Visualization of Music Designed for Children with Severe Disabilities

Andreas Rubensson
Abstract

Visualization of Music Designed for Children with Severe Disabilities

Andreas Rubensson

The children participating in the MUMIn-project at the special school Årsta grundförskola are already developing their learning skills and creativity through music. Although they have a problem. They have not used a program that visualizes the music played in a way that is understandable and rewarding. In order to further develop their skills in cause-effect relationships, such a program is highly sought after. By creating an application designed to be run on a computer at the same time as the children are playing music on MIDI-instruments connected to the same computer, the problem could be solved. The visualizations would be shown on a projected screen and display animations that were designed to be as easy to understand as possible but still have room for further exploration if they would be too simple for some of the children. Even though the children were on different skill levels, how they played music along with the visualizations showed that the created application both helps the children to connect cause-effect relationships and also help develop other skills like for example motor skills. The created application could because of these results be a very useful learning tool in further work in the MUMIn-project.
## Contents

1 Introduction 3

2 Background 4
2.1 The MUMIn project 4
2.1.1 The Children 4
2.2 Processing 4
2.3 MIDI 5

3 Purpose 5
3.1 Research questions 6
3.2 Limitations 6

4 Theory 7
4.1 Magic music visuals 7
4.2 Perceiving and understanding a computer program 8
4.3 Motivating children with disabilities 9

5 Methods 10
5.1 Observations and interviews 10
5.1.1 Preparing demonstration programs 10
5.1.2 Observations and interviews 11
5.1.2.1 Observing 11
5.1.2.2 Interviewing 11
5.2 Developing the program 12
5.2.1 Units and software 12
5.2.2 Handling the sound inputs 12
5.2.3 Designing and developing the main application 13
5.2.3.1 Menus 13
5.2.3.2 Visualizations 14
5.3 Evaluation 15

6 Results 16
6.1 Observations and interviews 16
6.1.1 Preparing demonstration programs 16
6.1.2 Observations and interviews 19
6.1.2.1 Observing 19
6.1.2.2 Interviewing 19
6.2 Developing the program 20
6.2.1 Units and software 21
6.2.2 Handling the sound inputs 21
6.2.3 Designing and developing the main application 21
6.2.3.1 Menus 21
6.2.3.2 Visualizations 25
6.3 Evaluation .................................................. 28

7 Future Work ............................................... 32

8 Conclusion and Discussion ............................ 33
1 Introduction

Music has been a central piece of human culture for ages but how important is it to actually see the music that you are playing? At the special school Årsta grundskola an ongoing project called The MUMIn project [6] already helps the children at the school to develop their creativity and learning abilities by playing music. However, the learning disabilities and visual impairments they have makes it hard for them to communicate with their teachers and personal assistants when things get hard and problems arise, as well as having problems perceiving things people may take for granted. The children unfortunately have a serious problem. They have until now never used a program that visualizes the music played in such a way that is good and rewarding for the children. The children are in need of a computer application that can help the children understand cause-effect relationships with the help of musical instruments and visualizations of the music played, in a perceivable and understandable way.

The program used right now is too complicated for the teachers when it comes to setting up suiting visualizations for the children and does not give appropriate visual feedback. The music visualized right now currently displays too many and badly sized objects, and does not reflect specific actions made by the children. This is overwhelming to the children since it displays too much information. This draws the focus away from the screen by itself and redirects it to other things.

How can a new program be made to meet the children’s actual needs? How can we evaluate if the program reach its purpose when communicating is hard? What methods need to be done in order to determine the qualities of the program so that the same qualities found in the old program are not used again? These are all questions in need of an answer if a successful new program is to be made.

This project contributes with an application that brings the visualizations down to the children’s level. By making objects more visible and distinct, and correctly reflect the actions made by the children through animations, the children can learn to better connect the teaching of cause and effect as well as learning how to connect specific animations to specific actions made on the MIDI-instruments.

By making an application that is also simple for the teachers to use and visualizes the music played at the children’s level, this new application can replace the old program and give the children new grounds to explore.
2 Background

This section will describe what The MUMIn project is, the children participating, and also the software used when developing the final application.

2.1 The MUMIn project

This project in visualizing music is a part of an already ongoing project called The MUMIn project. The MUMIn project is a collaboration between the Department of Information Technology at Uppsala University and the special school Årsta grundsärskola in Uppsala. The main purpose of The MUMIn project is to make it possible for the children at the school to develop their creative abilities with the help of music and visual feedback through modern information and musical technology. [6]

2.1.1 The Children

The children participating in The MUMIn project have different disabilities such as cognitive disabilities, movement disabilities and sensory disabilities. [21] Some of the children also have Cortical visual impairments (CVI), which can be summarized as that the children can see but they do not understand what they see [9], or epilepsy. Because of this, various aspects have to be taken into consideration when developing the application for this project. For example, to avoid giving the children with epilepsy seizures, flashing lights have to be avoided. To make it easier for children with CVI to see what is happening on the screen, high contrast colored objects on a black background should be used. Since a high percentage of the children with disabilities has some kind of CVI, this is a high priority. The reasons for what colors should be used is further explained in chapter 6.3.

2.2 Processing

The beforehand chosen programming tool for this project was Processing [1] [18]. ”Processing is a flexible software sketchbook and a language for learning how to code within the context of the visual arts.” is the description of the software by the people behind Processing. Processing is designed for programming visual interfaces and was briefly introduced during the course Syllabus for User Interface Programming II [8], where I first encountered the software. When planning this thesis project with the supervisor, we decided to use Processing because of its uses in creating graphical user interfaces and also since I had used it before, thus already having experience of the tool.
The Processing language is a text programming language designed to teach and be used in computer programming in a visual context. Processing itself is written in Java and when a Processing program is run, it translates the programming and runs it as a Java program. This way, the programs are supported by machines running on for example Linux, Macintosh or Windows. The Processing language is object oriented and is very similar to the programming language Java, and that is something that was taught in earlier courses in the Bachelor Programme in Computer Science at Uppsala University [2]. The possibility to write programs in Processing in the same way as programming languages Python and Javascript also exists but is not used in this project. [18]

The version of Processing used in this project was 3.2.1, hence the name Processing 3 at some websites. When already having experience with Processing and already having programming background, not too much time had to be put in learning new tools and/or a new programming language.

New versions of Processing, version 3.2.2 and 3.2.3 was released during this project, but was not chosen to use in case of incompatibility with any of the libraries used or to avoid conflicts with already written code.

