what the visualisation showed. This shows that the design of the visualisation works as expected and fulfilled the design goal. Almost all users thought that adding colour to the visualisation would be a good improvement. Users stated that the highest value should be red and the lowest value should be green. Some said that the colour of the bar should show a different value. The users were less enthusiastic about the light intensity because this would be more difficult to distinguish. Therefore the coloured LEDs will be added to the visualisation. They will show a different value than the height of the bar. One of the requirements was that the visualisation needs to be easy to use and user-friendly. The users overall said that the visualisation was easy to use and that no technical background was needed. The user test pointed out that a small explanation at the beginning will make the visualisation even more user-friendly.

4.5 - Functional Requirements

To build the first prototype Functional requirements are needed. These requirements describe must have features of the visualisation. The functional requirements are described below:

- The mechanism should be able to move one bar for each user;
- The bar has to represent the amount of speaking time per user;
- The bar has to change according to the different values;
- The mechanism should work with a stepper motor and a gear;
- The visualisation must be able to show the data over time.
- Multiple bars should be able to change to the values at the same time;
- The mechanism should not be visible to the user and should be hidden in a case;
- The mechanism should be made out of available materials and manufacturing techniques;
- The bar should be accurate enough to change height so that the data can be easily compared with each other;
- The mechanism should be durable and should function for a long time without breaking;
- All the electronics should not be visible to the user;
- The electronics need to be easily accessible for adjustment and reparations in case the visualisation does not work.

4.6 - Technical specification

To let the bars move according to the values received from the Sociometric Badges there are various options to use. All options are depicted in Figure 27.

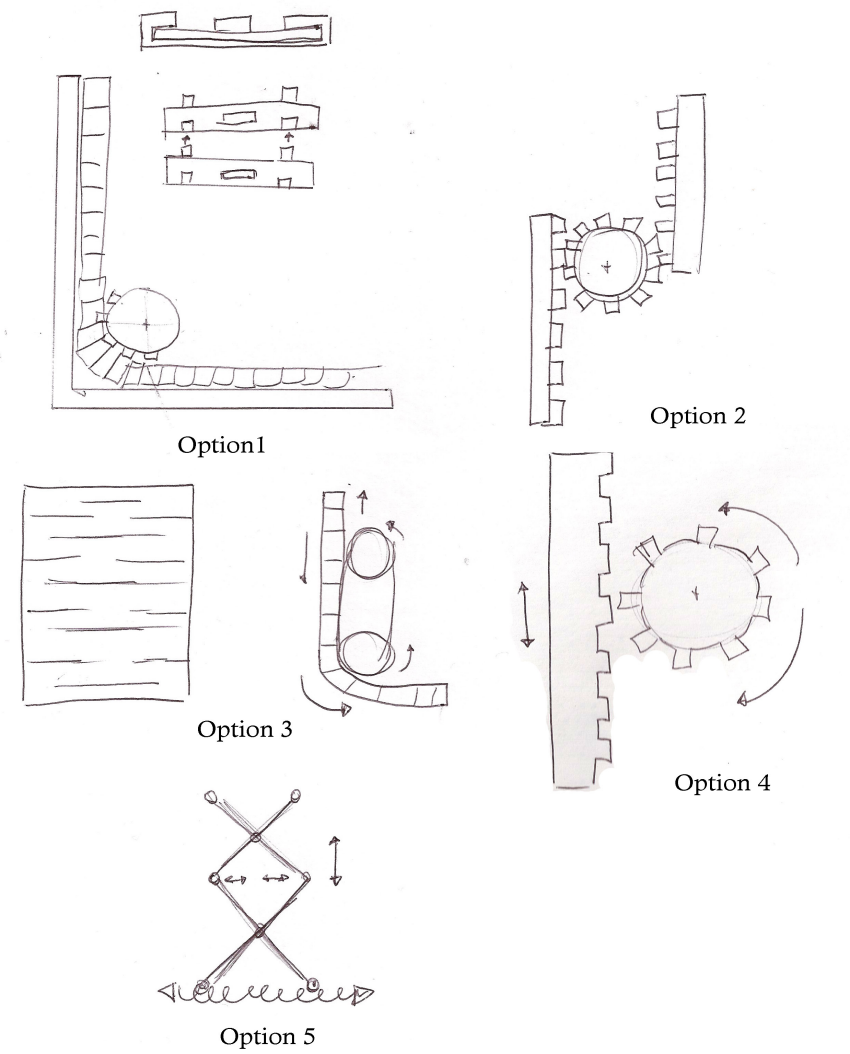


Figure 27: The different options for mechanisms to move the bars

Option 1 makes use of separate blocks that are able to click into each other. These blocks have a cut-away where the gear can get grip on the blocks and push them into a groove made to slide the block up. This needs a lot of precision and detail and if one block is not working the whole system can get stuck. Therefore this option is dismissed.

Option 2 tries to minimise the space needed beneath the casing of the visualisation. The gear will turn to move the left gear rack down and the right gear rack up. The obstacle with this option is that the gear will need to move along with the gear racks to achieve the goal of minimizing the space needed. This will give multiple complications and this option is therefore also dismissed.

Option 3 makes use of wood that has incisions to make it flexible. Thanks to the wood being flexible it possible to bend the wood around the gear and sliding it in horizontal direction. This will reduce the height of the visualisation. Unfortunately the incisions will make the wood fragile and the visualisation will be less durable and more prone to breaking. Therefore also this option is dismissed.

Option 4 make use of a gear rack and a gear that is attached to a stepper motor. The gear rack will be held in place by a wooden case around it to prevent if from shifting or standing askew. This option is the most straight forward and will also cause the least complications. Therefore this mechanism will be used for the visualisation.

Option 5 makes use of a spindle and a scissor folding technique. This technique is often used in attic stairs. Two spindles are needed that twist in opposite direction and the scissor mechanism will increase and decrease in height.

4.7 - Conclusions of Specification Phase

The specification phase specified that the visualisation will be a hexagon with moving bars that will show two different values. The bars will contain coloured lights. The height of the bar will show the amount of speaking and the colour will show how much the user has interrupted someone else. The user test also made clear the visualisation might need some quick explanation before use to make it easier to understand. Functional and user requirements are defined and the mechanism is specified. The bars will move with the use of a gear rack system. These will be taken into account in chapter 5.

Chapter 5 - Realisation

As described in Chapter 2 - Method and Techniques, the Realisation Phase builds upon the functional specifications. The functional specifications will help to make the architecture of the complete system. This is described in chapter 5.1. The architecture of the system will be divided into system components. These components are described in chapter 5.2. With the system components the first prototype can be build. The first prototype will be described in chapter 5.3 along with functional testing of this prototype. A description of prototype 2.0 can be found in chapter 5.4. Prototype 2.0 will be user tested in chapter 5.5. Errors found with the user test can be adjusted in the final prototype 3.0. This will be described in chapter 5.5.

5.1 - Complete System

To find out how to build the first prototype, it is important to look at the whole system first.
What components does the system contain and how are they connected? What materials are needed to build the prototype? The complete system consists out of one mechanism which is multiplied for each bar. The bar will be moved by a stepper motor. This mechanism is shown in figure 28.

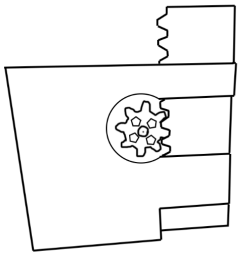


Figure 28: A drawing of the bar mechanism

5.1.1 - Block Scheme of the Complete System

The system consists out of 6 components that are linked to each other. This can be seen in the block scheme in figure 29. The Arduino is connected to the stepper motor and controls the system. The Arduino receives data from the computer through an USB cable. The Arduino controls the Stepper motors and the Led's that change according to the received data. The whole system is powered by an adaptor of 12 V.

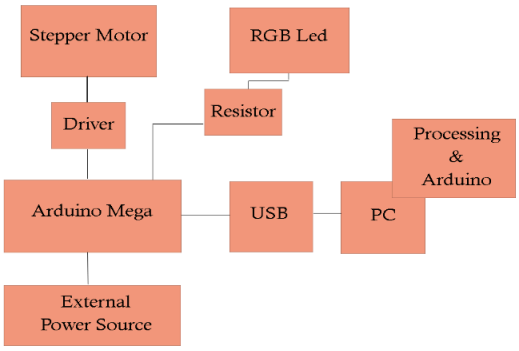


Figure 29: A block scheme of the system components.

5.1.2 - Materials

To build the prototype different materials are needed. All the materials needed are described below:
The programs that are used:

- Fritzing, for layouts of the system components.
- Arduino, for programming the Arduino board.
- Processing, for sending the data from the computer to the Arduino.
- Excel, for data processing.

The electrical components that are used are:

- Arduino Mega 2560 R3 incl. USB cable
- 3 x Pololu Motor Drivers A4899 (pinout in appendix 3)
- 3 x Stepper motors, Wantai 42BYGHW60, 1.7A, 1.8 deg/step (specification in appendix 4)
- Connection cables Female - Male
- Connection cables Male - Male
- Power adapter, 12,6 V - 1A
- 2 x Breadboard 400 points
- 3 x RGB LED Diffuse 5mm Cathode
- 9 x Resistor 330Ω

Other supplies that are needed:

- 12 x Screws 3mm x 15mm
- 12 x Screws 3mm x 20mm
- 12 x Bolts 3mm
- Electrical Tape
- Glue for Plastic and Wood
- Acrylic Plates suitable for laser cutting
- Wooden Plates suitable for laser cutting

5.2 - System Components

The system consists out of multiple components. In this section, all of these components are described in more detail.

5.2.1 - Arduino Board

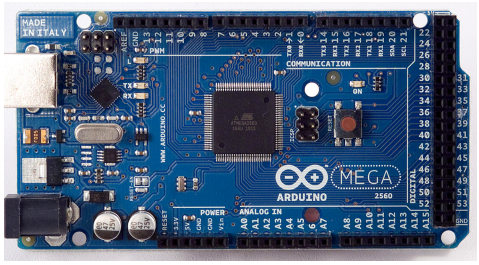


Figure 30: A top view of the Arduino Mega 2560 [20].

The Arduino Mega 2560 is a microcontroller board based on the normal Arduino Uno. The Arduino Mega can be seen in figure 30. It has 54 digital input/output pins, 16 analogue inputs and 4 serial

ports. It can be connected to an USB cable and power source. It is a plug and play concept. The Arduino Mega comes with a program called Arduino in which you can program by using java. The Arduino Mega contains 256 KB flash memory where the code can be loaded onto. The Arduino can be used to control different actuators but can also read data from sensors. The Arduino also has protection against shorting and over current. This will protect the computer from any harm. This makes the Arduino the perfect microcontroller to control the LED's and the stepper motors [21]. The pin layout of the Arduino Mega can be found in appendix 5.

5.2.2 - Stepper Motors

To move the bars up and down a gear is used. This gear is attached to a stepper motor. A stepper motor is a DC electric motor which is capable of rotating forwards and backwards. It is known for its power and reliability. These stepper motors are each connected to a driver with 4 cables and powered by an external power source of 12V. The stepper motors will be controlled by the Arduino. Figure 31 shows a schematic on how the stepper motors are connected to the Arduino.

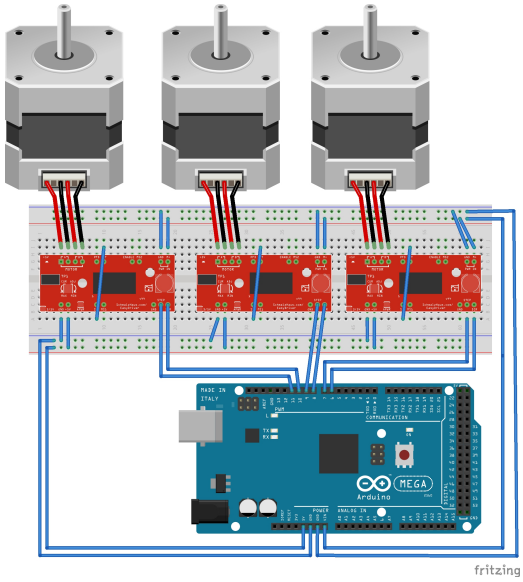


Figure 31: Schematic of the connection of the steppers to the Arduino (Sketch made in Fritzing).

5.2.3 - Drivers

To protect the stepper motors, drivers are used between the Arduino and the stepper motors. An A4988 Micro stepping Driver is used for each motor. The driver protects the motor from too much current and a too high temperature. The driver also makes it possible to change the amount of current with a potentiometer. The driver makes it easier to control the stepper with a step and direction pin [22]. Figure 32 shows the driver and how to wire it. Figure 33 shows how the three drivers are connected to the Arduino and the steppers.

