# AUDIOLIZED ART

## Medialogy 4th Semester

### Group 404,Summer 2013


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**Abstract:**

This report is about augmenting static art through the implementation of sound interactivity, with the goal of making it more interesting of an experience. The report researches the various fields of art and sound interaction. Based on this research, a prototype sound-interactive artwork is designed and developed. This early prototype is then used for experiments, so as to obtain the point-of-view of the users, for improving the prototype. The completed prototype is then tested in a final experiment in contrast to a similar, but motionless artwork. The results from the final experiment are then analyzed. The results show that; though variation of test subjects is somewhat narrow, results show a clear indication of the interactive artwork being more interesting than the motionless artwork.

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# 1. Introduction

The most common type of art is, to us, the traditional painting or portrait, created on a 2D surface. As this type of art often seems somewhat- or downright dull, the aim of the project is to make it more interesting to watch. With this type of art having been around for as long a time that it has, we decided to focus on somehow augmenting this type of art through the use of audio analysis.

Inspired by Peter Root's *Sound Reactive Drawings*, the main focus of this project is the moving of objects within a given 2D image, so as to make the viewing of it a more interesting experience.

This concept could then be developed to the point of being applicable for art worldwide, making the well-known art-pieces of history come to life with the sound of the audience.

By researching sound analysis, static (no motion/stationary) art and related topics and state of the art, we hope to accomplish the goal of creating a prototype capable of augmenting art through the use of sound.

## 1.1 Initial Problem Statement

How is it possible to enhance the experience of art by having a dynamic painting responding to sound?

The report researches the various fields of art and sound interaction. Based on this research, a prototype sound-interactive artwork is designed and developed. In the pre-analysis we have found similar artworks regarding the motivation stated above, the term for these artworks being sound installations, which become good inspiration for the project. In analysis we gathered information on how art is created, grid systems being an important part of it, followed by sound features, this information being crucial when implementing the prototype. Based on this research, a prototype sound-interactive artwork is designed and developed. This early prototype is then used for experiments, so as to obtain the point-of-view of the users, for improving the prototype. The completed prototype is then tested in a final experiment in contrast to a similar, but motionless artwork. The results from the final experiment are then analyzed.

# 2. Pre Analysis

## 2.1 Introduction

This chapter will take in consideration all the research required for creating the final problem statement. It will start out with a description of what art is and will continue with sound art and a few examples of sound installations. In order to get an idea of available products, which resemble the idea specified in the initial problem statement, a state of the art section, containing sound installations, will be written. Before writing information regarding a potential target group, some research in general, that could be considered an option for this idea, was made. From that, the final problem statement was written.

## 2.2 Art

According to the initial problem statement, art is an important part of the project and a topic which requires research. In order to get an overall idea of what art is, a few definitions acquired from different sources were written below. It can be noticed that the definitions differ amongst each other thus a short explanation was given after the definitions were written. The reason art differs is because art is a difficult subject to define.

### 2.2.1 Art Definitions

*"Art is the expression or application of human creative skill and imagination, typically in a visual form such as painting or sculpture, producing works to be appreciated primarily for their beauty or emotional power."* (Oxford Dictionaries 2013)

Institutional definition:

*"A work of art is an artifact upon which some person(s) acting on behalf of the artworld has conferred the status of candidate for appreciation"* (Stanford Encyclopedia of Philosophy 2012)

Historical definition:

*"Art is a kind of representation that is purposive in itself and, though without an end, nevertheless promotes the cultivation of the mental powers for sociable communication*" (Stanford Encyclopedia of Philosophy 2012)

Johanna Drucker in her essay "Art" in *Critical Terms for Media Studies*:

*"The persistent belief in the modern to contemporary period is that the distinctive identity of art derives from the unique ability of individual artists to give formal expression to imaginative thought."* (Drucker 2007, 1)

The first definition is the theoretic meaning of art, however, art is a very philosophical term and therefore controversial and many definitions for art have been created throughout time. In the text above, there are some examples of the definitions given by many different philosophers throughout centuries. Art has been spread out through centuries in many forms. According to the centuries, the art pieces were influenced by specific factors during that time.

For example, during the northern Renaissance during the 15th and early 16th century, popular art was mostly made by using oil painting with cool light and high amount of details in comparison to Expressionism, when the color trend was focused on violent colors and stylistic distortion to cause empathy to the viewer. (Hirsh 2013)

Since art contains a handful of definitions and it means many different things for many different people, we can refer to art as "visual culture". This kind of visual culture has certain effect on people and a great influence in their life. Some of the basic functions of art, according to Ellen Dissanayake are; to express, illustrate, redefine reality, redefine art, persuade, mediate, therapy and many similar functions. (Belton 1996)

### 2.2.2 Digital Art

After getting an idea of what art can be and how art is defined, digital art is the next subject that will be looked into. Firstly it must be discussed what is meant by digital and what conditions digital art must fulfill in order for art to be called digital. Digital means that the material, information and exhibit are created with the help of a computer, which means the art, is digitalized. There are different ways digital art can be perceived, digital art can be created by coding a program or an image, this way the “artist’s” creation cannot be accidental, it is all well thought programming code that creates some artwork, therefore it cancels out the role of randomness in artistic creation (Tresp 2013).

Art that is created using digital art software, such as Corel or Photoshop, can be viewed on a digital platform as well. Examples of digital art are media such as videos, game art, virtual reality or digital. To sum up, digital art is the type of art that can only be created through the means of digital technology (Vaidyanathan 2013).

## 2.3 Sound Art

Sound art is thought of as a new form of art, contemporary art, however instead of focusing on pleasing the eyes of the viewer it uses sound to create artistic audio experience thus involving the main notions; hearing and listening. Hearing and listening have two different meanings, people hear more often than they actually care to listen to the sounds. When talking about sound art, listening is an important process, the viewer, listener in this case, must go through to understand and be entertained by the art displayed. (d.umn 2011) Sound art is a relatively new term that appeared in 1990, however artists have been practicing art and presenting their artworks for decades before that time, this term was only established during the year mentioned before (Worby 2006). Before this time, sound art was considered experimental-music or performance, not associated with musical performance, however, the art of putting sounds together was considered activity of composers and musicians (Aldrich 2003).

There is no clear definition of sound art, some suggest that the term is used this way to describe the concept in relation to traditional art; however in the case of sound art, the artist uses tones and audio effects the way a painter uses colors and shapes. Since this form of art is a rather new field there are many different ways to achieve sound art, so therefore it does not have a certain way for creating sound art, such as contemporary visual art does not necessarily focus on using paint and canvas.

Some examples of sound art are: kinetic sounding sculpture, automatons, experimental radio, sound installations, instrument making, graphic scores, sound poetry, video art, acoustic ecology/ phonography (Reider 2012).

There are no specific types of sound arts or sound artists, however, there are many, some sound artists create sound art that is mostly rooted in music (Worby 2006). Some artists root their music in fine arts such as sculptures, installations, conceptual art or poetry, text and voice. Soundscape composers are also sound artists who use sound to articulate characteristics of certain places (Ellis 2008).

When working with sound art, there is several way of presenting the art. Some of these ways could be through speakers or headphones, but the one we take interest in is in the form of a installation.

### 2.3.1 Sound Installations

Sound art has become mostly popular through installations, which are often found at modern art or experimental art museums and these sound installations encourages people to listen. An example of a sound installation, which was built around the year 1958, will be shortly described. This was set up in Brussels World Fair. The predominant sound theme was nuclear disarmament, which included many sounds of electronic shrieks, whines, moans and sirens put together, thus “bombarding” the user with the sound. Later on, a new installation called “Poème èlectronique”, also known as “a story of all humankind” was introduced; this included a combination of architecture, films, sculptures, lighting schemes and spatial music, while the theme of this sound installation was to depict the evolution of human societies.

Critics have mentioned that this way the person will no longer hear the sound but feel that they were placed in the heart of the sound source thus living the sound; however others believed that the sound was overwhelming and numbing. From this it is to be noticed that sound installations can be interpreted very differently by different users (Born 2013, 74-75).

This overall section will cover the devices and products, which represent sound art, that are already on the market. The reason for writing a sound installations section, is to gain knowledge regarding what products are already out there and to get inspiration. Several different products will be displayed with information regarding what they do, why we chose to research it and how we can use this information in the project.

To sum up, sound installations are a form of sound art; these installations do not have a main core that each installation should present. The most common things in sound installations are abstract sounds connected to visuals, below, a few examples of sound installations will be shortly described.

### 2.3.2 FS/Partial

Sound installations mostly include interactivity and the following installation, which can be seen in the figure below, includes interactivity with the option to learn new things regarding the topic the artist chose, which in this case are partials. This installation can show the additive synthesis visually of the Fourier series to the user while creating sounds accordingly. The visuals are triggered by the user, they can control over 8 harmonic partials and this is where the interaction comes in. The height of the tube controls the amplitude of the sine wave played, and the direction from left to right, changes the frequencies higher.

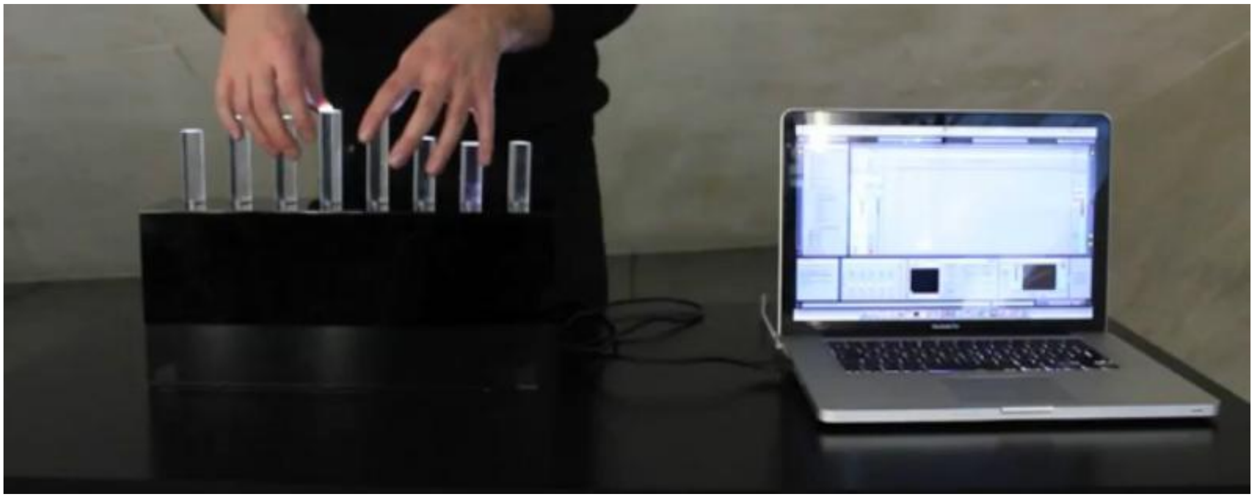

Figure 1 – FS/Partials setup

This example Figure 1 of sound installation includes features that are related to our current field of research which are art/visuals interaction to the public and teaching the user information by using sound and visuals, however this may not be a painting but it is considered a piece of art, however, a good inspiration for this research (Tudela 2013).

### 2.3.3 Spine

"Spine" Figure 2 is a much larger sound installation compared to the previous one, which includes the features the installation presented above does, one of the main features are visuals. In this case the "spine" contains twenty glowing cubes hanged by the ceiling, which change lighting schemes according to the user walking below it. It also includes an atmospheric sound composition, which reacts to the nearby visitors. This is one way to include users to the art and make them listen to the music.

Figure 2 - Spine, sound installation

However, the creators of this installation gave this art piece “emotions” which they describe as it being sometimes shy, sometimes moody, at times aggressive or too curious. This is an example of how sound art can express emotions, which is a good way to think of installations and a good inspiration when creating a product (Kollision 2012).

### 2.3.4 Dyskograf

The “Dyskograf” Figure 3 is an example of using visual creativity while creating music or sounds. An example of a Dyskograf can be seen in Figure 3. This installation is a graphic disc reader, which means the user can make small drawing, lines or circles on a disc specially created for this installation and when placed in this Dyskograf it will play sounds according to how the graphic is read on the disc (Lucas, Raguenes and Yro 2013).

Figure 3 - A Dyskograf being used

This installation differs quite a lot from the ones before, as it was noticed the FS/Partial is mainly used for learning purposes, while the Spine for exhibition and last the Dyskograf is a tool for creating music in a creative and intuitive way. It is an inspirational product, since the user interacts with the disk to create sound, this is done with drawings, and therefore, it is similar to the idea represented in the initial problems statement.

### 2.3.5 Drawing with Sound

"Drawing with Sound" Figure 4 is a product that relates to people interested in creating art (Opensen 2012).

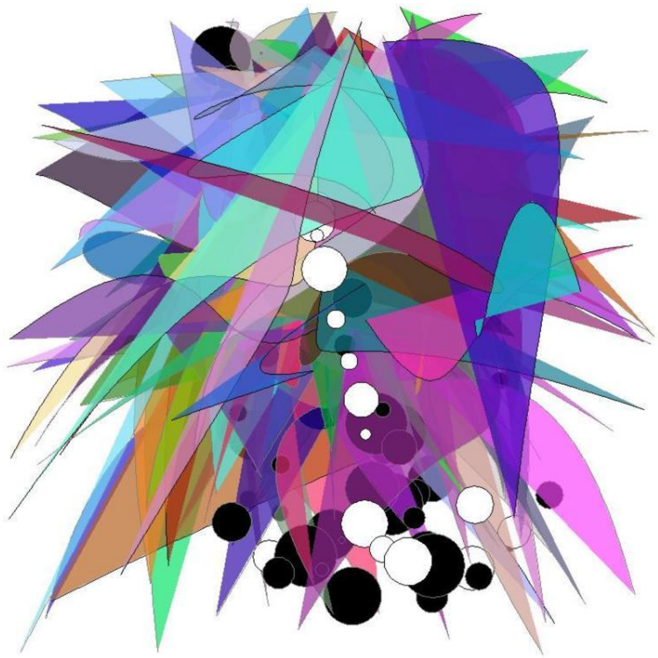

Figure 4 - An example of art drawn with the 'Drawing with sound' product

Drawing with Sound is a program that allows for easy interaction with a blank canvas. Through sound it is possible for people to create shapes and sizes with a random placement.
The reason this research regarding this program is done, is that we want to have interaction with visualization via sound. This application generates visual feedback on a blank canvas based on the sound that is recorded. This could relate to the project, in that sound can be applied to change visualization.

### 2.3.6 Reactive Sparks

"Reactive Sparks" (Figure 5) is a project with screens placed next to a highway (Lerner 2007). In this project the developers use the frequency of the sound of the cars to change the position of the sparks that are shown on the LEDs. There are microphones attached to the screens that record the sound of passing cars and indicate it on the screens. The sound of passing cars generates 'sparks' on the LED screens which are based on the speed and frequency of the cars passing by. This product relates to our project in the way that they sample the surrounding environment and affect the outcome on the screens as such. An idea would be to utilize the soundscape of the closest environment in a likely fashion in this project.

Figure 5 - Reactive sparks showing five LED screens

### 2.3.7 Sound-Reactive Drawings

"The Sound-Reactive Drawings" is an ongoing project where an artist named Peter Root has drawn scenery and done so that the different layers of the scenery react to audio feedback (Root 2001). The different layers in the image react to sound input such as wind, sea and cars. The idea behind the dynamic image is to have it move according to sound being recorded. The reason we chose to research this project is that it depicts a dynamic image in regards to sound. The way that the sound has an effect on the image is interesting, because it is several objects that are moved instead of a blank canvas of which new objects are added via sound as seen in some of the other products.

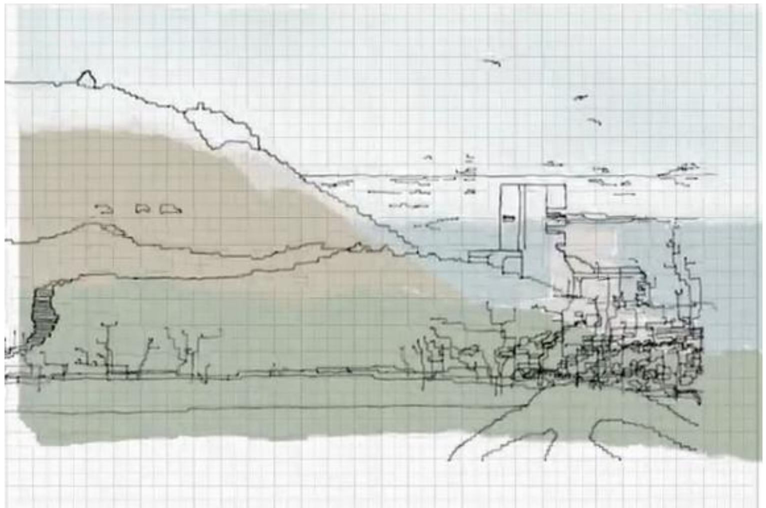

Figure 6 - Sound reactive drawings showing an image of multi-layered drawings that reacts to sound

## 2.4 Sub conclusion

To sum up, art is an important part in this project, as stated in the initial problem statement the research was focused on enhancing the experience of art. During this research, we have gathered a lot of information regarding sound and art, such as sound installations, which played an important role in setting some guidelines when creating a final problem statement.

## 2.5 Final Problem Statement

How can a user intuitively interact via sound with a 2D dynamic artwork if they are controlling it and how will this influence their interest compared to equivalent static art?

# 3. Analysis

The analysis will be going through the art terminology that has been deemed relevant for further research; grid systems and the golden ratio are terms that will be described. Next, sound is defined in technical terms and linked, in terms of relevance, to the project, as well as sound recognition, followed by computational auditory scene analysis. The analysis then presents the various types of interaction, interaction design in general as well as sound- and art interaction, and how they are relevant to the project, before moving on to what software programs can be used, followed by what software programs will be used. Finally, the Analysis is rounded up by stating the characteristics of the pinpointed target-group, as well as the established design requirements of the hypothetical product of the project.

## 3.1 Art

Art is many things, it can be cultural or personal and it has no limits to what people can accomplish in regards to art. In this project however we are only interested in some very specific things that art can do, these being how art can tell a story and entertain the people. We want art to help create something, which can be a new way of experience the joy of art and to accomplice this we take aid using technology to create this new way of seeing and experiencing art.

### 3.1.1 Grid System

Having a grid system is an important aspect to creating attractive design and art. A grid system is a sort of structure used to map the canvas of which a person is working with. A grid is used to divide a plane into smaller fields so that elements of design, illustration and color can be separated in a better way (Brockmann 1981, 11). The purpose of a grid is to most efficiently create graphic design that is pleasing and solves visual problems (Brockmann 1981, 13).

*"By arranging the surface and spaces in the form of a grid the designer is favourably placed to dispose his texts, photographs and diagrams in conformity with objective and functional criteria."* (Brockmann 1981, 13)

The ultimate goal of using a grid for creating art is to please the audience.

Here is an example of a grid system:

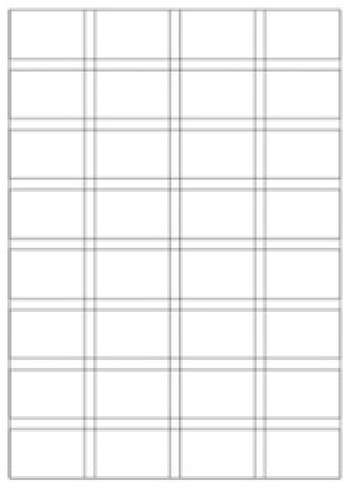

**Figure 7 - A setup of a grid system**

The example above shows a grid that roughly fits an a4 page. The squares indicate where objects would be placed in order to make an aesthetically pleasing design. The area in between the squares is called gutters. An example of how a grid could be used would be to place some textboxes in the squares, and maybe even an image filling up a few boxes. As long as the edges of the text or image follow the edges of the gutters, it falls in line with the prospects of using a grid system.

### 3.1.2 Golden Ratio

It is important to keep the golden ratio in mind when designing and creating art. Golden ratio is a term that indicates the most prominent points in a plane. As seen below, it is a curve going from one corner to one point in the opposed side of the canvas.

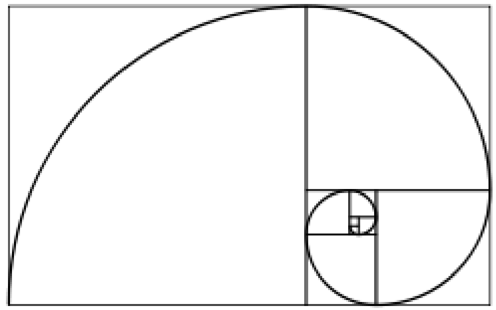

Figure 8 - Fibonacci Spiral

The Golden ratio helps designers place important objects in a painting since the eye will naturally fall on the positions that the Golden ratio will indicate. As seen in the example above, the golden ratio can be placed as it is, but also if it is mirrored. Flipping the Golden ratio example above will show that there are four points in a plane of that given size, since the example can be mirrored on both the x and the y axis.

It is important to note that the line indicated in the box is the line of sight for the viewer. This means that the first place for the eyes to fall would be in the lower right corner, and then the line in the box indicate the line of sight of someone viewing the image in question.

The golden ratio is directly linked the Greek numerical “phi” which is 1.618033987. What is meant by this is that the golden ratio line would be located in 1.6/2 of the image. (Pentago n.d.)

In this project it would be ideal to use the golden ratio to design the interactive image that the audience will interact with. The idea behind using the golden ratio in our interactive image is that we want the audience to have a pleasant experience and we want to place the elements within the restrictions of the golden ratio. The golden ratio is also useful for guiding the eyes of the audience, making sure that we highlight the important objects and elements for the audience. It also helps emphasizing the story of the image (Pentago n.d.).

### 3.1.3 Static Art

Static art can be represented by a normal motionless and non-dynamic picture, the kind of art commonly used in a museum. This sort of art has been used for centuries to express emotions and for people to interpret stories. The things we want to use from static art are that, when we create something that the viewers want to try, it needs to be an artwork they want to look at as well. This means that it should be nice to look at or at least just be at a point where its lack of artistic properties is not disturbing, we are not trying to create a piece of art since art normally follow some specific guidelines and artistic rules. Static art can only be enjoyed or watched by using one's eyes whereas dynamic art could also utilize hearing or smell.

**Figure 9 - An example of static art, the Mona Lisa (www.upload.wikimedia.org n.d.)**

### 3.1.4 Dynamic Art

Dynamic art is the opposite of static art, meaning pictures with motion. It can be described as if the dynamic element would give a new dimension to the painting bringing in motion, which can in some cases amplify the story being told or the emotion being expressed. The aspects from dynamic art that could be used are making a story more interesting to the crowd that does not find any pleasure in looking at a static picture, thereby making what we hope is a good mix between the emotions of a static picture combined with a more complete experience from our dynamic aspect.

Another aspect of dynamic art is cinemagraph. A cinemagraph is a still photo but with some motion in it. Cinemagraph is when a static picture has some moving elements thereby combining static and dynamic. This effect can be used to bring static pictures to life or setting the mood in a picture. Several examples of this can be seen online at places such as www.cinemagraphs.com. For our project this relates by giving us the opportunity to only have small changes to the art according to sound and still look pleasing and to some extent tell a short story.

**Figure 10 - First of two cinemagraphs**

**Figure 11- Second picture of the cinemagraph, where the foot has moved**

Cinemagraph is yet another example of how dynamic artwork can be made. As seen in Figure 10 and Figure 11 there is only a little change between each frame, but when played back, it is easy to see the change. Therefore, it is relevant for the project to research about this subject in order to give the product a better understanding of different art genres

### 3.1.5 Storytelling in Art

Grid design, dynamic and static techniques, are all used to create a product that will guide the user through a story where they themselves are giving an input, this is something that we are trying to accomplish when working on our project. The reason why it was chosen to research in storytelling through motion is that we want to be able to catch the attention for the users who might not be into the experience of looking at a static picture. By telling the story through motion, we hope that the viewers of the artwork will be interested in the story and therefore find the artwork interesting. This correlates with the final problem statement, as it is required to research if a dynamic artwork can be more interesting than an equivalent static piece of artwork.

One way that might ensure that the interactive artwork is more interesting is to determine if it is possible to tell a story through artwork.

When doing research of storytelling in general, we might be able to apply concepts from the theory behind storytelling. Storytelling in general revolves around having a story with different characters. These characters then have character development, which might give the viewer or reader a sense immersion and involvement. Furthermore, storytelling can also be developed and the story can evolve by having sequences of different events.

*"In a broad sense, stories are defined as unique sequences of events, mental states, or happenings involving human beings as characters or actors."* (Nakasone and Ishizuka 2007, 324)

Grid design, dynamic and static techniques, are all used to create a product that will guide the user through a story where they themselves are giving an input, this is something that we are trying to accomplish when working on our project. A big reason for us choosing to use storytelling through motion is that we want to be able to catch the attention for the users who might not be into the experience of looking at a static picture. By telling the story through motion, we hope that the users will be interested in the story and find that interesting.

Storytelling is a very broad subject and there is a lot of theory regarding how to develop good and interesting stories. Since it is such a widely spanned subject it is very difficult to research and apply to a product. Therefore, we are not going so much in depth with the theory etc. but rather acquire basic knowledge about storytelling, so it is possible to try to implement the theory behind storytelling in the product.

## 3.2 Sound

The word 'sound' can have different meanings and sound as we know it can be and contain many things. For example, sound can be music, but sound can also be thought of as more theoretically. For instance sound is made of waves, frequencies etc. And in order for this project to have any substantial content, this section will research on the topic of sound and go in depth with sound how works in general. This includes in depth look on the theory behind sound and how sound is defined in general. Furthermore, a look into what sound recognition really is will also be included. Since there is a desire and need for the report to go in depth with sound theory and sound recognition, this section will cover these subjects. These subjects will be relevant for further research, on how to create art that will respond to sound and how/what the art will respond to.

### 3.2.1 Sound Definition

As mentioned, the word 'sound' can have different meanings as well as the pivot of different subjective opinions. And according to Robert Pasnau (Pasnau 1999) the standard view of 'sound' are even "*[…] incoherent.*" (Pasnau 1999, 309) as Pasnau describes it, there is a problem and the problems lies within the different subjective opinions.

*"On the one hand we suppose that sound is quality, not of the object that makes the sound, but of the surrounding medium. […] On the other hand, we suppose that sound is the object of hearing."* (Pasnau 1999, 309)

But the supposition is that in order to establish the true nature of sound and to overcome any subjective and incoherent theories, there is a need to identify a more theoretically definition of sound.

According to Andy Farnell (Farnell 2010, 17) the real nature of sound consist of waves and vibrations, these waves are also known as sound waves (Apple 2013). The waves then move through a vibrating medium, this medium "*[…] is any intervening material between two points in space*". So basically Sound is sound waves of vibration these sound waves originate from vibrations of objects and these vibrations are then scattered in all directions (Apple 2013).

When the theoretically definition of sound has been established, a more thorough discussion with the intention of uncovering the subjective incoherencies can occur. The reason for the framework to uncover any incoherencies, is because of the desire to obtain a more specific non-theoretically definition, in order to fulfil the requirements of the final problem statement.

As Pasnau (Pasnau 1999, 311) mentions the standard view of sound is incoherent, and he defines the standard view of sound as being "*[…] at the place where they are generated.*" and that sound is not heard as being in the air.