2.3 MIDI

Musical Instrument Digital Interface, or MIDI for short, is the most commonly used system when representing acts of music in a real time environment. [18] Midi was released in 1983 as a way to encourage different kinds and brands of digital music equipment to use the same representation of the digital data sent. MIDI represents a number of different events when using the MIDI-instruments, such as what note is hit, tempo, velocity, pitch bend and so on, as numerical values. These values nearly always have a 7-bit resolution, meaning that the values usually reach from 0 to 127. [18]

Because of its numerical value representation of the events, MIDI is very useful to work with in a programming environment. Mapping for example an integer representing a note being hit to a movable object is very convenient for this project’s final application where the actual music played is to be visualized in a correct way.

3 Purpose

Can a computer program be designed that will aid children with learning disabilities in learning cause-effect relationships? This is the main question that this bachelor thesis project in the area of computer science will look to answer. The main challenges and problems are how a number of suitable visualizations based on sound parameters can be designed to make the children learn this cause-effect
relationship, and for the teachers how to make the visualization dynamically editable in real time through an easy and effective user interface.

3.1 Research questions

This project raises three primary research questions:
RQ 1: What visual expressions of sounds are possible for the children to both perceive and understand?
RQ 2: What expressions are motivating to these children?
RQ 3: How could a computer program be designed and constructed that visualizes sound in a perceivable, understandable and motivating way?

3.2 Limitations

The project is limited to one specific school, Årsta grundsärskola, and The MUMIn project’s current work at the school. It is not built to work for every special school in Sweden but is instead adapted to suit one primary school only. Because of this, the application developed will use the Swedish language in its menus to avoid misunderstandings. The project is also not supposed to be a completely finalized program but instead the focus will be on developing the idea itself. The finalized product will be a Proof of concept, a rough prototype, that will be working and show how the program will be used.

This project should result in an application for a Windows OS-environment. The reason for it being designed for a Windows OS-environment is because Årsta grundsärskola uses such a computer for their music sessions and also because I as the developer is developing on such a computer as well. This will avoid problems specific to the operating system as far as possible and also avoid troubles when testing and evaluating the program at the school. Since Processing translates the running program into a Java program, it should work on any platform anyway, but no unnecessary risk is taken.

The application is primarily built to be used while the children are playing music. The sound is visualized based on simple characteristics of the sound, for example using the pitch and velocity of the MIDI-signals or amplitude of the microphone input.

The primary user group, the children, will not use the menus and be able to alter the settings themselves but will instead use the application in the actual playing session. Changing settings and navigating through the menu will instead be handled by teachers and personal assistants, thus making two user groups. However, the main focus is on the visualization of music rather than the appearance of the menus.
When developing the application, Processing will be used. New plug-ins/sound sources should also be able to be added easily in the application.

4 Theory

The following chapter will describe what kind of visualization program that the school currently use along with the theory behind how to make a computer program that is perceivable, understandable and also motivating for the children.

4.1 Magic music visuals

At Årsta grundsärskola where The MUMIn project is active, a program called Magic Music Visuals, or Magic for short, is used [10]. This program is run when the children are playing music and works as a way of visualizing the music played.

![Figure 1: Photo of the projected screen showing one way that Magic is used to visualize the music played](image)

Figure 1: Photo of the projected screen showing one way that Magic is used to visualize the music played
According to the supervisor of this project and people working at Årsta grundsärskola, who are also part of The MUMIn project, Magic is too complex and does not give the desired feedback to the children. It is too complicated to create ways of visualizing that suits the children’s needs and seems to be more suited for advanced users.

Like Figure 1 shows, too much is displayed on the projected screen and the children are not given appropriate feedback of the music they are playing. When keys are hit, the colors only shine brighter and the color objects do not seem to have a clear structure. Figure 2 shows similar problems. Although the music is visualized in differently in Figure 2, where not as much is going on, it is still unclear what causes the colored objects to look like they do. Similar to the first visualization, the colors only light up more when music is played. Nothing is moving in any of the visualizations and it is too hard for the children to connect the cause and effect of the music played. Since this program is the only one that they currently use at The MUMIn project, they are in need of a new and better way of visualizing the music played in a proper way for the children.

4.2 Perceiving and understanding a computer program

Similar to this project, others have tried to make software aimed at children with disabilities. Design issues found in a specific project called ”HCI Challenges In Designing for Users with Disabilities” [17] was for example the usage of large graphical elements, the usage of distinct colors, sound and keeping things simple. Many of the found issues were also found when observing and interviewing (chapter 6.1.2.2) in this project. The methods used for finding the issues and
how to evaluate were also similar.

Since it is common for children with CVI to have disorders of eye movement control, animations of moving objects has to be adjusted so that it is possible for the children to see them. The disorders of eye movement can make it hard for the children to be accurate when doing fast eye movements. It is even known that children commonly choose to watch TV programmes where the subjects has limited motion. So in order to make it possible for the children to see the visualizations, they can not be animated too fast and the objects has to be of reasonable size and shape so that they can actually be seen. There are ways that children with CVI use in order to be able to perform every day visual tasks. For example recognizing color and remembering different sequences. These methods can be very useful in the visualization application. By making the animated objects of different color and actions being repetitive, meaning that the same action perform the same animation, would increase the ability for the children to see what is going on in the visualizations and further understanding them better. Therefore, the constructed application needs have these qualities in order to reasonable from a visual perspective. [12]

In order to know if the constructed program match the children’s level of understanding, the program should be tested and analysed. This has been proved to be an effective method, even for adults with learning disabilities [22]. When doing this, it has to be looked after if the children are using the different visualizations as intended, or at least trying to in an obvious way for the observers. For instance, how the children are using the MIDI-instruments while watching the screen has to be observed to see if the outcome is what is expected or not. If the children, even though they might be able to see the objects, can not understand the effects of their actions, the purpose will fail and the application will be unsuccessful.

4.3 Motivating children with disabilities

Participating in challenging activities is already considered to be an important part of the development of children with disabilities. In order to improve their skills, the children are in this case playing music on MIDI-instruments. When doing so, they improve both their motor and cause-effect skills since those skills are needed to play on the MIDI-instruments and make sound. [16]

Since Gamification [15] has been proven to work for people without disabilities [14], it can be something worth testing in the visualization application. Using gamification to motivate people with disabilities has already been used in other projects with good results [13]. By constructing simple games in the visualization application, where the children need to perform specific task on the MIDI-instruments, the games can be the challenging activity that the children need in order improve the disabled children’s skills in a motivating way. The rewards may not be designed the same way as in many other gamification so-
lutions, but the children should still be able to see that they have succeeded in performing a specific task.