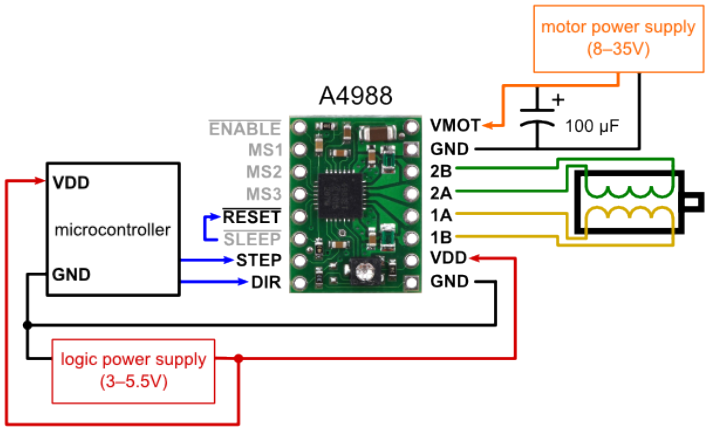


Figure 32: Wiring diagram for connecting the Pololu A4988 Motor driver [22]

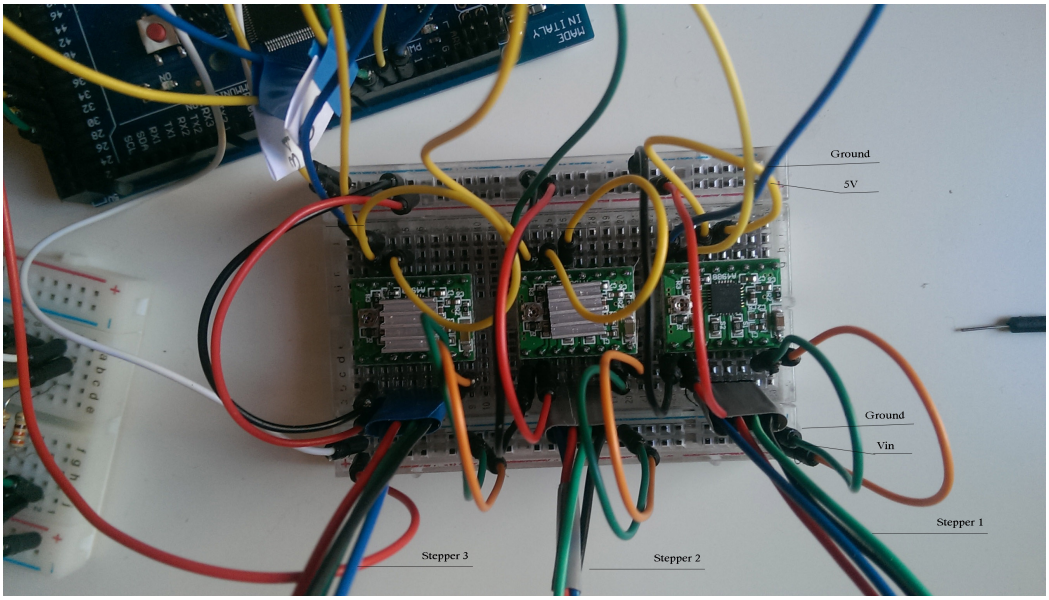


Figure 33: The Arduino connected to the A4988 driver and the Stepper motor.

5.2.4 - RGB LEDs

During the prototyping phase, RGB LEDs will be added. The LEDs are 5 mm thick cathode with diffuse light. Figure 34 and 35 shows how the RGB LEDs are connected. Each LED has 4 pins, a green, red pin, blue pin and a ground pin. The colour pins will be guarded by a resistor of 330Ω per pin.

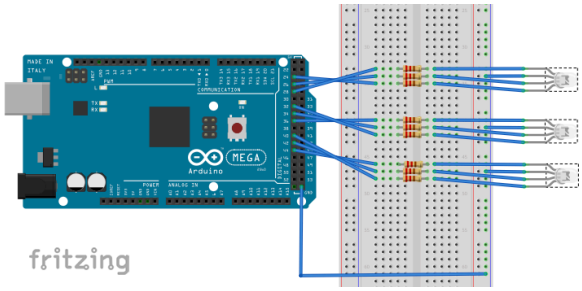


Figure 34: A schematic of the connection of the RGB LEDs (sketch made in Fritzing).

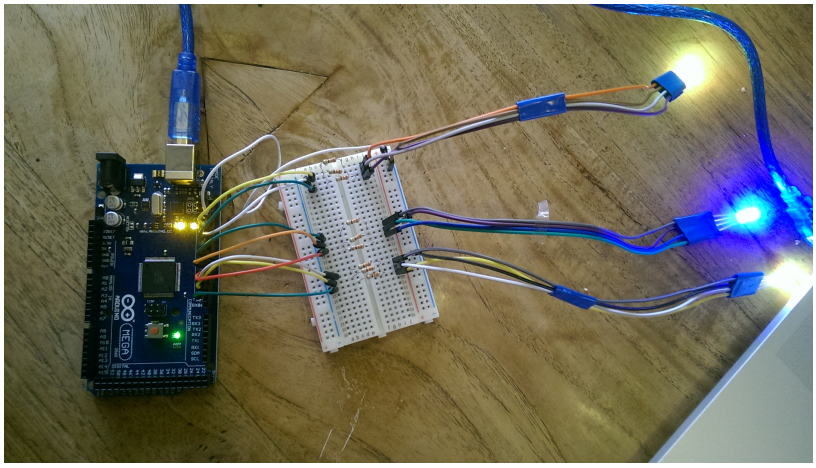


Figure 35: The setup of the three RGB LEDs.

5.3 - Software

All the components are controlled with code for the Arduino and the data processing. This section describes the most important parts of the code. Figure 36 shows the different programs and the different actions that will be done in the program.

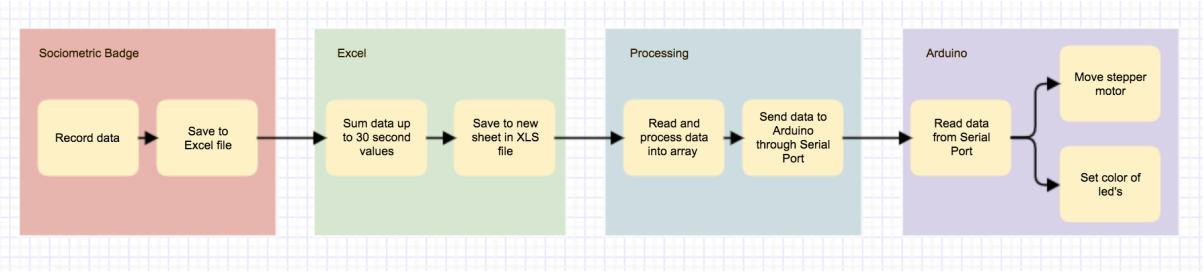


Figure 36: A diagram of actions per program.

5.3.1 - Arduino Code

The Arduino has it's own IDE, which works with C++. The program Arduino is used to control the mechanism of the visualisation. The most important parts of the code will be explained. The complete code can be found in appendix 6. The Arduino gets it's data from the computer through the Serial Port. This is a build in function of the Arduino to communicate with a computer. The computer sends an array, which contains the data from the Sociometric Badge to the Arduino. The array contains the headers of the data and the values. More about the data that is sent will be described in chapter 5.3.2.

The function serialRead() reads the data from the serial port and when a "," or an "/n" is found and splits the data into small pieces of data called substrings. Headers are added to mark the substrings. The substrings are saved into the array called "value". Value now contains all the substrings with headers that are received from the serial port.

To control the steppers a library is used [23]. This is an already build in library in the Arduino IDE. With this library, the stepper can be controlled with simple commands such as step().

A function was made to move the steppers, this function is called setStepper. The data from the Sociometric Badge is loaded into a value for each stepper. The steppers are moved by distracting the position where the stepper needs to move to by the current position. For example when the stepper needs to move to position 1000 but the stepper is already at 400. 1000 - 400 =600 and the stepper moves 600 steps. After moving, the current position will be changed to the new position.

Next to the steppers, there will be RGB LEDs. There are 3 LEDs, each LED has its own variables: The redpin, greenpin and bluepin. To change the colour of the LED the function setColour is used. The value of the red, green and blue pin will be set according to the received data. This function determines the colour of the led by looking at the height of the value. The LED will change into 4 different colours. From blue to red, blue being the value which represents the least amount of interruptions and red being the value representing a large amount of interruptions.

5.3.2 - Processing Code

The data that is received from the Sociometric Badge is transferred into an excel sheet. To send the data to the Arduino IDE a program called Processing which supports java. To read the excel sheet and use the serial port to send it to the Arduino, two libraries are used.
The serial library of processing [24] and the bezier data library [25]. The complete code can be found in appendix 7.

By using the Bezier data library, the xls file is loaded. Based on in which sheet your data is stored, the right sheet will be opened. The program will start by reading the first row of the xls sheet. It reads through the excel sheet by reading through each cell and then going to the next row. The data is put into an array called “val”. These values are multiplied by 20 to get values from 0 till 600. There is a delay to make sure the data is sent properly to the Arduino before skipping to the next row.

A String called output is made and this string is filled with the “val” array and the headers to mark these values. Between the values a “,” is added to separate the values and the information is sent to the Arduino through the serial port.

5.3.3 - Data processing

The Excel sheet that is received from the Sociometric Badge contains a large amount of data which is not used. Therefore its is important to process the data into a simple data sheet. Excel is used to do this. The used data can be found in appendix 8. The original data shows the values per second. This will be summed up per 30 seconds in a new Excel sheet. This can be done with the following formula:
SUM(OFFSET(“sheet that contains the used data”$”First row that contains the data”; (ROW()-ROW(“sheet that contains the used data”$”First row that contains the data”))*30;0;30;1)).

In the case of the excel sheet that is used for the prototypes the formula is:
=SUM(OFFSET(t_speech_profile1!$C$3;(ROW()-ROW(t_speech_profile1!$C$3))*30;0;30;1))

By using this formula the new excel sheet will contain the speech and interruption data of all the user per 30 per seconds. This data is summed up to 30 seconds to show more difference between the users and to make the data quicker to show. This can be easily adjusted by changing the 30;0;30;1 to another value.

5.4 - Prototype 1.0

The first prototype is made by laser cutting the mechanism out of wood. The different parts are screwed and glued to each other. For the first prototype, only one stepper motor is used. The stepper motor is connected to the Arduino and the Arduino to the computer. The first stepper motor is tested by a simple code which lets it rotate up and down. The bar moves up and down by the rotation of the gear which is attached to the stepper motor. This can be seen in figure 37.

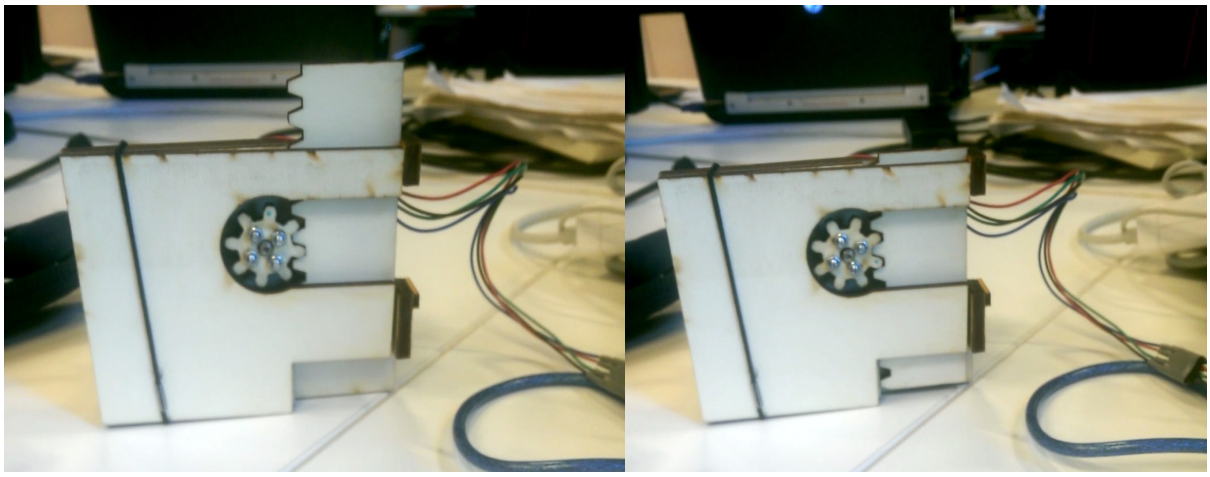


Figure 37: Movement of prototype 1.0.

5.4.1 - Cut out prototype 1.0

The mechanism is cut out of wood with the use of a laser cutter. 5 mm thick triplex wood was used for prototype 1.0. The design is shown in figure 38.

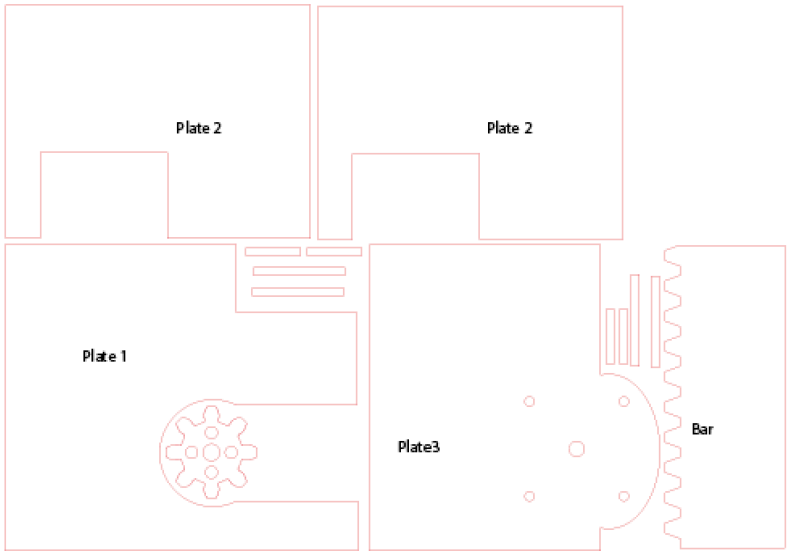


Figure 38: Wood Cutout version 1 for one bar.