### 3.2.2 Audio Features

There are four features that are used to describe incoming sounds. These are loudness, pitch, timbre and duration and these will be explained in depth in the following sections. Each one of these features have different importance in the composition of sound, however they all depend, to a certain degree, on the physical features of the sound such as frequency, pressure, duration, etc. An example would be the fact that the pitch is very dependent on the frequency, in fact without the frequency, a pitch cannot be detected (Rossin 1989).

#### *3.2.2.1 Physical Sound Features*

This section will briefly describe what is meant by each terminology used and how they relate to the audio features that are of interest in this case. As stated above, sound features depend on physical parameters of a sound, a simple sketch of how these depend on others can be seen in

Table 1, which can be found in (Rossin 1989).The table shows the dependence of the sound features to the physical parameters, for example loudness is very dependent on the sound pressure, hence the 3 plus signs.

**Table 1**

| Physical Paramete⇩ | Loudness | Pitch | Timbre | Duration |
|---|---|---|---|---|
| Pressure | +++ | + | + | + |
| Frequency | + | +++ | ++ | + |
| Spectrum | + | + | +++ | + |
| Duration | + | + | + | +++ |
| Envelope | + | + | ++ | + |

Sound pressure can be described as extremely small variations in atmospheric pressure to which the ears respond, these pressures can, not only be heard by ears but can also be recorded by microphone, and this is measured in decibels.

Frequency is represented by the number of cycles of sound waves per a unit of time, therefore it is usually measured in cycles per second and 60 cycles per second are equal to 60 Hz. The sound spectrum is a representation of sound which contains the amount of vibration of the individual frequencies in the sound; this is usually measured with a microphone, which measures the sound pressure levels. Spectrums are usually used for complex sounds where there are more different sounds in a room and each are measured in this spectrum. (Wolfe n.d.)

Envelope of sound is composed of the attack, sustain and decay of the sound input. The initial start of the sound is called the attack, in Figure 12, the attack is represented by number (1), while sustain is (2) and decay is (3). The envelope attack can be of two types; fast and slow, if the attack of the sound is close to the peak (B), then the attack is fast, examples of these types of attacks are gunshots, claps or door slams. On the other hand, slow attacks take longer to build the sustain of the sound, for example stepping on a dry leaf or tearing a sheet of paper slowly. Sustain is mainly the time that the sound will be sustained, while the decay represents the time taken to decrease in amplitude and become silent when the sound has reached end. (Mott's n.d.)

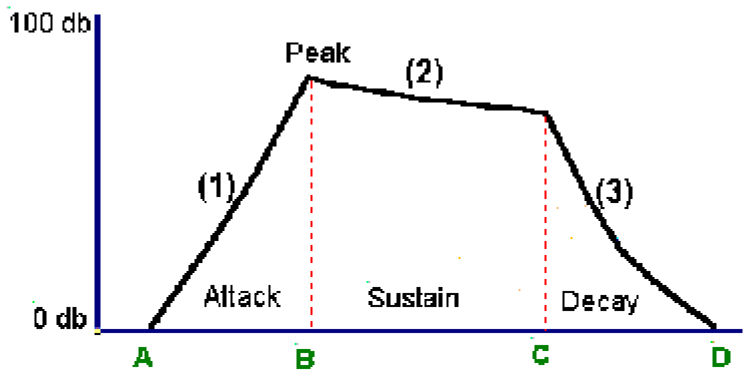


Figure 12 - This is an sketch of envelope

### *3.2.2.2 Sound Features*

#### 3.2.2.2.1 Loudness

Sound pressure and loudness are different things; however they both represent features that describe the sound. Loudness levels, compared to sound pressure levels, are expressed in phons. Phon is not a widely used unit to measure sound, however a scale was created to measure the loudness sensation of pure tones, which is called sones. The sone is represented by the loudness of sound with frequency at 1000Hz at a sound level of 40 decibles/40 phons.

Even though loudness is a sound feature that sound consists of, when a sound is recorded via microphones or heard by people, the sounds pressure is more often measured than loudness level.

#### 3.2.2.2.2 Pitch

After getting an idea of what frequency is referred to, we can move on to the pitch, which is characterized by the frequencies and the ear's response to these frequencies. Pitch was defined in 1960 by the American National Standards Institute as *"that attribute of auditory sensation in terms of which sounds may be ordered on a scale extending from low to high*"- (Rossin 1989, 109). Usually, pitch scales are considered music scales and a change in pitch is an octave. The basic unit of musical scales can be considered the octave, therefore notes in this scale with one octave apart will have 2:1 frequency ratio, however when talking about subjective pitches, scales with the unit mel are used. As stated in the physical sound features section, the pitch is dependent on the frequency and 0 – 16 kHz frequency range is equal to 0-2400 mels, pitch measuring unit (Rossin 1989, 109-115).

When measuring pitch it is important to take in consideration the duration of the sound or musical note. Some researchers believed that a pitch can be developed and recognized only after 2 cycles of the sound waves, however brief tones of shorter than 2 cycles are described as "clicks".

Another important aspect, which needs to be considered when creating a product such as the one that this report is aiming for, is to know the effect of multiple sounds interfering. Such points are mentioned in "The Science of Sound" where it is explained that tones with a lower frequency, which interfere with the tested tone, the pitch will shift upward, so the scale will point higher and in a reverse situation the scale shift will occur downward. Therefore, it is safe to conclude that if there is a tone interfering with the main sound the pitch is shifted according to the amplitude of the side tone exceeds the main tone. (Rossin 1989, 115-124).

However In the case of complex sounds, the pitches depend on the duration and timbre of the sound.

#### 3.2.2.2.3 Timbre

The timbre is a sound feature that represents the tone/sound quality or also known as "tone color". The definition of this feature states that a timbre is noticed when two sounds, with same loudness and pitch, are not heard as similar or the same sounds. Timbre depends on a lot of sound features and attributes, one of the things are the spectrum of the sound, the waveform, the sound pressure, the frequency and the temporal characteristics of the recorded sound. Compared to the other sound features presented above, the timbre does not have a certain unit that measures how much timbre is noticed or how it is created. However, it has been noted when listening carefully to certain instruments, that the difference in timbre consists in the series of harmonics of the sound created. In "The Science of Sound"-Rossing, a certain scale can be seen, which describes the timbre sounds as dull, sharp or brilliant. In 1877, general rules on how the ear detects timbre were created, however adjectives are used to describe certain timbre. For example simple tones, sounds of tuning forks or organ pipes, have soft, pleasant tones, while complex tones are very distinct and rough/cutting (Rossin 1989, 126).

#### 3.2.2.2.4 Harmonics

Harmonics is achieved when the sound created is composed of sound waves with certain frequency which sets in motion harmonic waves. Harmonic components of a tone can be determined by using Fourier analysis in sound, which is used to describe sound analysis, spectrum analysis or harmonic analysis. Joseph Fourier formulated Fourier analysis theory; *"Any periodic vibration can be built up from a series of simple vibrations, whose frequencies are harmonics of a fundamental frequency, by choosing the proper amplitudes and phases of these harmonics"* (Rossin 1989, 127).

#### 3.2.2.2.5 Sub Conclusion

In the table further up, the different aspects of physical parameters are explained in regards to each sound feature. The different sound features falls under different parameters and looking at the table tells us that the different features are directly connected to the physical parameters. The loudness is related to pressure which is why it could serve as a good feature to connect to the size of objects in the interactive image. When trying to reach a high pressure level in a sound, one can easily imagine increasing the size of an object.

### 3.2.3 Sound Recognition

As it is stated in the final problem statement, the focus of this project is to develop a dynamic painting that responds to sound. In order to achieve this correspondence, research in computational sound recognition will be conducted to obtain the knowledge required. When the analysis of sound recognition takes place, it might also be an advantage to look into how computational speech and/or voice recognition functions, as well as how computers can recognise and interpret these signals.

The reason why this report will go in depth with how computers can interpret and manipulate these frequencies, is because of the need to have correspondence to sound within paintings. Because of this need, it is ideal to research in speech, sound and voice recognition as their might be further use, of the knowledge on these subjects, in the future.

When it comes to sound recognition and how computers can interpret the signals from voices and various sounds, a technically approach cannot be avoided as the computer have to know some way of interpreting the sound waves from various sound sources. This computational interpretation is typically done by analysing the frequencies from a sound source as well as other technicalities that defines sound waves and makes sound interpretable. (K. D. 1998)

When sounds from voices or other sources are created different sound waves are created and each of these sound waves has different frequencies. What happens when the recognition occurs is that the computer intercepts these frequencies and processes the signals and then interprets them in its own way.

*"Features that appear to be important for musical instrument recognition include (but are not limited to): resonance characteristics (e.g., the frequencies and bandwidths of formants), amplitude envelope (attack, decay, and tremolo characteristics), inharmonicity, spectral centroid (which is known to correlate with perceived "brightness"), onset asynchrony (the relative attack times of low- and high-frequency partials), pitch, and frequency modulation (e.g., vibrato, jitter). In sounds produced by natural sources, these features will strongly covary;*

*for example, a source with a narrow resonance (indicating loose coupling between excitation and resonant body) will exhibit a slower attack than one with a broad resonance.*

*In an artificial recognition system, it is desirable that the signal representation capture as many of these features as clearly as possible [...]."* (K. D. 1998)

*"The general theory of sound-source recognition that I propose can be stated simply. Recognition is a process—not an achievement or goal. It is the process of gathering information about objects in the environment so as to more accurately predict or infer their behaviour".* (K. D. 1998)

According to Rabiner & Juang (Rabiner and Juang, Fundamentals of Speech Recognition 1993, 2) there are many different disciplines to consider when using speech recognition systems.

*"One of the most difficult aspects of performing research in speech recognition by machine is its interdisciplinary nature […]. Consider the disciplines that have been applied to one or more speech-recognition problems:*

1. *signal processing […]*
2. *physics (acoustics) […]*
3. *pattern recognition […]*
4. *communication and information theory […]*
5. *linguistics […]*
6. *physiology […]*
7. *computer science […]*
8. *psychology […]*

*Successful speech-recognition systems require knowledge and expertise from a wide range of disciplines, a range far larger than any single person can possess"*

These are some disciplines to consider when creating great speech recognition systems and these disciplines are important to have in mind when working with how speech recognition works. These disciplines might also be applied to the very idea of having dynamics in a painting.

## 3.3 Computational Auditory Scene Analysis

In conjunction with the research on the topic of sound an enhancement of the analysis as well as the overall framework will occur, providing the project with more material as well as a breeding ground for future use.

Therefore Computational Auditory Scene Analysis (CASA) is well suited for a discussion, as it is a system that seeks to develop computational "hearing" meaning that computers will have the ability to hear and distinguish sounds as we humans do.

*"Broadly speaking, CASA may be defined as the study of auditory scene analysis by computational means. […] one may define the CASA problem as the challenge of constructing a machine system that achieves human performance in ASA."* (Wang and Brown, Computational Auditory Scene Analysis: Principles, Algorithms, and Applications 2006, 11)

This definition indicates that CASA can be defined as the same as auditory scene analysis (ASA) but with the computational aspect. Therefore it would make sense to research about ASA in order to successfully find the definition of CASA.

As a dynamical painting will benefit from the research done in CASA systems, the dynamical portion in the painting might benefit from the human body when looking into how certain parts of the human body functions.

*"One way to make CASA more biologically relevant is to limit the scope of investigation to monaural (one-microphone) or binaural (two-microphone) input [...].* (Wang and Brown, Computational Auditory Scene Analysis: Principles, Algorithms, and Applications 2006, 11)

(Wang and Brown, Computational Auditory Scene Analysis: Principles, Algorithms, and Applications 2006)

The benefits of having a product that is biologically relevant and that has hearing that simulates a human's would be the enhanced experience the user will get from the product. This might mean that the interaction with the product will have more depth, if the human hearing is simulated as the product can react in multiple different ways to interaction. For instance, if the product is biologically relevant, the interaction could make use of among others the range of the sounds produced, the placement of the sound, the panning of sound etc. Further, interaction will be an important topic to look into, therefore this will be considered in the following section.

## 3.4 Interaction

Interaction occurs when an object is being influenced by a subject. There are many different kinds of interaction, some of which will be explained in this section.

A smartphone is a good example of something that has a multiple aspects of interaction. When using a smartphone you are using the touchscreen which is an interface. You are interacting with the smartphone by touch but it is also possible to use something called speech recognition, which is an example of sound interaction.

Sound interaction will be explained in this section. The reason for explaining the sound interaction is that it is important for the project since sound interaction is relevant to the project. The interaction in this project refers to the audience interacting with our 2D art installation using speech recognition.

The product could include a variation of techniques that will allow for the audience to change specific objects in the dynamic image regarding their position and posture. The techniques used might include the pitch of the sounds that the audience is making, the frequency and the amplitude.

### 3.4.1 Interaction Design

Interaction Design is when a product is designed with interaction in mind. In this project's case, the reason for creating a project with interaction design in mind is to create user experiences that enhance and augment the way people enjoy art installations, and to involve the audience with the art that they are (Rogers, Sharp and Preece 2011, 9).

When creating a product, it is important to consider how the audience will have an effect and influence on the dynamic artwork which is also why it is very important to have a simple yet effective interface. The user experience is also very important to have in mind, since it is the way that people feel about a product and how pleased they are by using it (Rogers, Sharp and Preece 2011, 13).

#### *3.4.1.1 Interaction Types*

There are four main types of interaction: Instructing, Conversing, Manipulating and exploring. It is important to define which of the four different types that are focused on, because the designers of the product will know exactly how the product works (Rogers, Sharp and Preece 2011, 46).

1. Instructing – The user is issuing instructions to a system. The user can be using a menu, typing in commands or speaking commands.
2. Conversing – The user is having a dialog with a system. The user has a more fluent interaction with the system in full 'sentences' where the system returns either text or speech.
3. Manipulating – The user interacts with objects in a virtual or physical space. The user manipulates the objects by opening, holding, closing or placing them.
4. Exploring – The user moves around in a physical or virtual environment. The user experiences a 3D virtually real environment or moves about in an area in real life.
   (Rogers, Sharp and Preece 2011, 47)

When designing a dynamic art installation that responds to sound, the most ideal interaction type to use would be manipulating. The reason that manipulating falls in line with creating a dynamic 2D painting, is that the user is manipulating objects in a system, which is what we want in our project.

When the target group is interacting with the interactive image, the manipulation will occur via the sound input that the product registers. The sound input that the product registers could be based on the sound features; loudness, pitch, timbre and duration (Sound Features).

### 3.4.2 Sound Interaction

This section will cover the concept of including interaction with sound into a given design, what sub-components the overall concept contains and how this is relevant for this particular project.

The concept of interacting with sound does seem to be on the rise, as more and more innovative developers dive into this topic, however, it is still at this point in time a somewhat complex area for this project to approach. The reason for this is that the majority of the sound installation section, concerning this field, revolves around making gadgets and devices that create a sound to which the human mind responds, whereas this project aims to have the device receive and react to a given sound generated by humans – be it speech, footsteps, etc. In the paper *Interaction with sound: An interaction paradigm for virtual auditory worlds* (Röber and Masuch 2004) Niklas Röber and Maic Masuch, of the institute for Simulation and Graphics, explain how sound interaction can be defined, by dividing it up into core components, and how these components individually function.

When it comes to interacting with sound, the concept can be, according to Röber and Masuch: "*[…] be split down to navigation, the interaction with objects and communication with other characters*" (Röber and Masuch 2004, 4). Of these three components, the interaction with objects would seem to be the most prudent choice of research for the goal of this particular project, as it revolves around the interaction between human and gadget with the focus being one of the two acting as a listener. Within this section, is the information regarding the interaction technique the radar device or radar interactor, that functions as explained in the following quote:

"*Everything that gets lit by the radar answers in a predefined manner, by either a verbal description or an agreed sound signal […] Every response is amplified by the distance in a way that closer objects appear closer.*" (Röber and Masuch 2004, 5)

While keeping in mind that the functionality mentioned above sets up the device as both the emitter and receiver of sonic information, it does provide an insight of how the sound received by this project's product could incorporate some sort of amplification, and pin-pointing, of sound sources in the gadget's surrounding environment, in order for it to prove capable of performing as a sound interactive device.

### 3.4.3 Art Interaction

Interaction with art gives another perspective on what art is and what art can be, because in traditional art the artist is the only one who decides what is in the picture, it is up to the viewer to interpret it in that way. Whereas with interactive art the viewer also plays a role in "creating" the art he or she sees and also is the one to interpret the meaning of the art giving it a new kind of experience.

The meaning of interaction with art is that the audience can in some way interact or change what happens in the art giving it a new experience. An example of this could be art installations where an artwork is displayed in a room, and where the whole room should be considered a piece of the art. This is because the room and the things in it help changing the mood or meaning of the artwork. (Paul 2008, 71)

Figure 13 - An example of an art installation it like seen below where the entire room is the art experience

Another piece of interactive art could be something like an interactive art work presented in a normal picture frame but where the users can interact and change things in the picture, much like we are trying to create.

When looking at interactive art there are many different possibilities, such as what the artwork should be, a painting, a wall or many other things and what aspect of the artwork is possible to interact with, colors shapes or something else.

## 3.5 Intuitiveness

The design of the dynamic painting might have some complications in regards to interactivity and how it should be performed. The reason why some complications may occur is because of the traditional way of viewing paintings. This traditional way of interacting with paintings may become problem for the product, this is something that is required to be addressed so a solution to the problem can be found.

When thinking about how people interact with a normal static painting usually the case is that the viewer observes the painting silently without any interaction other than their imagination wandering free as they watch the painting. The issue might be that people are not familiar with dynamical paintings and especially not talking and making sounds in order to interact with paintings as the traditional way might be a behavior that is hard to put an end to.

Furthermore it is necessary to experiment if this intuitiveness has been achieved in the product. The way to do this would be to have a usability experiment with a couple of people, in order to find flaws and fix them before the final experiment will occur. This usability experiment should eliminate a lot of flaws and can make the product achieve increased appeal and efficiency.

According to Steve Krug:

*"Experimenting one user is 100 percent better than experimenting none. Experimenting always works, and even the worst experiment with the wrong user will show you important things you can do to improve your site."* (Krug 2006)

Steve Krug talks about usability experimenting in websites, but the theory he talks about in his book can also be applied to other kind of products. For example how the usability experiment of the dynamic painting should be conducted.

What also might help the end product of this project a lot would be by applying the theory of Donald A. Norman. Norman is design and usability engineer who wrote the book called "The Design of Everyday Things" in this particular book he addresses the issues of not designing products the right way and leave the consumer helpless.

*" "You would need an engineering degree from MIT to work this," someone once told me, shaking his head in puzzlement over his brand new digital watch. Well, I have an engineering degree from MIT. […] Give me a few hours and I can figure out the watch. But why should it take hours?"* (Norman 1988)

What Norman could contribute to this product would be to design the dynamical painting as intuitive and natural as possible so the user does not " *[…] push doors that are meant to be pulled […]"* (Norman 1988)

The last one is a metaphor for not confusing people and makes the product ready to use with no complications.

There are different ways this interaction with the painting might seem intuitive and occur natural.

One of the ways would be to adjust the sensitivity of the sound input to a higher degree so when the viewer has to interact with the painting, any small sounds such as footsteps, whispers, a friction with the viewer's clothes etc., will activate the dynamics in the artwork. Perhaps the sound sensitivity might work as an ultimate means of usability, but this however has to be experimented before an actual statement on this matter can be expressed.

Another way to make the interaction occur would be to completely go overboard, and it is however felt that this might produce biased results, as the participants might get a completely different experience out the product. Because of this, it is not the preferred way to accomplish intuitiveness.

A completely different approach would be to indicate with a symbol, either out of the frame or inside the painting, that the dynamic painting is sound responsive. This symbol could be a microphone or a head with sound waves coming out of the mouth.

## 3.6 Technology available

When looking at our final problem statement, we can see that we might work with dynamic artwork and sound. There are many different programs that can be used in this case, so before we choose, we need to look more into them.

### 3.6.1 Java

Java is an object-oriented programming language. Java is capable of drawing shapes and lines. It is difficult to draw in Java, as everything needs to be hard coded and there is no graphical user interface to 'draw' sprites. Drawing in Java will result in pixel perfect drawings since you code everything and does not rely on a mouse or tablet to draw with (Fata 2004).

- Pros

  - Easy to integrate Max 6.
  - Supports a lot of platforms.
  - Easy to draw simple art
- Cons
  - Hard to draw advanced art
  - Little sound support
  - CPU heavy

### 3.6.2 Processing

Processing is program made for creating drawing and animations from various inputs. We have previously used it together with Arduino and it is easy to connect to other things as well, Max 6 being one of them (Kriss 2006).

Processing is a language in itself, as well as an integrated development environment. It is built on Java which makes it easy for us to use.

- Pros
  - Made for 2D graphics and drawing.
  - Supports many inputs (including Max 6)
  - Easy to learn and use
- Cons
  - Not a language we know very well
  - No native sound support

### 3.6.3 Max 6

Max 6 is visual programming language, which means everything is drag and drop with no coding at all. We are learning how to use Max for sound manipulation and sound design. It is our preferred way of using sounds before passing data along to another program.

Max does not offer any drawing or animation functionalities by itself, so we need to use an external program to pass variables to, which can then draw things.

- Pros
  - Made for sound manipulation
  - Very easy to use
  - Can send UDP data
- Cons
  - Doesn't have any graphics

### 3.6.4 Chosen Technology

Now that we have looked at different applications it is time to go in-depth with our choices.

#### *3.6.4.1 Max 6*

The art is supposed to be shown at different public places and it needs to be easy to interact with. One of the programs we wanted to use was Max 6. Max 6 is a sound creating software with we wanted to use as the base engine for our sound recognition. It can also be used to manipulate sounds. One of the thoughts we had for displaying our artwork was to use a language such as Java or Processing to make the graphics for the artwork. But we might want to have a graphical user interface for just the sounds. This is accomplished quite easily in Max. There are different ways of creating nice graphics and waveforms of the live sound in Max and it could be useful for the target group or the developers to see things like, waveform and spectrogram, and be able to adjust things like, volume and filters, without having to go through the code.

#### *3.6.4.2 Java*

If we go more in-depth with the actual way of displaying our artwork we should take a look at geometric primitives in Java. Using geometric primitives in java we can draw a lot of different images using simple code. This can be done using things like Line2D, QuadCurve2D, CubicCurve2D, Arc2D and of course using standard geometric figures such as Rectangle2D, RoundRectangle2D and Ellipse2D (Oracle 2013).

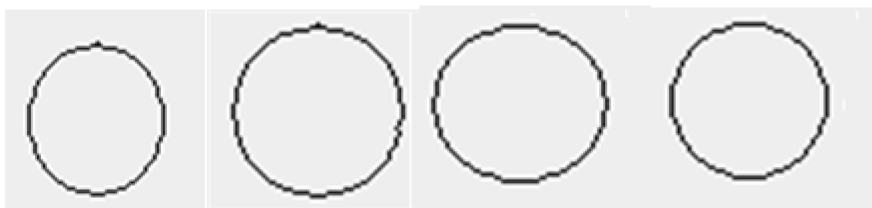

Figure 14 - A demonstration of 4 circles we have manipulated using width and height

When you have a simple drawing, for example one made by hand, it is not very hard, but it takes time, to recreate it in Java, using the described methods above. Because it is coded and not drawing in vector, using Photoshop or Illustrator, the image can be manipulated, to some extent, easily.

If we look at the four ellipses in the figures above, we have four almost identical ones. If this was for example the head of a person and we circled through them, faster at high volume from an outside source and slower at the low volume, it would change the artwork so people would feel they are controlling it, but it wouldn't change the artwork so much as it got out of hands.

Our changes are small; we are not changing an ellipse for a rectangle, so our users would see a dynamic artwork that changes to their behavior rather than just being a static image.

#### *3.6.4.3 Displaying artwork*

For displaying the artwork we can use a couple of different things. If we want to have an easy to use plug and play version, it would be optimal to display the artwork on a laptop. A laptop includes a screen for displaying the artwork, a microphone and a processor to run to program that creates the artwork.

For a more public display of the artwork it would be best to split up the different components in order to get a bigger screen, more microphones and a better processor. For a screen one could use a projector to display a very large version of the artwork. A setup of multiple microphones should be used. Different groups of microphones could change different aspects of the artwork and not reply on a single sound source as a laptop would. Since there is now a larger screen and more microphones a better processor is also needed to do the sound recognition and rendering of the artwork. Here a more powerful desktop computer would be ideal.

In a museum a projector might not be ideal for a small exhibition but a larger computer screen than a laptop would definitely needed. A TV screen would work great and a pair of microphones and a small desktop computer could easily power it.

Binaural microphones can be used for the setups. Binaural microphones is a way of recording in stereo where you can record in a 3D space and by using a stereo headset you can listen to the sound in a 3D space. Recording using binaural microphones will give us a more interesting way of analyzing the sound since we will be able to also use the position of the sound as a parameter to change.

## 3.7 Target Group

In this project we are aiming for a wide target group, which means that we do not have many requirements for the people testing our product. The reason for having a wide target group is that we want to test the difference between a static artwork and an interactive art installation. This will be explained further upon in the experiment chapter.

The users are merely meant to have a general idea of how common technology works in order to consider the aspect of an interactive art installation compared to a static art installation. As for requirements, we have restrictions for their age and any handicap that might obscure the results of the test.

An age range is set to span between the age of 18 and 40, as the developers believed it to be simpler to create a technological device comprehensible by someone certainly familiar with today's basic gadgets in general.

The subjects can be either female or male, since the gender will not affect the testing. The users should have proper sight in order to be able to see the product. The users should also not be mute, because the product should be interacted via sound.

## 3.8 Design Requirements

The analysis includes a lot of information on what different techniques to use and theory on subjects related to our final problem statement. All the research done in the analysis leads to creating the design requirements. The design requirements will work as a sort of conclusion on the analysis chapter. The design requirements indicate how the prototype should be designed. Gaining the knowledge regarding sound theory and interaction is what lead to some of the requirements that are stated for the design of the product. After obtaining the knowledge it seemed that creating the product via these requirements would make most sense. The two microphones make sense in regards to record the audience most efficiently. Displaying artwork

### 3.8.1 Functional

- The prototype should use two microphones
- A computer is necessary for the processing of the interactive artwork
- A display or projector is needed for displaying the interactive artwork
- A static version of the image is required for comparison

### 3.8.2 Non-functional

- The final product should be intuitive to use
- Both artworks should be interesting
- The artwork needs to have dynamic objects that change according to sound input

# 4. Design

The design chapter will show what the concept of the product is and explain why we chose to design the product the way that we did. Our goals and expectations with the product are to increase the audience's interest in an interactive artwork. Also to experiment if an interactive image will be interacted with more. The design chapter also applies knowledge gained from the analysis into the product and will hopefully result in the ideal product. The design is also based on the design requirements that are drawn from the analysis, to make sure that the product does not have any unnecessary functions, and that it can be a solution to the final problem statement. The design chapter works as guidelines for the developers to use when creating the product.

## 4.1 Design Idea

This section will describe the ideal idea of the interactive image and a discussion of how the objects on the screen react will be featured. The general product idea is to have specific objects moving according to specific sound features.  These specific sound features will for instance be the pitch, frequency, amplitude etc. of sounds and voices.(Sound Features)

The product idea is to have specific sounds that need to be produced, which involves having specific sound feature data from the sounds produced. The objects in the painting will then react to the specific sounds related to what the objects represents and what sounds they would make in reality. For instance in order to interact with the car, in the painting, one will have to make car sounds. Moreover, in order for the cloud to react to the interaction of the user, a wind sound in the sense of blowing in to the microphone would have to be produced from the user. This way of interacting with the objects will have to apply for all the objects.