5 Methods

To answer research questions (chapter 3.1) RQ 1 and RQ 2, I will perform interviews and observations, and in order to answer research question RQ 3, I will construct a program and evaluate it with the children.

5.1 Observations and interviews

The observations and interviews are essentially divided into three parts. The first part will be about how to develop demonstration programs for the interview. The second and third part will be about the actual observations and interviews, where the methods used are described along with the reason for why they were chosen.

5.1.1 Preparing demonstration programs

Before making observations of the children playing music and interviewing relevant people at the school, demonstration programs will be developed in order to see if I as the developer am having the same idea of the children’s needs as the people at the school. The demonstration programs will make use of MIDI-input from a connected MIDI-instrument.

In order to set the level of complexity on a basic level, colored objects will be used on a dark, solid colored background. The motivation behind this is to make it easier for the children to see and separate the objects from the background. The objects will then animate according to the values of the input from the MIDI-instrument. If the children will be able to see and understand then RQ 1 will be answered. Simple games will also created as a way for the children to even further develop their skills in a motivating way, and thus answering RQ 2.

The idea of the demonstration programs is to increase the children’s ability to connect cause and effect. Making the same objects move, and how they move, when pressing the same keys could make them explore what keys make the specific objects move or for example how fast they play can change the movement further.
5.1.2 Observations and interviews

On the observation session, when the children will have their regular music playing sessions, the duration of 20-25 minutes for each child will be used to observe them play music. This duration is what each child is currently given for playing music. Afterwards, interviews with one of the teachers involved in The MUMIn project along with the supervisor of this project, who is also involved in The MUMIn project, will be done as well. The teacher is a special needs educator, oriented towards images and drama, and

5.1.2.1 Observing

In order to get a better understanding of how the music sessions in The MUMIn project works and how the children are playing, observations of the children playing will take place at the school. When observing, three different children will be playing music one by one on three separate music sessions. While the children are playing, I as the observer will sit in the back of the room in order to be as small of a disturbance as possible. Everything that can be of use to the visualization application will be noted. Where the children’s focus are, how they are playing, what kind of disabilities they have and how the current visualization is failing them will specifically be looked after. All of the information gathered will be used to find out the qualities of the future created application.

5.1.2.2 Interviewing

The interview will be prepared to be a mix of a semi-structured interview and a unstructured interview, meaning that some pre-prepared questions will be made but are able to be reworded and also giving an option to explore new topics as they arise in the conversation [11]. This way, I can get an idea of what I should think about when developing the program without using only my questions since I have no experience and little knowledge of how they work at the school with The MUMIn-project. In order to minimize the few preconceptions I have from my talks with the supervisor before the project started, the interview will be kept at this level of structure. The questions that will be used in the interview are:

- Is there any kind of visualization of the music that is being used now, and if so, what is bad about it, i.e. why is this new application needed?
- What kind of MIDI-instruments are used?
- Should the application only visualize or should simple games be applied as well?
- What kind of colors and objects are liked?
When doing the interview, the two prepared ways of visualizing the music played, as described in chapter 5.1.1, will be demonstrated to get constructive feedback to see if progress is made in the right direction.

5.2 Developing the program

This section includes what kind of software that will be used when developing the application, what methods of handling the sound input that will be used, what methods that will be used when designing and constructing the actual application, and finally how the evaluation of the program will be made.

5.2.1 Units and software

The following units and software will be the mainly used ones during the developing and testing of the visualization application:

- **M-Audio Keystation Mini 32 - 32-Key Portable Keyboard Controller**, a MIDI-keyboard. [3]
- The external microphone of a *HyperX Cloud Headset* [4] as well as the internal microphone of a *Lenovo ThinkPad Edge E540* PC [5], Running on Windows 10 Home 64-bit.
- **Processing**, version 3.2.1 for Windows 64-bit. [1]

Other MIDI-instruments at Årsta grundsärskola will also be used to check their functionality with the application but will not be specifically used in testing and developing.

5.2.2 Handling the sound inputs

The sound inputs visualized will be retrieved from the standard unit microphone used on the computer and the MIDI-instruments, sending data with the MIDI standard. Processing has a number of libraries [18] at the user’s disposal that cover this area. For handling the sound inputs from microphones, the Processing Foundation’s own Sound library [18] will be used and for handling the MIDI-signals, a contributed library called *The MidiBus* [19] will be used. Through *The MidiBus*, buses receiving data from the connected MIDI-instruments will be created. The buses are able to see what key has been hit and released through functions in the library [20]. When pressing a key, the buses will not only receive the pitch of the key represented as an integer, but also more data such as the velocity of the actual pressing, also represented as an integer, along with more data.
5.2.3 Designing and developing the main application

To allow the teachers to switch between different visualization modes without having to shut down the currently running program, an interactive program where everything the user would want to do built-in will be designed. Unlike the demonstration programs that were separate from each other, this program will allow for users to quickly change the current visualization to the playing child’s preference. This means that essentially, the qualities of the program should be divided into two parts: One part where the focus is on making the menus as easy to navigate through as possible and the other part where the focus is on making visualizations of the music played.

Since the focus of this project in total is on making the visualizations good for the children and not on making superbly looking menus for the teachers and personal assistants, as mentioned in chapter 3.2, the main purpose of the menus is to be as straight forward and easy to navigate through as possible.

5.2.3.1 Menus

According to the people working with The MUMIn-project, Magic is too complex. To be of preference, simple choices at every page of the menu will be designed for this application. From the main menu, to avoid unnecessary complexity, few options should be designed to be available to the user. An option to change settings, another to go to the play music mode and finally an option to quit the program are the only actions that are essentially necessary in the main menu. The design will also be constructed to resemble other programs that the teachers may already use in their everyday lives to make the learning curve even more flat.

In order to be able to do the navigation between the different pages of the menu, buttons will be designed. Each button will be designed with a label saying what page it directs the user to and having a color that is distinct from the background.

In the settings page, all possible options will be designed to be clear and distinct from each other to avoid confusion. When having the results of the interviews (chapter 6.1.2.2) what has to be done on the settings page can be designed. Buttons will be used as switchers between different modes and value sliders when needing to modify more specific values. By dragging the value sliders to the left or right, the user can decrease or increase the corresponding value. The value corresponding to the value sliders will also shown next to the slider to make the change more obvious for the user. The displaying of the values will also could make it easier to remember a “good setting” for a specific child for example.