Plate 3 contains hole so the plate can be screwed onto the stepper motor. Plate 2 is glued on top op plate 3 and plate 1 is then glued on top. The gear is attached to the stepper motor with the use of a mounting hub and some small screws. The bar fits between plate 1 and 3 and can now be pushed up and down by the gear.

5.4.2 - Functional Testing Prototype 1.0

During the process of making prototype 1.0, minor errors are found and adjusted. This is called functional testing. The first error was found before the plates where glued together. Plate 3 has no support for the bar to move up and down. Therefore another plate was needed, which is shown in figure 39. This plate is glued on top of plate 3 and supports the bar.

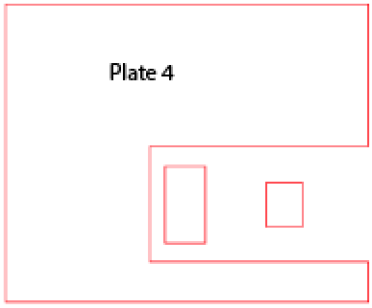


Figure 39: Extra cutout for prototype 1.0

When all the plates were glued together, another problem arose. This had to do with the movement of the bar. The gear forced the bar to go up but the gear also tilted the top of the bar to the outside of the mechanism. This would cause problems if a top plate would be attached because the bar would get stuck with the top plate. This could be prevented with little pieces that could connect plate 1 with plate 4 on the right side. The little pieces are also shown in figure 39. The bar sometimes gets stuck between the gap of plate 4. This can be prevented by filling the hole up until the place where the screws stick out.

In the current design, the stepper motor hangs in the air. The thickness of the wooden plates is not strong enough to counterbalance the weight of the stepper motor. Therefore a solution is needed to support the stepper motor. This can be done with the use of another plate like plate 2. Another solution would be to put a block underneath the stepper motor.

The first prototype was made out of wood but because the final design contains led's, the bar should be thicker and hollow inside. Wood does not reflect or show light. Using plastic instead of wood would be a good solution for the light problem.

5.5 - Prototype 2.0

Prototype 2.0 is an improved version of prototype 1.0. Both prototypes are showed in Figure 40. Every error that was discovered in the functional testing of prototype 1.0 has been changed. The mechanism is now laser cut out of a 5mm plate of acrylic. The acrylic reflects the light of the LEDs that will be added at a later stage. Prototype 2.0 has a thicker hollow bar, which needs more power to push it up and down. Therefore an extra gear will be added beneath the first one. Both gears will be attached to the same stepper motor. One gear on top op the mounting hub and one on the bottom. Figure 40 shows the new bar and gear.

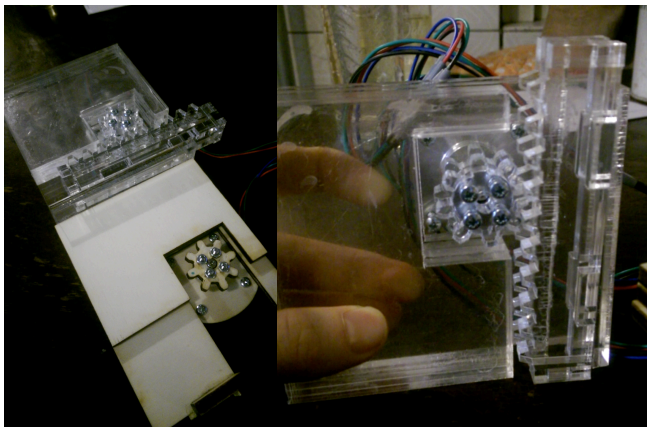


Figure 40: Prototype 1.0 and 2.0 together on the left and Prototype 2.0 on the right.

At first, only one mechanism is made. If the parts are assembled without errors another two mechanisms will be cut out. In total this makes 3 mechanisms. The first design sketches contained 6 mechanisms because researched showed that this was the best and most efficient number of people to brainstorm with [12][13]. Prototype 2.0 is a proof of concept. If 3 mechanism works then an extra 3 are easy to add. Figure 41 shows the three mechanisms. The top plate is taped to the mechanism instead of glued because the screws still need to be reached.

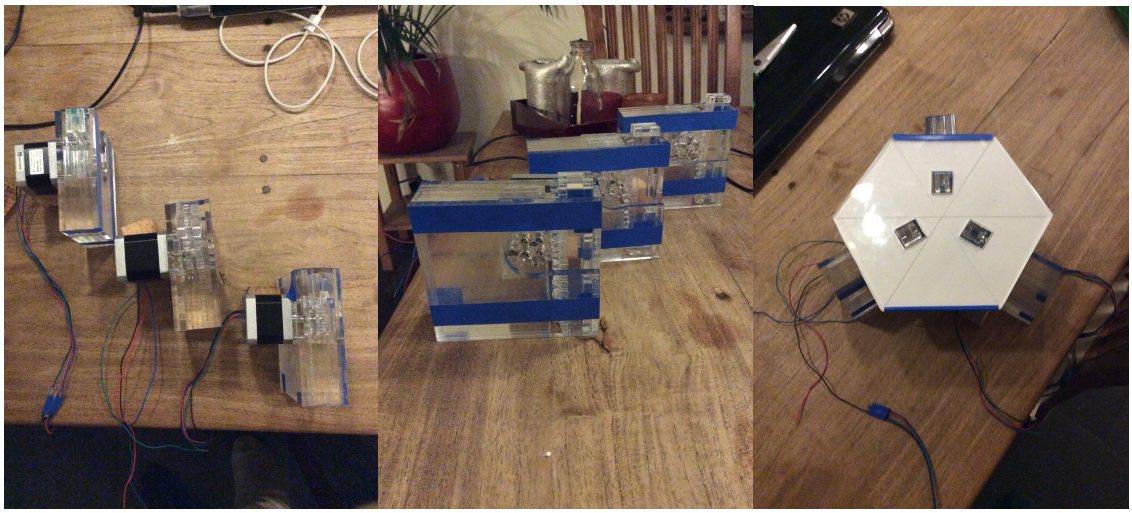


Figure 41: The 3 stepper motors with the mechanism and the top plate.

One of the user requirements is to make sure that the electronics are not visible to the user. Therefore a top plate will be added. This plate will hide the electronics from the user and will put the focus on the bars and the lights. The top plate is also cut out of 5 mm acrylic. To make sure the electronics are hidden a normal paper is put on the bottom of the acrylic top plate. The hexagon plate is divided into 6 partitions and shown in figure 41. These partitions all represent a user. For this prototype as already explained only 3 users will be able to get feedback.

5.5.1 - Cutout Prototype 2.0

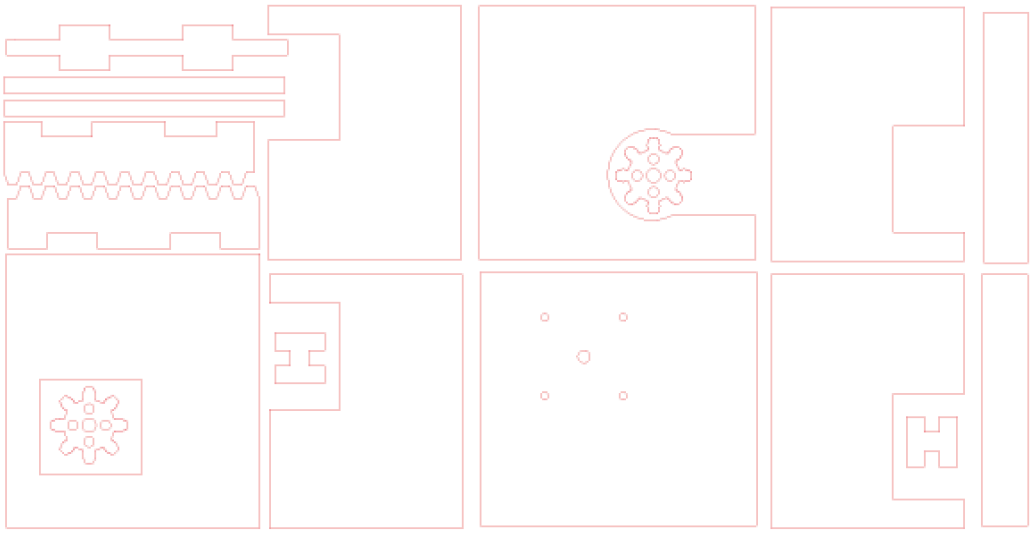


Figure 42: Cutout of plastic for one mechanism of prototype 2.0

The bars are now thicker and hollow. To realise this a clicking system is needed. This also makes it easy to access the back of the bar where the LED will be put. The bottom plate that is attached to the stepper motor now has more surface to prevent the bar from getting stuck. Figure 42 shows the cutout for one mechanism.

5.5.2 - Adding RGB LEDs

When the bars are assembled the RGB LEDs can be added to each bar. The LEDs can be attached inside the bar. The LEDs will show 4 colours and with these colours it will show the interruption behaviour of the user. The colours will be: Blue for not interrupting at all or very minimal, green for a normal amount, orange for too much and red for very annoying interruption behaviour. Each LED will be put inside a bar. The LEDs have enough cable so they will not slide out of the bar when the bar moves up or down. Figure 43 shows the LEDs inside of the bars. The acrylic reflects the light through the whole bar. This way the LED can be at the bottom of the bar but the light will still be visible.

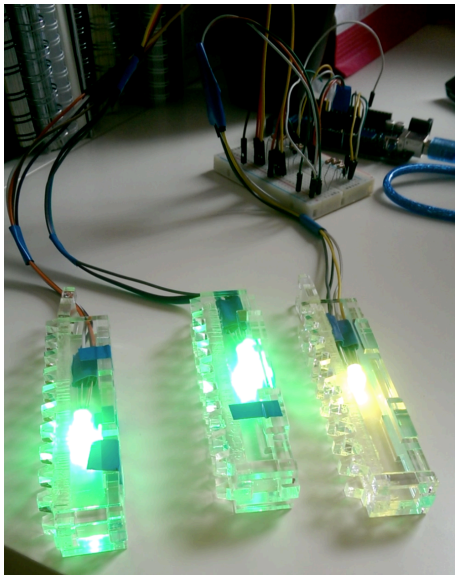


Figure 43: The RGB LEDs inside of the bars

5.5.3 - Functional testing Prototype 2.0

During the assembly of the prototype 2.0. Some minor errors were discovered. The holes for the spindles of the motors was a bit too tight. This caused the motor to get stuck or not give enough power to rotate the gear and push the bar. This problem was solved with help of sanding paper. The motors were not functioning properly on a 9 v battery, therefore a power source of 12v was attached to the Arduino. The cable of the LEDs prevents the bar to be closed on the bottom and the mechanism to stand properly. Therefore a hole on the bottom of the bar and mechanism was needed to give the cables space to move. At the moment it is not possible to rotate the stepper motors at the same time. It is important to see if the user gives comment on this in the coming user test. If this is a big problem the code of the stepper might need adjustment. To make them rotate simultaneously.

5.6 - User Testing Prototype 2.0

This user test will ask the users to look at the visualisation. The users will be asked questions about the design itself, the movement, colour of the bars, the height of the bars and if the visualisation is user-friendly. This user test is important to find out what needs to be changed according to the users. The user test is done with 20 users and starts by asking them about their age, gender and study background. The user test and the answers of all the 20 users can be found in appendix 9.

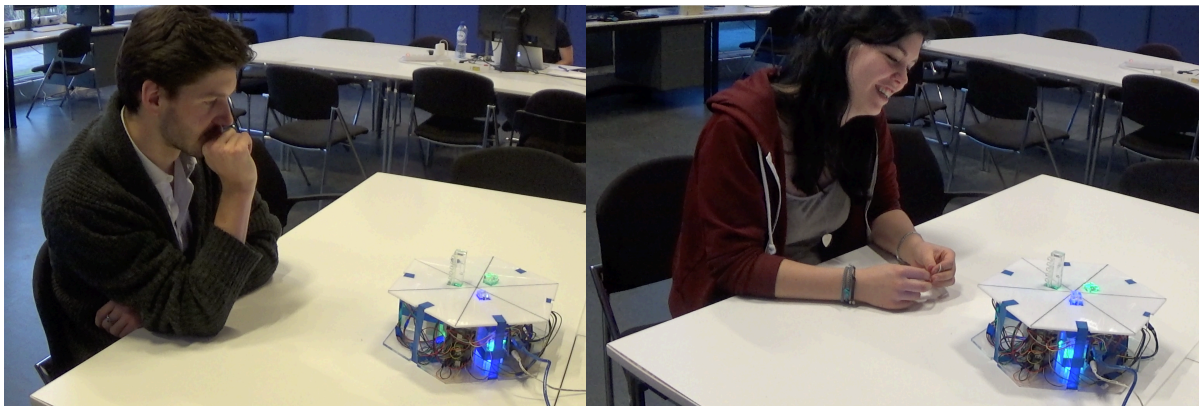


Figure 44: Setup of the user test 2.0

The users are asked to sit next to the visualisation as showed in figure 44 and the first 3 questions are asked without the visualisation doing anything and without any explanation. The first question is: *What feeling do you get if you see this visualisation?* This is a simple question to start with. The answers of the users were completely different from each other: some users stated that: "It looks like a pie" and some said: "I am curious". When the users were asked: *On a scale from one to five how eager are you to try this visualisation?* They gave an average of 4,05 with a standard deviation of 0,68. This means the users are eager to try the visualisation. To test this assumption a one-sided t-test was done, with the null hypothesis being that the answers equal to the average = 3. The t-test gave 6,842, which means that the null hypothesis can be rejected and that the answers are more positive than the average of 3. The answers of the users are depicted in figure 45. It shows what how many users gave a certain number on the scale of 1-5.