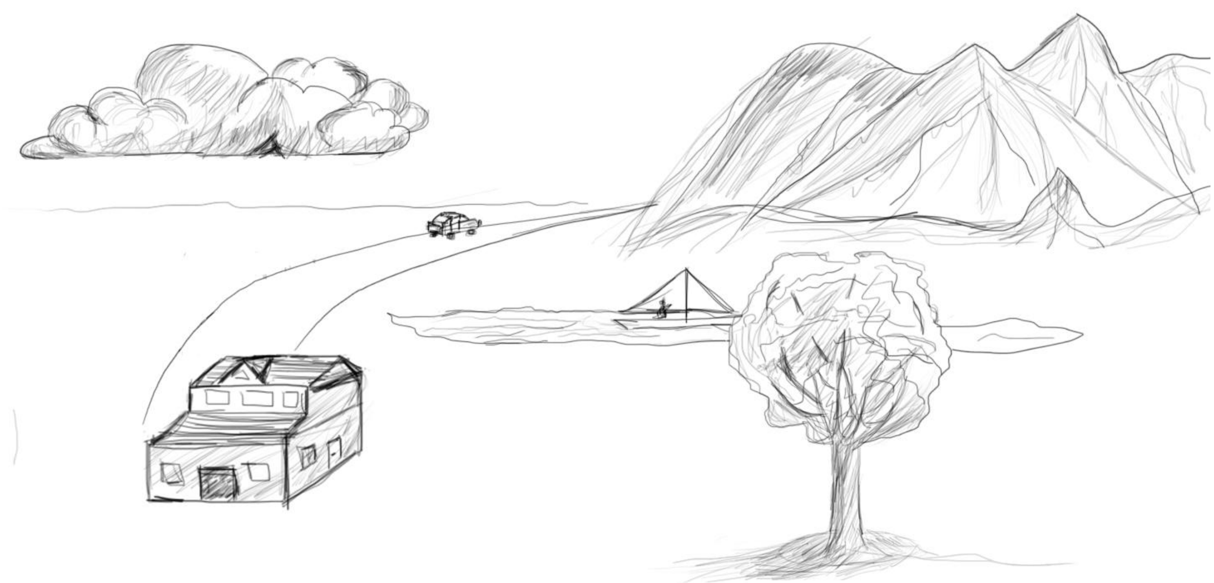

**Figure 15 - Depicting a draft of the ideal artwork**

On the artwork above you can see the concept art we have done for our artwork. The idea behind it is a landscape where a house is located by a lake, with a mountain in the background. There is a tree located on the right side of the artwork. Above the house there is also a cloud, and in the lake there is a person on a boat. The mood that we aim for in this artwork is calm and relaxed. The reason why we chose to have a tree and a cloud is that they are in synergy. The lake also goes great with the tree and cloud since we can alter them all with the imitation of wind. The house is added so the viewers can relate, since everyone has a home. The mountain is added in order to give some balance to the image. The car is good for adding further movement to the artwork.

It is worth noting that Figure 15 is the draft for the ideal prototype artwork; the graphics will be closely related to that of a painting in the real artwork as well as colors will be added in the ideal artwork

What this allows is for the objects in the interactive painting to have a sort of identification, meaning that the different sound features produced by the user will be somewhat similar to the sounds of the represented objects or it could be said to be a sound imitation of the objects in the painting.

Therefore, the sound features, in relation to the painting, have to correlate with the sound the objects in the painting would make in real life. Because of this, the idea can have inconveniences relative to the interactivity of the product and how intuitive the product is, as the users might have different understandings of, for instance, how a car sounds and how a tree sounds.

## 4.2 Art on Screen

As the general idea for the final product is to have both static and dynamic objects represented in the interactive painting, the overall product idea will be discussed in this section. This includes the different features that will be included in the final product, Storytelling in Art aspect.

The general idea of the dynamic artwork is for it to have elements that can give the viewer a sense of story. Hence for it to be a storytelling piece of artwork that will let the user experience the artwork through their own imagination and what is displayed, to create their own interesting story based on the small story we present to them. This should, if done right, allow the viewers to have a different view of what the story is about, what happens in the picture and why.

The storytelling includes graphical elements that will be able to give the user some input in form of small stories being told, so they can form a story with their imagination as mentioned above, therefore not being abstract. It does not mean that the graphical elements will move in the sense of progression. Instead the painting will consist of different elements, some static elements and some dynamical.

It is important to emphasize that the main focus of this project is to develop and test functionality of interactive aspects, rather than aesthetics of artistic aspects. This choice of focus was made by the developers. As such, test subjects should provide the developers with feedback on the success or failure of the interactive elements added to the art-piece.

### 4.2.1 Graphics Choice

For this product, the choice for the representation of the painting was to go with a 2D graphical representation, as it was felt that it would resemble a real static picture the best. We assume it will also be easier and more convenient to manipulate with 2D graphical elements rather than 3D graphical elements.

### 4.2.2 Image Color

We want both the dynamic- and static image to have colors as opposed to being in black and white. The reason for the image being in colors is that the goal of the project is to try and get as much attention from the viewers as possible, and increase interest as much as possible. It is believed that with color, it is easier to spark interest in the viewers.

#### *4.2.2.1 Color Symbolism*

In our product we have a lot of different objects that have different colors. The reason behind those colors is that they should represent the object that the given object is trying to resemble. This means that we have chosen some different objects, for instance a house. The reason, for example, for the cloud being the color blue, is that we want the cloud to seem realistic opposed to abstract, such as reminding of the sky, having the same color as an actual sky would have. The same goes for a tree, the reason the trunk is brown is that a tree has a brown trunk in reality. The reason for recreation the same colors in our objects as in reality is that we want the image to symbolize the objects that is known by all in reality. We also have the colors change interactively according to sound input. The hue and saturation of the object's colors will directly be influenced by the sound input, like when the cloud gets very dark it will start to rain.

## 4.3 Interesting

The product we end up with has to be interesting opposed to being educational. The reason for focusing on interesting rather than education is that we want to experiment if a dynamic artwork is more interesting as a static artwork. We want to experiment if we can draw in the audience's attention with a dynamic painting, and if it is easier to get the viewer's interest.

We want the image to tell a story because the goal of the dynamic painting needs to be interesting, and get enough of the attention from the viewers that we would be able to experiment the level of attention to a similar static image. Having a story in the painting would help to get and keep the attention for longer than a painting with no specific meaning. (Storytelling in Art)

The story of our image is told with the different objects that are present. Having the lake, the tree and the cloud suggests the climate, and the person standing next to the house suggests that the story revolves around that person. Our story is subjective on the most part, since we want the specific details to be determined by the audience. We don't tell our story with the animations we alter the objects to indulge the audience further in the product. The idea behind our product is that we have set a frame and some limits as to what the story could include, but the most part is left up for the audience to consider. The frame of the story includes the objects being very realistic compared to abstract art, so the imagination of the audience most likely will be somewhat related to real life. We want to focus on realistic reconstructions of the environment opposed to creating abstract art. Another thing to add is that with the color selection that we have done, the objects in the artwork are represented as the actual objects in real life – with the same colors in order to further help the audience think of real situations. That being said, we have put the environment up as we have in order to give a sense of the outside world, and the rest is up for the audience to consider. If we were to have longer animations we would not leave as much up to the viewer's imagination as smaller animations does. For instance, if we were to control the car object in our image to leave the screen and not come back, the audience would be further limited in regards to what the backstory of the car is. The mood of the image is also something that relates to the story of the image since the colors will change according to the sound input from the users, and this helps further develop the story of our interactive image.

## 4.4 Grid Design and Golden Section

When creating paintings, one important thing to have in mind is the placement of the different objects in the picture. The placement of the objects is important as the visibility and the noticeability is dependent on the object placement.

If a specific character is desired to be noticed right at the first glance of the picture, creating a grid and a using the golden ratio is helpful. The two techniques are also useful in order to create the desired feelings and in order to control the viewer's attention towards the objects. Furthermore what is important in the painting should be highlighted the right way. Different placements of objects can have drastic changes in the emotions that a painting can invoke. In order to assure the right object placement, the golden ratio is applied to our concept drawing.

As the grid system is described more in detail in (Grid System)**,** this section will go in depth with how we use the grid system in our product design. The reason for creating a grid system and using the golden ratio is to create a more appealing and intriguing painting.

Basically what the grid system does is to proportionally resize the objects, in for instance a painting, correctly.

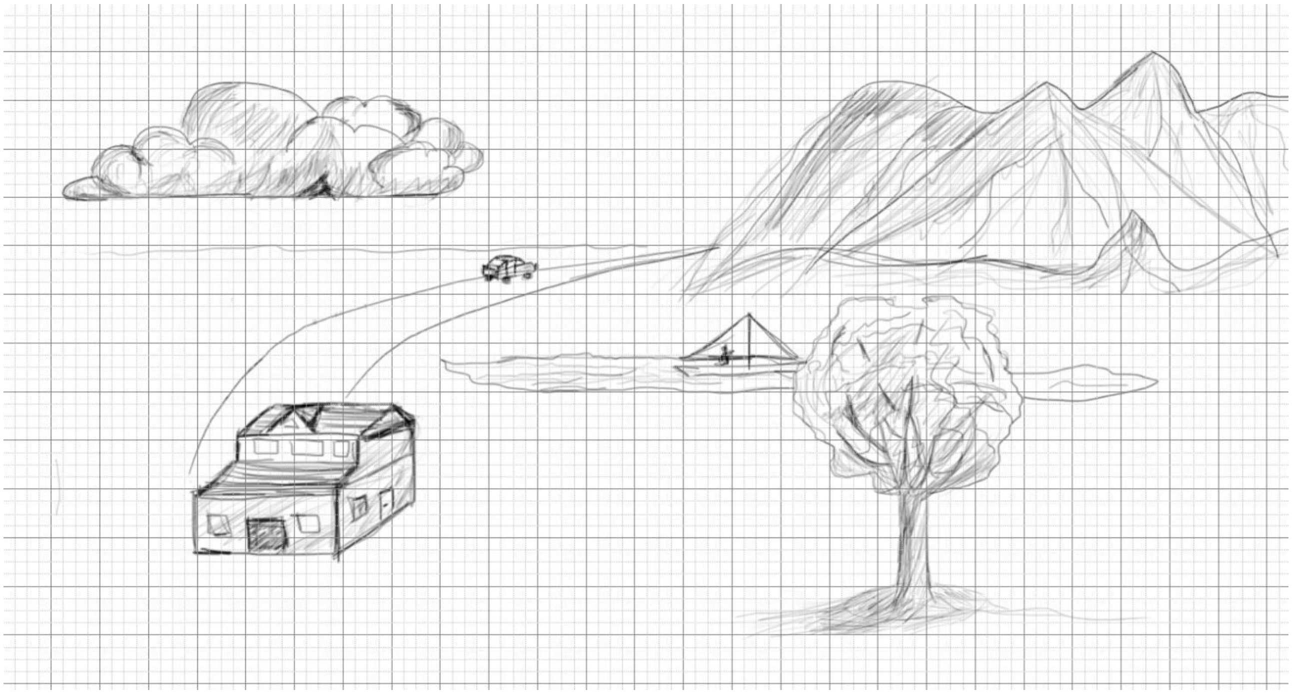

Figure 16 - Concept art of the interactive painting, depicting the proportioned grid design

As displayed in Figure 16 the objects in the concept art is proportioned in the grid squares which balances an artwork by placing the objects in grids, furthermore there is the advantage that the art will be increasingly organized and therefore more pleasing to look at.

The grid system and the golden ratio were also used in the concept art in order to create conformity between the objects, in regards to the placement of the different objects, thus providing the product the ability to be interesting.

In this case, the golden ratio has been used in a very specific way, as the interactive painting has to correlate with the story telling portion of the painting, which should be expressed. By highlighting different objects within the pattern, we can guide the viewer's eyes and mind. It can be possible to tell a story via the placement of objects, in this case we are putting emphasis on which objects are interactive.

It is previously described in Section (Golden Ratio**)** that the points of the golden ratio can be visualized with a Fibonacci spiral. This spiral can create the points needed for the golden ratio to add up. In the interactive painting these golden ratio points have also been used for the concept art of the interactive painting in order to create focus on some specific objects.

It is a deliberate move to place these objects in the golden ratio as it is desired to, in correlation with the way the story should be portrayed, have focus on these objects as the viewer should imagine their own story. An example could be: "Is it a vacation?", "Is there a storm coming and is that car leaving?" etc. Therefore it was chosen to draw focus to the cloud, the mountains, the tree and the house. Also there is a drawn focus to the car, this focus is created by the lines, of the road.

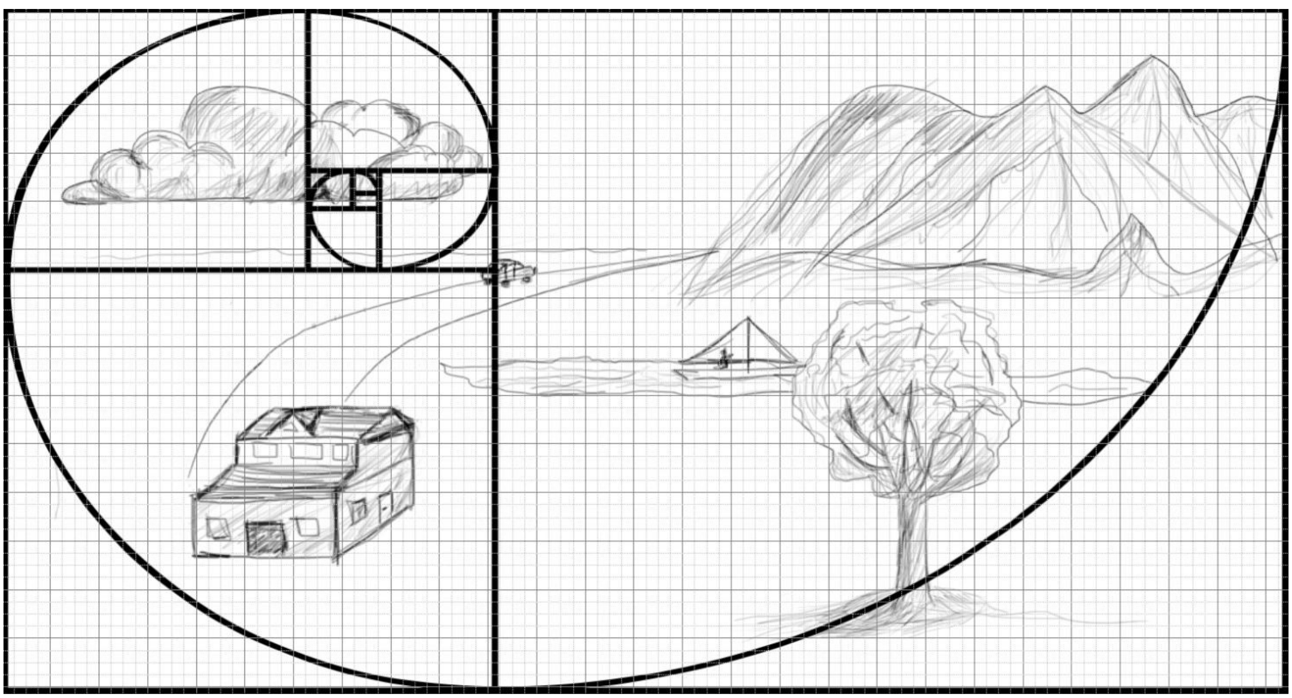

**Figure 17 - The concept art with the applied Fibonacci spiral that creates one point of the golden ratio**

In Figure 17**,** one of the golden ratio points is displayed. In this particular case it is the golden ratio point for the cloud.

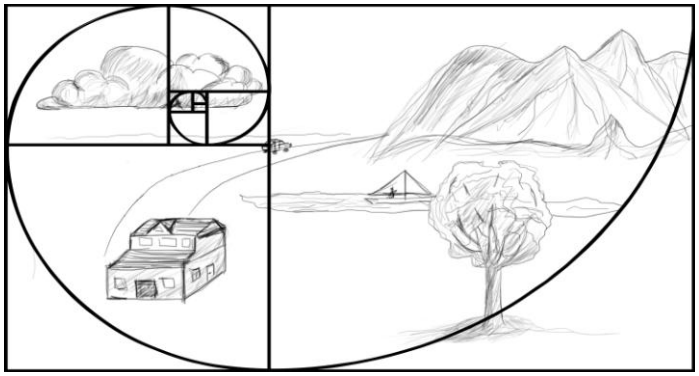

Figure 18 - The concept art with the applied Fibonacci spiral from the top right corner

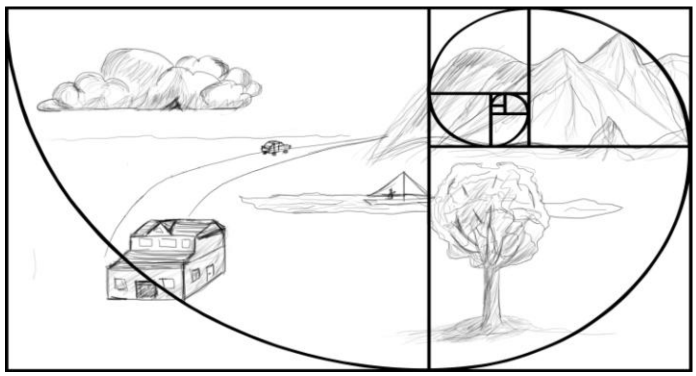

Figure 19 - The concept art with the applied Fibonacci spiral from the top left corner

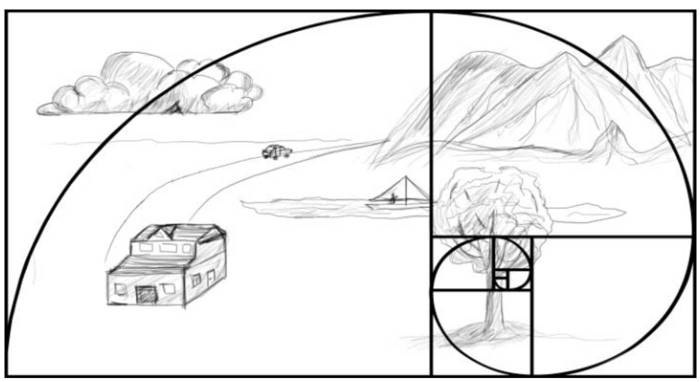

Figure 20 - The concept art with the applied Fibonacci spiral from the bottom right corner

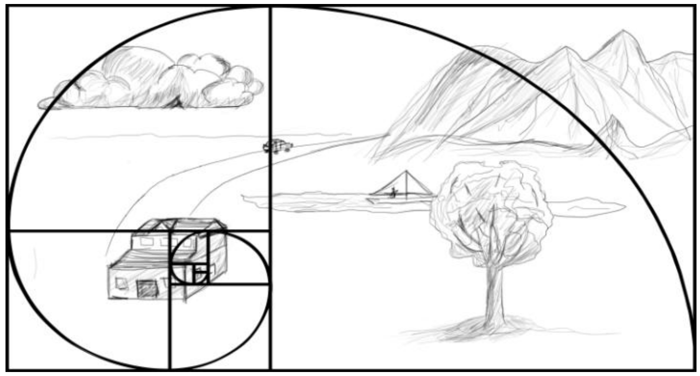

Figure 21 - The concept art with the applied Fibonacci spiral from the bottom left corner

As depicted in the particular four objects that are focused on are respectively the cloud, the house, the mountains and the tree. As it is previously mentioned, it is done in order to achieve the desired effect in the eyes of the viewers. In this case the desired effect is to let the viewer's understand what objects are interactive as well as give emphasis on the possibility of a story. And in order to achieve the desired effect, the object's placement in Figure 18 was chosen in order to start the imagination process. And even though it is a simple picture that contains few elements, the golden ratio can still contribute to achieve the desired focus on some objects.

Furthermore it is important to have in mind that the overall concept art and the grid design as well as the golden ratio might not work in the final product, the interactive painting, as objects will move according to the sound input of the user. However, this concept, and the different features imbedded within is a goal to strive for and it is essential for what the framework is trying to accomplish.

## 4.5 Hardware

The design of our hardware will explain the physical setup that we have in regards to both the dynamic- and static image. The dynamic setup will be placed in a public room that allows access to more than a couple of people in order for the noise level to exist without being too high. The setup will have a display to show the dynamic image. This display will be a screen that allows people to get a good view of what is on the display. On the left and right side, microphones will be mounted on the display. Two microphones are used, in order to properly receive the sound.

The setup will also require a computer, since we need something to generate the image and receive the input from the microphones.

The static setup will be very similar, in regards to display and computer. The only major difference will be that the setup will not require any microphones, since the image does not respond to sound. The setup will be set in a public space similar to the dynamic image, in order to keep as many aspects similar as possible, so we get usable feedback from the experiment group.

### 4.5.1 Display

In our setup we will use a screen which is larger than 15”. The reason for wanting a screen that is bigger than 15” is just so that the objects are clear. It would be optimal to use a flat screen TV, but any other sort of screen would suffice.

### 4.5.2 Microphones

We will use two microphones for our setup because we want to fully utilize the recording of the room that it is in. Two microphones will allow the product to record all the sound and make sure that nothing is missed. The microphones will be of regular sort, since binaural microphones are used for imitating the human hearing and the position of a sound in a room, where we just need to record the elements of the sound and not the positions. The microphones will be placed on the sides of the screen in order to optimally record the sound in the room.

### 4.5.3 Computer

In the setup we need a computer to be able to run the interactive image and then show it on the screen, which is set up in the room. The computer will not be in plain sight since it would serve no purpose to have the audience to see it.

### 4.5.4 Environment

For this specific product, it is important to have the right surroundings in order to get the best representation of the experiment results. In order for this environment to meet the different requirements, a discussion on the best location and what surroundings will complement the product the best in conjunction with the experimenting of the product, will be featured.

The environment for the product should be in closed surroundings, if possible in a room, as opened space will cause biased experiment participants, as well as the dynamic picture would be uncontrollable if it was placed in a public location due to all the sound sources coming from various directions.

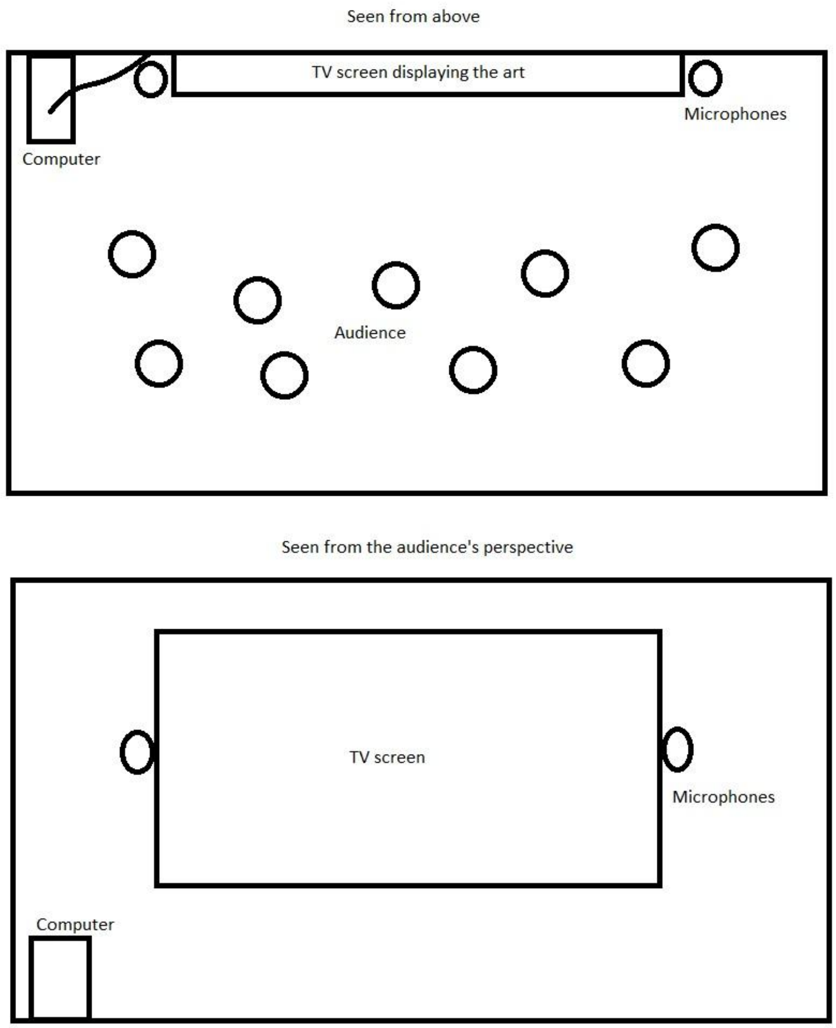


**Figure 22 A concept drawing of how the environment is set up**

## 4.6 Sound Recognition Features

As the interactive artwork has visuals in order for it to be a painting, it is also a requirement for the painting to have sound recognition in order to be interactive in regards to motion and dynamics. This interaction and dynamics in the painting will be provided from sound created by the surrounding environment and sound created by the viewer's themselves.

In order to assure that the interactive painting consists of sound recognition features that work, it is required to discuss particular sound features that will contribute to make sound that functions properly in the interactive painting.

As a discussion of the different sound features was featured in Sound Features**,** this section will merely reference back to these features and put them in perspective in regards to the interactive painting. This is required, because certain thresholds in sound exist, which need to be determined in order to find the correct range of sound features so the interactive painting can have dynamics.

Some of the thresholds that exist are for instance; the highest frequency of sound a human can produce also known as the vocal range. This frequency threshold needs to be determined otherwise if wrong frequency data were to be implemented, interaction might not occur at all.

The different sound features that might affect the interaction with painting could for instance be the amplitude, the vocal range, the pitch etc.

Another reason why the vocal range is important is because the dynamics of the objects in the interactive painting might change accordingly to the different frequencies that is produced and provided to the painting, thus giving the painting a better depth of interaction.

As with the vocal range, it is also required to find a range for the amplitude once again to create a more in depth interactive experience.

These different sound recognition features are going to be thoroughly explained in the Implementation Section**.**

### 4.6.1 Sound Input

The interaction between the audience and the interactive image will be via specific sound features, which are analyzed and then used for positioning and rotation of the objects in the artwork. The ideal way of using the microphones would be to have two microphones. The interactive artwork will use a set of different sound features in order to register and label the noise/sound in the room of the product. The four aspects of sound that the interactive image will react to are: loudness, timbre, pitch and duration. The definitions of the attributes are stated in the

Analysis. The reason that we have these three attributes of sound is to make sure that the interactive image is dynamic enough to respond to what the audience is saying. The reason for using multiple features is that we can analyze the sound to an extent that will allow ideal interaction. The ideal interaction is having the audience imitate the sound of an object on screen in order to modify that object. Loudness is essentially how loud the sound is, that the audience is making. This is useful for changing the size of elements in the image since the size of the object can easily be connected to the amplitude or loudness of the sound. The pitch is how the tone of the sound is. This is useful for dynamically changing the objects rotation or color based on the frequency of the sound.