When a specific mode button is turned off, it will be red and the label will end with ”Av” (“Off” in English) or if it is on, it will be green and the label is ended
with "På" ("On" in English). The label along with the change of color makes it obvious if something is turned on or off. The label will also allow for colorblind people to see if something is turned on or off, if the color change itself is not visible enough. The chosen type of input will be shown the same way with the addition of a check mark.

While discussing further additions to the settings page with the supervisor, it was found out that a way to calibrate the middle tone used for the different visualizations should be supported. Therefore a way for this will also be designed.

Like the other pages in this program, choosing what visualization to use should be as simple as possible. Big distinct buttons with labels telling the user how they visualize will therefore be designed at the visualization selection page. To make it even more clear of what they do, what types of input the visualization support or if the visualization support a game mode, small icons will be put right next to the selection buttons. The icons will also be given descriptions at the bottom of the screen to avoid misunderstandings. The reason for this is to make the menus as minimalistic and as straight forward to understand as possible.

When a visualization mode has been selected, the amount of clicks to change settings will also be made to be as few as possible. Instead of having to go back to the main menu in order to access the settings page, a settings tab accessible when playing music will be developed to be just a click away to the user.

At every page on every button, visual feedback will be given through a slight change of color when hovering over it. This will make it obvious to the user that an action is possible. There will also be a back button at every page that takes the user go back to the previously visited page. When playing music, the back button will be accessed through the dropped down settings tab.

5.2.3.2 Visualizations

Based on the results from the interviews (chapter 6.1.2.2), the concepts of the two demonstration programs was decided to be kept as visualizations for the final application. From the observation results (chapter 6.1.2.1), it could be seen that the water speakers put on the table was great at grabbing the children’s attention. Therefore, a way of simulating those will be designed as a third visualization. When having discussions about a fourth visualization with the supervisor, the idea of visualizing a tree swaying back and forth came up and will be designed as a fourth visualization.

The main goals of the visualizations are to answer the three research questions (chapter 3.1). The different visualizations will be designed so that the objects in the different visualizations are easy to tell apart from the background and from each other. By using brightly colored objects on a dark background, make
the animation of the object correctly correspond to the input and be repetitive, and making the animations slow enough in order for the children to be able to follow the objects with their eyes, RQ 1 will be sought after to be answered. By the use of game modes or even make some animations more challenging to perform, the visualizations can be motivating and when developed answer RQ 2. If it shows that RQ 1 and RQ 2 are fulfilled via this application, the whole application and the methods used are an answer to RQ 3.

The visualizations should support at least one of the possible inputs (MIDI or sound captured by the microphone), or both if it is possible to do it in a smart and intuitive way for the children. Because it was clear from the observation results (chapter 6.1.2.1) that at least all children play on the instruments, and less use of the microphone, the visualizations will be primarily built on using MIDI input.

The different visualizations will be designed so that they can increase the children’s motor skills and color recognizing skills, teach the children about the relation between left and right actions to left and right effects. When using the microphone as input, the children will also be able to see the effect of making noise. These motivations can all be summarized into being able to understand cause-effect relationships.

5.3 Evaluation

The evaluation of the program will be similar to the observations made when finding out the qualities of the application. Everything relevant about how the children interacts with the visualization will be noted down. Since the children can not communicate well, noting everything seen will be very important, from how they play music to if the eyes are on the screen or not. Structured interviews will not take place but questions about the design of the menus and if the functions on the settings page are well made and easy to understand will be asked to the people who will use them. The main focus of this evaluation will be to trying to see if the application can catch the children’s interest and focus, and if the new application is more liked than Magic. Processing will be installed on the school computer that is running the sound programs that are used when the children are playing music in order to run the visualization application.

Similar to the observations made earlier (chapter 5.1.2.1), observations will be planned to be made at Årsta grundskola. The main difference from the old observations is that the developed application will be used. When evaluating, all visualizations will be evaluated along with game modes and different input types. Before the observations starts, an opportunity to speak to a low vision therapist about the project and visualizations will exist. What had been made during the development will be looked at with the therapist and input given on possible improvements will be used in further development. After the conversation,
changes will be made to the visualizations according to the therapist’s input. The low vision therapist works with developing tools and methods that can help support the children’s visual issues.

At the first evaluation, a single child who is available at the time will try the application for 30 minutes. Since only one child will play, the results will be small. Because of this an additional time of evaluating will be scheduled to be performed in order to get a bigger pool of observation results.

At the second evaluation, three different children will try the program in separate music sessions. The same things looked after in the first evaluation will be looked after again and everything will again be noted. The children will play for 20-25 minutes each.

6 Results

The following subsections shows all of the results of the outcome from the work methods described in the Methods chapter (see chapter 5).

6.1 Observations and interviews

Following are the results from the making of the demonstration programs, the observing of children playing and interviewing one of the teachers involved in TheMUMIn project along with the supervisor of this project.

6.1.1 Preparing demonstration programs

The preparation of the demonstration programs resulted in the following programs:
Figure 3: The first demonstration program picturing the jumping balls in action

Figure 3 shows the demonstrated program in action where the green balls is the balls with the assigned notes and the blue ball being the target in the game mode.

In order to give the children appropriate feedback of their actions and to correctly correspond a MIDI-instrument and its notes, the first demonstration program picturing 12 objects, representing the 12 notes of the chromatic music scale (A-G#), was made and can be seen in Figure 3.

In order to set the bar of the program on a very basic level, the objects used were set to be colored circles, representing balls, on a solid colored background. This was made to make it easy the see and separate the objects from the background. The balls were put at the bottom of the screen, evenly spaced. Each ball was also signed a tone, meaning that the input pitch from the MIDI-instrument modulo 12 would give an integer that can be used to affect the same ball. Since the pitches from the MIDI-instruments reach from 0 to 127 (as described in chapter 2.3), the same note would return the same value from a modulo operation, no matter the octave. When a key is hit on a MIDI-instrument, the ball with the corresponding note jumps up a bit on the screen and then falls down to the bottom again. The height of the jump is determined by the velocity of the key press. Since the balls are falling down to the bottom again, the same key has to be pressed repetitively in order to reach the top.

The game mode in this demonstration program worked by repeatedly pressing the same key until the corresponding ball with the same x-coordinate would hit the target’s height. When the target is hit, it is given a new random position and the child must perform the same task in order to hit the target again.
Figure 4: The second demonstration program picturing the particle system along with the two targets

Figure 4 shows how the demonstration program looks with, in this case, the red particle system in the middle as well as the two targets on separate sides of it.