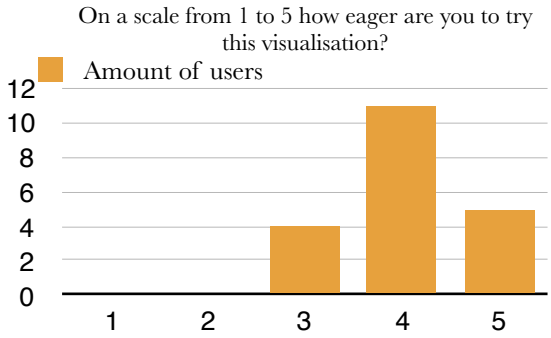


Figure 45: Answers to question about how much the user would like to try. N=20

The users were asked: *If this visualisation would be on the table during a brainstorm would you be distracted?* 12/20 stated that they would be distracted by the visualisation. 6/20 users would not be distracted, the

2 other users say that they need to know what the visualisation does before they can say anything about it.

After these first questions, an explanation is given about the visualisation. The exact explanation can be found in appendix 9. After the explanation, the visualisation is turned on and the visualisation will start to move according to the data. The data that is shown to the user is the data of user 3. This data can be found in appendix 8. After the visualisation has stopped, 2 questions were asked: *What have you interpreted from the feedback that was given to you about your "behaviour" in the brainstorm?* The data that was shown represented a user that talked a lot and interrupted a couple of times during the brainstorm. Almost all users (18/20) understood that they had talked a lot. The users did not see the interruption data well enough, this resulted in 5/20 users saying that they did not interrupt a lot. The other users did not mention it or stated that they could not see it well enough.

The users were asked: *If this feedback would be shown in the break of a brainstorm session. How likely is it, on a scale of 1 - 5, that you use the feedback that is given to change your attitude after the break?*
After the first 5 users, the question was changed and a scale was added. Therefore, this question was answered by 15 users. The average of the users is 3,7 with a standard deviation of 0,88. This means that the users are likely to use the feedback after the break. To test this assumption a one-sided t-test was done, with the null hypothesis being that the answers equal to the average = 3. The t-test gave 3,214, which means that the null hypothesis can be rejected and that the answers are more positive than the average of 3. The score is displayed in figure 46.

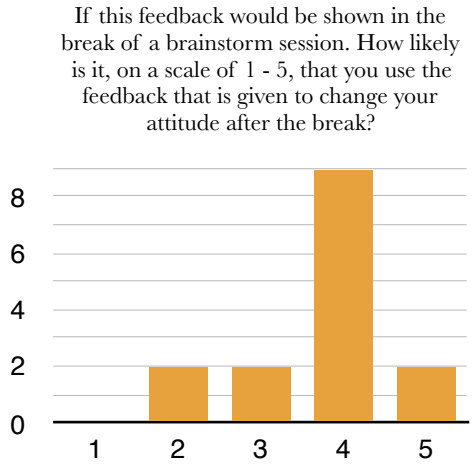


Figure 46: Likeliness of using the feedback that is given to change attitude. N=15

To check if the users understood the change in height and the colour of the bars, the following questions were asked: *What was according to you the change in colour? What did the colour show?*
6/20 users said that the colour represented the amount of interruptions. 5/20 users explained what colours they had seen. Most of these users did not mention the red colour and the yellow colour. This was also mentioned by 5 other users, which stated that the colours were not visible enough. There were 4 users who did not know what the colours meant anymore. This means that they either did not understand the explanation or did not understand it. It might be a good improvement to add a legenda so the colours are always clear.

Did you understand the change in colour? Although some users did not know anymore what the colour change meant (2/20) almost every user understood the change in colour (16/20). There were 2/20 users that said no to the question. *What was according to you the change in height?* Almost all users understood the change in height. 16/20 stated that it represented the amount of talking. This means the users understood that the height of the bar showed the amount of talking. 3/20 users explained how the bar change in height. While the remaining user said he/she did not understand.

To find out if the users were confused by the different values that were shown the following question was asked: *Was it confusing that the colour of the bar showed a different value than the height of the bar?* 2 users said that they found it confusing seeing two different values at the same time. The remaining users did not find it confusing.

After the questions about the data shown in the visualisation, questions were asked about the design of the prototype. The fist question was: *On a scale of one to five, how much do you like the design of this prototype? Why?* The answers of the users are showing figure 47. The users gave an average answer of 3.7 with a standard deviation of 0,86. This means that the overall users think the design looks good. To test this assumption a one-sided t-test was done, with the null hypothesis being that the answers equal to the average = 3. The t-test gave 3,621, which means that the null hypothesis can be rejected and that the answers are more positive than the average of 3. A user mentioned that the casing could be better and another user stated that it is very big and the remaining space could be used better.

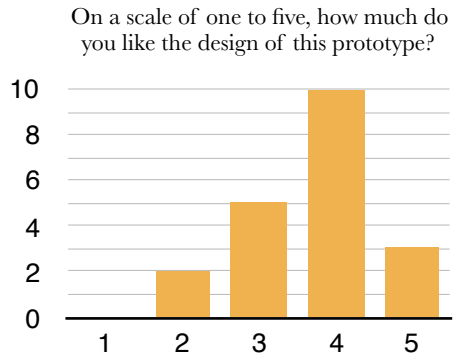


Figure 47: Answers on a scale from 1-5 about the design of the prototype. N=20

To find out what users think of the visualisation the following questions were asked: *What do you remember the most about the prototype?* The users gave diverse answers to this question. The answers that were given the most are: The noise, the movement of the bars, the bars itself, the colour of the bars, the feedback and the shape. *How did looking at this prototype make you feel? (happy, frustrated, angry, excited, bored, etc).* Just like the question what the users remembered about the visualisation, the answers to this question are also divers. The answers that were given are: Excited, Interested, curious, happy, enthusiastic, funny and even not feeling anything was mentioned. *Having looked at this product concept today, on a scale of one to five, how much would you be willing to use it once it has been refined and why?* The answers the users gave according to a scale of 1-5 are shown in figure 48. The average of the answers the users gave is 3,9 with a standard deviation of 1,02. This means that overall the users would like to try the visualisation once it has been refined. To test this assumption a one-sided t-test was done, with the null hypothesis being that the answers equal to the average = 3. The t-test gave 3,943, which means that

the null hypothesis can be rejected and that the answers are more positive than the average of 3. Most users stated that they at least would like to try it once to see if it works properly.

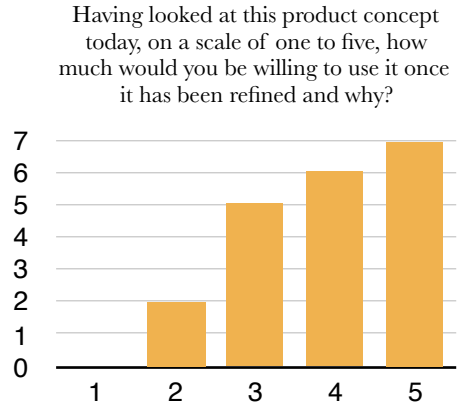


Figure 48: Willingness to use the finished visualisation. N=20

One of the main user requirements states that the visualisation needs to be easy to use and user-friendly. To find out what the users think of the usability and the user friendliness the following questions were asked. *Do you think you need a technical background to understand this visualisation?* There were 2/20 users that said yes to this question. The rest of the users said that they did not need a technical background to understand this. *On a scale of 1 to 5 Do you think this visualisation is user-friendly and easy to use?* Figure 49 shows the answers the users gave about the user friendliness and the ease of use. The average of these answers is 4.05 with a standard deviation of 0,82. This means that the users thought the visualisation was easy to use and user-friendly. To test this assumption a one-sided t-test was done, with the null hypothesis being that the answers equal to the average = 3. The t-test gave 5,688, which means that the null hypothesis can be rejected and that the answers are more positive than the average of 3.

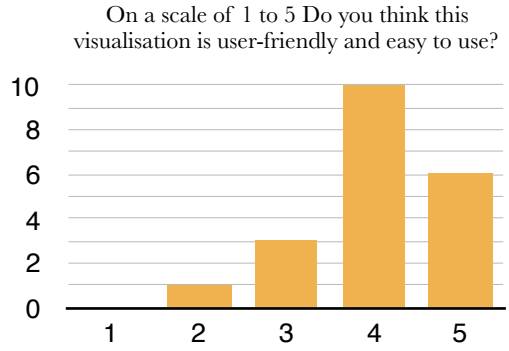


Figure 49: Answers of users about ease of use and user-friendliness. N=20

At the end of the user test, users were asked about their overall opinion. The user was asked: *What is in your opinion is the key benefit offered by this visualisation?* Users stated that it helped them become self-aware, it gave feedback, it helped people understand, it is a good way to show raw data, it gave self-reflection, it helped realise and it gives the opportunity to change your behaviour. Finally, the users were asked if they had any further remarks. Users suggested to integrate it into the table, add a reference point on the bars such as stripes, to make it less noisy, give average with more intervals instead of summed up data, make it modular and to change the colour scheme.

To conclude, this user test was done to find out what the users think needs to be changed. Questions were asked about the design, movement, colour of the bars, the height of the bars and the user friendliness. The answers of the users showed that the visualisation was clear but the colour of the lights was difficult to see. This needs to be changed, either by placing the LEDs higher in the bar or by using different colours. Especially the yellow and the red colour were not visible. Overall the users understood the concept of the amount of interruptions. It just wasn't visible enough to draw conclusions. The users liked the design and were enthusiastic about how it looked and felt. The user test showed that the users thought that it was easy to use and user-friendly. Next to the change in colour of the LEDs or LED positions the users suggestions were very useful.

5.7 - Final Prototype 3.0

By looking at the results from user test 2, a couple of improvements need to be done. The first improvement is adding plates at the side of the visualisation to make sure the users don't see the electronics. These plates will be cut out of wood and sprayed silver to change the wood look which did not really match with the white acrylic of the top plate. The visualisation with the side plates is shown in figure 50.

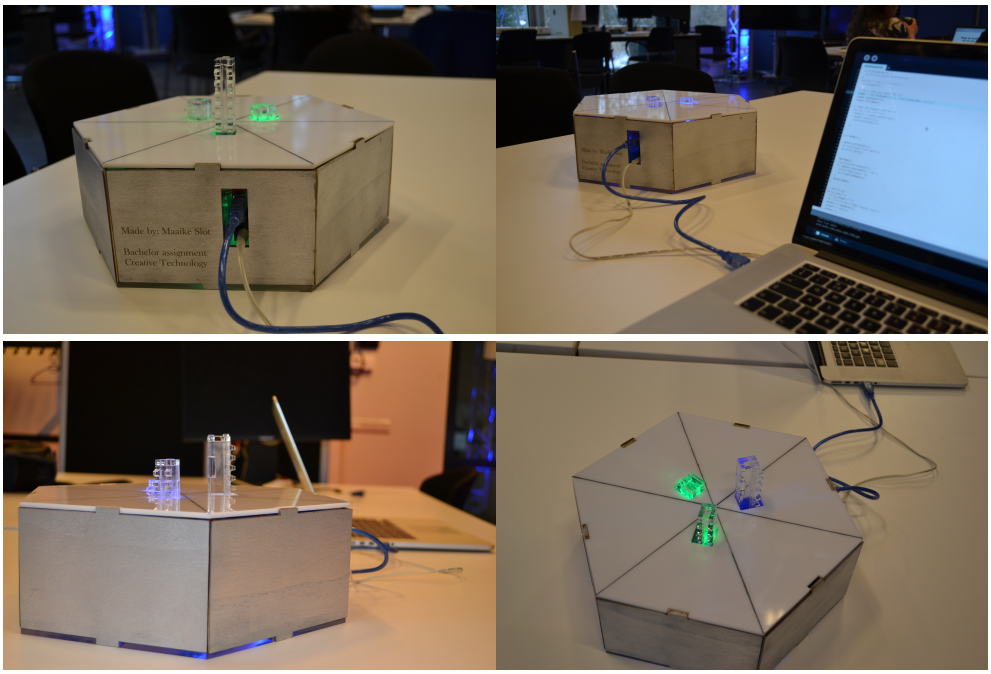


Figure 50: Prototype 3.0.

The users stated that the LED colours needed to change or the LEDs needed to be placed differently. To see if the LEDs would not hold the bars back without the side plate. The LEDs and bars are attached to each other again. The holes that were made for the cables of the LEDs is made higher so the cable will not resist the bar from moving up and down. A legend is made to give a quick view of the colours and their meaning. This is shown in figure 51.

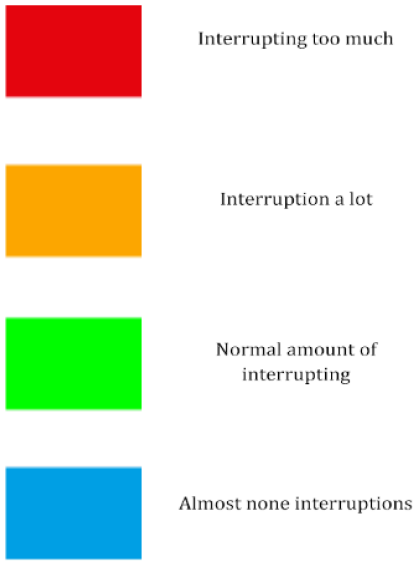


Figure 51: Legend for colour

This legend is added to make sure the users understand the change in color and when the user forgets this they are able to have a quick view of the colours.