### 4.6.2 Animation List

This section will describe a list of animations that we use in our interactive image. Here the different objects from the picture and what they do will be described. The overall idea of what the sound input will do is in regards to having sound recognition. What this means is that the software connected to the interactive image will be able to analyze the sound input and then compare it to different levels of sound features that are directly connected to the object that they are trying to interact with. An example would be, to have the sound of wind blowing analyzed so that we can check for the audience to recreate such a sound and then having the clouds moving to the information gained via the microphones.

#### *4.6.2.1 Cloud*

The cloud in the image will be interacted with via amplitude and sound recognition. The clouds x position will change based on the audience imitating the sound of wind blowing. The size of the cloud will dynamically change based on the amplitude of the sound that the audience is making.

The color of the cloud will also be changed based on amplitude, so that when the wind is blowing a lot, at a high volume, the cloud will go very dark and it will start raining. The idea behind this animation is that it changes the mood of the image.

#### 4.6.2.2 Car

The car will be able to move when the audience imitates the low rumble of a car. When the audience maintains a certain frequency for an extended amount of time, the car will be moving on the road. The idea behind this animation is to get the car moving when the audience imitates a car engine sound.

#### 4.6.2.3 Tree

The tree crown will react to a sound similar to the cloud animation. When the audience is imitating the sound of wind blowing, the crown will bend and move as a real tree would with its branches and leaves. The crown will also change saturation from a green color to a brownish orange color. The idea behind the color change is that when the amplitude reaches a certain level, the tree will be as if it was autumn and leaves will start falling from it, like the raindrops from the clouds.

#### 4.6.2.4 Lake

The waves in the lake will increase in force and size when the audience uses low pitch noises and suddenly switching to high pitch in a constant manner. This will give the idea of the water in the lake to become less steady when the pitch increases. The sail of the boat that is located in the lake will also react to the sounds coming from the audience.

#### 4.6.2.5 Man

In our artwork we have a man standing on a boat. The man will walk around when the audience imitates a person walking. The man will walk back and forth on his boat, for however long the audience keeps the walking sound.

#### 4.6.2.6 Background

The background color will change according to different settings. The colors will indicate different seasons. This directly connects with the objects on screen and their current state of color and position. Having the clouds rain, the leaves fall and the background become more dimmed down, all suggest the autumn season.

## 4.7 Sub-conclusion

The design chapter indicates the ideal design and how the design would preferably be created. The implementation of the product will be done with the design in mind. The choices made regarding the design are based on the knowledge gained in the analysis as well as newly made research in the design chapter itself. The reason for choosing to design the product with color is that it will be more aesthetically pleasing, and the reason for choosing to use 2D, is that it goes well with the platform it will be displayed with. The design should be interesting in order to be able to confirm our final problem statement.

# 5. Delimitation

The design chapter has described the ideal design of our prototype, based on the information gathered from the pre-analysis and analysis. The implementation section will describe the way that we created the prototype, which is a limited version of the ideal design. We were not able to implement the ideal design because we did not have neither the time nor knowledge to do so. The ideal design includes having sound recognition that can analyze the sound input to such an extent that when the target group imitated an object, e.g. the sound of walking, the program would be able to realize this and move the objects accordingly. We ruled that this would take too long to implement since we would not only have to write the program for it, but also acquire the knowledge needed in order to do so. We chose to have specific sound features connected to specific objects, and to have the movement in the image limited.

Instead of having utilized the sound features stated in the design, we chose to use loudness, brightness & pitch. These are three sound features that are derived from any given sound recorded via a microphone. The loudness changes the sun, cloud and tree. The sun rotates faster or slower depending on the loudness of the sound. The cloud's size is what changes in regards to the loudness. The tree crown also is dependent on the loudness of the sound, allowing the size of the crown to change accordingly. The brightness is used for the movement of the cloud, moving from left to right and back, as well as the wheels and the wave. The wheels are angled by the brightness of the sound. The wave positions are determined by the brightness, only moving when a certain level of brightness is obtained. This means that whenever the brightness of a sound is above a certain amount, the waves will move between two predetermined positions and as soon as the brightness of the sound goes below a certain level, the waves stop moving. The tree crown also responds to the pitch of the sound that is received via the microphone, and changes opacity based on it.

# 6. Implementation

The implementation section will describe how the prototype was implemented with the design aspects in mind. The design chapter serves as an efficient way to set up the concept that the developers can use when creating the actual product. This section will include a lot of technical information regarding specific tools and techniques used in order to create the product that was designed and molded in the design chapter. There will be three main subjects presented; Java, Max and Drawings. The Java section will describe the overall functionality of our code in regards to our prototype, present some code and explain what they do. The Max section will describe how we have used Max to receive and analyze sound via the microphone. The code and the patches will be explained as well as how the Max connects to Java. The drawings chapter will describe how we have created the images used in our prototype.

## 6.1 Java

In the analysis we are discussing different programming languages to use for the implementation. This was done so we could get an overview of the technology available and see the different pros and cons. We chose to use Java and in this section there will be a walkthrough of the program and the important parts will be explained.

### 1.1.1 Class structure

Our program consists of four classes that each have a specific task. The four classes are: P4, GUI, RecieveFromMax & Board. We have created a UML class diagram to show this presented in Figure 20 UML Class Diagram. Larger version can be found on the CD.

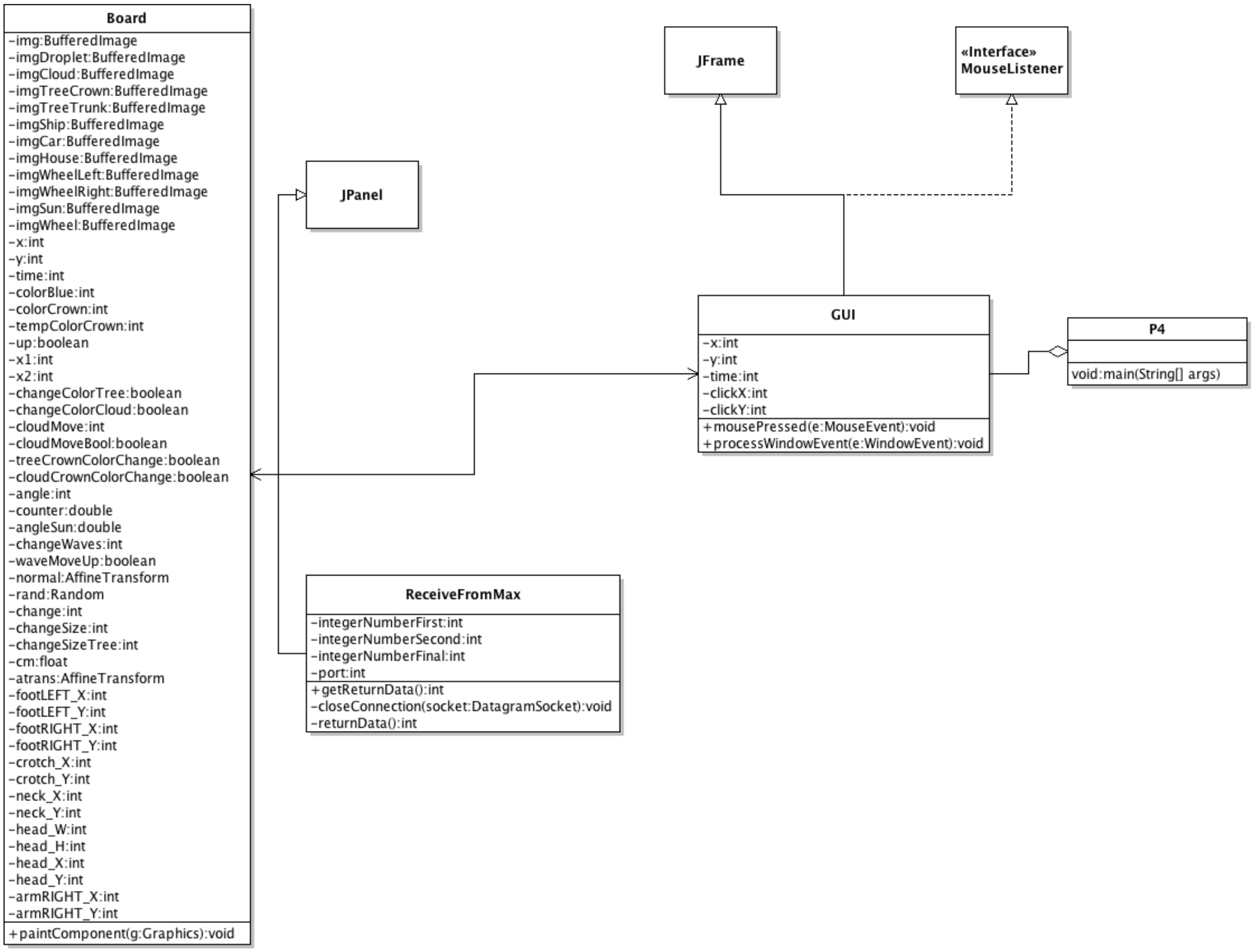


Figure 23 - UML Class Diagram. Larger version can be found on the CD.

First, we have our P4 class Figure 24 This class contains our main method and creates a new instance of the GUI class. The P4 class does not contain anything else because the main method is static and therefore everything else we want to use directly in the method has to be static. Using many static methods is not an Object Oriented (OO) approach and therefore we just get a new instance of GUI and place our non-static objects in the GUI class.

```
public class P4 {

    public static void main(String[] args) {
        GUI gui = new GUI(1500,800,100);
    }
}
```

Figure 24 - P4 class

The GUI class is where we create our JFrame, which is the frame of the output window. The JFrame contains some default methods, which can create the top bar with the three buttons for closing/minimizing/maximizing the window. We also set up a border-size so the program is contained within a certain resolution. Figure 25 shows the constructor for the GUI class with the setup of the JFrame.

```java
public GUI(int x, int y, int time) {
    super("P4");
    super.frameInit();

    this.x = x;
    this.y = y;
    this.time = time;
    setLayout(null);
    setContentPane(new Board(x,y, time));
    setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
    pack();
    setVisible(true);
    setResizable(false);
    setDefaultLookAndFeelDecorated(true);
    setSize(x,y);
    addMouseListener(this);
    //this.add(new Board());
}
```

Figure 25 GUI constructor

The RecieveFromMax class is where we have the connection between MAX and Java. As seen in Figure 26 the class takes an integer as input and sets the port for which to communicate with Max with to that integer. The class then connects to Max and returns an integer from Max. This integer is then available to us using a get method.

```java
    public ReceiveFromMax(int port) {
        this.port = port;
        returnData();
    }
```

Figure 26 ReceiveFromMax Constructor

The Board class is where the most part of our coding is. It is where all the objects are drawn in the JPanel.

The JPanel is what is inside of the JFrame, the surface that allows us to draw upon. The objects being drawn get different sorts of information regarding how to be drawn. The other objects (cloud, tree crown, waves) get information from Max and are drawn and colored accordingly. The objects are drawn by using the paintComponent method, as seen in Figure 27.

```
    public void paintComponent(Graphics g) {
        g.clearRect(0, 0, getWidth(), getHeight() );
        Graphics2D g2 = (Graphics2D) g;
        g2.setStroke(new BasicStroke(8));
```

Figure 27 paintComponent

The paintComponent method works like any other method. It runs through the lines of code one by one. When asking for data from Max the paintComponent waits for an answer from Max before continuing the program. This causes problems when Max cannot send a new number to Java. If the number in Max has not changed since it was send to Java the last time, Java thinks that Max does not have a number. This can cause a problem if the number does not change that often. This is a problem we had with the pitch from Max. Later in the implementation, it will be described how we overcome this specific problem.

### 1.1.2 Code Examples

In this section, there will be a walkthrough of the methods that needs the most explanation from the different classes.

In the Board class we use different draw methods for drawing specific objects or shapes. Most of these are straightforward but can look strange if you are not familiar with them.

If we look at the CubicCurve2D, which draws the waves:

CubicCurve2D.Double(x1, y1, ctrlx1, ctrly1, ctrlx2, ctrly2, x2, y2);

The CubicCurve2D consists of four coordinate sets. There is the x1, y1 that is the start point. Then there is the end point at x2, y2. The two middle coordinate sets are the control points. These two points decide how the curve is going to look.

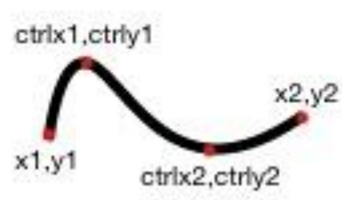


**Figure 28 - Representing the cubic cube graphically**

In the Board class we are also using multiple AffineTransform methods to rotate or shear objects. Rotation is done using:

getRotateInstance(angle,x,y)

```
        AffineTransform atSun = AffineTransform.getRotateInstance(/*-Math.PI / 6*/ angleSun,
                                                                  0+imgSun.getWidth()/4,
                                                                  (imgSun.getHeight()/4)-50);
        g2.setTransform(atSun);
    }
```

**Figure 29 - Rotate image**

The parameters here are the rotation angle and the point at which to rotate around. Figure 29 shows how to do the rotation for the sun, in our code.

Whenever we want to get some data from Max we use something like this:

```
        int tempRain;
        ReceiveFromMax returnRain = new ReceiveFromMax(8900);
        tempRain = returnRain.getReturnData();
        tempRain = tempRain / 5;
```

**Figure 30 - Receive data from Max**

First we name a new instance of ReceiveFromMax and call it returnRain. We give it an argument of 8900, which is one of the ports that we want Java to use for communication to Max.

Next we want to get the data that Max returned to returnRain. We can get this data by calling returnRain.getReturnData(). This is necessary because the variable in ReceiveFromMax that holds the data is private. Using the get method we can access the variable even though it is private. tempRain now holds the integer from Max and can be used later in the program. This could be to set the position of an image or the rotation angle of an image.

The ReceiveFromMax class is a lot more advanced than the rest of the program. This is necessary since inter-program communication is not a simple task.

The idea with the ReceiveFromMax class is to have a connection between Max 6 and Java. We could not find any preexisting classes so we created our own. This is done using UDPSend in Max to send the data to Java. If Max uses a specific IP address and port, Java can 'listen' for this and 'catch' the data. There are two different kinds of data to send from Max; integers and floats. Integers are whole numbers whereas Floats are decimal numbers. Much of the data we have in Max is floats and it would be natural to send these numbers directly to Java. This proved to be more challenging than first though. We found a tentative way of getting the float numbers from Max but since it is not used, and therefore not explained in this section it can be read in the commented code. We chose to scale the numbers in Max and then send them to Java as integers. This was done because the formula for receiving integers is much easier to use and we then have the possibility for scaling the numbers back to floats in Java.

When we need to get numbers from Max we call ReceiveFromMax(port), as explained previously in this section. This is the constructor of the class which needs a port number. The port number is the specific port we want to communicate through. We can open multiple ports at the same time but we cannot send multiple numbers at the same port.

Our Board class is setup to draw the get data from Max, then draw the painting and finally clear the screen. This is done over and over at a varying frame rate based on the computer speed and how many calculations that needs to be done.

Since we can't send multiple numbers over the same port we need to disconnect from the port and close the connection before trying to get new numbers. An example of this can be seen in Figure 31.

```
private void closeConnection(DatagramSocket socket) {
    socket.disconnect();
    socket.close();
}
```

Figure 31 - Close connection to Max

In the constructor we set the class' port to the local port, from the constructor, using 'this'. Then we call the method returnData(). This method contains a try-and-catch and if the method catches an exception it will return 0 else it will return the number received from Max.

```
public ReceiveFromMax(int port) {
    this.port = port;
    returnData();
}
```

Figure 32 - ReceiveFromMax constructor

The next thing we do is to create a new DatagramSocket called socket. The DatagramSocket is the point where Java can receive UDP data. We use the port number that was passed to the class from the constructor Figure 33.

```
private int returnData() {
    try {
        DatagramSocket socket = new DatagramSocket(port);
```

Figure 33 - DatagramSocket

Before we can actually receive any data from Max using the DatagramPacket we need to set up a buffer that can contain the packet. We create a new byte array called buffer. This buffer we can use for the new DatagramPacket we create called packet. The DatagramPacket needs two arguments; a byte array and a length. For convenience we use the buffers length. We can now receive the data from Max using socket.receive(packet).

Here we receive the packet from the socket Figure 34.

```
byte[] buffer = new byte[512];
for (; ; ) {
    DatagramPacket packet = new DatagramPacket(buffer, buffer.length);
    socket.receive(packet);
```

**Figure 34 - Buffer and DatagramPacket**

If we just print out the packet, we get e.g. *java.net.DatagramPacket@1c52ac68*. This is not something we can use for anything, therefore we use packet.getData() to get the actual data from the packet. This results in *[B@77b4ee5e*, which we still cannot use for anything. The data is good enough, but for us to use it, we need to convert it to integers that can be used in calculations. Therefore we create a new ByteArrayInputStream called *bin* and as the DatagramPacket, it needs a byte array as argument. This time we use the packet.getData() as the argument, since it contains the data we have received from the socket Figure 35 .

```
ByteArrayInputStream bin = new ByteArrayInputStream(packet.getData());
```

**Figure 35 - ByteArrayInputStream**

To read the new data from the ByteArrayInputStream we run a for-loop that runs from 0 to the length of the packet.

The first thing we do in the for-loop is to read the first byte of the byte array into a variable called *data*. This is done using the method read() from the ByteArrayInputStream. We now have an integer, which we can start to use Figure 36.

```
for (int i = 0; i < packet.getLength(); i++) { //Run through the packet and read the data.
    int data = bin.read(); //Read the next byte of data from this input steam.
    if (data == -1) { //If the data is equal to -1, we have reached EOF.
        break;
    } else {
        //System.out.print((int)data + " ");
        if (packet.getLength() > 12) {...
        }

        if (packet.getLength() < 13) {
            if (i == 10) integerNumberSecond = (int) data;
            if (i == 11) integerNumberFirst = (int) data;
        }
    }
}
```

Figure 36 - For loop

The ByteArrayInputStream gives us 12 numbers, 'i' starts at 10 and ends at 11, as seen in Figure 36 We just need the last two numbers from the ByteArrayInputStream, so therefore we have that if 'i' is equal to 11, integerNumberFirst is equal to the data from bin.read(). The same thing happens if 'i' is equal to 10. An example can be seen in Figure 37

```
if (packet.getLength() < 13) {
    if (i == 10) integerNumberSecond = (int) data;
    if (i == 11) integerNumberFirst = (int) data;
}
```

Figure 37 - Assigning integer values from array

The two numbers we now have from the ByteArrayInputStream goes from 0 to 255. Using the formula; (256*second)+first, we can calculate the number Max send Figure 38.

```
integerNumberTotal = (256*integerNumberSecond)+integerNumberFirst;
closeConnection(socket);
break;
```

Figure 38 - Integer calculations

An example is the number 542. We want to send that number from Max to Java. When sending the number to Java the ByteArrayInputStream will look like this:

105 110 116 0 44 105 0 0 0 0 2 30

As mentioned before we just need the last two numbers. These two number can then be added to the formula, which would be; (256*2)+30 = 542.

When the calculation is done, the number is stored as, integerNumberTotal. Then the socket is disconnected and closed.

We can now retrieve the number from another class using getReturnData().

## 6.2 Max6

The program which was used to connect with the Java environment is Max. It allows for recording of sound and analyzing it with the help of different, already implemented patches. The patches, which were used to implement the design idea, will be described in this section.

The important and necessary Max 6 externals were found on the website http://web.media.mit.edu/~tristan/maxmsp.html, where it was necessary to download the certain patches that have been used in order to be able to implement them in the max patch and the prototype.

### 6.2.1 Fiddle Patch

The fiddle patch was created by Miller Puckette, as seen in the description of the fiddle patch, and the main objective of this patch is to estimate the pitch and amplitude of the sound input from the microphone. Fiddle uses certain arguments in order to be set some boundaries for peaks and pitches that will be output. The first argument sets the analysis window size, followed by a number which is connected with the simultaneous pitches that it should try to find, also known as attacks, 20 is then the number of peaks in sound that should be considered and last the number of peaks to output. The important things that were used for the implementation of the prototype are the outlets of the fiddle patch which are basically giving information regarding the pitch, amplitude, raw pitch and amplitude and individual sinusoidal components, which in our case are not important to look into as it is not used.

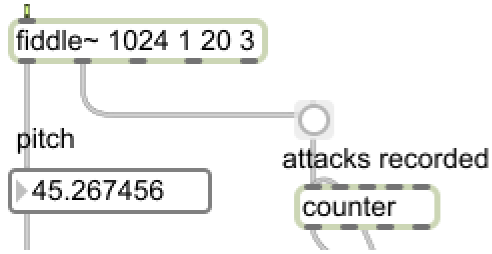


Figure 39 - Our fiddle patch from our Max patch

The outlets that were mainly used when creating the prototype were the first two outputted numbers, which are the numbers gathered from analyzing the pitch of the incoming sound and counting the attacks noticed in the sound. The pitch outlet is ranging from ~20 to around ~140, where the number 135 was the default number outputted when the fiddle patch could not detect any pitch in the sound, a normal, lower pitch is usually output as numbers ranged between 40-56, a higher pitched voice or sound is usually registered as numbers between 70-80. When this was tested in a soundproof room, it was noticed that frequencies higher above 1000Hz were represented by the numbers 83 and above and a sound with the frequency 10000Hz, a very high frequency for a sound to be heard, was numbered around 124, therefore it was concluded that 135 was the maximum number the outlet will output when showing the pitch, while 135 was, at the same time, the default number.

### 6.2.2 Analyzer Patch

The analyzer patch includes more sound-feature detection compared to the fiddle patch. Analyzer also uses arguments when analyzing the incoming sound, however, compared to the fiddle patch, it does not necessarily require these arguments in order to compute the incoming data and therefore no arguments were given when the prototype was implemented, since it was not necessary to set any boundaries to the incoming sounds.

Outputs of the analyzer patch are; cooked pitch, loudness, brightness, noisiness, bark decomposition, onset detection, raw pitch and sinusoidal composition. As stated, this patch also includes the pitch detection feature adapted from the fiddle patch; however the fiddle patch's pitch detection has a more improved version than the analyzer patch, therefore this patch was used separately in order to have more focused pitch detection.

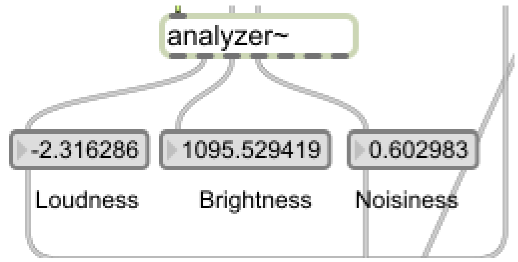


Figure 40 - Our analyzer patch from our Max patch

Another output of the analyzer patch is the loudness, this feature is one of the important aspects when recognizing sound features and creating animation on the screen. Loudness is the second outlet of the analyzer patch and in the patch this feature ranges between -96 dB and 30 dB. During the functionality testing in the soundproof room it was noticed that when the room was quiet the number outputted ranged between -60 and -55, when using neutral loud sounds it went up to -40 to -50 and when quite loud it reached -20 to – 30.

Third output is brightness; brightness is usually associated with the timbre of the sound. It is believed that the brightness of sound correlates with increased frequency, for example the vowel 'E' sounds brighter than the vowel 'O'. In the analyzer patch, the brightness ranges from 0 Hz to 22 kHz and it was noticed that the brightness is set around 14-16 kHz in a soundproof room only when it's quiet in the room. Brightness reacts to words and therefore it is used to show changes from quiet to talking (Schubert and Wolfe 2006).

Noisiness is the last outlet that is used in the implementation of this prototype and it is mainly used in order to update the java painting at all times, since noise is an always changing number.

### 6.2.3 Max 6 and Java Connection

The sections above described the important patches that were used in the implementation; this section will include explanation and presentation of the entire max patch that was used when triggering object animations.

Figure 41, A, shows the introductory part required in order to start the analyzing and recording of the sound, this part includes the audio in the "umenu" object in Max, which is connected to a selector object. The slider, gain~ object, is used in order to turn the volume of the recording to the maximum, therefore not having troubles trying to analyze the features of the incoming sounds.

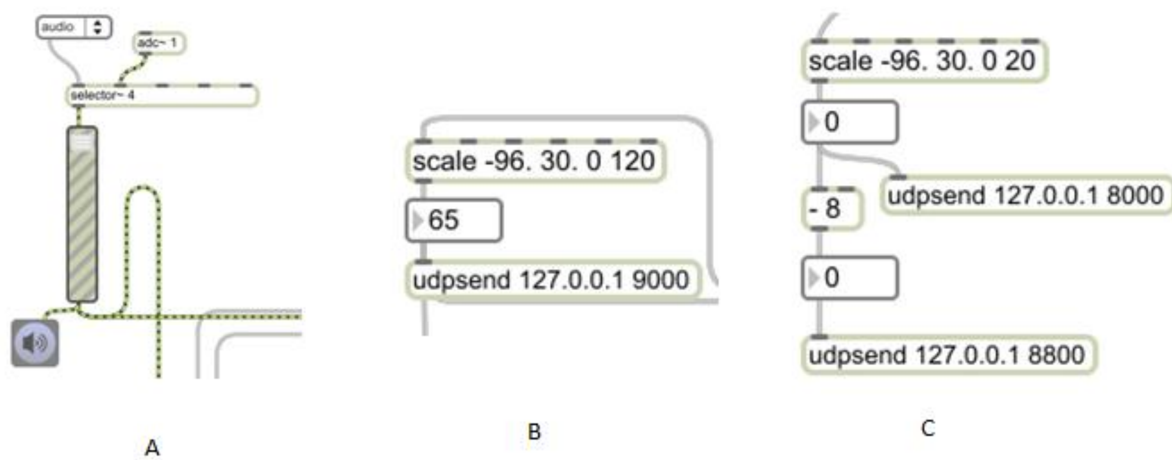


Figure 41 - The functions Load microphone, cloud size with loudness and the sun and rain with loudness

Figure 41, B, represents the numbers used and sent to the Java program, through the port 9000. The chord connected to the scale object leads to the loudness outlet from the analyzer patch and the numbers gathered are scaled to a positive range which is from 0 to 120, therefore being able to send positive integers to java. The loudness that is scaled and seen in this figure is connected to the cloud size, therefore when the loudness is a high number the cloud will be resized accordingly.

Figure 41, C, shows the connection of the object "sun" and "rain" with java. The sun starts rotating while the rain is triggered to fall. Firstly the numbers received, in this case also, from the loudness outlet of the analyzer patch, are scaled from -96 and 30 to 0 and 20, which mean

Java will receive only integers from 0 to 20 which represent the loudness. The sun is represented by the port 8000, while the rain by the port 8800, compared to the sun, the numbers sent to the rain are slightly changed, in this case it can be seen that -8 is being subtracted from the incoming numbers and therefore sent to the port 8800,slightly changed.