A second demonstration program was also made. The program was as a modified example of an existing simulation example called *Simple Particle System* [7]. It was modified to resemble a centralized flame or fireworks that moved left or right depending on the keys pressed. The reason behind this modification was that the original particle system made the particles fall from a specific point in a wide area. By making the particles last for a short period of time and making the particles move in all direction from a single point, the children’s eyes could more easily focus on a smaller area.

The idea behind this was that it could help the children connect the cause of hitting a key to the effect of the particle system moving left or right. Alike the first demonstration program, a game mode was developed. This game however does not only require the user to move the particle system to hit any target, but the target with the matching color. Every time the particle system hits the target with the same color, the particle system is moved to the middle of the screen as well as being given a new color, and new targets show up, with one of them having the same color as the particle system.

Both demonstration programs responded well to the input of the MIDI-keyboard and was ready to be demonstrated when doing the interviews.
6.1.2 Observations and interviews

The observations and interviews held place at the 8th of November at 12 p.m.. The planned amount of time of the observations stayed the same (20-25 minutes per child) and the interview afterwards lasted for about 30 minutes.

6.1.2.1 Observing

While sitting in the back, a lot of information could be noted and the children played music as if I was not there. Following is a summary of the observations:

- The three children had very different disabilities.
- Being different from each other, they used the MIDI-instruments very differently, from tapping the keys of the MIDI-instruments carefully to hitting the keys aggressively. The way of playing might not be linked to their specific disability, but the observed children played differently nevertheless.
- Some children not only uses the MIDI-instruments, but also use a microphone. The exact purpose of the microphone was not clear since the child sat in front of a mirror, only seeing himself when using the microphone.
- Water speakers put on the desk got a lot of attention, at least a lot more than the visual feedback displayed on the screen.
- The visualization feedback software used now, Magic, does not seem to give the children very responsive and repetitive feedback. Too much occurs on the screen and the input is visualized more like a force pulse going through the screen, making colors on already existing objects brighter for example, rather than giving appropriate feedback. To see the cause and effect of what the children are playing is difficult.
- Multiple MIDI-instruments are used at a time.
- A quote saying "Today she found the water speakers" made me question if it means that the children discover new things every time, and it was confirmed to be the case by the teachers.
- It can be hard to keep the children focused on playing music and on the screen.

6.1.2.2 Interviewing

Some of the questions stated in chapter 5.1.2.2 were answered already when observing, like the one asking what kind of MIDI-instruments that are used, and were therefore not asked in the interview. Even though the questions were
short and simple, and could have been answered with as short and simple
answers, a lengthy conversation held place and provided much needed information.
The unstructured part of the interview allowed to give a bigger picture of the
situation. The information gathered from the answers and conversation was
summarized as follows:

- The children like moving objects. That is something that gives excitement,
  confirmation that something is happening.

- Since the children often look down at the MIDI-instrument and then up
to the screen, it is important that not too much is happening too fast.
Otherwise animations might complete before they are even noticed by the
children.

- Some of the children have CVI. This means that not all colors suit them.
Red and yellow objects on black backgrounds are the best color choice for
these children and should therefore be available in the application.

- Both games and visualizations only should be used with easy options to
switch the game mode on and off. The visualizations used in the games
could be used for visualization only for example.

- It is better if there is too little happening than too much. If too much is
happening, the children get overwhelmed by all the information and lose
their focus on the screen.

- If objects move slow, it is easier for the children to follow the movements
of the object and it is exciting for them.

- Use distinct objects and colors. The difference between background and
object is what is sought after. Also, too much colors should be avoided.

- It is important that the children can develop their skills in recognizing
cause and effect. They will explore speed and pitch (what key they hit).

The demonstration of the first demonstration program was very liked by the
interviewee and was something that they were looking for. It would give good
feedback to the children as well as not displaying too much at once. It was
decided to keep developing this idea for the final application.

The other way of visualizing was not as suiting for the children since it displayed
a bit too much particles. However it was told by the supervisor to be kept for
now.

6.2 Developing the program

The following subsections shows the results of the developing of the application.
The results are divided into three main parts: the first part shows the results
of how the units used worked when developing the application, the second part
shows how the different methods of handling the sound inputs worked and finally
the results of the designing and developing of the main application.

6.2.1 Units and software

The chosen units and software worked without problems and were all functioning
throughout developing. The developing was made in Processing version 3.2.1
but it also ran on the later released version 3.2.3.

6.2.2 Handling the sound inputs

The sound inputs handling worked with the libraries used. The Sound library
and The MidiBus were both useful and provided enough methods to fulfil the
primary qualities of the program. The MidiBus did however lack methods that
could meet some wished extensions such as usage of the pitch bend or mod-
ulation effects on a MIDI-instrument. The MidiBus also did not cooperate
well when trying to use more than one program that uses the same MIDI-
buses.

6.2.3 Designing and developing the main application

The results of the designing and developing of the main application are divided
into two parts. The first part shows the results from the making of the menus
and the second part shows the results from making the visualizations of the
music played.

6.2.3.1 Menus

The designing of the menus gave the following results:
The main menu is the first page that the user sees. At the main menu, there are three options available to the user. The user could go to the settings page, go to the visualization selection page or exit the entire program. To avoid annoying misclicks on the exit button and to resemble other programs, the exit button was placed in the top right corner, and the other two main choices in the middle. How the result of the designing of the main menu can be seen in Figure 5.

The settings page was designed to have all found changeable, through the results of the interview (chapter 6.1.2.2) and discussions with the supervisor, needs that could differ between different children. From top to down, the following settings are accessible:
• A value slider that changes the background color from the default black to white along the grayscale.

• A trigger button switching color schemes if children with CVI are using the program.

• Two selector buttons where the user can switch between using MIDI or microphone input.

• A game mode trigger button that displays different targets if activated.

• A value slider that changes the multiplier of the input force with a default value of 1.

• Two selector button where the user can choose what key that should be used as the middle key.

How all the buttons and sliders are aligned is shown in Figure 6. In Figure 6 the chosen background color value is 0, the CVI mode is turned on, the chosen input type is MIDI, the game mode is turned off, the sensitivity of input is 1.000 and the middle tone is set to the standard mode. This is an example of how the settings page can look in action.