5.8 - Conclusion Realisation phase

The realisation phase began with describing the different system components and materials that were needed to build prototype 2.0. At first, one mechanism was build out of wood to see if this worked. After testing, 3 mechanisms were built out of acrylic and the visualisation was made with all the component. During the process, the software was integrated with the system components. To make sure the users could not see the electronics a top and a bottom plate were made. The bars of the prototype was made hollow and thicker than the wooden version to make space for LEDs. Some errors were discovered and adjusted to make prototype 2.0 a fully functioning prototype. A user test was conducted to find out if the prototype achieved the design goal. The overall answers of the user test were positive. Users are willing to try it and would like to use it again. Users thought the design looked and felt good and the visualisation is user-friendly and easy to use. Some minor errors were discovered. These errors were adjusted in prototype 3.0. Prototype 3.0 is the final prototype that functions as a proof of concept for further development this visualisation.

Chapter 6 - Evaluation

As described in Chapter 2 - Method and Techniques, the Evaluation Phase evaluates on the sub questions, design goal and the functional and user requirements. This is done in the discussion which can be found in chapter 6.1. The design goal will be answered in the conclusion, which can be found in chapter 6.2. The evaluation phase will be concluded in chapter 6.3 with an evaluation of future work that can be conducted.

6.1 - Discussion

The goal of the graduation project was to design and build a visualisation of the Sociometric Badge that gives feedback on the behaviour and collaboration of the team members in a brainstorm session. Two sub question were answered to help achieve the design goal. The first question was: *What are important factors of a brainstorm session, which can be measured with the sociometric badge?* The important factors of a brainstorm session were found in the background research. The important factors have in common that everybody should get the same amount of speaking time and the same amount of opportunities to share their ideas. The Sociometric Badge is capable of measuring a lot of different variables that can be related to the import factors. The variables that are chosen to be shown by the visualisation are the amount of speaking and the amount of interruptions per user measured over time. The data is shown per 30 seconds and should give feedback to the users about their behaviour in a brainstorm session. This should encourage users to make sure everybody gets space to share its ideas.

The second sub question was: *How can the visualisation be designed to give user-friendly and easy to understand feedback on the brainstorm session to the user?* During the design process, the user was taken into account. User scenarios were described to learn more about the usage of the users. These user scenarios where translated into user requirements. The user requirements can be used to test if the visualisation is user-friendly enough and easy to use. To test the initial prototype idea a user test was done. This user test showed that the design of the visualisation worked as expected and fulfilled the design goal. Users thought that adding colour would work better than adding light intensity. The users overall said that the visualisation was easy to use and that no technical background was needed.

A second user test was done to test the third prototype. This user test tested the reaction of the users to the movement of the visualisation and the ease of use and user-friendliness. Users reacted positively to the visualisation. Almost all of the users understood what the visualisation showed and stated that they were likely to use the feedback. The user test showed that some improvement was needed with the LEDs. The colours were not bright enough and not visible enough. The user tests described above are meant to make sure the design is user-friendly and easy to understand for the users. Errors that were discovered were adjusted to make the visualisation, even more, user friendly and easy to use.

The goal of the graduation project was to design and build a visualisation of the Sociometric Badge that gives feedback on the behaviour and collaboration of the team members in a brainstorm session. To see if this goal is achieved the user requirements can be checked. The visualisation is made physical and portable, it is not obtrusive

and does not block the sight of other users. According to the results of the user tests, the visualisation is easy to use and user-friendly. Users also thought that it was inviting. The visualisation is made foolproof and is able to withstand touching to a certain limit. When real force is used, the data that is shown will not be realistic anymore. The visualisation needs a bit of explanation. During the design process, the amount of needed explanation is kept as little as possible. The users need to input the data into the excel file, start processing and run the code. The input of data is made as simple as possible and without any complicated steps.

Next to the user requirements, the functional requirements can also be used to test if the design goal has been achieved. The first functional requirements were met. The mechanism moves one bar for each user and the bar represents the amount to speaking time per user. It changes according to the different values over time and the bar change accurate enough to compare the data to each other. The user test showed that users were able to compare the data to each other and the users understood the different values that were shown.

The mechanism needed to show the data at the same time. Unfortunately this requirement was not achieved. The stepper motors move consecutively but fast enough so the changement does not require a large amount of time. The functional requirements stated the mechanism and electronics should not be visible to the user. Therefore a top and side plates were added to the visualisation. The electronics needed to be accessible even though they were hidden behind the side plates. To achieve this, the top plate is not permanently attached to the other plates but it is made removable.

The last requirements state that the mechanism should be durable, only available materials and manufacturing techniques should be used and that the visualisation should function for a long time without breaking. During the design process, choices were made to make the visualisation as durable as possible. Durability was one of the main criteria during the choice of the mechanism. The choice for the gear rack was made because the other mechanisms would possibly break quicker or were not sturdy enough to resist force from another direction. The material and manufacturing techniques that were available did have an effect on the design choices. The stepper motors that were available were not the smallest stepper motors that could be used. Therefore the visualisation became larger and heavier. To conclude, the functional requirements are all achieved with one exception. The fact that the bars do not move simultaneously does not have a large impact on the achievement of the design goal. This functional requirement can be taken into account when further development of this prototype takes place.

6.2 - Conclusion

The design goal has been achieved. This can be proven by looking at the final prototype in figure 52 and by looking at the user tests that were done. User were very positive and as described in the discussion all important user and functional requirements were met.

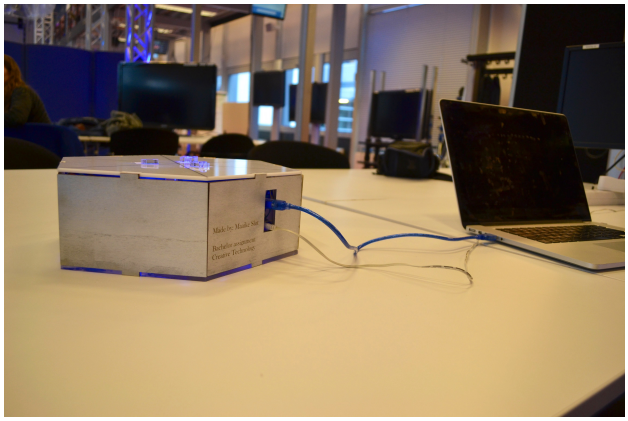


Figure 52: Picture of Final design

The final design uses the bars and coloured LEDs to show feedback about the amount of speaking of the user and the amount of interruptions a user has made per 30 seconds. This information gives feedback on the behaviour and collaboration of the team members in a brainstorm session. The users can use the information to change their own behaviour and collaborate better by helping each other achieve balance in their brainstorm. Users in the second user test stated that one of the key benefits from this visualisation is that it make the user self-aware. The idea is that everybody gets the same amount of speaking time and that the users don't interrupt each other all the time will help to improve the efficiency of the brainstorm session. The effect of the feedback on the users and whether it really has an impact on the collaboration during a brainstorm session still remains to be researched.

6.3 - Future Work

The final prototype is a proof of concept. There are several things that can be improved to make this prototype a real product. As stated before in this thesis, the data that is received from the Sociometric Badge is not real-time. There is a lot of development in the area of Sociometric Badges. When the badges are capable of sending real-time data the visualisation should be adjusted to this. During the user test, a user said that giving real-time feedback might be distracting. He suggested that the data should be shown in intervals. For example, the bars should change every minute once to show the average data of that minute.

Showing real-time data is something that might not be available in the coming years. There are improvements that can be made in the meantime. The prototype only had 3 mechanism at the moment. This can be easily multiplied and fitted into the design. This makes it possible to use the visualisation with 6 people. At the moment the bars move consecutively. This is not a problem because the users are not bothered with it. When 6 bars move consecutively this will cause a long waiting time. Therefore the code might need adjustment to move the 6 bars consecutively and faster.

The visualisation can be made leaner. More expensive stepper motors will be smaller and the mechanism can then also be made smaller. This will also reduce the amount of weight of the visualisation and will make it more portable. At the moment the visualisation is connected to a computer. For further development, it might be a good idea to send the data with the use of Bluetooth to the Arduino so it is wireless.

Further research can be done to see how users react to the feedback, if they really change and what it does to the group dynamics. With this information, the visualisation can be improved to make the information that is given even more effective. The research can also be done to find out what a phenomenon really is in the terms of brainstorming sessions. This might be a speaking turn, an event or a conversation topic. When the Sociometric Badge is capable of sending real time feedback it might be a good idea to show the data per phenomenon. This might require the software of the Sociometric Badge to analyse the data into more depth, but it will probably lead to better results in the research on the effect of the visualisation on the users.

Appendices

Appendix 1: Planning

MAAIKE SLOT - S1445871
CREATIVE TECHNOLOGY
UNIVERSITY OF TWENTE

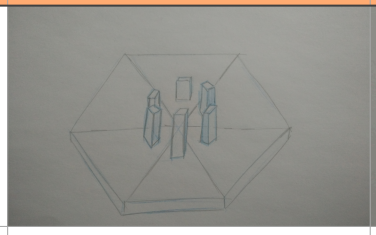
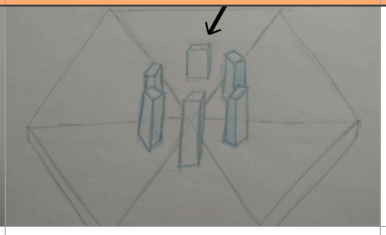
Graduation Project Planning

November 2016 - February 2017

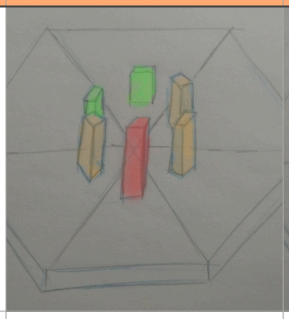
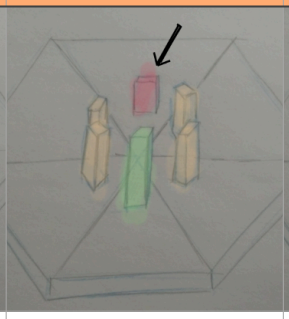
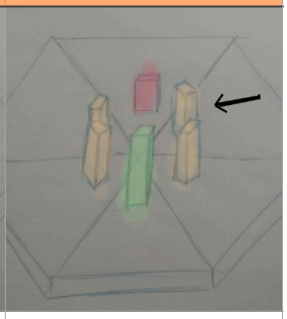
TIME	WEEK 46	WEEK 47	WEEK 48	WEEK 49	WEEK 50	WEEK 51	WEEK 52	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5
Ideation												
Documentation of design process done	X											
Making final prototype sketches	X	X										
Specification												
Make Usercases		X										
Make storyboards		X										
Rapid prototyping		X										
User testing		X										
Collecting a data set of a brainstorm			X									
Realization												
Making mechanism			X	X								
Writing code for mechanism			X	X								
Integrating output SB with code				X	X	X						
Making the bars					X							
Adding the leds					X							
Integrating mechanism with code				X	X	X						
User testing with expert users						X						
Evaluation												
adjust design according to feedback user testing									X	X	X	
last user test										X		
Report												
	finish ideation section	write specification section	write realization	...	...	...			...	...	...	finish report

Christmas Holiday

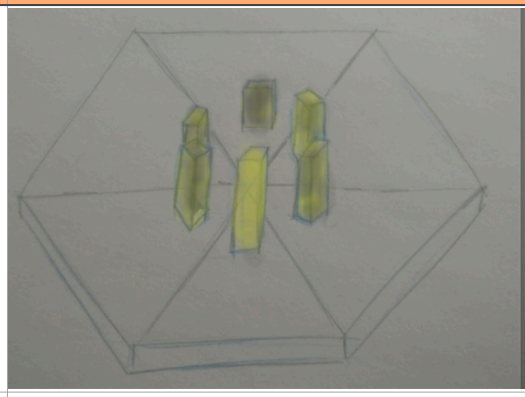
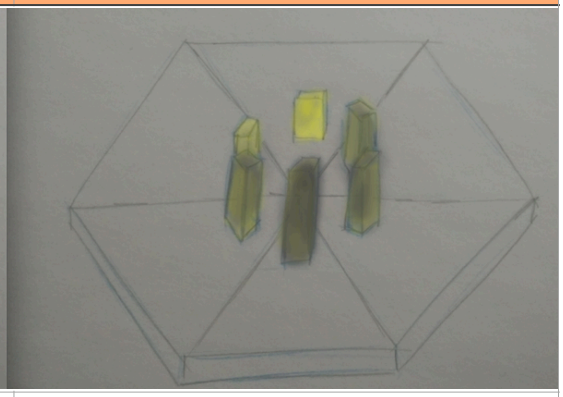
Appendix 2: User Test 1

User	Imagine that you are sitting at a table and you get this feedback. What information would you get out of this?	Imagine that you are the user at the back. What would you get from this information?	Do you think colour will add something to the design and why?
Picture shown			-
1	The big triangles are different aspects. The small cubics are indicating the amount of that specific aspect.	The cubic is small than the others. I am as that user listened more than other did. I would imagine the size of the cubic is presenting the amount of talking in the brainstorm.	It is depending on what the cubics are measuring if they indicate the amount of talk then yes other than that no. The amount of talk is not directly connected to the quality of the feedback.
2	The volume that I had used during the brainstorm, how often I had interrupted others and tips on how to guard yourself from doing so, and maybe the amount of pauses between talking so I know how efficient I get my points across.	That I haven't talked as much as the other people in the brainstorm.	You could colour code the people who are represented in the visualisation. For example participant 1 is blue, participant 2 is red, etc.
3	Some statistic relative to others sections/people at the table	That I'm relatively small/ weak relative to others.	If used wel colour could add information about the usefulness of input provided or something
4	The bar is higher so i get the impression that i am giving enough input during the brainstorm	I need to put in less input	Yes you can read that off very quickly
5	The roles of each person in the session (e.g. dominance in the conversation)	I was quite passive during the conversation	Yes, to show the amount of times you interrupted