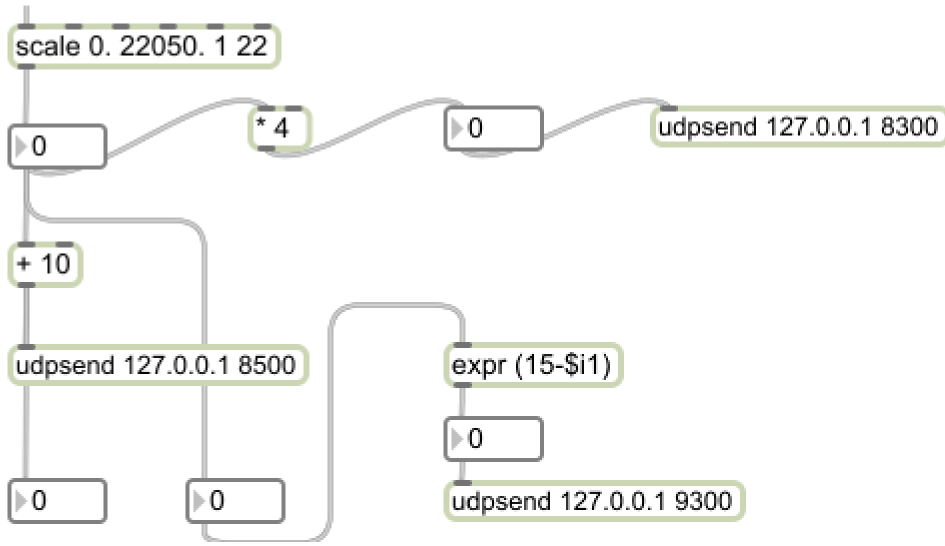


Figure 42 –waves, cloud, wheels connected to brightness

The same process can be noticed when looking at the connected ports going from the brightness outlet of the analyzer patch numbers are scaled and slightly changed in order to fit the animations planned. This can be seen in Figure 42 and 3 ports are to be noticed, port 8300 is manipulating the sea waves, while port 8500 manipulates the x axis of the cloud, therefore allowing the user to move the cloud according to how much he/she talks or remains silent. The last port 9300, is used to control the wheels of the vehicle inside the painting, the numbers are subtracted with 15 before being sent to java.

Figure 43, shows the code example which manipulates the numbers sent to Java to change the opacity of the tree crown. In this case, the sound feature that is used is pitch from the fiddle patch, however the pitch number outputted is not a constant changing number, therefore certain calculations have to be made. The way these calculations were programmed can be seen in Figure 44,firstly the "if" sentence checks if the input that is connected to, is equal to 10, if this is true then it will reset the counter object to 1. Before resetting the counter, the outputted numbers are divided by 2 and thus sent to the pitch numbers which are added together, these numbers are also added with the output of the noise, which is constantly changing, therefore being able to always send a number to Java even though this number will be almost the same.

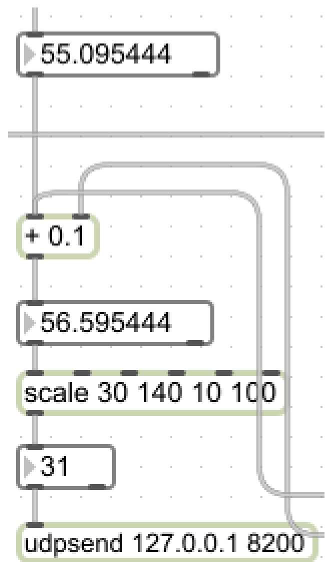


Figure 43 - Port to Java-tree crown

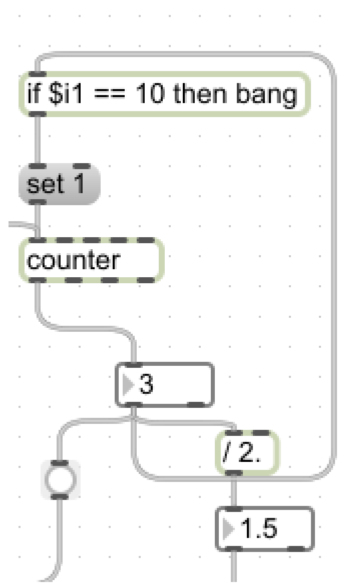


Figure 44 - Example of ”counter” code

Overall, the implemented objects in Max are the sun, cloud, tree crown, car wheels, sea waves and rain. All these objects' animations are interactively triggered by the user by using the implemented features of the two patches, analyzer and fiddle. The sun rotation is triggered by the loudness that is recorded; the cloud size is scaled according to how loud the user speaks while the tree crown works the same way, taking a wider range of the painting if the user speaks loudly. The cloud is also triggered by the brightness of the sound, which moves the cloud on the x axis from left to right and vice versa. Pitch changes the alpha value of the tree crown, therefore becoming light color and turning into darker green, the wheels turn according to the brightness, so if a user holds a steady note, they will keep turning until he/she stops.

## 6.3 Usability Experiment

In order to make sure that the product is both easier to use as well as to point out any design flaws or errors the product might have, a usability experiment is conducted.

The usability experiment participants revealed errors and design flaws that might not have been noticed otherwise. Therefore a complete redesign of the product will take place in order to cope with these design flaws and program errors and in order to improve the product.

As mentioned in Intuitiveness**,** the usability experimenting is usually done by having a facilitator, that is in the same room as the experiment participant and an observer that observes the experiment participants actions. The facilitator guides the experiment participant and is the person people go to with questions. The observers is in another room looking at the actions and behavior of the experiment participants. In this experiment case the observer and facilitator was the same person. Throughout this section, the person who acted as facilitator and observer will be referred to as the observer. (Lazar, Feng and Hochheiser 2010, 273-274)

The usability experiment was conducted by using this method. The observer in this case was present during the experimenting in order to note any unusual behavior and any kinds of sounds the participants was making. The observer also noted any questions, which the participants might have. Thus, in conjunction with the questionnaire, the experiment participants had to answer, it was ensured that the optimal amount of information was noted in order to pin point any errors and design flaws the product might have.

The experiment was conducted using five experiment participants, this particular amount was used in order to capture approximately 80% of the usability problems a product has.

*“Many people say that five users is the magic number and that five users will find approximately 80% of usability problems in an interface […]”* (Lazar, Feng and Hochheiser 2010, 263)

The individual experiment participants were introduced to the product and then sent into the room where the observer resided. The room contained only the observer and the product itself.

It was made clear that the experiment participants were not going to be filmed and the experiment was completely anonymous

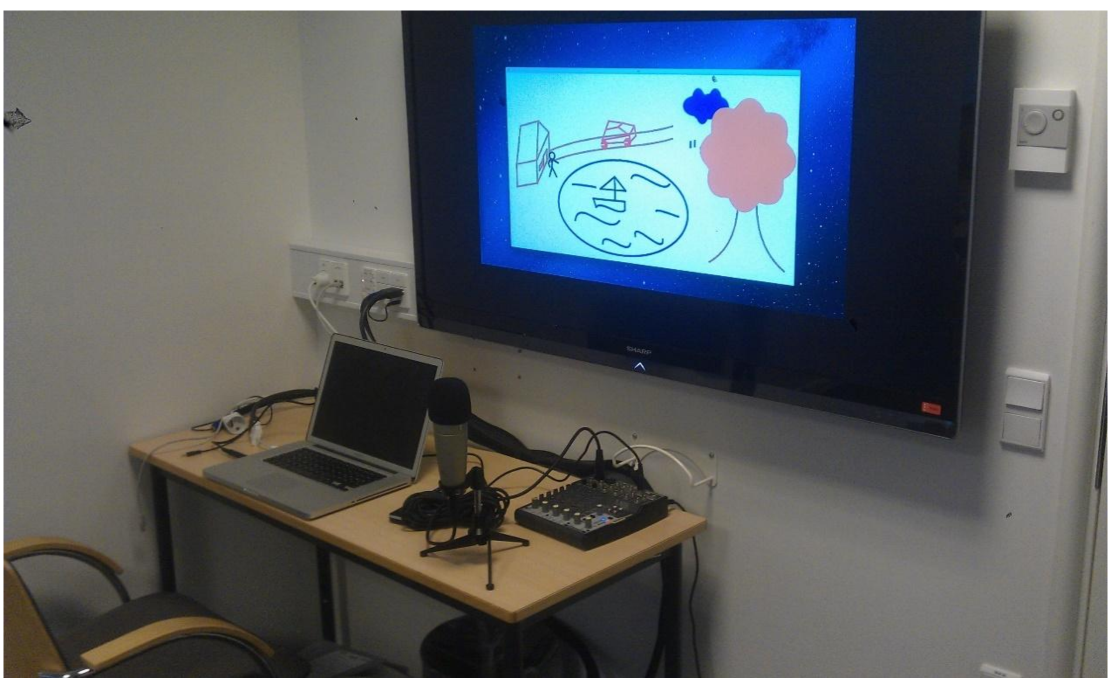

**Figure 45 - The actual setup of the product, during the usability experiment. The user had to interact with the microphone on the table.**

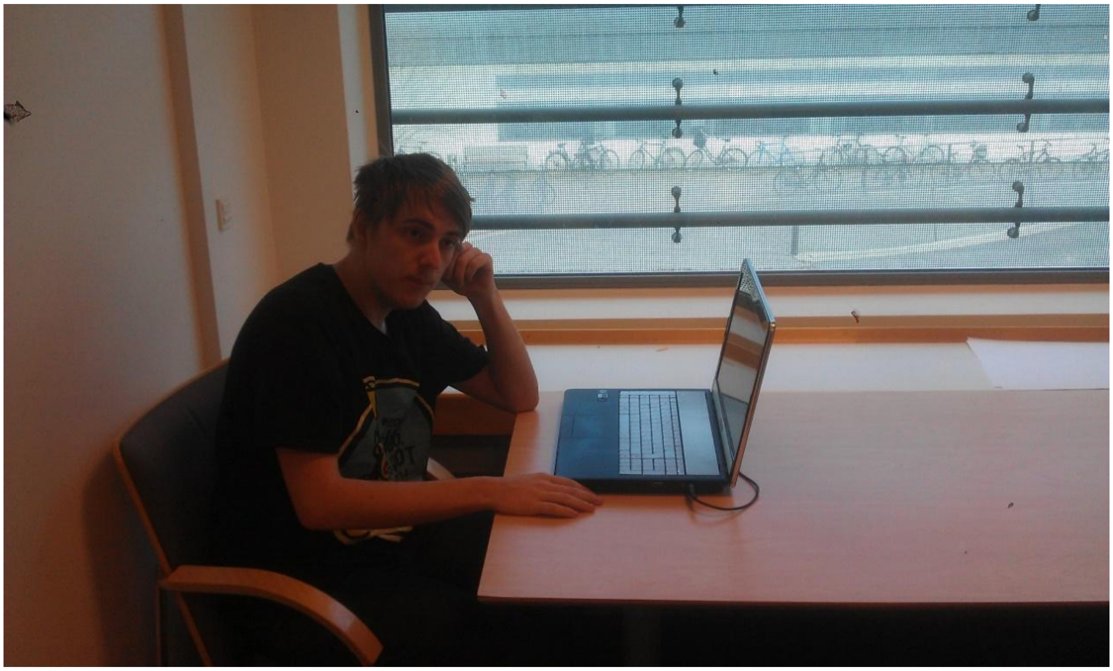

Figure 46 - The observer taking notes during the usability experiment.

After the experiment participants had been using the product, they were asked to answer a questionnaire. This questionnaire consisted of questions regarding the interactivity of the product and the ease of use. However the experiment participants were also asked to give any suggestions for improvement of the product. All the results and the notes taken during the experiment all indicated and suggested areas of the product that could be improved.

For instance, the results indicated that the product was not intuitive enough, and it had to be made clear that the microphone was a medium for interaction with the product. Another example is that the majority of the experiment participants had no idea how they controlled the different objects, as these statements suggests:

*“It is hard to figure out how to control it”*

*“I did not figure out how to control it at all”*

*“I don’t get the idea of it, the colors, the shapes and the fact that even when Im doing nothing stuff happens”* (Appendix 9)

"It" in this case is referring to the product itself.

The fact that the participants had these experiences strongly indicates that the controls of the product have to be polished in order to work better. Especially the last quote indicates that it is unclear whether the user has control of the objects or not, this suggests that the visual output form the screen, should also be more evident. In conjunction with these quotes the observer had to mention, to several of the participants, to use sounds to interact with the painting. This could indicate that the microphone should be more in focus and it should be more apparent that it is the microphone and their voice that is the main source of interaction.

The goal of this usability experiment was to test the intuitiveness of our product and to see if it was possible to 'break it'. We conducted the test in order to see how the audience interacted with the prototype but we also wanted to observe the test and find out if we needed to limit their access to the technical aspects. This means that we wanted to see if the setup itself was good enough, which also helped us realize what changes we needed to make to the prototype in order to get some better feedback.

### 6.3.1 Usability Methods

The methods used were a questionnaire as well as the specific role of the observer.

The reason why a questionnaire was chosen to record the expressions and opinions of the experiment participants, instead of a qualitative interview, was because of the concrete answers that quantitative methods give. The Likert scales used (Lazar, Feng and Hochheiser 2010, 132) in quantitative interviews can provide us with these concrete answers. Furthermore, a qualitative interview might pressure the experiment participants to lie about the product, and force them to say the product is great while their sincere opinion is that they think the product is bad. In this case, their honest opinions are sought after, as it is required to find design flaws and errors of the product.

As mentioned earlier, the observer's task was to watch the experiment participant and their behavior, while noting the specific ways the participants interacted with the painting.

The observers task is quite crucial to a usability experiment, as the user's interaction with the product and how this interaction occurs are valuable information when seeking to improve a product.

*"[…] usability experimenting have one basic goal: to improve the quality of an interface by finding flaws in it. Usability experimenting should discover interface flaws that cause problems for users."* (Lazar, Feng and Hochheiser 2010, 252)

These specific methods mentioned in this section are used primarily to achieve the optimal result from the usability experiment. Meaning the way the different methods are used, are tailored exactly to our usability experimenting needs.

In conclusion, the usability experiment gave the framework information that is able to improve the product in a way that will enhance the usability and therefore presumably enhance the experience of the product.

After revising all the different statements and noted behaviors, different changes has to be made for the product. These changes will be revolved around the experiment participants opinions, and try to incorporate all the suggestions the participants have had.

These changes include amongst others, drastic changes in the look of the product and making the interaction element, the microphone, more apparent.

## 6.4 Drawings

When we created the first version of our prototype we used Java exclusively to create the artwork. This resulted in our prototype looking like Figure 47

Figure 47 - Our first prototype

With the feedback from our usability test we decided to change the prototype completely. Almost all of the drawings in the first prototype was removed and exchanged with actual drawings made in Paint Tool SAI.

This section will go in depth with the different graphical elements that is contained in the product. A brief explanation of selected objects will be featured while a description of how the implementation of these objects has been done. This section will not be too detailed, as the focus of the prototype in correlation with the FPS is not to try making the artwork aesthetically appealing. Rather the prototype is exploring if the interactive painting is more interesting compared to the static painting.

The concept of the different drawings where developed on a piece of paper. A picture of the drawings where then imported to Paint Tool SAI and the drawings (shown below) were then drawn in Paint Tool SAI, using the concept drawings as a template to draw from.

When the objects were drawn, they were imported in to Adobe Photoshop in order to remove the background of the objects, so the background would become transparent and therefore not cause a visible overlap of the objects.

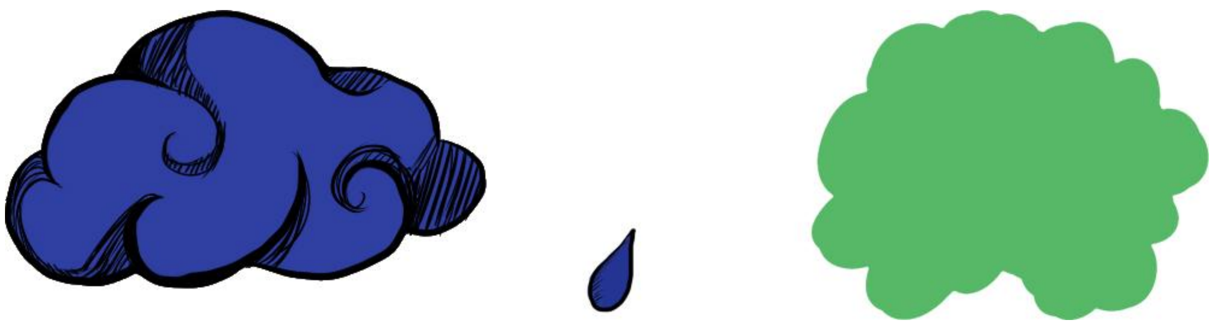

**Figure 48 - Example of a few objects that is visible in the prototype.**

From left to right the cloud, one of the many raindrops and the tree crown. These were as mentioned drawn in Paint Tool SAI and was then implemented with the help of Max and Java.

After the images have been drawing they will be imported into java using BufferedImage. We can read the image file using ImageIO.read(new File("path/filename.ext"));

This needs a try-and-catch-statement around it, since the loading of the image can fail, if the file does not exist. If we didn't have a try-and-catch, then program would end, if the file load failed. This is not the case, since we have the try-and-catch. Figure 49

```
try {
    img = ImageIO.read(new File("Images/background1.jpg"));
    imgDroplet = ImageIO.read(new File("Images/coloredDrop_fixed.png"));
    imgCloud = ImageIO.read(new File("Images/coloredCloud_fixed.png"));
    imgTreeCrown = ImageIO.read(new File("Images/crown.png"));
    imgTreeTrunk = ImageIO.read(new File("Images/Coloredtree_fixed.png"));
    imgShip = ImageIO.read(new File("Images/coloredboat_fixed.png"));
    imgCar = ImageIO.read(new File("Images/car copy.png"));
    imgHouse = ImageIO.read(new File("Images/house_fixed.png"));
    imgWheel = ImageIO.read(new File("Images/wheel.png"));
    imgSun = ImageIO.read(new File("Images/sun_fixed.png"));
    //this is where you load it
} catch (IOException e) {
    System.out.println("Image load error with error message: " + e.getMessage());
}
```

**Figure 49 - Loading images**

When we want to draw an image we can use drawImage(img,x,y,w,h,null). This makes it easy to change the placement and size using simple arithmetic operations Figure 50.

```
g2.drawImage(imgWheel,(580+returnCar.getReturnData()),255,(int)122/2,(int)125/2,null);
```

Figure 50 - How to draw an image

The new prototype, the final one, then looks like Figure 51**.**

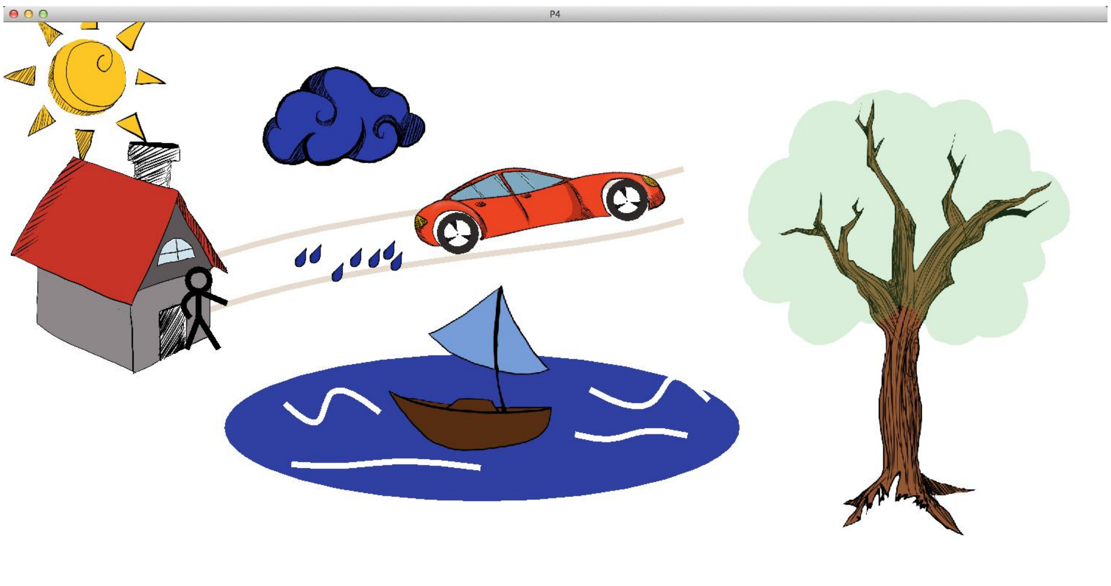


Figure 51 - Our finished prototype

## 6.5 Sub-Conclusion

After doing the usability experiment we can conclude that some changes were required in order to improve our implementation – making it easier for the target group to interact with the prototype. The usability experiment showed us what flaws the prototype had which led us to improve the prototype. One of the important points to take note of was that the test participants were not certain as to how they were to interact with the prototype. This led us to change the setup, and only allowing the microphone and screen to be presented.

When we did our usability experiment we used an early stage of our product which had objects that were drawn in Java instead of being images that were drawn in appropriate software. This means that the image was less aesthetically pleasing than the final version of the product. This lead to the experiment participants not knowing how to interact with the prototype, which lead us to use drawings that were created in Paint Tool SAI in order to make the product more aesthetically pleasing. The Max implementation worked well since the sound was recorded and analyzed as intended. Most of the experiment participants tried voice commands, which indicates that the Max implementation could have been done otherwise, in order to please the target group further. Since we went from drawing the objects in Java to use external software and then altering the drawings within Java, we can conclude that the prototype is improved.

# 7. Experiment

After completing the implementation, the prototype was in the state where it could allow the start of the experiment process. The experiment chapter will have a description of the experiment process, mainly the objective of the experiment, what needs to be done and how, followed by information regarding the methods used to proceed the experiment. There will also be an explanation of the pilot experiment including the overall process. Lastly, the final experiment conducted will be described and the data results gathered. The results will be discussed upon and the process will be concluded upon in the end.

## 7.1 Experiment Hypothesis

Before starting the experiment certain hypotheses need to be set and ideas that will be experimented must be written down, therefore it is a good idea to set few hypotheses to have as goal when designing the questionnaires; therefore a null hypothesis has been derived.

The null hypothesis claims that, using sound to interact with a painting compared to observing an equivalent static painting has no effect on interest.

However an alternative hypothesis, in case the null hypothesis is rejected, is:
An interactive painting is more interesting than a static painting.
Therefore we expect the user to prefer the dynamic image and spend more time observing and interacting with it.
After the test has been done the ideal results would be that the dynamic picture is more interesting than the static. If this would be the case then the final problem statement can be confirmed and it would be possible to prove that interactivity can make an otherwise normal static piece of art more entertaining by adding an interactive aspect to it.

After the usability test was conducted, it was learned that the dynamic painting was not intuitive interactive and what they felt was that animations are illogically triggered by sound, and therefore some changes to the picture were made, with the hopes this will make it clearer what elements were interactive and in what degree they are interactive. If this succeeds and the product is easier to use the results will be positive since they add this new aspect, however if the changes we have made makes it harder for the audience to use the product, the results could be influenced by the fact they find it silly or boring because they can't control the interactive aspects correctly.

## 7.2 Objective

This section will contain a description of this experiment's plan, which will be a detailed explanation of the setup of the environment, the steps that need to be followed for an optimal testing process and the questions that need to be asked in order to achieve expected results. The aim of this experiment is to see whether interactive, dynamic paintings are more interesting than static paintings. Therefore, two prototypes are required and a comparison between those is to be made. We will be doing a within-subject test, and the reason for conducting the final experiment as a within-subject test scenario is that it will allow us for better comparison between the interactive and static prototype. The main objective of our experiment is to confirm our final problem statement.

When getting ready to test the product, setups of the product environment are required. The first step is to set each of the prototypes in two different rooms, for each one of the prototypes, the setup is slightly different.

One of the prototypes, the static version of our painting, which will be set up in one of the rooms, will not include a microphone and only show the painting itself on a screen. A second room will contain the dynamic, interactive version of the painting, which will include a microphone which will be set in front of a screen. The screen will then show the dynamic painting which is being run on a computer hidden from the sight of the participant. This room should only contain a single screen and only one microphone, this is important because we don't want any distracting objects in the room. During the usability testing in the implementation chapter it was noticed that showing the computer that builds the prototype can be a bad thing and might cause the testing participants to lose focus or focus on the wrong things, therefore it is wise to avoid showing the whole setup.

A guide will be necessary when performing the experiment, the guide will give information to the participants recruited he or she will tell users to step close to the screen. In the case of the dynamic painting it will be where the microphone is placed but will be the same spot for the static painting too. The guide will also tell information about what they need to do and how the experiment will go. The guiding information will differ slightly when talking about the functionality of the prototype, for example for the static painting, the participant will be asked to observer the prototype whilst for the interactive, the participant will be asked to interact, however it will mainly be the same information for both prototypes. This is considered a good idea because it minimizes the difference between the two experiments, the static and dynamic paintings. It is important to have this in order to avoid a lot of bias when comparing the two prototypes. An important reason would be to make sure the user does not consider the setup of the paintings a huge difference when rating a comparison between these two.

Throughout the experiment process, while the participants will be left to interact and view the prototypes, an observer will be seated behind the participant and note down participant's activities and interactive actions with the prototypes. However this can cause bias due to the fact that the participant will feel intimidated by the observer and will not try to give daring sound input to the prototypes. An alternative would be to record the participants and watch recording afterwards while writing down notes, however, similar to just having an observer in the room, this can also cause bias. A reason why video recording participants is not a good idea is because the thought of being video recorded might make people feel uncomfortable, however this can also happen in the case of an observer. Video and audio recording, on the other hand, needs consent in order to be able to be performed and thus if participants refuse to be recorded, important observations might be lost.

Another important aspect that needs to be considered when comparing the two artworks is time spent in the rooms. When the experiment participants will be in the room to test the product, the amount of time that they spend on observing the prototypes will be noted so that we can compare it to their questionnaire results and amongst each other. The amount of time spent while interacting with a painting or observing it might be connected to the participant's interest in the painting.

An important requirement for the test is when testing the 30 people, we want to have half, meaning 15 people, to start with the static and 15 to start with the dynamic so, they are not all influenced by the same picture, when going to the other one. We hope to get valid results when testing our product while going for this approach, and another benefit might be that we are able to test both halves at the same time, and thereby saving time doing the tests. Another benefit would be to allow verbal and written feedback from test participants regarding the comparison of the two experiments and the difference between them, therefore, participants will be answering questionnaires separately, after visiting each prototype but also questions when finishing with both experiments.

The participants will be asked to answer two different questionnaires at the end of each experiment; the steps that this will be performed will be quickly explained. Participant will be asked to enter the first experiment room with one of the prototypes and after the participant is done, they will answer a short questionnaire, then will be asked to inspect the second prototype and then answer a new questionnaire, which will ask the same questions that were asked for the first one, but put in the case of the second prototype visited and questions regarding the comparison between them (Appendix 1).

### 7.2.1 Experiment Setup Steps

1. The first thing that needs to be done is to set up all the rooms, prepare them for the participants, ready up the questionnaires and the observer.
2. A guide will inform the participants that they can leave at any given time that they feel like they are done, not to touch the equipment and a short introduction saying they should interact with the dynamic image via sound (this not being said for the static image) (Appendix 4).
3. An observer will be seated in the room and make notes according to how the user behaves around the prototype.
4. The observer will have to time the participants and how long they took to interact with the paintings and observe it, this time will be then compared to the observer notes and questionnaire results.
5. The participant will enter one room at a time and then followed by the other prototype, participants will test the two prototypes in an organized fashion.
6. When the participant has finished observing the paintings, he/ she will be asked to complete a questionnaire.

## 7.3 Pilot Experiment

Considering the results of the pilot experiment as well as how the pilot experiment was conducted and considering the feedback that was given from the participants. By analyzing these results and by implementing the improvements in the final experiment. It is now possible for the final experiment to be more professionally executed and give the framework results that are less biased as well as suggestions to how the final experiment can improve conduction wise.

A brief description of how the actual pilot experiment was performed will be featured. Furthermore, an analysis of the answers from the participants will take place, as well as an analysis of the feedback from the participants of how the experiment was conducted. It is expected, that these analysis will provide the framework with data that can improve the actual experiment.