Through the two selector buttons in the bottom, the user can calibrate what key to use as the middle button or choose a default value. Since the pitches represented in MIDI reach values from 0 to 127, 64 is used as the default value. If the user would like to set a different button as the middle button, if for example an instrument used has a more limited set of keys, the calibration button can be pressed and the user is instructed how to set a new key as the new middle key. The chosen mode is displayed like the other mode buttons, with green and red colors with the addition of a check mark on the chosen mode to make it even more clear.
The designed visualization selection page resulted in what can be seen in Figure 7. A big label on top tells the user what page is active and the buttons with their label show the different visualization modes available. Right next to the buttons, small icons are displayed, showing what the different visualizations support. The icons have descriptions below the buttons that explain what they mean.

The compact settings tab that is accessed when playing music resulted in what is shown in Figure 8. The settings tab is triggered by pressing a button with the down arrow located at the top of the screen. In Figure 8, this action has already been performed and the button is now located below it with an up arrow. The reason for the button being at the top when playing music is to avoid collisions with the animated objects. When pressing the button, the settings tab will drop down and all the settings found on the original settings page can also be found here in a more compact way. This will grant the user with the big advantage of being able to dynamically modify values while staying in the playing music.
session, making it possible to instantly see the changes of the modifications. This is something that will not be available from the settings page accessed through the main menu and is therefore of great importance.

To minimize the settings tab, the user has to press the same button that made it drop down, which when the settings tab is dropped down, is located below it. It will also be possible to press anywhere below the tab itself to minimize it, resembling other programs where this action will be possible.

6.2.3.2 Visualizations

The following visualizations are the results of the developing of the application. These visualizations are the ones brought to the later stage Evaluation, which results can be read in chapter 6.3.

Figure 9: The visualization called ”Hoppande bollar” (”Jumping balls” in english)

The first way of visualizing music resulted in the visualization shown in Figure 9. The balls jump when pressing specific notes assigned to them. The jumping balls visualization was a slightly modified version of the first demonstration program, according to the interviewee’s input (chapter 6.1.2.2). The colors of the balls was slightly changed in order to achieve better contrast. Other than that, the jumping balls visualization’s functionality worked in the same way as the first demonstration program did. The same game mode was also kept, where the child must hit the ball on the same x-coordinate until it reaches the height of the displayed target.

Making it possible to use microphone input to move the balls was also designed for this visualization. When making sound, all balls will move up on the screen depending on the amplitude of the sound that the microphone captures.
The second way of visualizing is shown in Figure 10 and was designed to represent how the water speakers work. Two large balls were designed to jump if the child pressed keys to the left or right of the middle tone of a MIDI-instrument. The left circle jumps if the pressed key’s pitch is lower than the middle tone and the right circle when pressing keys higher than the middle tone. Essentially, it was designed to be an easier version of the jumping ball visualization. When jumping, a "jet of water" is seen from the bottom of the screen to the corresponding ball. It is simply a square with a thin, but visible, width which height depends on the corresponding ball’s y-position. A microphone alternative was also made for this visualization. Like the jumping balls visualization, the two balls will rise equally when speaking and with the power of the amplitude of the sound.
Figure 11: The visualization called "Fyrverkeri" ("Fireworks" in english)

The third way of visualizing resulted in a fireworks/particle system visualization and can be seen in Figure 11. It was an almost unchanged version of the second demonstration program. The only thing that was modified after the interviews was the colored targets, and thus the particle system itself can only be given random primary colors of the additive coloring system. This means that the targets and particle system can only be of the colors: red, green, blue, yellow, cyan, magenta and white (the possibility of a target being black was avoided since it would not be seen on the default black background). This was to avoid that colors that are not very visible was being given to the targets. The center of the particle system move left or right depending on if the pitch of the key pressed is higher or lower than the middle tone. If the pitch is lower, it moves to the left or if it is higher, it moves to the right.

Figure 12: The visualization called "Svajande träd" ("Swaying tree" in english)
The fourth and final visualization was designed to simulate a tree that sway in the wind and can be seen in Figure 12. The tree itself was made to be a bezier curve which end anchor points dynamically changes in order to animate the tree. In processing, four points are used to draw the bezier curve, two anchor points in the ends of the curve and two control points [18]. The start anchor points of the curve was set to be in the middle of the screen and never change. The animation occurs when the end anchor points change their values, along with small changes to the control points closest to the end anchor point. The tree crown was simulated by setting a particle system, similar to the one used in the fireworks visualization, to the end anchor points of the bezier curve. When keys are pressed to the right of left side of the middle tone, the tree is pushed to the left or right, similar to the water speaker simulation and fireworks visualization. When passing the x-coordinate of the middle of the screen, the tree automatically leans towards that way and to the bottom of the screen. To push the tree back to the other side, the child has to repetitively press the keys of the opposite direction. Microphone input is also possible for this visualization. When sound is captured by the microphone, the tree is pushed towards the middle with a speed corresponding to the amplitude of the sound.

6.3 Evaluation

Following is a summary of the opinions that the low vision therapist had when looking at the visualization application:

- There does not have to be a difference in color schemes between children with tougher CVI as long as high contrast colors are used since those are the most visible for the children.

- Make the colors of the balls in the jumping ball simulator different so the children also can connect color to the keys. The teachers might also paste colored dots on the keys of the MIDI-instruments, representing the colors of the balls.

- If a child with tougher CVI is playing, there should not be so many balls, and a wide gap between them so that it does not get crowded.

- Recolor the other visualization modes to colors with higher contrast to the dark background.

- The swaying tree visualization was something that she hoped she could use in her studies because of its range around the whole screen.
The conversation with the therapist resulted in some of the visualizations being changed. The jumping balls was recolored according to the therapist’s input.
and their final look can be seen in Figure 13. How the balls are displayed when
the CVI-mode is turned on is shown in Figure 14. The water speaker simulation
was also recolored to have colors with higher contrast and the final result of the
look can be seen in Figure 15.

Since the therapist did not agree on that specifically red and yellow objects
on a black background was necessary (like the teacher said in chapter 6.1.2.2),
the same color schematics would instead be used for all children. The colors
used were all designed to have high contrast to the background. The jumping
ball visualization was the only one who was given a specific CVI-mode, where
less balls are displayed with large spacing between them, to avoid making the
balls crowded. The conversation also lead to the CVI-mode button not being
shown in the settings tab to all visualizations except for when the jumping balls
visualization is active.

The application did not function with other program that uses the same MIDI-
buses. This was something related to Java and the system. Since this area
was not of my concern, it was decided to evaluate the program without music.
With the supervisor’s permission, I also did not have to look for solution to this
issue.