6	That I provided a lot of input	That the person has given relatively little input, and should be engaged more	Yes, colour can provide a very clear indication. My suggestion would be to use a green-to-red colour scale which shows your level of aggressiveness in discussing

	What colour should the highest bar be? And the lowest?	Imagine that you are the red bar. What information would you get out of this?	Imagine you are the red bar at the back. What information would you get out of this?	Imagine you are the orange bar. What information would you get out of this?
picture shown				
1	The highest bar should be red and the lowest blue	If I was the red bar the I would get the information that I would talk a lot.	I was not present or I was not responding a lot.	I would be statisfied while the majority of the group is orange
2	The colour should not represent the same data as the height, then you are using two encodings for one set of data. Which is confusing.	I talked a lot and I interrupted others a lot.	I did not talk a lot but did interrupt very often. Probably due to the fact that others were not providing me with time to speak up, needing to interrupt others to be able to contribute to the brainstorm.	Don't know, but I would assume that I talked an average duration and interrupted an average amount of times.
3	Green to red if its the same as height, but I would not line them, then it would be redundant information	I talked a lot but didn't add much	That I obviously sucked and was silent	That I talked averagely and was average.
4	Highest: Light blue, Lowest: Green	Red is negative. I have given to much input	I did not give enough input	I am in the middle with my input

5	I would not colour based on activeness but on interruptions	Loudest person in the conversation	Passiveness in the conversation	Medium activeness in the conversation
6	Colour should be independent of bar height	Maybe I should stfu	That I should spew more bullshit	That I should increase the amount I talk in order to be appreciated

User	Do you think that the intensity of light will add something to the design?	Which bar should be the lightest and which bar should be the darkest?
Picture shown		
1	No, I think the better option is to go for the different colouring.	The darkest should be the one which said less and the light one should be the one which said the most. The light one is the one which is most present is a discussion.
2	Yeah, I think so, but I feel that the shift between white and colour or black and colour would be more fitting. Intensity is hard to distinguish.	The bar that is the lightest should be the person who talked the most clearly? Otherwise, it could represent the amount of pauses that a person takes while talking? Or the amount of questions he puts forward.
3	maybe more than colour it could show quality. (the 'lightbulb' factor/index of ones contribution)	best idea's or most useful person or something should be lightest
4	Yes, it puts the focus on people who are the talking the most and who are talking the least	The highest bar has to be the lightest and the lowest the darkest
5	I think it's as effective as green-red scale	Darkest = most passive
6	Yes, it gives a clear but non-judgemental indication of participation	Lowest bar should be lightest, because they should be pushed to provide more input

User	I would like to use this feedback tool while brainstorming	I think the feedback tool is unneccessarily complex	I think the feedback tool will be easy to understand	I think that I would need the support of a technical person to be able to use this feedback tool	I can imagine that most people would learn to understand this system very quickly
Picture shown	-	-	-	-	-
1	3	3	2	5	2
2	3	5	1	5	1
3	3	4	2	2	2
4	2	5	1	5	1
5	2	3	5	1	5
6	4	4	1	5	2
Average	3	4	2	4	2

On a scale from 1 - 5, agree - disagree

User	Using the feedback tool in a brainstorm would improve my creativity	Using the feedback tool in a brainstorm would improve my collaboration with the group	Using the feedback tool in a brainstorm would improve my attitude during the brainstorm	Using the feedback tool in a brainstorm would improve my contribution to the brainstorm	I need to learn a lot of things before I can use the feedback tool
Picture shown	-	-	-	-	-
1	5	3	3	3	3
2	4	3	3	4	5
3	3	3	2	3	3
4	4	2	3	2	4
5	2	4	4	4	1
6	3	3	3	3	5
Total	4	3	3	3	4

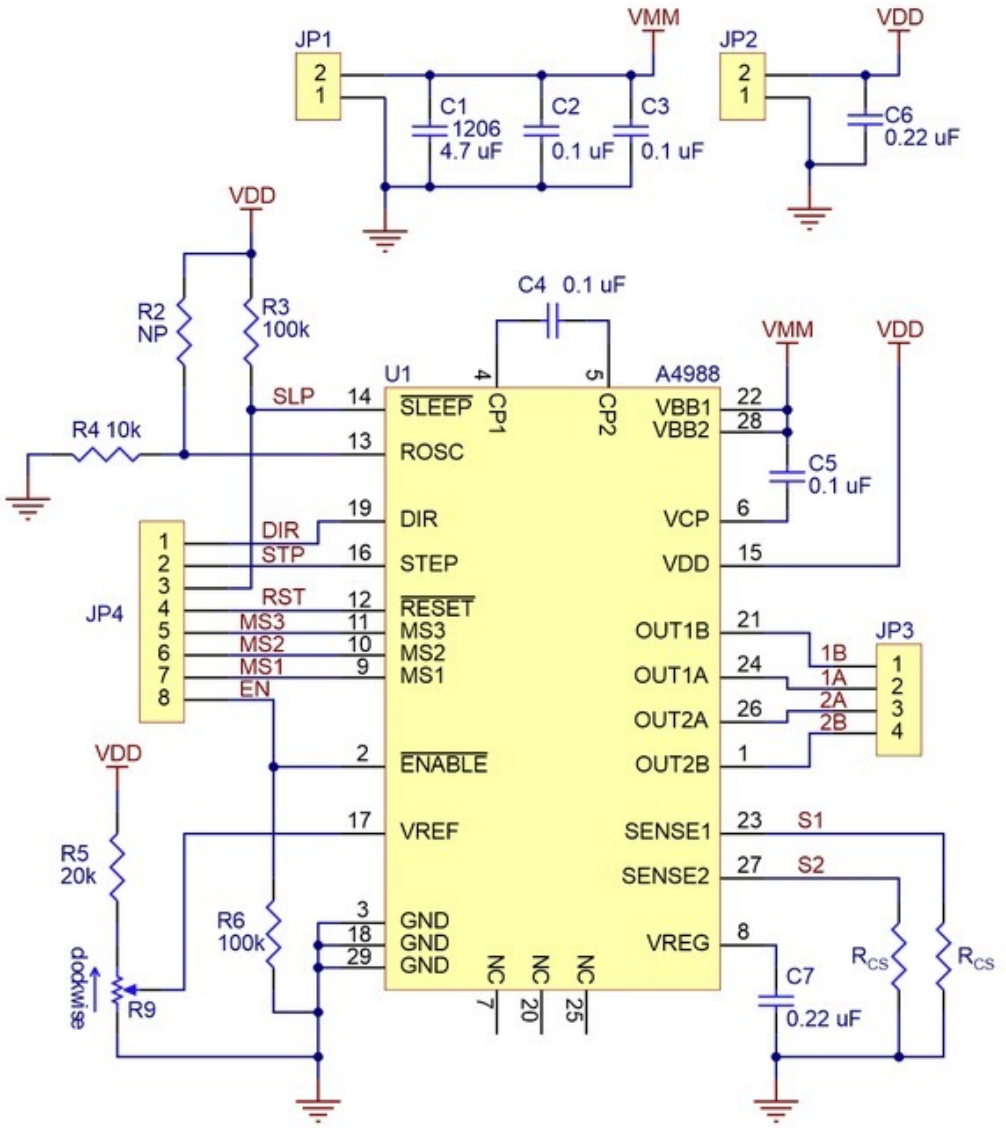
On a scale from 1 - 5, agree - disagree

User	I think the feedback tool needs to show this information:	Any further suggestions?
Picture shown	-	-
1	Legenda of what the meaning is of the bars and their colour. I would like to see a more relative value.	The hexacle has a lot of free space. The size/ colour of each part could also differ.
2	How clearly you have talked, and maybe a transcription of the brainstorm?	I think I contribute to a brainstorm fairly well already, but there might be missing something I don't know is a problem. Therefor it is hard to know if I have any use for this product.
3	Quality is a something that, if possible should be included	
4	Maybe add the value of your input, there are many people who just say random stuff. and there are popel who tell less but have good ideas	
5	When the person speaks the most (beginning of conversation or end)	
6	The think the feedback tool should show the aggressiveness of discussing of people, in order to give feedback to people that overrule others by raising their voice.	Quiet people often have deep thoughts, but might not like to talk much. Should you force people to have equal time speaking during a brainstorm?

Low	High	Comment
-	Red	
-	-	I would not colour based on activeness but on interruptions
Green	Red	
Green	Blue	
Green	Red	
-	-	Colour should be independent of bar height

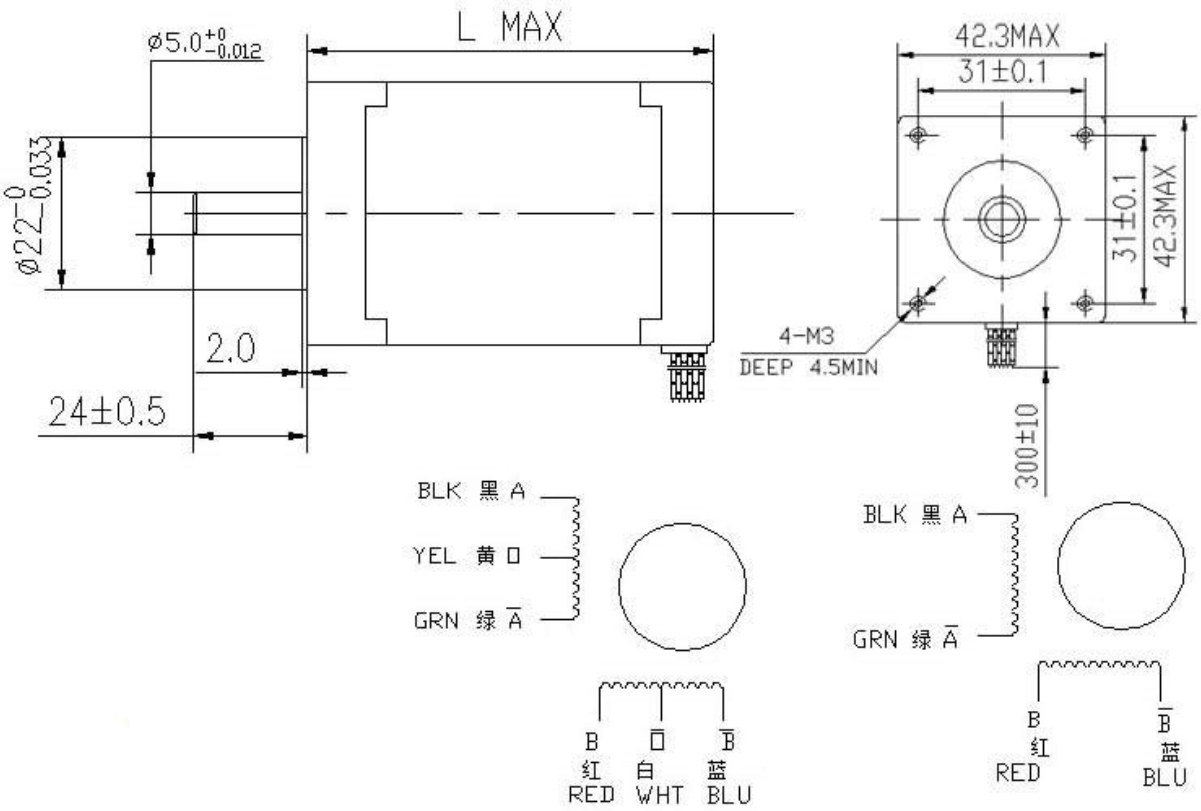
Table 3: What colour should the highest bar have? and the lowest?