### 7.3.1 Description

There were two rooms; each room contained a prototype each. One room with the interactive painting and the other contained the static painting. The purpose was then to do a within-subject experiment, which makes it possible to compare the results of the answered questionnaires. The within-subject experiment will be explained in further detail in the final experiment section.

Figure 52 - Depicting the setup of the interactive prototype in one of the rooms.

The participants were shortly introduced to the prototype, and were then placed in one of the rooms. They were placed in front of the painting and in the interactive they were also placed in front of the microphone.

In both of the rooms, there was an observer. The observer timed the participants and noted their behavior towards the prototype. When they felt like they were done, they exited the prototype room and were placed in front of a computer to answer a questionnaire. Before they answered the questionnaire, they had to sign a certification of consent saying that we were allowed to use the results of their answers and that it is approved to use any observing their might be.

In both of the rooms all electronic equipment was hidden in order to keep the room tidy and in order not to confuse the participants. A lot of equipment might give the impression of other means of interaction than sound.

A small interview was then conducted where the participants were asked if they had any improvements to how the experiments were conducted. The answers from this interview will be focused on, as the answers will have a significant importance to how the actual experiment is to be conducted in the future.

It was also noted which room the participants entered first and second as there might be a difference between the answers in the questionnaire, depending on which room they entered first.

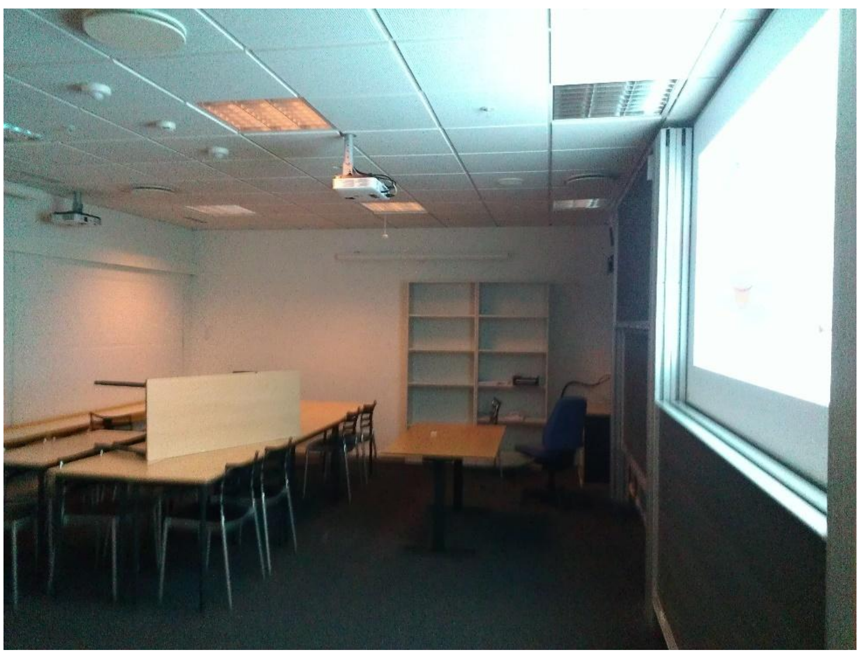

**Figure 53 - The setup in the static prototype room. As the Usability Test indicated, the equipment in the setup has been hidden. This is also the case with the interactive prototype.**

### 7.3.2 Methods

In this section we will describe the methods used in the final experiment of the project. The questionnaire section will describe what a questionnaire is and why we chose to use that method for testing. The observer section will explain the idea behind having an observer in the experiment room.

#### *7.3.2.1 Questionnaire*

For the questionnaire we have chosen to work with a quantitative test. When asking the test participants about their experience with the product, we have chosen to do this using a questionnaire, which is because we find it easier to analyze the answers afterwards and make statistics based on the results. We aim for testing our product on 30 people and giving them all questionnaires. (Lazar, Feng and Hochheiser 2010, 150)

The main reason for choosing a quantitative method of getting and analyzing our results is that it will allow us to analyze raw results in an easy way. Since we are testing 30 people, it would also be difficult to make qualitative interviews with them all, but another reason for choosing quantitative is that we would not get much more out of the results if they were received with a qualitative method based on our target group. Our target group is very wide and we have not given many attributes that are required from the people because we want to compare how dynamic works vs static and we do not care to compare the art itself.

To have a well written questionnaire that makes it easy for the participants to express their opinion we have chosen to use the Likert scale (Lazar, Feng and Hochheiser 2010, 132). The reason for using this scale is that the

Likert scale offers a greater answer variety since the test participants would have 7 different points for each of the questions to rate their opinion. This is also a very good method to use when we later on will put all the answers together to create statistics and get an overall opinion on our product.

When the target group is in the room to test the product, the amount of time will be noted so that we can compare it to their questionnaire results. By noting the time, we want to see if the amount of time is connected with how much the target group enjoyed the dynamic versus the static image.

#### *7.3.2.2 Observing*

Observing refers to a person being studied in order to gain information. When observing something, notes are often taken and sometimes it is recorded on video.

It is possible to observe via natural sight with taking notes, using a camera and recording the feed or to physically observe them but without them acknowledging the presence of the observer. An example of these could be having a person in the room study the target group interacting with the image and then taking notes.

An example of video recording is to have a camera in a corner or maybe even have two with different angles to the user and image. An example of the last scenario would be to have a one way mirror where the subjects cannot see through, but the observer can.

When the target group is testing our product, we want to observe them.

By observing them, we can see how they interact with the interactive image and possibly even learn something that we can use to further improve our product. There were observers at both testing scenarios, dynamic and static, so that we can learn how our audience interacts with both.

In our project we had a person taking notes that was outside of the peripheral of the audience. The idea behind having a person taking notes makes sure that we only get notes on the important things that are relevant to our project instead of having a lot of video recorded that has to be viewed in order to find out if it contains any usable information. We had to get their acceptance on being video recorded which would cause some people not to test our product.

### 7.3.3 Results

This subsection will provide the reader with a selection of the raw data from the questionnaires answered during the pilot experiment. The reason why it is relevant to talk about the raw data in the pilot experiment section is because the results from the questionnaire provided the group with a discussion which led to a change in the questionnaire. By looking at the answers, new questions were also added. However this section will only look at the raw data while the discussion section will feature a discussion of the answers and justify why these new questions were added as well as why changes to the already existing answers were added as well.

A selection of the answers to "What did you think about the product?" (Appendix 2):

"*It did not seem to react to the sounds i was making too well, it just seemed that its looping the same animation over and over again. When I would make some noise, some slight changes were noticeable like rain from the cloud, but it did not really entertain me.*"

"*still confused as to what the point was, which was a little more fun the first time, this second time with the moving pictures it was just getting frustrating*"

"*It did not seem to react to the sounds i was making too well, it just seemed that its looping the same animation over and over again. When I would make some noise, some slight changes were noticeable like rain from the cloud, but it did not really entertain me.*"

There are answers for all the results which are given on a Likert scale from 1 to 5 – from 1 to 5, 1 being agree and 5 being disagree. 4 is somewhat disagree, 3 is neutral and 2 is somewhat agree. The total amount of people doing our pilot experiment is six people.

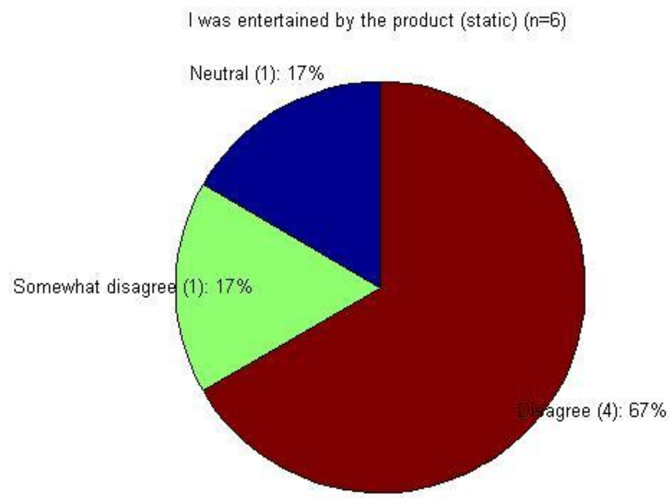


**Figure 54 – A pie chart of how many participants found the product entertaining**

This graphs show the answers to the question: "I was entertained by the product". For the static version, one person is neutral. One person somewhat disagree. Four people disagree.

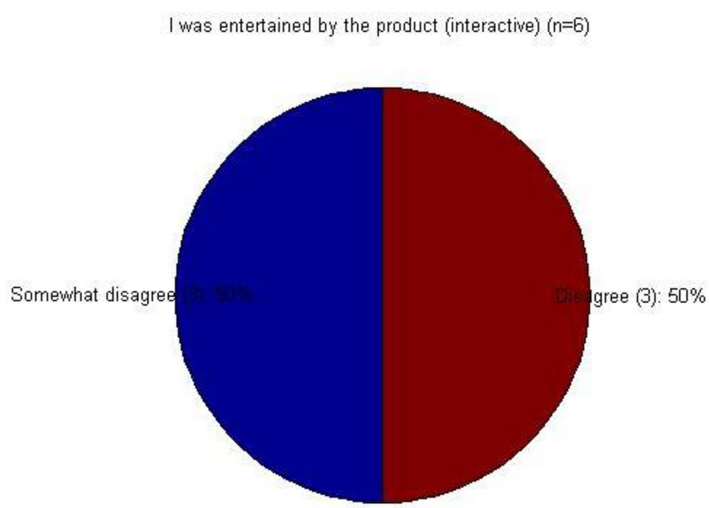


**Figure 55 – A pie chart depicting the entertainment value of the interactive prototype**

This graphs show the answers to the question: "I was entertained by the product". For the interactive version, three people somewhat disagree and 3 people disagree.

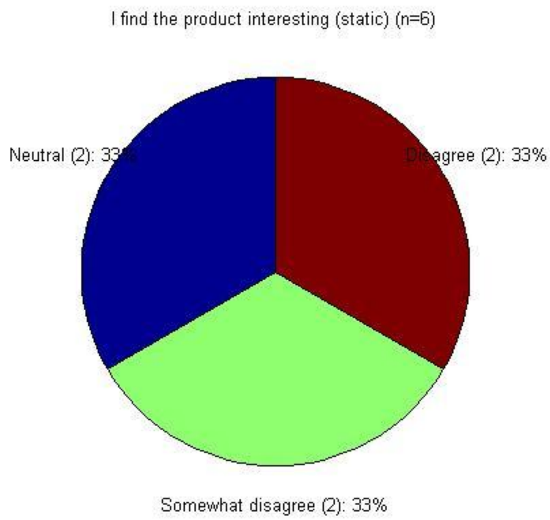


**Figure 56 - A pie chart depicting the entertainment value of the interactive prototype**

This graphs show the answers to the question: "I find the product interesting". For the static version, two people are neutral. Two people somewhat disagree. Two people disagree.

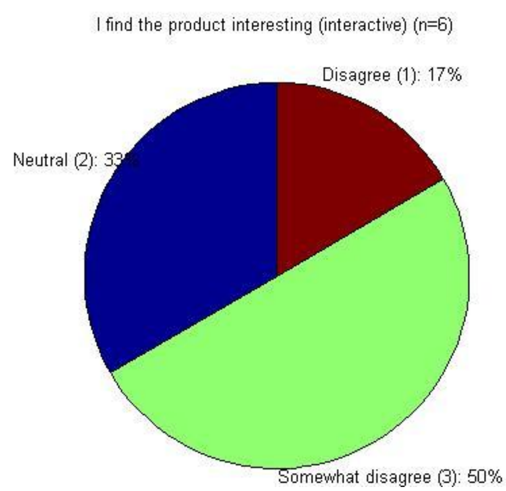


**Figure 57 - A pie chart depicting the value of interest for the interactive prototype**

This graphs show the answers to the question: "I find the product interesting". For the interactive version, two people are neutral. One person disagree and three people somewhat disagree.

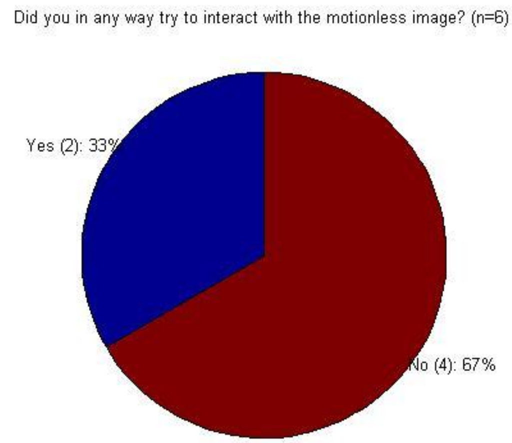


Figure 58 - A pie chart depicting whether or not participant attempted to interact with the motionless prototype

This graphs show the answers to the question: "Did you in any way try to interact with the motionless image?" Two people agree and four people disagree.

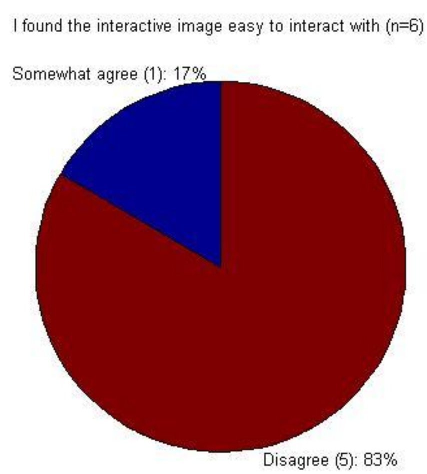


Figure 59 - A chart illustrating how many individuals found the interactive artwork easy to interact with

This graphs show the answers to the statement: "I found the interactive image easy to interact with" One person agree and five people disagree.

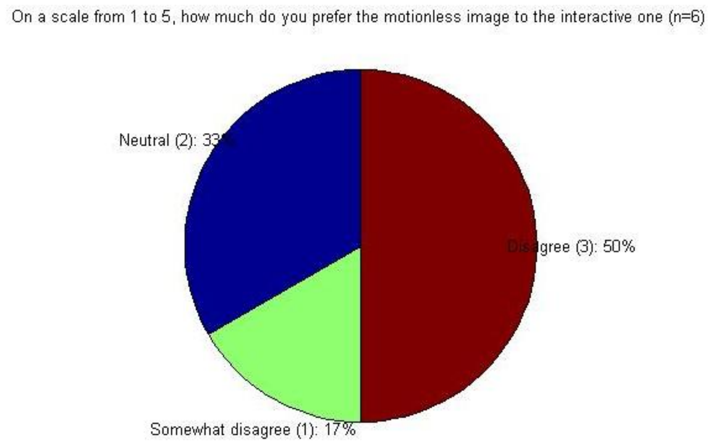


**Figure 60 – A chart illustrating to what degree participants preferred the motionless image to the interactive one**

This graphs show the answers to the question: “On a scale from 1 to 5, how much do you prefer the motionless image to the interactive” Two people are neutral, one person somewhat disagree and three people disagree.

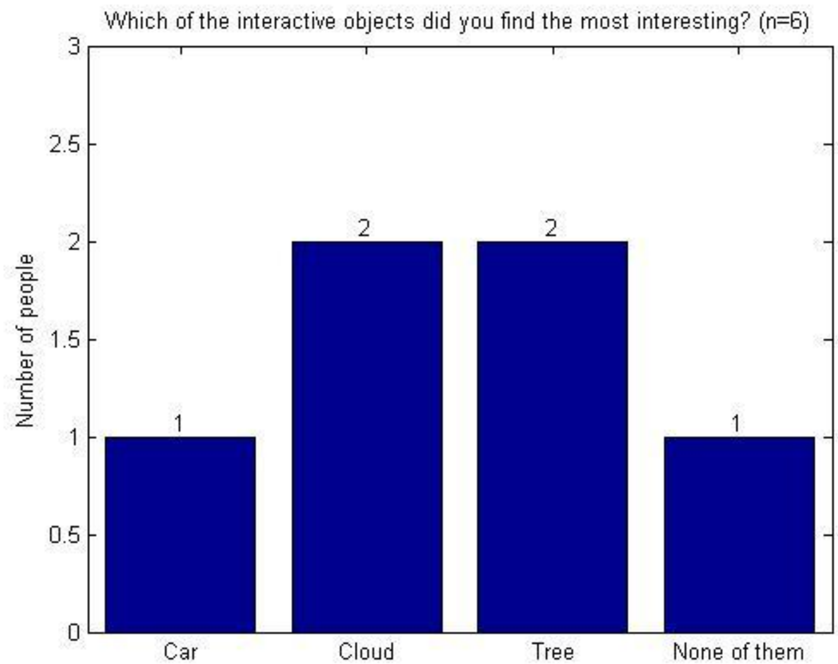


Figure 61 – Depicting the most interesting interactive objects

This graphs show the answers to the question: "Which of the interactive objects did you find the most interesting?" Two people are neutral, one person somewhat disagree and three people disagree.

### 7.3.4 Discussion

The Pilot Experiment indicated, amongst other things, that there had to be made a change in the prototype introduction that was given to the experiment participants. In general, the experiment participants were not sure when they were done interacting with the different paintings and the majority was quite nervous and did not know what to do. This was especially the case with the static painting. The nervousness was enhanced because of the observer watching them in the room.  This was indicated when the participants were asked if they found the observer a disturbance or if they found the observer intimidating.

*"A little bit"*

*"In a way, it was distracting. Made me feel kind of silly."*

*"Yeah. In the dynamic test."* (Appendix 2)

The majority of the participants were also contacting the observer even though they were told not to. This might have been a trait of nervousness.

However, one of the participants also said that the observer was not a hindrance at all. Nevertheless, the majority of the participants agreed that the observer was an annoyance. A participant suggested that a recording device might be a way to conduct the test instead, which might reduce the nervousness during the experiment, as that would perhaps not be as disruptive as an observer or even a camera. In conjunction with having a recording device, a decision was also made to only have the recording device in the interactive room, as this room is the only room where the painting is changed with sound. As well as the recording device might emphasize on interaction with the static room.

As mentioned, the majority of the participants did not know what to do in the rooms and did not get the prototypes. The problems occurring with the introduction might be the lack of a coherent introduction. When the participants were asked what suggestions for improvement of the test, they had. The answers were uniform and the answers suggest that an improvement on the introduction had to be made, as mentioned.

*"Tell the participant what is going on, and what the objective of the test is"*

*"More instructions"*

"*Explain a bit more about what is going on. I could not figure out how to interact with it. Tell more about what is going on. It feels a bit like you're wasting time in their*"

These answers indicate that the final experiment needs a refined introduction where the participants will get a better understanding of the prototype and what they have to do.

When considering that the participants did not know what to do and that they did not know when the interaction with the painting was done. A change that has been made, in this regard, is the introduction to the participants, when they enter the room. The new introduction clearly states that the participants have to interact with or observe the painting, depending on whether they are in the static room or the interactive room. The participants should also be told that they should do so until they feel like they are done. The reason for this is because the experiment participants did not know what to do in the room and all of the participants asked the observer for help.

A flaw that occurred during the pilot experiment was that the small interview, where the participants were asked if they had any improvement, was implemented after the two first participants. Therefore, there was not recorded any suggestions of improvement from the two first participants. However, it was still possible see clear indications of what needed to be changed for the final experiment.

After the pilot experiment, a discussion within the group was made with the experiment results in mind. The results led to a revision of the questionnaire as it was felt that a few of the questions were not clear enough and these questions would perhaps cause bias.

The revision of the questionnaire also led to changes in the Likert scale questions, as the negative statements, meaning the disagree part, in the Likert scale had to be answered with a high number. This was changed so the disagreeing part is now located in the low numbered scale. The reason for this is that it is felt that when grading an answer, it would make more sense to have the highest number being a positive grading.

New questions were also added to the questionnaire in order to give the framework more data to work with and to compare. These questions include “Did you think the simplicity of the artwork affected your opinion of the prototype functionality?” answers to this question can identify if biases are created with the simplicity of the prototype. “What specific sounds/noises did you use to move different objects.” this question was made in order to identify if the participants know what they are doing in order to interact with the prototype. It is relevant to have this question to see if there is any correlation between the interest of the prototype and if the participants know what they are doing.

The questions “On a scale from 1 to 5, how much do you prefer the motionless image to the interactive one” and “On a scale from 1 to 5, how much do you prefer the interactive one over the motionless one” were also added to the final test questionnaire. It is supposed that answers to this question will give the framework very specific suggestions that one painting will be preferred over the other.

An optional final comments box was also added to the questionnaire, to give the participants an option to give any comments they might have to the prototype in general.

These questions might help the Final Experiment to conclude and create a more in depth discussion of the future results from the experiment.

The answers from the results also suggested a need to change the interactive prototype itself. As mentioned, the majority of the participants did not quite get what to do, how to interact with the interactive painting and what sound features did what. Therefore, a change in the interactive prototype was made, making it clear that when there is no sound produced the nothing in the interactive painting will move. Also a change to the behavior of the objects was also made. The objects size ratio has been changed so a further increase in size will take place and hopefully make it clear what sound features is connected to what object as well as how the interaction takes place.

## 7.4 Final Experiment

All the changes in the pilot experiment were made in order to improve the final experiment and get better results, which should, as mentioned, be able to prove or disprove the final problem statement.

This section will cover the final experiment itself, explaining how the experiment was conducted and the events that are noteworthy which are not indicated in the results of the experiment. The results of the experiment will be displayed and discussed upon in a later section.

The room that we placed the motionless prototype in is presented in the Figure 62 below. It has the screen on the wall and a dictaphone on the table as well as the computer hidden below the table. After the first few participants went into the static room we ruled that we did not need to record them in the motionless room, since it gave them the idea that they had to speak which was unintended.

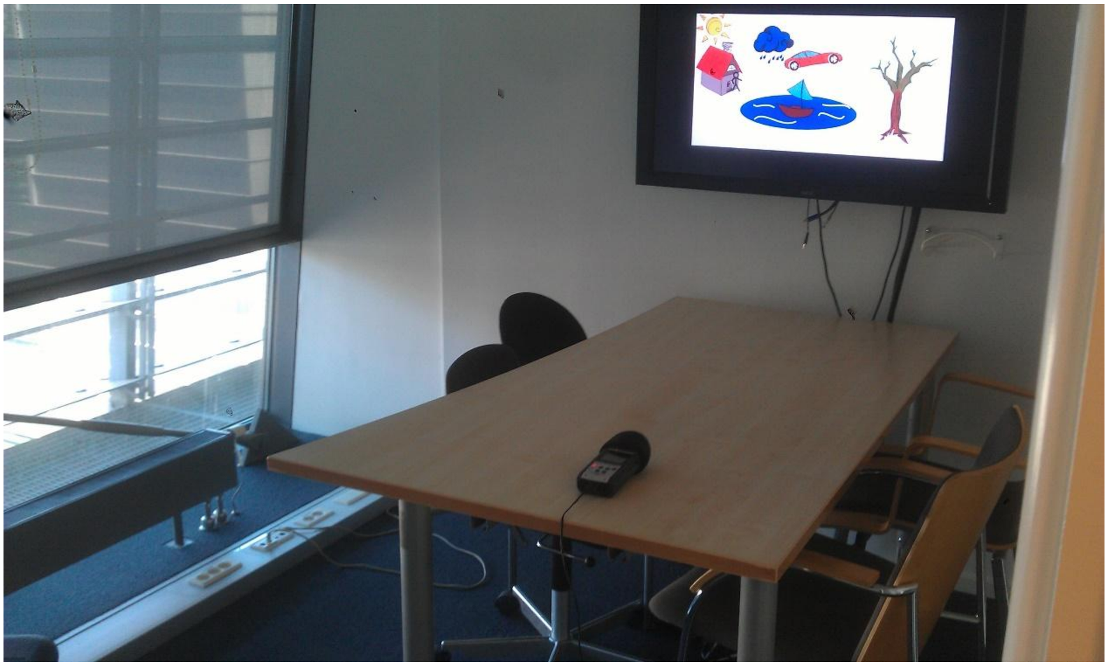

Figure 62 – Our static prototype in our experiment room

The room that we placed the interactive prototype in is presented below. It had a screen on the wall, the microphone on the table, the dictaphone was on the right side of the microphone and the computer was hidden behind the white board to the left. As soon as the test participants entered the room, one person would go behind the wall to start the program and the other person gave an introduction to the prototype.

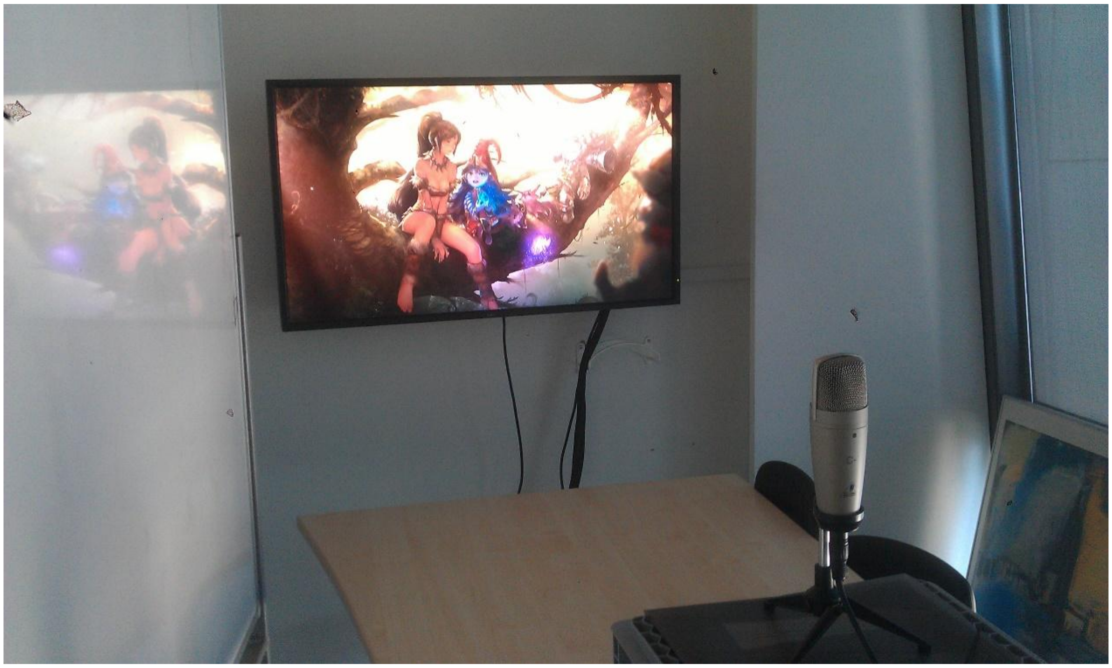

Figure 63 – Our interactive prototype in our experiment room.

The procedure that is stated in the experiment setup steps is the one that we followed when conducting the Final Experiment**.** The setup of the rooms went as planned, but the only place we had a few issues were the guides giving the introduction in the beginning. At first they were not absolutely sure on what to say, but after the first participants it went according to the plan.

The general people who were elected to experiment with our prototype were students and faculty that were within the immediate vicinity of the test rooms. The total amount of participants was 36, which is more than planned. When the participants were in the rooms we timed them, and the average time for a person to use in the interactive room was 2 minutes and 10 seconds. The average time for a person to use in the static room was 58 seconds.