The first evaluation took place on the 6th of December at 12 p.m. and was
performed on a single child with MIDI-instrument input only. This child used a
wheelchair as his transportation tool, he was almost verbal and can speak with
few slightly scrambled word, and his motor skills was in comparison to other
children at the school well developed. I1 was very lively and alert and played
with enthusiasm. The child will be called I1, as in informant one, throughout the
report. The first visualization evaluated was the jumping ball visualization. I1
could connect that specific key presses would make specific balls jump. When
the game mode was tried, he also pressed the same key repetitively to make
the same ball jump in order to reach the target. When the game mode was not
active, I1 could sometimes ask to switch visualization, but the game mode made
him motivated to keep playing. The water speaker simulation was too simple
for I1 and he got bored using it. The fireworks simulation was only evaluated
with the game mode set on. I1 could connect left and right movements and
what keys made the particle system move in those directions. The purpose of
the game was understandable and I1 effectively moved the particle system to
the target with the corresponding color. The swaying tree visualization was
harder to manage. The tree would often fall to the bottom of the screen and it
was hard to make it rise again, or fall over to the other side. Because of this, a
button was developed that would be shown in the settings tab for the swaying
tree visualization only. The button, when pressed, restores the tree’s position
to its starting position, standing upright in the middle of the screen.

I1 played with a moderate aggressiveness and the value of the sensitivity was
increased so that the animations made by a key press were more effective. I1
cheered and laughed a lot while playing. These results showed that the visual-
ization can be used without music.
Afterwards the teachers in the room confirmed that the menus were easy to navigate through and understand. The different settings were also easy to understand and their purpose was clear.

The second evaluation session held place on the 13th of December at 12 p.m. During the evaluation, the visualization program was run on the supervisor’s MAC computer instead of the school’s Windows OS computer. The reason for this was because he found a way to make a virtual MIDI-bus as input to a sound program running on his MAC, thus making it possible to use both the visualization application and hearing the music played. The same things as in the previous evaluation was looked after. This shows that the application works on multiple platforms.

The first child was the same child as in the previous evaluation, I1. The first visualization evaluated was yet again the jumping balls with the game mode active. I1 showed again that he understands the purpose of the game and what makes specific balls jump. I1 would also try to figure out how to make all balls jump and went through them from right to left by pressing the keys of the MIDI-instrument. I1 continually pressed the same button in order to make a specific balls jump to greater heights. The water speaker simulation was not evaluated on I1 again since he got bored of it quickly in the previous evaluation session. The evaluation of the fireworks simulation with the game mode active gave the same results as the previous evaluation session. I1 could again connect left and right movements of the particle system and would repetitively press the same button in order to reach the target’s position. The evaluation of the swaying tree was similar to the previous evaluation session, but this time it was more clear that I1 tried really hard to make the tree rise and fall over to the other side. I1 would press the same key over and over again to make it move in the desired direction. The effect of having a music program active was not obvious. The water speaker simulation was yet again evaluated, but with microphone input. I1 understood that making loud noise would make the big balls fly high into the air. I1 would first make a loud noise, let the balls sink a bit to the bottom of the screen, and then make noise again to make them rise.

When evaluating the application on the second child, the water speaker simulation was evaluated first. This child, who will be called I2 hereinafter in this report, had more severe disabilities than I1. Like I1, I2 sit in order to be transported around, he did not use his voice to speak or communicate, instead sign language is used in order to communicate with him. I2’s motor skills was not on the same level as I1 but he could still use the MIDI-instruments without problems. I2 was also not as lively and alert as I1, but did instead look more calm and did not play with the same enthusiasm. I2 would hit the keys of the MIDI-instruments hard, which made the big balls jump, and then he would follow their movements with his eyes as they moved to the bottom of the screen before hitting the keys again. It was not clear if I2 understood that keys pressed to the left of the middle note made the left ball move and pressing keys to the right of the middle note made the right ball move. When evaluating the jumping balls
visualization, the results were similar. I2 hit the keys hard and then followed them with his eyes to the bottom of the screen before hitting the keys again. At rare occasions, he tried keeping them in the air by pressing the keys at a faster pace. The evaluation of the fireworks visualization with the game mode inactive showed a change in how I2 played on the MIDI-instruments. There were no longer a hard hit and then following any objects slowly. I2 would instead hit the keys at a moderate speed, which made the particle system move. If I2 understood how to make the particle system move left or right was not clear. It was also not obvious if I2 followed the particle system’s movement with his eyes. The swaying tree visualization was not evaluated since it was considered too complicated for this child. The major results taken from I2’s evaluation was that the playing behaviour changed between the fireworks visualization and the others evaluated.

When the third child evaluated the program, the water speaker simulation was the first visualization once more. The third child will be called I3 throughout this report. I3 could, like the others, not walk by himself and was transported in a wheelchair. I3 had more severe motor skills than I2 and had problems focusing on more than one thing at a time. I3 was very lively and alert and played music with in an aggressive way. Thus, I3’s play style was to look onto the MIDI-instruments and hit the keys hard. I3 rarely looked up on the screen but when he did, he would follow the balls movement to the bottom of the screen. I3 seemed to listen more to the music instead of seeing the visualizations on the screen. The jumping balls where then evaluated. I3 was more interested in seeing what happened on the screen with this visualization. I3 would play intensively and then look up to follow the balls movements. I3 would also sometimes look at the screen and press the keys of the MIDI-instrument more careful to see what happens. The overall play style would however still be, play first with the eyes on the keys, and then look up to see what happens on the screen. The other two visualization was not evaluated with I3.

7 Future Work

More variety of visualizations to even further satisfy the needs for the children is something that could be implemented further. By adding more visualizations, the application would give the children space to explore the different visualizations further. To increase the children’s skills in different areas, more game modes, ways to make the objects move or different color modes could be developed further in the future.

One major thing that could be developed further is making the microphone input based on the frequencies that are caught. Right now, all objects are animated the same way when the microphone captures sound. If the animations would be based on frequencies, the children could use different sounds to create different animations and perhaps connect the cause and effect of this.
The applications is made so that it supports new additions of moving objects. By adding new kinds of animated objects, the children can learn different shapes for example. The design of the application could also be improved to be more aesthetically good looking from the teacher’s perspective.

8 Conclusion and Discussion

My thoughts on the final applications are positive. Feedback from the observations and interviews, through the development phase to the final evaluation has all been positive and have really motivated me to create something that could seriously mean something to the children.

The results from the observations before developing the final application gave the following claims about the qualities of the application:

- The application’s sensitivity of the input should be editable. For example, the impact of the velocity of the input. This way the more careful children can get noticeable feedback the same way as the children that play more aggressive.
- A visualization similar to the feedback of the water speakers can be useful to get the children’s attention.
- The feedback must be repeatable and not display too much on the screen so that the children can keep track of the moving objects with ease.
- Must support input from more than one plugged in MIDI-instruments.
- Make the visualizations interesting and explore-able in its simplicity so that the children does not lose interest.