Appendix 3: Driver pinout[22]

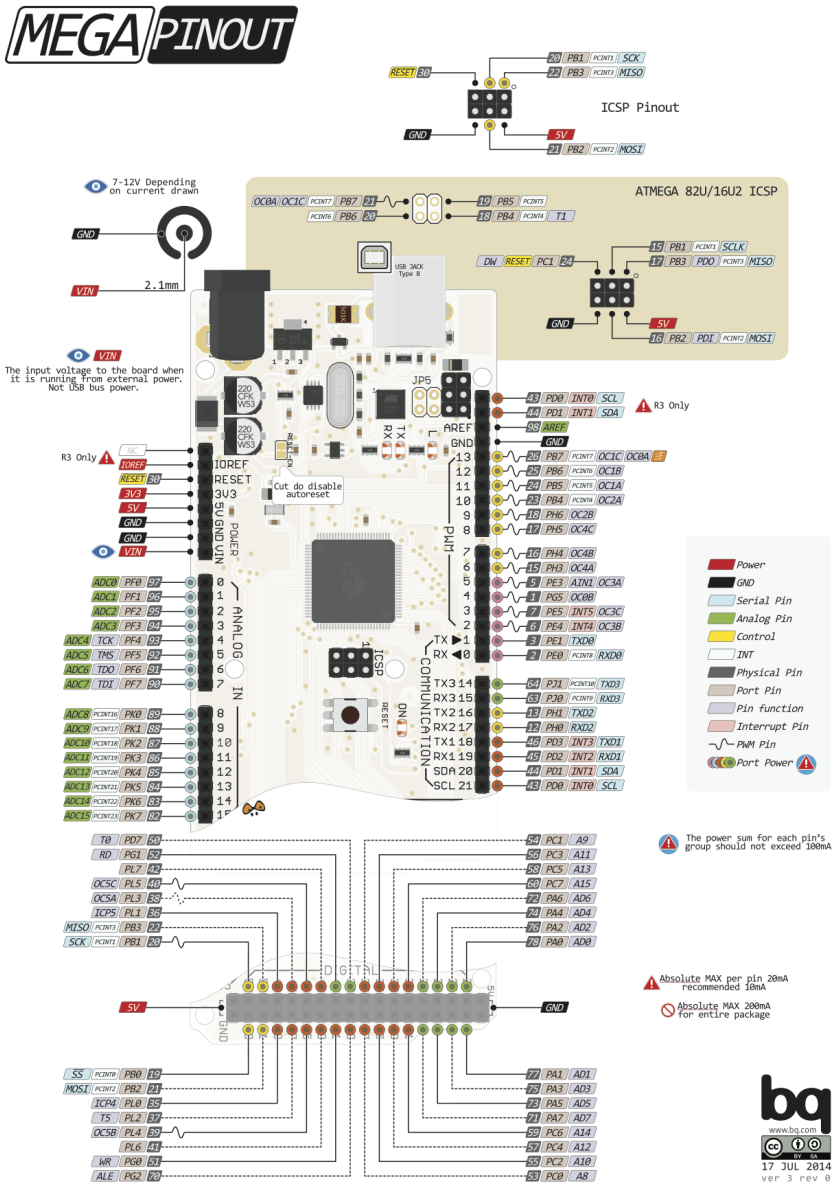


R_{CS} is **50mΩ** for units with green resistors and **68mΩ** for units with white resistors

Appendix 4 : Layout Stepper motor [26]



Appendix 5: Arduino Mega pinout [27]



Appendix 6: Arduino Code

```
/*
 Stepper Motor and RGB LED Controller
 language: Arduino

 This program is made to control a visualisation of the sociometric badges
 It controls steppers and LED according to the gained data received from the serial port

The stepper and LED pins need to be adjusted when connecting in a different way.

 Created Dec. 2016
 Modified 4 jan. 2017
 by Maaike Slot

 */
#include <Stepper.h>
//defining pins of the steppers
Stepper stepper1(100,11,10);
Stepper stepper2(100,9,8);
Stepper stepper3(100,7,6);

// declaring pins of led 1
int redPin1=42;
int greenPin1=44;
int bluePin1=46;
// declaring pins of led 2
int redPin2=36;
int greenPin2=34;
int bluePin2=38;
// declaring pins of led 3
int redPin3=26;
int greenPin3=30;
int bluePin3=28;

//making variable for led 1
int tempCol1 =0;
int newCol1 =0;
//making variable for led 2
int tempCol2=0;
int newCol2=0;
//making variable for led 3
int tempCol3=0;
int newCol3=0;

//making variables for stepper 1
int currentPos1 = 0;
int tempPos1 = 0;
```

```
int newPos1;
//making variable for stepper 2
int currentPos2 = 0;
int tempPos2 = 0;
int newPos2;
//making variable for stepper 3
int currentPos3 = 0;
int tempPos3 = 0;
int newPos3;

//making an array and variable for the received data from serial
int value[] ={0,0,0,0,0,0,0};
char headers[]={'a','b','c','d','e','f','g'};
String buff;



void setup(){
  Serial.begin(9600);

  // set all the led pins to OUTPUT
  pinMode(redPin1,OUTPUT);
  pinMode(greenPin1,OUTPUT);
  pinMode(bluePin1,OUTPUT);

  pinMode(redPin2,OUTPUT);
  pinMode(greenPin2,OUTPUT);
  pinMode(bluePin2,OUTPUT);

  pinMode(redPin3,OUTPUT);
  pinMode(greenPin3,OUTPUT);
  pinMode(bluePin3,OUTPUT);
  // set the speed of the steppers
  stepper1.setSpeed(200);
  stepper2.setSpeed(200);
  stepper3.setSpeed(200);
}
void loop(){
  serialRead();
  colourLed();
  setStepper();
  //Serial.println("ColourStepper done");

}
void setStepper(){
//read values for stepper
  newPos1=value[1];
  tempPos1=newPos1;
```

```
  newPos2=value[3];
  tempPos2=newPos2;
  newPos3=value[5];
  tempPos3=newPos3;

  //move steppers 1
  stepper1.step(tempPos1-currentPos1);
   //move stepper 2
  stepper2.step(tempPos2-currentPos2);
    // move stepper 3
  stepper3.step(tempPos3-currentPos3);
    //set values to new position
  currentPos1= tempPos1;
  currentPos2= tempPos2;
  currentPos3= tempPos3;
}

void colourLed(){
  //read values for leds
  newCol1=value[0];
  tempCol1=newCol1;
  newCol2= value[3];
  tempCol2=newCol2;
  newCol3=value[5];
  tempCol3=newCol3;

   //-------------Setcolour function for led  1----------------------
  void setColour1(int red, int green, int blue){
  digitalWrite(redPin1,red);
  digitalWrite(greenPin1,green);
  digitalWrite(bluePin1,blue);
  }
  //-------------Setcolour function for led  2----------------------
  void setColour2(int red, int green, int blue){
  digitalWrite(redPin2,red);
  digitalWrite(greenPin2,green);
  analogWrite(bluePin2,blue);
  }
   //-------------Setcolour function for led  3----------------------
  void setColour3(int red, int green, int blue){
  digitalWrite(redPin3,red);
  digitalWrite(greenPin3,green);
  digitalWrite(bluePin3,blue);
  }

   //-------------function to read the serial----------------------
void serialRead() {
    if (Serial.available() > 0) {                     //if the serial is available
```

```
    while (Serial.available() > 0) {
      char in = Serial.read();                    //input the data from serial to in
      // if (isDigit(in)) {
      buff += in;                                 // add these chars to the buff string
      // }
      //Serial.println(buff);
      if (in == '\n' || in == ',') {              // if an enter or a comma is detected
       // Serial.println("found space");
        char c = buff.charAt(0);                  //c = the char at 0
        buff = buff.substring(1);                 // buff = the rest of the string
        for (int i = 0; i < 7; i++) {
          if (c == headers[i]) {                  // c is equal to the header
             value[i] = buff.toInt();             // the rest of the buff is loaded into the
array value as int
            //Serial.println(headers[i]);
            //Serial.println(value[i]);
          }
        }
        buff = "";                                // after this empty the buff again
      }
    }
   }
  }

   //-------------Setcolour function for led  1---------------------
  void setColour1(int red, int green, int blue){
  digitalWrite(redPin1,red);
  digitalWrite(greenPin1,green);
  digitalWrite(bluePin1,blue);
  }
  //-------------Setcolour function for led  2---------------------
  void setColour2(int red, int green, int blue){
  digitalWrite(redPin2,red);
  digitalWrite(greenPin2,green);
  analogWrite(bluePin2,blue);
  }
   //-------------Setcolour function for led  3---------------------
  void setColour3(int red, int green, int blue){
  digitalWrite(redPin3,red);
  digitalWrite(greenPin3,green);
  digitalWrite(bluePin3,blue);
  }
```

Appendix 7: Processing Code

```
/*
 Data reader from excel and serial reader and writer
 language: Processing java

 This program is made read the data from an excel file and send it over the serial port

 Created Nov. 2016
 Modified 5 jan. 2017
 by Maaike Slot
 */

import processing.serial.*;
import de.bezier.data.*;

Serial myPort;
XlsReader reader;

private int[] val = new int[widthFile]; //inputs values into integer array of data
private static final int widthFile = 7; //input the amount of values on one row
private char headers[] = {'a', 'b', 'c', 'd', 'e', 'f', 'g'};
//String[] head = new String[widthFile]; //inputs headers into string array of headers
//private String title;

void setup() {

  // set up of serialPort
  try {
    String portName = Serial.list()[1];
    myPort = new Serial(this, portName, 9600);
  }
  catch(Exception e) {
    println("no ports available");
  }
  for(int i = 0; i < widthFile; i++) {
    print(out());
  }
  // This reads and opens the xls
  reader = new XlsReader(this, "smallbadgedata.xls");//input file here
  reader.openSheet(1);
  reader.firstRow();

/*// Read the headers and set it
  for(int i =0; i<widthFile;i++){
    head[i] = reader.getString();
    reader.nextCell();
    //println(head[i]);
```

```
 }
 */
}

void draw() {

 myPort.write(out());
 println("data from table");
 println( out());


 NextRow();
 //println(serialRead());
 if (myPort.available() > 0) {
  print("data back: ");
  print(serialRead());
 }
 delay(5000);
}

// define out
String out() {
 String output = "";
 for (int i = 0; i <val.length; i++) {
 output += headers[i];
 output += val[i];
 output += ',';
 }
 return output;
}

String serialRead() {
 String buff = "";
 while (myPort.available() > 0) {
  buff += (char)myPort.read();
 }
 return buff;
}

void NextRow(){
 reader.nextRow();
 for(int i=0; i<widthFile-1;i++){
  reader.nextCell();
  val[i] = (int)(reader.getFloat()*20); //gets value and multiplies by 20
 }
 delay(4500); //the delay to set to the next row
}
```

Appendix 8: smallbadgedata.xls

This link leads to the online version of the smallbadgedata.xls:
https://drive.google.com/file/d/0B1KzPgFMFLyJZXRKaXJmeHZaLVU/view?usp=sharing

Appendix 9: User Test Prototype 2.0

First show the visualisation but do not let it move or change colour. Only state that it is a visualisation

Questions before test:

User	Age	Gender	Study
1	20	M	CreaTe
2	19	M	CreaTe
3	22	M	CreaTe
4	19	V	Atlas
5	21	M	CreaTe
6	23	M	CreaTe
7	21	M	CreaTe
8	19	V	Atlas
9	21	V	Psychology
10	22	M	CreaTe
11	24	M	CreaTe
12	22	V	CreaTe
13	22	M	CreaTe
14	24	V	CreaTe
15	18	V	CreaTe
16	21	M	Psychology
17	22	V	CreaTe
18	53	M	Civil engineering
19	52	V	Psychology
20	24	M	Engineering and Management

User	What feeling do you get if you see this visualisation?	On a scale from one to five how eager are you to try this visualisation?	If this visualisation would be on the table during a brainstorm would you be distracted?
1	Starwars like feeling, looks like the double wing	4	Yes it gives lights and it depends if it's moving or not.
2	I am feeling bleu, calm rest	4	if it doesn't move too much and has some intervals it wouldn't distract me
3	Looks nice with the colours	4	No, because i don't know what it is going to do
4	Curious what it does	5	Yes because I am easily distracted
5	Really interested	5	As long a i don't know what it does yes
			Would you be distracted by this visualisation during a brainstorm?
6	It's blue and looks pretty good	4	Yes, Because there is a thing in front of me
7	Curiousity, i already know what it does	4	Probably, Cause I am already easily distracted, especially with something new and with lights and because it is interactive or its gonna be
8	I looks modern, it feels like it a measurement thingie	4	No, Its a simple minimalistic design.
9	Difficult, hard to make, very technical, A bit misterious	5	Yes, I am easily distracted by things.
10	Beautiful, looks like a pie and is very interesting.	3	Yes, but not more then usual
11	It look pretty hip	4	Yes, because the lights attract attention and I am easily distracted.
12	I am very curious	5	If i don't know what it is yes, if i do know it is, then it depends on what it does.
13	Leds, It looks good, But I don't really feel something for it	4	It does not work yet so no
14	Looks like Pie, it is abstract, modern and does not really show anything yet	4	If I know how it works, probably not. The first time that I look at it I might be more distracted then when I am used to it.
15	Hexagon	4	No not really
16	Wood	3	Depends on how it works
17	The colours	3	Yes I probably would be
18	Wat does it do?	4	I don't know what it does yet so i don't know

User	What feeling do you get if you see this visualisation?	On a scale from one to five how eager are you to try this visualisation?	If this visualisation would be on the table during a brainstorm would you be distracted?
19	Blue, light,	5	Yes, I am already
20	It looks good	3	No not really

First explain: This is the SocioMetricVis, this visualisation is made to provide information, the interactions within the brainstorm session. The SocioMetricVis works with the Sociometric Badge. This is a sensor which records the group dynamics. How much you speak, how much you have interrupted someone and if your pitch has changed etc.

Imagine that you are in a break of a brainstorm session. During the brainstorm session the data was recorded that will be shown to you now. The data will not be recorded life and the data that is shown is not your own data. I would like you to look at the visualisation and afterwards I will ask you some questions. The height of the bar is equal to the amount of talking you have done and the colour of the bar represents the amount of interruptions you have made while others where speaking. kleur legend, welke bar is de pesoon en ze moeten nara de bar kijken

* show the visualisation* The data of user 3 was show to everybody.

Questions asked afterwards

User	What have you interpreted from the feedback that was given to you about your "behaviour" in the brainstorm?	If this feedback would be shown in the break of a brainstorm session. Would you use the feedback that is given to change your attitude after the break?	What was according to you the change in colour? what did the colour show
1	That i have talked a lot, The colour might not be clear. Explain the colours or make them more clear.	Yes I think so especially for the speaking an interruption	The amount of times i interrupted
2	I was talking a lot, I did not interrupt.	No I am stubborn	I was looking into the visualisation because i could not see the colour very well. The only change i saw was nothing to green and then i assumed the nothing was red.
3	That I do talk a lot but I don't interrupt people, so the other people are really quiet	No I don't think so, if it were to be red then I would, It shows that I talk to much, so it's up to them to talk more.	I went from blue to green. and then to blue and green.