Two laptops were set up with the questionnaires. When the participants were done with the first room they answered the first questionnaire, giving a description of the product and the opinion of it. After the second room they answer the second questionnaire that is more in depth.

Two people had the job of introducing the experiment participants to the rooms, one person on each room. This way we made sure that every single person got the same introduction each time. There were two different introductions, one for each room. Some of the introduction were the same for both rooms, informing them who we are and that they should be in there for however long they wish. The introduction for the room containing the dynamic prototype said that they should try and interact with the prototype via sound. The reason for stating this to the participants is that when we did our pilot test, the participants did not seem to understand what the goal of our prototype was. The introduction for the motionless room just mentioned that they should enjoy the image, as well as the standard introduction (Appendix 4).

One member was out searching for people to experiment with our prototypes and creating a schedule so that we had a constant stream of people coming around for testing. One group member was in charge of getting the initials of the experiment participants as well as noting down which setup they went into first, and which they went into afterwards. The same person also made sure that the Dictaphone was recording the session in the interactive experiment. We also had a person sit at the questionnaire station, in order to help with any questions the experiment participants might have regarding our questionnaires (Appendix 1).

The person sitting at the questionnaire station also made sure that the participants signed the consent notion that we had, which will be mentioned further down.

### 7.4.1 Method

#### *7.4.1.1 Questionnaire*

In our final experiment we use questionnaires for getting feedback from the target group much like we did in the pilot experiment Questionnaire. One of the main reasons for using quantitative questionnaires compared to qualitative is that our testing group consists of 30 people and it would be difficult to interview them all. The main reason for using quantitative questionnaires to get feedback is that we want specific data as numbers as opposed to opinions. Since we compare two products that we show the target group ourselves, the target group does not need to have any previous knowledge regarding any subject. This means that we do not care what they do daily or what their hobbies are, we just want two opinions – one for each prototype. When using a questionnaire with quantitative feedback it is also easier to analyze the data of a lot of people, and doing statistics on it. One of the main methods that we used in the Questionnaire is the Likert scale. The Likert scale makes it easy for us to compare the results and analyze them.

###### 7.4.1.1.1 Pie chart

A pie chart is a way of indicating data in a simple but functional way. A pie chart is a 360° round circle with sections that indicate the amount of a certain number via the size of the section. The amount of space that is colored a specific color then indicates the specific number for that color in regards to the size of it. There are both 2D and 3D pie charts, which presents the data in either a flat space or a 3D space.

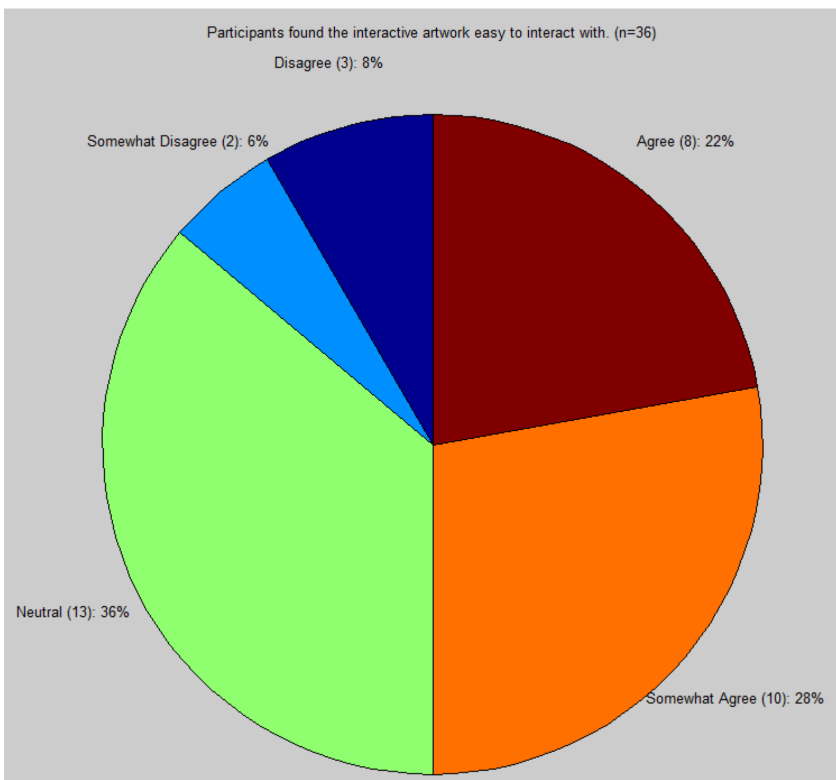


**Figure 64 – This is an example of one of our pie charts**

As you can see, there are several different colors that indicate how much of the total 100% (360°) circle that the data represents. In the edges the percentages are indicated as well as the amount of participants where the total amount of participants is indicated in the top.

#### *7.4.1.2 Experiment design*

The testing phase also includes a certain design pattern, this being the within-subject design. This type of design revolves around ensuring that every test participant experiences, and responds to, all of the test's different sections – in this case, the two images (static and dynamic).

The test did however not have an observer, thereby excluding the possibility of fulfilling the aspect of within-group design that revolves around having observations of the test participants before- and after-, or during the test. Rather than having an observer, the testers settled with making audio-recordings of the test participants, as this seemed like a more efficient way of observing the test without affecting it.

While the testing could arguably also be classified as having a between-group design, rather than a within-group design, seeing since half of the test participants experienced the static image first before moving on to the dynamic image (and vice versa) thereby creating two groups of testers, the overall test was deemed as mainly having a within-group design. The reason for this is, as mentioned earlier, the fact that every participant in fact did get to experience and respond to every aspect of the test.

#### *7.4.1.3 Experiment Type*

When choosing the setup of an experiment, we will present two different types: a true experiment and a quasi-experiment.

A true experiment revolves around everyone everywhere having an equal chance of being picked for the test phase of the experiment, while a quasi-experiment concerns itself with, basically, narrowing down the search-perimeter – e.g. true experiment allows everybody to be a test participant, and quasi-experiment only allows people within the age limit of 18-40years to be a test participant.

The testing phase of this project is set up as a quasi-experiment, meaning that random assignment is not used, for the collecting of test participants, while multiple groups and measures are included.

Random assignment revolves around having a lottery system to select test participants, with every individual within the target-group having an equal chance of being picked for the study. The testing was set up as a quasi-experiment, as the random assignment system would require the target-group to have no characteristics that might exclude other individuals in general. As such, this project's testing could not be a true experiment without disregarding the formerly established target-group features, such as age or professional interest.

While the project could have benefitted by having the testing phase set up as a true experiment, so as to ensure every individual in general – regardless of age, gender, profession, etc. – an equal chance of being picked for the test, the setup of a quasi-experiment was deemed more prudent, due to its slightly narrower search-perimeter.

### 7.4.2 Data analysis

#### *7.4.2.1 T-test*

A t-test is used to set two data sets up against each other to see if there is any significant difference, this is done by comparing two different data sets and sees if there is any difference and how big it is. What this means is that the t-test will calculate the difference within-subjects to see if the difference in groups is reliable or a product of chance. This means that when two different data sets are provided, using the t-test we can figure out if these two data sets have things in common and is alike or if they are different, using the average value and comparing the difference within and among groups. This means the only thing a t-test will tell us, is if there is if the difference correct and can be expected again if the test is conducted once more time or if it's pure chance. Even though this is the only information it gives us it is very useful, with this information we can see if our experiment has results we can trust or if they could be pure randomness. (Mcdonald n.d.)

When we work with our null hypothesis which is that our group A, being the ones starting in static and group B being the group started in interactive. The null hypothesis says that group A and group B has the same answers which we can conclude that they are not, therefore rejecting the null hypothesis. After this has been done we need to create a new one, which will be based on our findings in our test and made later.

This t-test is the test we will be using throughout our project; we had other choices like the ANOVA test which will be shortly mentioned in the appendix.

The formula for calculating the t value looks like this:

$$t = \frac{\sum d}{\sqrt{\frac{n(\sum d^2) - (\sum d)^2}{n-1}}}$$

t is the value that we require to search for the p value, in a t-table based on the  value.
The value is a value that we set. This value is a percentage, normally 1% or 5%, which is used to reject the null hypotheses.
d is the difference between two vectors of data. We are making two different paired t tests, one on how entertaining the static version is compared to the interactive version and one on how interesting the static version, is compared to the interactive version.
As an example of what the d value is, let us take the first five answers of motionless and interactive version of the question; I was entertained by the product.

$$E.d = [1\ 3\ 2\ 4\ 1](\text{entertaining, interactive})$$

$$E.s = [1\ 2\ 1\ 3\ 1](\text{entertaining, motionless})$$

$$d = E.d - E.s$$

$$d = [1-1\ 3-2\ 2-1\ 4-3\ 1-1] = [0\ 1\ 1\ 1\ 0]$$

The n value is the number of participants. In this example we will have 5.

$$n = 5$$

The numbers can now be inserted into the formula and we get a t value of 2.449.

$$t = 2.449$$

We will set the value to 5% and to find if we can reject our null hypotheses we need to look up the p value in a t table. The t table can be found in the appendix (Appendix 7).

The df (degrees of freedom) is; $df = n - 1$. In the t table we need to find the closest number to the t value from our df. Looking in the t table we can see that t is for a two-tailed between 0.10 and 0.05 and for a one-tailed it is between 0.05 and 0.025.

The number of tails depends on the hypotheses. If the hypothesis is that there is a change between the interactive and motionless artworks then we use a two tail t test, but if the hypothesis says that we will see an increase in the score, we will use a one tailed t test.

This is important to know how many tails you want since our results in this example depends on it. If we use a one tailed t test we have a p value of 2.5%p5%. This means that we can reject our null hypothesis based on the fact that p. If we on the other hand have a two tailed t test our p value will be 10% p5%, which would mean that p>. This confirms the null hypothesis and change the overall result of the test.

Later in the result analysis section we will create a paired t test for our data gathered and discuss the results.

#### 7.4.2.1.1 The P-value

The p-value is something you usually find after you have set your α-value when you want to either reject or confirm your null hypothesis. The α-value, significant level, which represents the P-value is normally chosen to be either 0.05 (5%) or 0.01 (1%). However we choose, to go with the 0.05 p value which is translated to 5%. This means there is less than 5% chance for our results to be randomized. This means that if our P-value is higher than 5% we need to reject the null hypothesis; if it however is lower we do not need to reject our null hypothesis. After our test has been analyzed we can look at all our p-values throughout the comparisons we have made. They all show us that we can reject the null hypothesis which states that results from group A is the same as the ones from group B, can be rejected. This means that the answers are not the same and the results also states that our results are valid and have a very low chance of being random. Much lower than our maximum, a 5% chance, of the results being random.

#### *7.4.2.2 Paired samples*

During our experiment phase we chose to use a paired sampling method. This means that we have placed half the test participants in one room and the other half in the other room, and then switching them around. This means we are using the within-subjects design rather than the between-subjects design ( Richard 1998).

Within-subjects design means that you have, in our case 36 participants, who go into both rooms where as a between-subjects design would have placed 18 in each room only. The strengths of using the within-subjects design are that we reduce the error variance associated with the individual differences. Whereas the weakness would be an effect known as the "carryover effects" which essentially is that the test subjects are influenced by which ever room there were in first, which was the case in our situation. We did experience some of this carryover effect when we had confused people coming out from the dynamic room and went into the static room, it felt like after the participants came out of the interactive room they found the static room to be useless or a waste of time and spend in some cases only 15-20 sec in the room. However the ones that came from the static room found the interactive more fun or at least spend more time in the room. (Mcdonald n.d.)

#### *7.4.2.3 Experimental and control groups*

When we are conducting our experiment we are using the control and experimental groups, for our project. What we did was we divided our test participants up into two groups so half would start in our static room, and the other half would start in the dynamic room. The reason for doing this is because we want to get half our participants through the static one first; this will expose them to a version of our prototype that essentially does nothing, which makes them our control group. We then provide them with a questionnaire to capture their feelings in that moment, and then place them in our dynamic room exposing them for our real prototype. (www.skepdic.com 2011)

### 7.4.3 Sampling

When recruiting participants for the experiment, there is a need to identify in what way the sampling was done. The recruitment of the participants for the experiment, were done by using accidental sampling, also known as convenience sampling as when doing this kind of sampling, participants are recruited according to convenience and accessibility.

*"Accidental sampling, as the name connotes, is a sample drawn accidentally, purely for reasons of convenience and accessibility. They are not generalizable and are useful for pilot testing."* (Ian, Chambers og Wint 1997)

The accidental sampling was done because of the ease of access to participants that would fit the experiments target group.

When doing the random sampling we had to exclude some people from participating in experimenting with our prototype. The main reason for excluding people was that they have tested our previous setups such as pilot test and usability test. Since they had tried either of them, we did not want to have any experiment participants being biased. We also excluded anyone that fell outside of our target group which means that only people between the age of 16 and 40 would be allowed to experiment with our prototype.

#### *7.4.3.1 Normal Distribution*

Normal distribution is a term mostly used when doing statistics. Normal distribution refers to when a graph is evenly spread out when displayed in regards to the data it contains.

*"The normal distributions are a very important class of statistical distributions. All normal distributions are symmetric and have bell-shaped density curves with a single peak."* (Narasimhan 1996)

The quote describes that it is a likely distribution which puts it in asymmetrical way and the data amount increases towards the middle and decreases towards the right side symmetrical to the left side. Normal distribution is also known as the 'bell curve'. Presented below is an example of a normal distribution.

There are two different aspects that are required in order to confirm the normal distribution; the mean and the standard deviation (Narasimhan 1996). The mean is the peak of density, otherwise known as average. The standard deviation indicates how spread-out the bell curve is. Having the mean increase or decrease will not change the specific normal distribution, but rather change the position on the x-axis of it, it changes the number of which the average is. Changing the standard deviation will change the curve, since the area of which the curve covers. If the standard deviation is increased, the width of the curve increases.

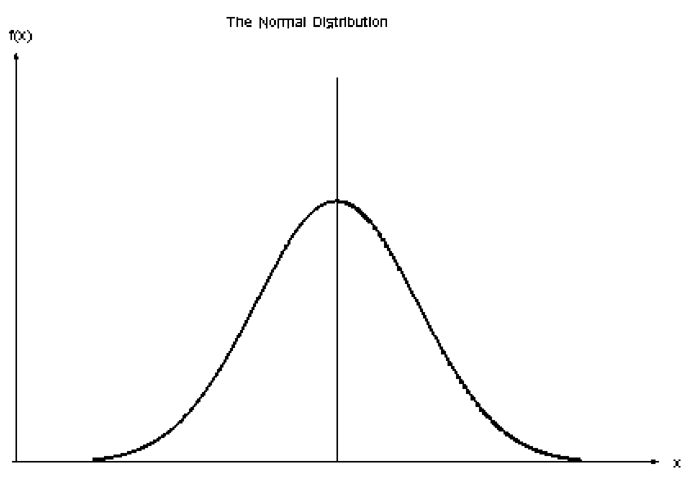


**Figure 65 – A normal distribution bell curve (www.itl.nist.gov n.d.)**

### 7.4.4 Consent

When the target group was experimenting with our product we recorded them as opposed to using an observer. The reason we steered away from using an observer is that the experiment participants from our pilot test found the observer disturbing. When recording people it is important to get their consent which we did. Getting someone's consent means that you get their signature on a paper where it says that they agree to being recorded.

> **"§ 263.** *Med bøde eller fængsel indtil 6 måneder straffes den, som uberettiget [...]*
> *3) ved hjælp af et apparat hemmeligt aflytter eller optager udtalelser fremsat i enrum, telefonsamtaler eller anden samtale mellem andre eller forhandlinger i lukket møde, som han ikke selv deltager i, eller hvortil han uberettiget har skaffet sig adgang."*

Presented below is the author's translation:

> *"With a fine or jail of up to 6 months punishment, goes to whoever without consent […] by the help of an apparatus secretly listen or records statements that occurred in privacy, phone conversations or other conversing between others or negotiations in closed meetings, that said person is not attending, or where he unconditionally has gotten access to."*

This quote is taken from (retsinformation n.d.), which is where the Danish 'straffelov' (penal code) is stated. The quote mentions that there will be a fine or up to six months in jail for someone that without consent records something in private such as phone conversations or private meetings. Since we got the consent of the people who experimented with our product, we abided the law.

### 7.4.5 Results

In this section the results will be presented. The raw data as well as a summary of the recordings will show the results of the final experiment. There will also be result analysis and a result discussion. In the raw data the numbers and percentages will be presented without further concluding. In the result analysis the results will be analyzed and in the result discussion the results will be discussed upon.

### *7.4.5.1 Test results*

This section will cover the raw data gathered through the process of the final experiment, including a brief description of each question setup and collected answers, as well as illustrations of certain statistics.

First off, the survey examines to what degree participants found the product entertaining and/or interesting, thereby checking if the viewing of the artwork successfully has created a positive experience for the user. These are the fundamental components of estimating whether or not one artwork type (static or interactive) is more popular than the other.

Results showed that, in regards to the interactive artwork being entertaining, out of the 36 participants; 2 disagreed, 16 somewhat disagreed, 11 were indifferent and the final 7 somewhat agreed.

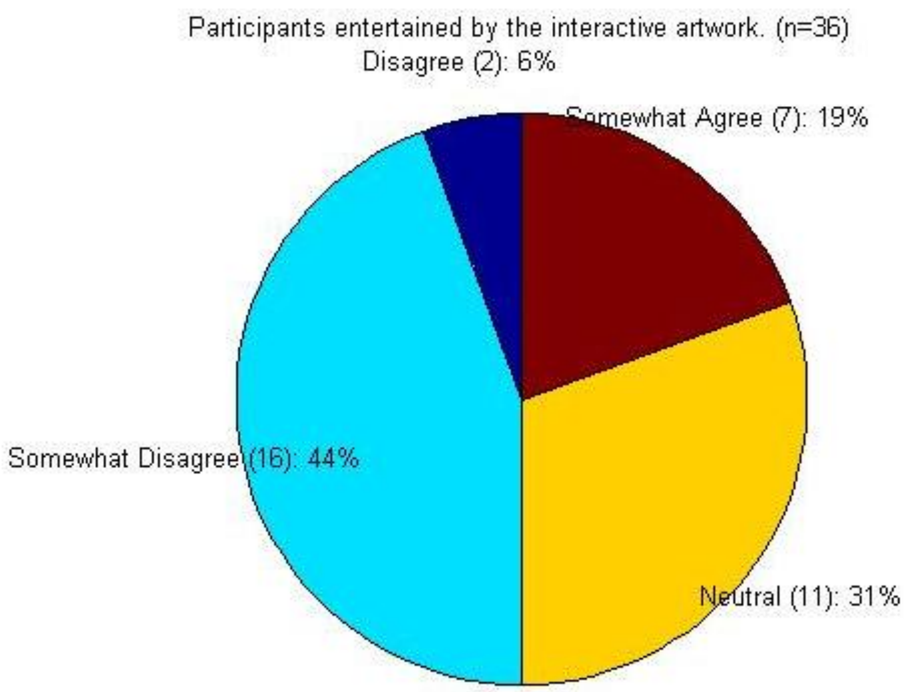


**Figure 66 – A chart illustrating to what degree participants found the interactive artwork entertaining**

Furthermore, in terms of whether or not the static artwork was entertaining, of the 36 experiment subjects; 26 disagreed, 5 somewhat disagreed, 3 were indifferent and 2 somewhat agreed.

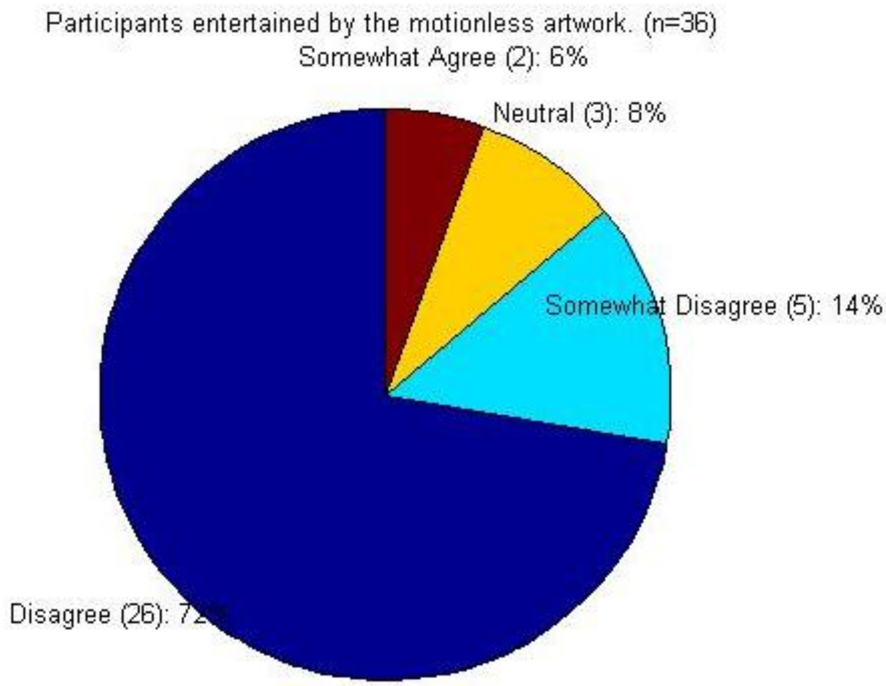


**Figure 67 – A chart illustrating to what degree participants found the static artwork entertaining**

When asked if they found the interactive artwork to be interesting, the results were; 2 disagreed, 10 somewhat disagreed, 14 were indifferent, 9 somewhat agreed and 1 person agreed.

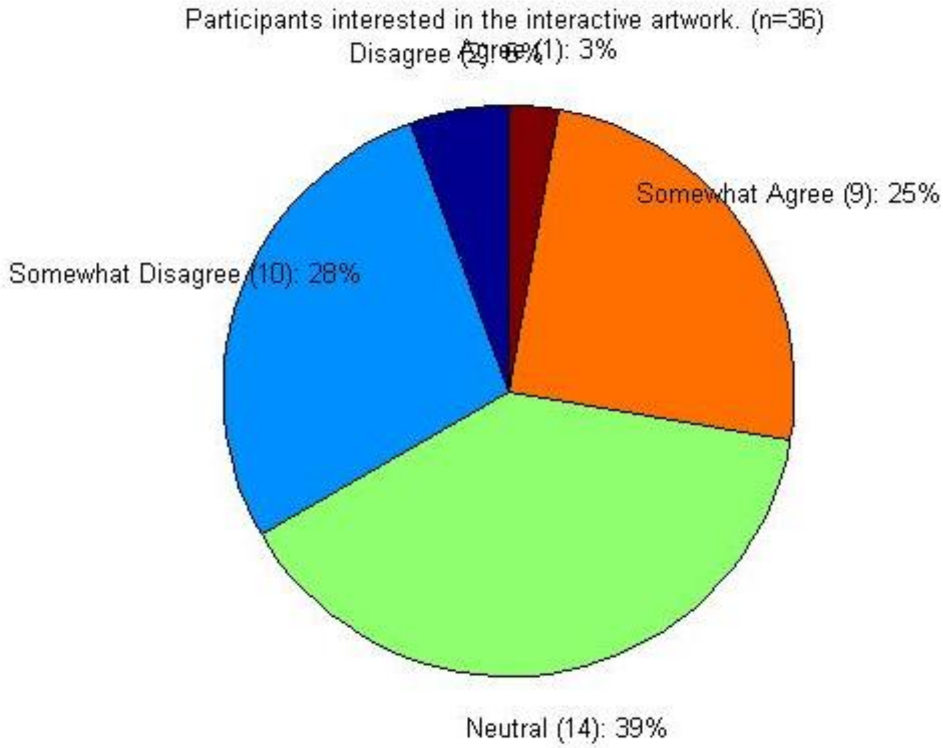


**Figure 68 – A chart showing to what degree participants experienced the interactive artwork as interesting**

The results regarding whether or not the static artwork was deemed interesting, by the 36 total participants, showed that; 18 disagreed, 11 somewhat disagreed, 5 were indifferent and 2 somewhat agreed.

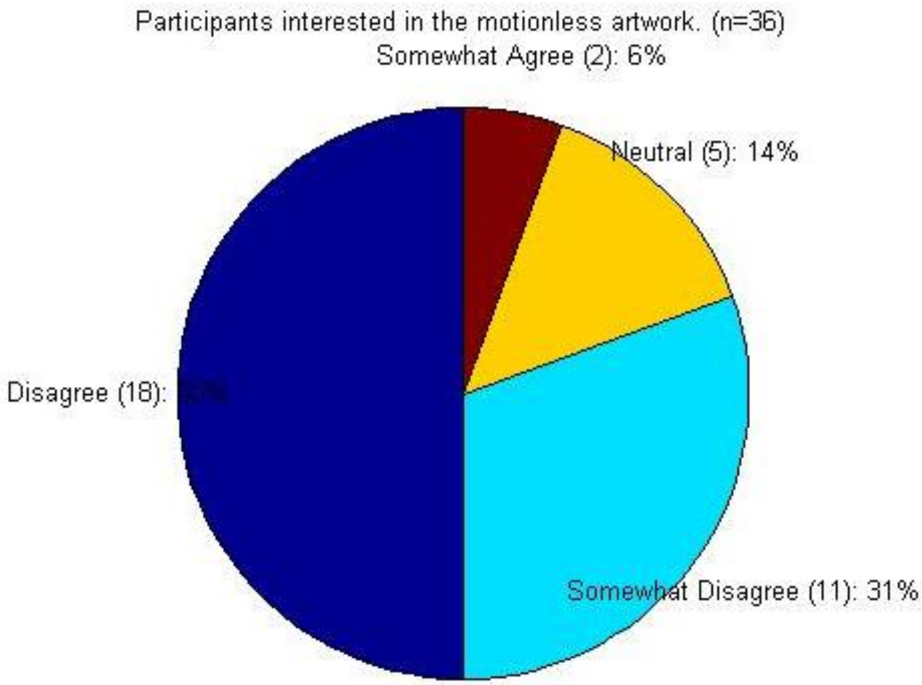


**Figure 69 – A chart showing to what degree participants experienced the static artwork as interesting**

Next, the survey allows for the test participants to freely express their individual point-of-view in regards to the overall experience by asking "*What did you think about the product?*". This allows for the testers to possibly discover previously unknown aspects, both good and bad, of the product and test-proceeding.

This resulted in numerous comments for both the static- and the dynamic image. In terms of the static image, people were split between not finding it entertaining or interesting at all, or simply being confused as to what the point of the image was, as many expected some sort of functionality.
Some of the comments expressing lack of entertainment or interest were:

"*Not much to say as it was just a static image with a couple of objects, so rather boring and uninteresting.*"

"I found it a bit weird. There was nothing to do beside looking which was not that funny"

Comments of confusion were, for example:

"*Nice picture – but I don't really get the point of me observing a non-interactive picture – which was of course a lot more boring than the interactive one. So of course the interactive one was more entertaining.*"

"*Confusing. Still can't figure out what the purpose is.*"

Only a single individual described the static image as interesting, by simply commenting:

"*Interesting.*"

Regarding the interactive image people were split between three different view-points. A large part found it to be a cool and interesting product and/or concept, while another large part were confused as to what the point of the product was, and lastly a few individuals found it to be not interesting or entertaining at all.