Since all of these claims came from the observations alone and how the children currently use the MIDI-instruments, the qualities were all highly prioritized and was ensured to be included in the final application.

When having retrieving the information from the interviews, the MoSCoW rules [11] was decided to be applied. The MoSCoW rules are used when prioritizing the requirements of a program. These classify the requirements into:

- Must have
- Should have
- Could have
- Want to have but Won’t have time

By using the answers given from the interview along with the observations, the requirements could be more easily prioritized to make sure that the most important parts of the application is being developed first and continue from
that point downward through the prioritization list. It was now more clear that
the prioritized requirements at this point of the working process is listed like
this:

- **Must have:** Support more than one MIDI-instrument simultaneously. Use
  movable objects that the children can follow with their eyes. Not displaying
  too much so that the children gets overwhelmed by all the information.
  Support both microphone and MIDI-instrument input.

- **Should have:** A way of switching between color schemes when a child
  with CVI are using the application. A visualization working similar to
  the water speakers since they were incredible at catching the children's
  attention. Visualizations that can keep the children's focus on the screen.
  Allow for exploration and learning so that the children do not get bored.

- **Could have:** A mechanism of changing the sensitivity of the input so that
  the visual feedback can be similar for children playing more careful and
  the more aggressive playing ones. Make it possible to switch between a
  game mode and a visualization only where the targets are not displayed
  at all.

- **Want to have but Won’t have time:** Nothing at this point in the work
  process.

Since the teacher that was interviewed said that red and yellow colored objects
on a black background was what the children with CVI could see best, the
original CVI-mode in the applications was designed to switch the colors of the
different visualizations to only include red and yellow.

All of the requirements found out at this point, right after the interview, were all
included in the final application. When the development started, some possible
qualities did not make it both due to time and complexity constrictions. How-
ever, since all of the primary qualities found between "Must have" to "Could
have" got included, the final application's qualities seems to be well priori-
tized.

When creating the menus, the focus was on making them as easy to understand
as possible. Since the teachers themselves confirmed this during the evalua-
tion of the program, the conclusion made is that the purpose of the menus is
met.

When creating the visualizations, it was harder to see directly if the purpose
is met. When evaluating the visualizations made with the children you had to
look again on how they play on the MIDI-instrument, if it changed with the
new visualization or not, and how you could confirm that the children are being
given the feedback they need, which is the main purpose of this entire project.
When evaluating during the first session, when informant one (I1) played, the
response was very positive. The laughs and cheers along with watching I1 play
music continually and actually appearing to understand how the visualizations
work made me draw the conclusion that the visualizations were successful. Even
though the evaluation took place without any music, they seemed to show that the visualizations could be used as an effective teaching tool anyway when it comes to training the motor skills and connecting cause and effect. A major problem in the first evaluation session was that the child playing was not a one of the children that were observed the first time. The result from the first evaluation was too small to see how the application would work for other children. The research question RQ 2 (chapter 3.1) could through this evaluation be answered since it showed that the game mode would motivate the child to further play on a specific visualization and be able to improve his motor skills.

The second evaluation session gave a bigger result and yet again proved that the constructed application could be useful. It also shows that the application is useful for children with different level of disabilities. By evaluating the microphone input on one of the children showed that the vocal skills of the children also can be improved by this program.

From the results of the evaluations, it can be seen that the water speaker simulation or the jumping balls are the best visualizations to start using when trying the program for new children. The fireworks visualization is good for both motivation and color learning. The swaying tree however proved to be a more complex visualization which required the child to have more developed motor skills as well as the ability to follow faster movements with the eyes. The evaluations shows however that the objects visualized are perceivable for the children and even understandable. How the children understands the visualizations can be shown in different levels. The child who evaluated the program in the first evaluation session and again in the second session (I1) showed understanding on why the objects moved like they did. The second informant (I2) understood that the balls jumped, followed them with his eyes and then hit the keys again to make them jump again. These examples prove that the application answers RQ 1, on how you can express visualization so that they are perceivable and understandable.

The evaluations could have been more structured in order to check all different kinds of visualizations and different input types. Some children barely spoke or made controlled sounds and used sign language and thus, only one child could evaluate the microphone input. This makes a rather small result on if it works well or not. All of the visualizations weren’t tested for all children either. It may have seemed obvious that the swaying tree for example would be too complex for the second or third child (I2 and I3) in the second evaluation session, but it was never really confirmed.

The conversation with the low vision therapist was probably the most important conversation about how the visualizations should look, and I was really lucky to get that opportunity since neither me or the supervisor knew that she would be there that day. Since her answer on what colors to use when a child with CVI was different to the teacher, I chose to stick with the therapist’s input. The reason behind this was because she had experience in vision as a low vision
therapist and that science support this. This made me change the functionality of the CVI-mode to something that I think is better for the children.

The usage of Processing is not regretted but does not seem to be the ultimate program for this kind of application. This is because of how it worked together with the currently used sound playing program. The library used to create the MIDI-buses was simple to use and it actually worked fine when no other program using any MIDI-bus was active. Immediately when a program using any MIDI-bus made the visualization application crash and it removed the possibility of having music active at the same time, and that removes an essential part of the MUMIn-project. Since the problem was not my program but how Processing and the library The MidiBus works, the responsibility of making both sound and visualization work was not put on me. The conclusion is that Processing is very useful for making easy user interfaces but struggles in other areas, like sound. Since RQ 1 and RQ 2 could be answered through this application, it shows that with the use of Processing, a program can be designed and constructed. Even though it might not be optimal as a sound program, its strengths in making graphical user interfaces stays strong.

The qualities found in chapter 7 all ended up in "Want to have but Won't have time", and I do not think they should have been placed higher in the priority list. One major future work is expanding the usage of the microphone input. However, it seems like this input is not the mainly used one, and thus ending up lower on the priority list.

There will always be room for more possible visualizations, but since the final application had a total of four visualizations that proved to have room for exploration and all performed well, I do not think the final application is necessarily incomplete and could be used as it is. The final application reaches the project’s purpose since even though the children have trouble communicating, it can be seen through observations that they understand how it works, and they repeat the same actions to achieve different goals of the visualizations. By repeating the same action to achieve things, it can bee seen that the feedback given is suiting the children well and the application works as intended.

References