User	What have you interpreted from the feedback that was given to you about your "behaviour" in the brainstorm?	If this feedback would be shown in the break of a brainstorm session. Would you use the feedback that is given to change your attitude after the break?	What was according to you the change in colour? what did the colour show
4	That I have talked to much maybe I need to be more quiet. Interruption gives advise.	Yes, it depends on the people that attend the session. I would then support then	It had a large amount of green, So I did not interrupt a lot
5	That i was probably talking a lot so I had great ideas to share	Yes, because a certain level of speaking means producing too much, this is annoying	It was difficult to see
		If this feedback would be shown in the break of a brainstorm session. How likely is it, on a scale of 1 - 5, that you use the feedback that is given to change your attitude after the break?	
6	I was talking a lot, starting slower and later I talked more	4 Depends if other people find it intrusive. I would check with my team member.	Interruptions
7	Apparently I was contributing a lot. I thought that the visualisation was going to move only once. I couldn't see the red colour. But the green and blues were very clear.	5 If this becomes part of this brainstorm you can see how well you have done and everybody will use the feedback and information to go on in the brainstorm.	It would be a good indicator if I talked to much
8	I haven't made a lot of interruptions and I did not talk that much but the amount of talking was kind of even distributed. There was not one person very dominant.	4 I think mostly that if you are the red and the heigh person you need to think by yourself that it needs to be changed. This could help.	It showed if you let people talk, you might get more quiet. Green is not bad
9	I did good, I was contributing to the conversation and the colour was mainly green so I behaved well.	4 If I notice that I am red then I need to rethink if I am doing the right thing	Green or blue, i did not see red or yellow
10	I talked a lot, did not interrupt much. I saw that the bar was high and that I tried to compensate it	4 I am aware that I talk to much, Suddenly this is visible that i talk to much. I would try to help someone to speak more. Especially user 2	It was shown by the leds
11	I talked a lot and I am probably the person who has the lead.	4 I would slow down. but then i would want to see it again after the brainstorm to see my progress	It should only show green yellow red.
12	I was distracted so I only saw the start and that I did not interrupt a lot.	5, I would let other people talk more if the bar is to high	I tried focusing on it but it was difficult
13	I talked a lot which is not a bad thing. It depends on what I want to do. If I am a leader of the brainstorm or someone else does not speak enough. Depends on my role.	4 If it works, and you look at it. After a few times and you understand it i would use and talk about the shown results. I would pay more attention,	It did not turn red right?

User	What have you interpreted from the feedback that was given to you about your "behaviour" in the brainstorm?	If this feedback would be shown in the break of a brainstorm session. Would you use the feedback that is given to change your attitude after the break?	What was according to you the change in colour? what did the colour show
14	I don't know. It is to difficult to see the relation. I would like to see an average of the whole brainstorm.	4 If it works but with a couple of factors, if you hear the feedback from others, this could be a reference tool. It depends on if you can relate to it.	I did not watch the colours
15	I need to talk more (data set 2 shown instead of 3)	3 would like to see the amount of input, but i don't like it to force me to give input. can be difficult	It showed interruptions
16	I think I thought the subject was very interesting because I talked a lot.	2 I would rater see a graph.	I think it showed something like the amount of speech
17	I was very loud	3, I would try to change my behaviour but i am not sure it would add something	The amount of interruptions
18	I talked more then the others	4, I think i would help the others to talk more	The interruptions
19	That I did not interrupt a lot but that i was talking all the time	4, I would discuss it with everybody but i am not sure if this will affect how i will behave	The times I interrupted someone else
20	I need to be more quiet and let others speak more	2, I think the others should speak more	It went from green to blue and back. Did not see other colours as you described

User	Did you understand the change in colour?	What was according to you the change in height?	Was it confusing that the colour of the bar showed a different value then the height of the bar?
1	Not really, green and blue do not give you a specific measurement.	The amount of time I talked	No not really
2	Yes, because I am a creater.	The change in height showed high and low and then high again.	No because you explained if at the beginning
3	A bit, they were mostly green and blue, the blue colour was difficult	I did not think the height was the biggest so it was an easy conversation	No not really because they are 2 different variables.
4	Yes, I would prefer blue as a neutral colour. so green not at all, blue in the middle an red not at all.	Red misses, I think it showed the amount of talking	No, because you explain
5	It is clear and simple	I talked to much in comparison to the rest of the group	No

User	Did you understand the change in colour?	What was according to you the change in height?	Was it confusing that the colour of the bar showed a different value then the height of the bar?
6	Yes, It was not a big change	How much you talked	No you should give people more time.
7	I was interrupting a lot and at the end it went to green so yes.	For me it would be more logical if the indicator of height would be for the interruption	No, the colour range made sense, because you had a value of it and it was almost the same as these height The data collates to each other.
8	Yes , it was explained before.	How much i talked.I am constantly comparing the height. did not look at the colours	No it were just two data points. You know what they mean it was not confusing
9	Yes, did not see yellow.	How much i talked in what amount	No
10	Yes, interruption	Amount of speech	No I think they match
11	yes, but it might not be the best	The amount of speech	No
12	Yes, just a scale	The height showed the amount of talking it thin	Yes i could not see my own colour
13	Yes it was clear	How much i have talked during the conversation	Not noticeable
14	Bleu was normal green not, I would have understood, but i forgot. a legend would be good.	It went from high to low. I was more heigh then low.	I could not watch both, but that might be a point of practice, it might be good to give people the option to choose whether they wanted a playback or an average.
15	No needed explanation	You explained it… height was amount of speach	No they are separate from each other
16	Green is the middle colour, led could be more clear	I talked a lot	I don't think so can imagine that it could be confusing
17	Yes	the amount of talking	No
18	Yes you explained	How much i have talked during the brainstorm	No, it was clear
19	Yes but i did not see the red and the yellow	It was really high and it showed that i talked too much	No I understood the difference
20	No, I could not see any real change except the blue and the green	The height showed the amount of talking	No but it was difficult to watch both

User	On a scale of one to five, how much do you like the design of this prototype? Why?	What do you remember the most about the prototype?	How did looking at this prototype make you feel? (happy, frustrated, angry, excited, bored, etc)
1	5, it looks really cool	The noise, It a really scifi noice which i like, it would be distracting if you use it during the session but in the break it would not be a problem	Excited and interested,
2	4, it needs to be prettier	Green	Interested.
3	3, It look really neat and it moves nice but the functionality is not there yet,	The movement	Excited curious
4	4 ,needs casing. it does not distract but the noise is distracting.	The colours and the led lights. The movement shows something which is good	Interested,
5	5, cant think of things that don't work , clear, simple, does what i needs to do.	The colours and the bars	Interested and curious
6	5, First of all i really like the cube and that it is all fitted into , simplicity, light make it nice	It was pretty fast movement, And it was not as intrusive as i thought it would be.	Happy
7	4, maybe change the gear into pistons to make it look more sleek it reminds me of boston dynamic tables.	Asking myself why it kept moving and realizing that is was a playback.	A combination of happy and curious
8	3, You miss things. If it was done it would be good.	The feedback while you are talking.	Interested
9	4, Very nice , it does not say much and that makes it interesting. what does it do.	The noises and it is very special that it react to your voice.	Enthusiastic en funny, happy,
10	2 , could be used within a corporate thing	The bars. The fact that i can see how it works. I think that is good.	Interested,
11	4 I like it, maybe a more fancy top plate	The noises , i liked it.	Funny/ interesting
12	4, but it is still a bit big for a small part.	The shape.	Curious
13	2 it looks good. the disadvantage is that it is not flexible there are three users now. It works less for 4 people. Maybe more flexible.	The fake brushed aluminum, i liked it.	Excited
14	4, it looks good might need a bit more finishing touch. Make it one colour. Put subtle lines in it.	The change that you did not expect. It is very important to show clear results.	Curious
15	4 like the colours very basic simplistic, would like the bars to be different	The colours the silver side glass and the plexiglass.	Did not feel a thing
16	4 modern	The measurement	Did not feel anything

User	On a scale of one to five, how much do you like the design of this prototype? Why?	What do you remember the most about the prototype?	How did looking at this prototype make you feel? (happy, frustrated, angry, excited, bored, etc)
17	3, It does not fit properly and the light are not good.	The noise of the bars and the gears grinding	Interested and curious
18	3. You should give it a tight casing and maybe make the bars bigger	The light of the bars	Excited curious
19	4 it looks good	The hexagon	Happy and interested
20	3. I think it needs a finishing touch but it looks good for a prototype	The movement of the bars	Mainly curious

User	Having looked at this product concept today, on a scale of one to five, how much would you be willing to use it once it has been refined and why?	Do you think you need a technical background to understand this visualisation?	On a scale of 1 to 5 Do you think this visualisation is user-friendly and easy to use?
1	4 or 5, I would really like to try it, would not be sure if i would really use it a lot	No not at all	4
2	3, I think it would be helpful but it is depending on the integration and the look/design	No but a bit of explanation beforehand is very useful	4
3	2, if i were a professional brainstormer, i would definitely try it. see how good it works	No	4, you should understand how the height and the colours work
4	4, I talk to much so i would like the feedback and I think others would to	No	4
5	5, Same a before, I would like to use this in a meeting to make it constructive.	No	5
6	4, if it would be a bit smaller and if it would add something.	No, it is not very technical is it, it is moving bars.	5 it is plug and play.
7	3, depends on how much brainstorming i am going to do. It is really nice for a big group. But for 3 people it might not add that much. With few people you can attend them more easily	No,	5 if the badges don't need configuration
8	5, I would like to get feedback	No	4
9	5, I did social studies and i would like to use it to see how i could improve in the conversation	Yes	5
10	5, Often you have different roles in a brainstorm session. I think it might replace the role of the organizer. This would make everything more structured	No	4
11	4, Because I would like to try it and I am curious about my own results.	No	4

User	Having looked at this product concept today, on a scale of one to five, how much would you be willing to use it once it has been refined and why?	Do you think you need a technical background to understand this visualisation?	On a scale of 1 to 5 Do you think this visualisation is user-friendly and easy to use?
12	5 i would try it at least once to see if it works well and if it helps	No not really, but i think a explanation is a good thing	3, just because you need an explanation
13	3 i would like to try it at least once, would not buy it though but for a project i would like to use it.	No	4. needs explanation
14	5, i would be curious to use it.	No, with a good legend a good design it would be easy to use	2 if you add a button and a good user interface.
15	3 i don't know if i would use it, try it once	No	5
16	4 i would like to try it in a real setting	No , but the colours need change	4
17	4, There is need for it so I think it would help.	No	4
18	3, I think it is interesting	No, not really	3
19	2, I don't know if I would buy it	Yes	3
20	5, Definitely	No	5

What is in your opinion is the key benefit offered by this visualisation?

1. The self awareness of the amount of how the person speaks and especially of ho much the person interrupt it is not necessarily bad but you have to be self aware of it.
2. Feedback geven over hoe een discussie gaat en een vergadering gaat. Het is erg belangrijk in context met persoonlijkheden , sommige mensen hebben meer feedback nodig.
3. Basically for people who interrupt a lot they will see how much they do, Most of them don't know this or don't pay attention to this, for the people who don't participate it is important
4. That it shows how much you talk, because it reminds me to be quiet once in a while, because you don't notice
5. It makes it more constructive and effective to brainstorm

6. That is actually gives you feedback. Maybe you remember it differently but this are facts.
7. Giving feedback on things that you don't pay attention to during a brainstorm
8. Instant feedback while you are having your discussion.
9.You can show people what kind of role they have during a meeting
10. Sometimes someone knows he or she talks a lot but this it the proof to make it objective in stead of subjective
11. I think it is an easy way to show raw boring data and to discus it to. especially to show people to change and let the realise
12. It offers you a opportunity to develop yourself, how you brainstorm and if you interrupt people. To improve yourself

13. Self reflection, I don't know if it changes something. but I reflect a lot. This does show data and I am interested if it is the same as my thought about the conversation.
14. Reflection and group process improvement.
15. You can use it to see how people talked , interruption are important
16. You get a good idea of what happens,
17. It give you information on how to change
18. I think it help you to realise how dominant you are. Especially when you are not aware of the amount that you have talked
19. Giving people the opportunity to help others speak more and the people speak less
20. Normally you think you know how you have acted in a meeting but now you will see the reality

Feel free to annotate any changes or corrections that you feel would improve this concept

1.The led cables can be adjusted to more flexible, change the colour scale make it from light green to firm red.
2. Integrate it into the table.
3. The smaller values might not be seen. More of a scale might be added. Something you can revert to. a referential point.
4. The sound is distracting. Maybe the bars could have stripes to show the values of the height
the led's could be brighter
5. The side plates need to be added

6. I like it but I do think you could have put 6 in there.
7. I am really curious if the playback or one average on the whole brainstorm. Maybe if it would be more silent it would work very well with a interval during a brainstorm.
8 No
9 Change yellow to another colour. That is more obvious, Pink! Change the noice
10 If the role of the leader of the brainstorm can be replaced by this visualisation then it has two tasks, taking care of the people that say to much and activating and motivating the people who are not.
11 No. Interview
12 It is very big for what it does
13 Fix the red light. the shape is a bit to static. maybe make it modular.
14 The remote and the average, I would show the average. It does something now and it needs a function and should be more clear. It must be something relevant.
15 I would like to see the quality
16. They might get more information that you missed. I would like a combination.
17. Make the bars less noisy, then it will be less distracting
18. Maybe make it less height? and the bars should be bigger
19. -
20. Change the colour scheme of the leds, change the red and al the other invisible colours.

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