Some of the comments from participants liking the interactive image were:

"*Much more interesting than the other one, especially when you simply blow towards the microphone and it resembles "wind" on the image comes rather naturally. […]*"

"*I liked it a lot. First I was a bit on the nerves as I had to make noises at the screen.*"

Comments from confused participants were, for example:

"*Could not find out what sounds did what. I seemed that any sound i was making made the cloud move and sometimes rain. Couldn't really figure out the point even though I think i tried for some time.*"

"*Had a hard time figuring out exactly what the purpose was. Could see the different things react to the sounds, but I expected something bigger to happen. As if I should make a specific sound pattern to make the different elements on the screen collide or something.*"

Some of the few negative comments for the interactive image would, for example, be:

"*Weird, I didn't know what to do. I just saw the higher pitch I made, the more objects made an animation. Not that fun. I just wanted to the man to walk, but he didn't.*"

"*Well it was rather boring since most of the animations just looped and only a few seemed determined by my voice.*"

Next, basic personal information is gathered to be capable of spotting irregularities of survey answers later on, such as having deviations in the gathered data show patterns based on age, gender and/or major.

Overall, the test subjects turned out to be 23 males (66%) and 13 females (34%), with an average age of 23.25 years – the youngest participants being 20, and the oldest being 34. Nearly every test subject majored in Medialogy with the exception of one humanistic informatics student and a PhD student.

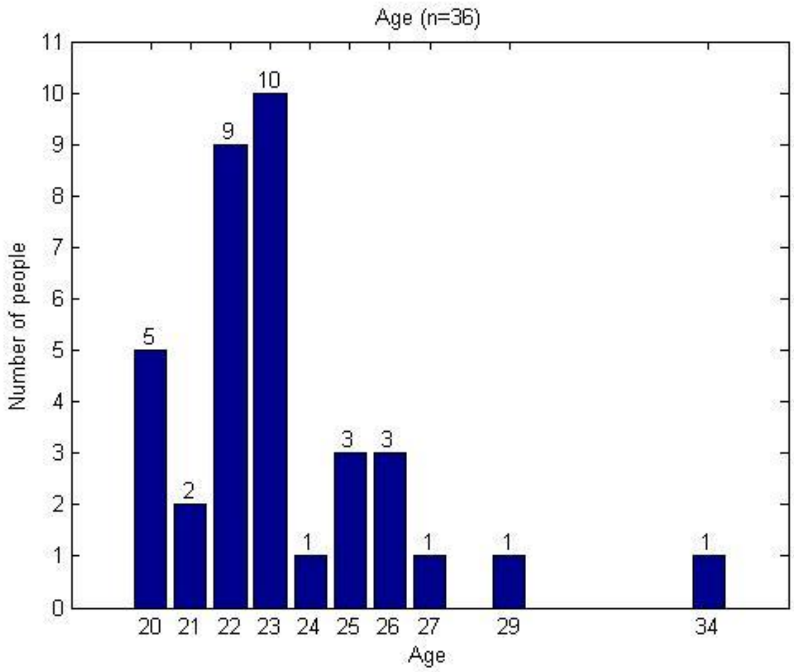


Figure 70 – A graph showing the various ages of the participants

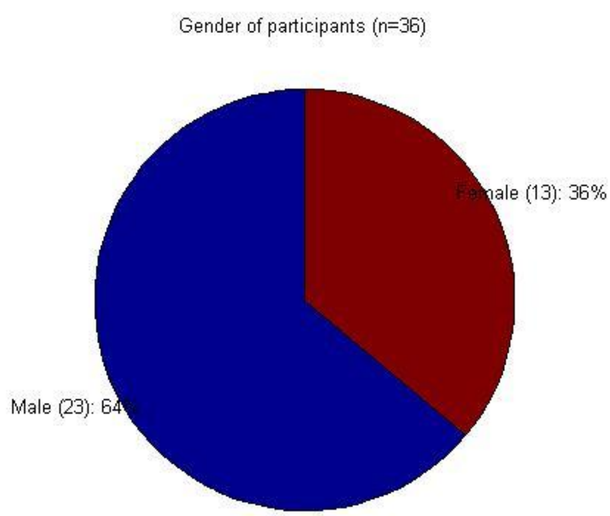


Figure 71 – A chart illustrating the amount of each gender represented in the experiment

In order to test for whether or not the product's usability is intuitive and easy to use, the test subjects are asked to what degree they agree with the statement "I found the interactive image easy to interact with". While 13 of the 36 participants were indifferent, the majority agreed to the interactivity being easy to approach, with 11 somewhat agreeing and 8 agreeing completely. Only a few individuals deemed the interactivity somewhat difficult to handle, with 2 somewhat disagreeing with the statement and 3 disagreeing.

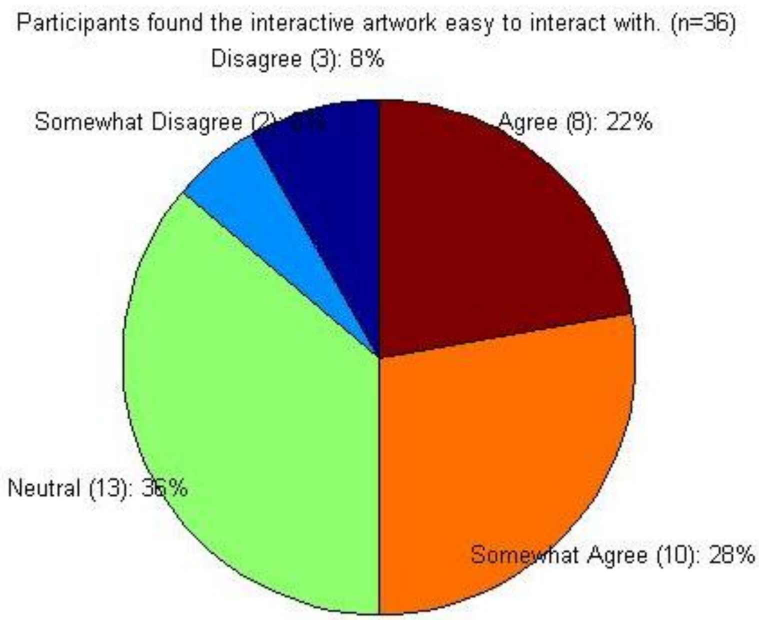


**Figure 72 – A chart for the answers to the statement: I found the interactive image easy to interact with**

Next, the survey asks for the test subjects to rate how much more they preferred one image over the other. This is done with two similar yet separate questions. "On a scale from 1 to 5, how much do you prefer the motionless image to the interactive one" and "On a scale from 1 to 5, how much do you prefer the interactive one image to the motionless one". This is done to determine if the interactive image has succeeded in being a more enjoyable experience for the user than the motionless image.

The results show that 31 out of 36 disagree or somewhat disagree with the first question, and likewise agree or somewhat agree with the second.

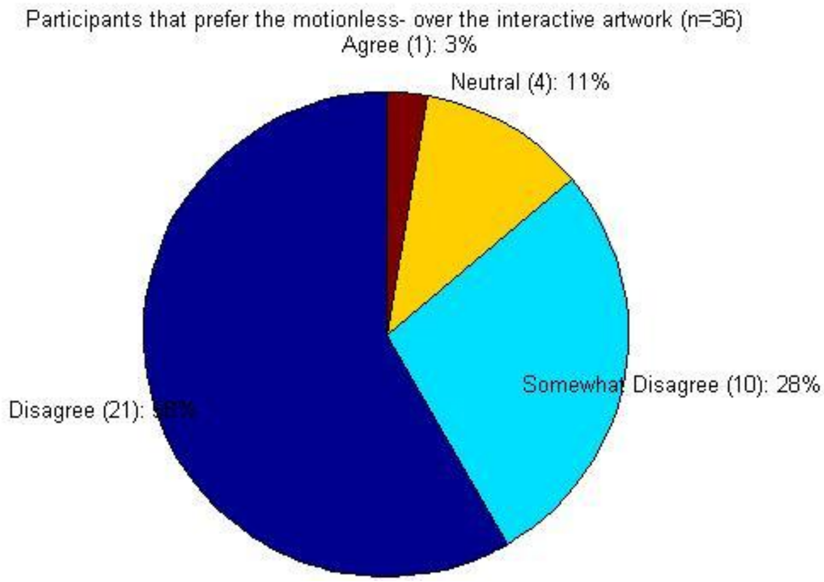


**Figure 73 – A chart of the replies to: On a scale from 1 to 5, how much do you prefer the motionless image to the interactive one**

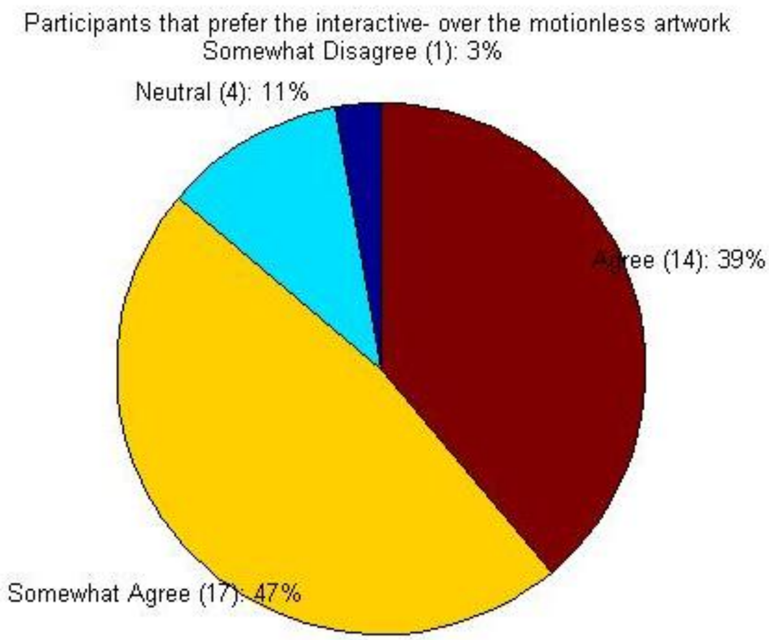


**Figure 74 – A chart of the replies to: On a scale from 1 to 5, how much do you prefer the interactive one image to the motionless one**

The survey then checks whether or not the participants attempted to interact with the motionless image with the question “Did you try to use sound to control the motionless image?”. The reason for this question is to see if any test participants attempted to interact with both images, despite having been given a brief introduction prior to experiencing the product.

Of the 36 test subjects only 8 reply that they tried interacting with it.

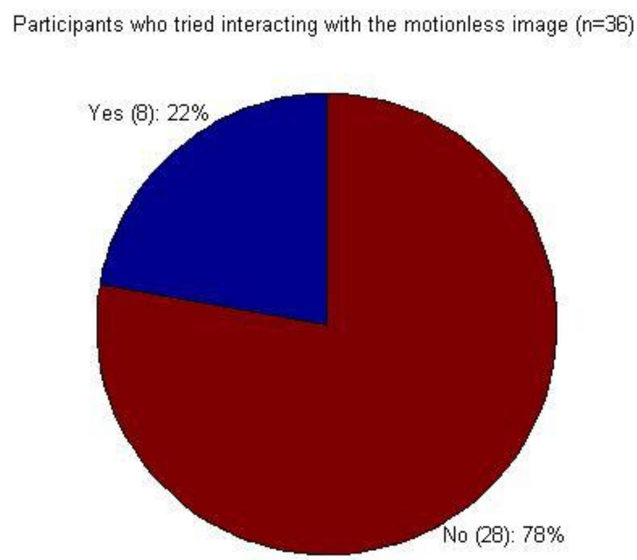


**Figure 75 – A chart illustrating what participants replied to the question: Did you try to use sound to control the motionless image?**

People are then asked what specific interactive objects of the dynamic image they focused on the most, with the question being formulated as “Which of the interactive objects did you find the most interesting?” and the structure of reply possibilities being Car/Cloud/Tree/Lake/Sun/None of them/Other. By asking this question, certain patterns of interest within the test-group can be discovered, allowing for the testers to analyze the effectiveness of the visual aesthetics.

Results show that the majority of people focused on the cloud and/or tree, as 21 of the 36 individuals rated the cloud the most interesting, and 15 rated the tree the most interesting. The lake and car were not rated as very interesting with a total of only 5 people finding them to be of the most interest. However, nobody believed none of the objects were interesting.

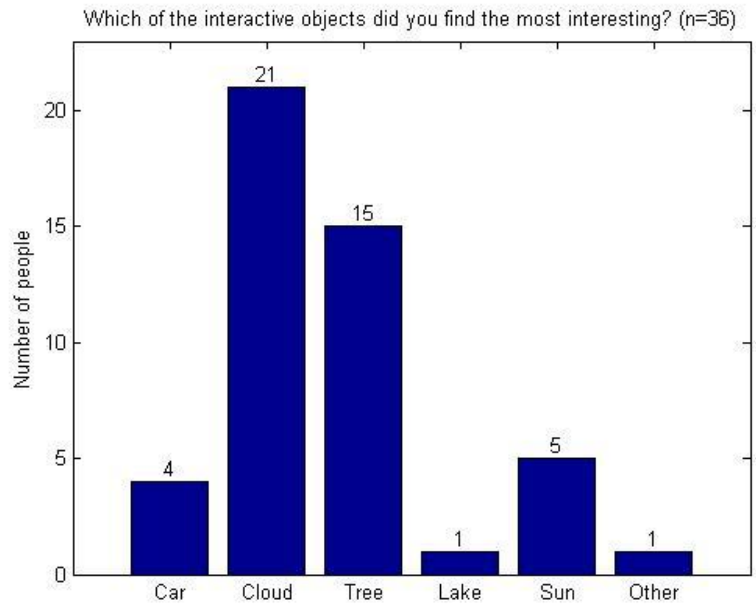


**Figure 76 – A graph displaying what interactive objects the participants deemed the most interesting**

Lastly, the questionnaire is rounded off with three questions with text-fields for answering, allowing for test subjects to freely formulate their replies.

The first of the three is the question "Do you think the simplicity of the artwork affected your opinion of the prototype functionality?". This question allows the testers to know if the product, in case of negative feedback, lacks in functionality, or if people simply did not enjoy the art itself.

The results revealed that 18 replied yes to having been affected by the visuals, in terms of rating the product, while 15 replied no. The remaining individuals replied that they did not know for sure whether or not the visuals had affected their opinion.

The second of the three is the question "What specific sounds/noises did you use to move different objects?". By asking this the testers can discover what sound variables most commonly were used when attempting to interact with the dynamic image, such as pitch or amplitude.

Results showed that people mostly attempted to make use of pitch/frequency, volume, imitating the real-world sound of the object and/or pronouncing the names of the objects, such as “car!” or “cloud!”.

Some examples of what people answered would be:

“*Whoosh sounds to move the cloud. Tried doing a wrom sound for the car. It spun the wheels. For the stationary objects such as tree and house I yelled the respective names.*”

“*I tried saying some of the names of the different objects. Then I tried to use different tones or volumes to see if that would have a different effect.*”

“*All of them. Mostly high and low pitches*”

Finally, the last question is simply to check of test subject might have any additional comments to anything what-so-ever, in terms of the test. The questionnaire was finished off with this, so as to ensure that test participants might have the opportunity to speak their mind regarding any aspect of the test, thereby possibly revealing a pattern in the overall test-group’s experience.
Approximately two thirds had a final comment to the test, stating that they were all slightly confused by the product and its purpose, and some individuals being curious, and therefore interested, as seen in some of the various comments:

“*Interesting. Curious to see what you want to do with it.*”

“*It was a cool experience.*”

During the experiment, the participants were timed and the results are displayed below.

Interactive prototype time:

Participants spent around 78 minutes in total when testing the interactive prototype, the average time of this is 1 minute and 18 seconds.

Motionless prototype time:

Participants spent around 35 minutes in total when testing the dynamic prototype, the average time of this is 58 seconds.

#### *7.4.5.2 Summary of the Recordings*

After listening to the recordings it became clear that a few general choices were made when interacting with the painting. Close to everyone tried to clap at some point, some clapped a few times where a few kept clapping in rhythm for a longer period of time. Based on the results, clapping seems to be the most common thing to do in order to make sound without using your voice. Another thing the majority chose to do was singing vocals going through the voice spectrum, trying to range from a deep to a high pitch noise using vocals like “a” or “I”. There were also a lot of the test subjects who choose to snap their fingers, scream or yell, and also a very common option was to call out commands.

Many of the commands were things like “car move” or “tree move”. Even though our painting does not react to the different commands it still reacts to the sounds being said when saying the words, this resulted in some people believing the commands worked and called out more commands, however a few of them called out commands and sounded disappointed after seeing the results.

Another thing some of the participants did was to stand there in silence, doing nothing for either a longer period of time or for the entire time they were in there. We later learned that some of the people we talked to after we did the experiment had given us feedback on the product but those people did not themselves see any feedback from product since they did not make any sounds. Luckily for us it was very few of the test participants who made no sounds while being tested, a few had some moments of silence and some giggled, most likely because they felt awkward interacting with the product.

Another popular option was humming or singing songs they knew to create sounds for the painting. It mostly started as the participant humming a tone deep or high pitch, then turned it into a melody, the other not quite as popular option was to sing, only a few of the participants started this and it only lasted around 5-10 seconds.

Another very popular thing to say is to call out the names of the objects in the picture, much like the one mentioned above where commands are used, this one however without the commands. The normal expression from the participants here is something like "tree, tree, tree" or "car, car, car", going through almost every object in the picture and generally calling them out three times each.

#### *7.4.5.3 Result Analysis*

In this section we will look at the results from the results section and analyze them, with the final problem statement in mind. We are going to make a paired t test on some of the results so we can compare the static artwork, which is our control group, to the interactive artwork. We are also going to look at the null hypothesis and see if we can reject it. It is important to note that the results, we are going to analyze, derive from 36 participants who, in conjunction with both experiments, answered the two questionnaires that relates to the two experiments.
As mentioned in previous sections, participants were asked certain questions for each of the prototypes they tested. This part will go through the results from these questions. Firstly they were asked whether they found the interactive or static artwork, depending on which they tested first, entertaining. There are 44% participants, which are 16 people, which answered that they were not entertained by the interactive artwork. Considering that the results are valid, we can assume that people are not entertained by an artwork which can be manipulated by sound. According to the results, we are unable to conclude that an interactive artwork in general is not entertaining, but the prototype that was used in the experiment was not as entertaining as it could be, meaning that the developers could have made it more entertaining. On the other hand, when looking at the same question asked about the motionless artwork, it is clear that they disagree with it being entertaining since a larger amount of people, 31 people (72%) did

not find the prototype entertaining. This means that almost double as many people find the motionless artwork less entertaining than the interactive prototype. By comparing the results from the two prototypes, regarding the entertainment of each of them, a difference in averages of 1.16 can be noticed, which means that, even though the participants did not agree that the interactive prototype was entertaining, they slightly disagreed with this statement, while they strongly disagreed with being entertained by the motionless prototype.

If we just take the number of people that somewhat agree with the two questions on the two prototypes, we have 7 people that somewhat agree they were entertained by the interactive artwork however only 2 people somewhat agree they were entertained by the motionless artwork, this means, if we take these results in consideration, we can assume that people were entertained by the interactive artwork rather than the motionless one.

Therefore by comparing the two, we can assume that an interactive artwork, when compared to a similar static artwork, will be more entertaining.

A second question asked was whether the prototypes were interesting. The results, regarding how interesting the interactive prototype is, indicate that the interactive prototype is somewhat interesting. The largest percentage of the answers shows that they are neutral. The amount of people being neutral on the subject is 14 people or 39%. The most popular opinion, neutral not considered, is that they somewhat disagree with the prototype being interesting. The amount of people that somewhat disagree with the prototype being interesting is 10. These numbers indicate that overall, the people somewhat disagree that the prototype is interesting. The large amount of people being neutral can also suggest that they are unsure regarding if the prototype is interesting. However, when looking at the static artwork results, it shows that 18 people did not find the prototype interesting. 11 people somewhat disagree with the prototype being interesting. This indicates that a large part of the participants were not interested. From this we can conclude that our motionless prototype is not as interesting, and that more than 75% were to some extent not interested at all.

By comparing the two results, gathered from the question to whether the prototypes are interesting or not, the average of the results from the interactive artwork shows a high difference from the average of the motionless one. This difference consists of a number of 1.16, which shows that the interactive artwork is proved to be slightly more interesting than the motionless artwork. The fact that the highest number of people disagree with it being interesting when talking about the motionless artwork and the majority is neutral regarding how interesting the interactive prototype is, can be reasoning to concluding that the interactive prototype is found to be interesting compared to the motionless artwork. When looking at the overall time, which participants spent in the room with the interactive prototype is 78 minutes, while the time they spent in the static artwork's room is around half of the time mentioned before, and this is 35 minutes. This means that, if we assume time is connected to how interesting the interactive prototype is even these results show that participants act as being more interested in this prototype. However, interesting is not directly connected to the time participants spent in each room, but the time can be a factor to whether they think it is interesting or not.

From this, it is to be stated that it cannot certainly be concluded that the interactive prototype is interesting, however it can be concluded, by looking at these results, that the interactive prototype, compared to the motionless artwork, is more interesting.

When looking at the results, where the participants were asked, if the participants found the interactive artwork easy to interact with, it is indicated that the majority of the participants were neutral about whether the interactive artwork is easy to interact with, this can mean that they were quite unsure whether they managed to interact with the prototype as the prototype was meant to be interacted with, however a selection of the participants did agree that the interactive artwork was easy to interact with. This was suggested by the 28% (10 people) of the participants that somewhat agreed and the 22% (8 people) that agreed when comparing these answers to the 8% that disagreed (3 people) and the 6% (2 people) that somewhat disagrees, it can be assumed that the interactive prototype was indeed easy to interact with, however with a few ups and downs. Also the fact that there are 36% of the participants who are neutral, and as neutral answers cannot count towards either the agree side or the disagree side it can be concluded that the interactive artwork is easy to interact with as majority of the participants agreed or somewhat agreed. When looking at the comments regarding the different prototypes the participants have tested and what comments they have about them, it can be noticed that more than 14 participants in the interactive artwork, stated somehow that they were confused about the prototype or what they were supposed to do, this can be one reason to why the majority of the participants were neutral when talking about the interactivity of the product.

The next statement is whether the participants prefer the motionless- over the interactive artwork. When looking at the results, 21 people disagreed and 10 people somewhat disagreed with the statement. This shows that a large proportion of the participants did not prefer the motionless over the interactive prototype and this, at the same time, sustains the fact that the motionless is less interesting or entertaining than the other. When talking about whether the participants prefer the interactive over the motionless artwork, the results sustain the conclusion stated above, that the interactive prototype is preferred. The results show that 14 people agreed to prefer the interactive over the motionless artwork and 17 people somewhat agreed with this statement. This shows that a large proportion of the participants prefer the interactive over the motionless prototype, therefore when talking about a comparison between these two, an interactive prototype would much rather be preferred and an interest would be much higher in such an artwork. There is a slight variation in results between the two questions that are 'opposed'. What is meant by this is that one could assume that, someone disagreeing with the statement that the motionless is preferred over the interactive, would mean that they agree with the interactive being preferred over the motionless one.

According to the recordings that were gathered during the experiment phase, the most common actions were clapping, use voice commands and going through vowel sounds. Clapping may be impulsive because actually making sounds and saying words when knowing they are being recorded does not make them feel comfortable with and thus resort to just making clapping noises. Using voice commands was also a common option for the participants when trying to interact with the prototype. This can be because a common new thing in technology is speech recognition and a lot of activations are triggered by voice commands, therefore participants felt it to be intuitive to use voice commands to trigger animations.

When comparing the results from the usability test to the final experiment test, it can be deemed that using voice commands is natural and something that is instinct related. However, since not many people managed to understand how the prototype works we can conclude that the product might not be intuitive enough to use. Some of the experiment participants did not fully understand how the prototype responded to sound, but they did understand that it did react to sound and therefore many people chose the cloud as being the most interesting interactive object, hence this took up a lot of space on the artwork and did a lot of animations.

#### *7.4.5.4 Result discussion*

From the results given by interest comparison between motionless and interactive we can conclude that the interactive prototype is more interesting. Overall the participants mostly agreed with the statement that the interactive prototype is more interesting than the motionless as well as mostly disagree with the statement that the motionless is more interesting than the interactive. This means that the interesting aspect of our final problem statement is confirmed. In regards to the entertaining results, it is important to note that it does not correlate with our final problem statement. We did not require testing the entertainment value of the product but we wanted to test it anyway. The reason for testing if our product was entertaining is that we wanted to see if our way of producing an interactive artwork had any entertainment value.

Furthermore, the dynamic prototype has a frame rate that could cause issues since it might be lagging. Lagging is when the frame rate drops low enough to give the impression that the image is not moving while the participant is trying to interact with the prototype, therefore this might have influenced the way the user interacted with the prototype and thus leading to people being confused and stating this in the comments about the products.

During the experiment certain biases occurred, which can lead to the fact that the results might not be valid or can't be used to conclude upon certain answers or the final problem statement. Bias refers to specific events that were out of our control when doing our final experiment. There were several elements that have been given attention in order to prevent bias but is unlikely for us to make sure the experiment did not undergo any biases.

The average age of the participants in the experiment is 23.25 years old and most participant's ages range between 20 and 24, so therefore the results mainly apply to people within that age range, therefore it might not be wise to say that people of older age might have the same opinions and would give the same results to the questions that were asked. Therefore in order to be able to generalize answers based on the age of the participants it is required to have a wider range of age in people to participate in the experiment, which in this case, as stated in the target group, analysis, the people should have ages between 18 and 40, however there must not be a too tight focus on just a smaller range of those. The same occurs when talking about the gender of the participants, ideally it would have been best to have an equal amount of females and males in order to be able to generalize the results.

Firstly it is important to notice that the time, which measured how long participants spent in each room, was started by the two guides, it was said that both should start when they leave the room, however it is not certain that the stopwatch will be started at the exact same point in the introduction of the participant to the prototype. The individual time of how long they were experimenting is then biased by the few seconds that the stopwatch start timer or when the time was stopped, varies.

Some of the people were uncertain regarding how to interact with the prototype or what to do with it, which could have caused them to stay in the room for longer time that expected. This bias could have been caused by the fact that the user either did not pay attention to all the information from the guide, since it included a lot of information, or the guide had forgotten a point on the information, nonetheless, this could be one of the reason the time recorded in the rooms might be biased.

Another bias encountered when the first two participants that experimented the product got an introduction with less information, which was not the exact same as the standard introduction that was given to the rest of the 34 participants. The first two participants were also recorded in the room with the motionless prototype, unlike the rest of the participants. Therefore, the first two participants can be considered to have been used for a second pilot experiment for the final experiment, which then lead to small changes to improve the experiment.

When talking about the times the experiment was conducted, which were in the morning from 11 to 13 pm and the second day the same time, it can be assumed that people were not really prepared to spend time on these prototypes since lunch occurs during those hours and therefore rushed answers might have been given. Another point that could influence the results is the fact that most participants were from the same study, Medialogy, with the exception of two, which means they could have recognized the programs used and how they work, and therefore know how to interact with the interactive artwork.

These are the overall ideas regarding how the testing went and what the problems might have been, however, some problems can be seen when looking at the questionnaires as well. An example of such an issue or perhaps a mere improvement to make it easier to gather the information and results and give clearer questions to participants, is a question asked after each prototype test, and that is what participants think about the prototypes. This question could have been a much more specific question such as what they think of the visuals or the functionality, controls, etc. Another improvement to a question would be to add a different answering option when asking about the simplicity of the artwork and their opinion of functionality, that is if they agree with this, to answer yes or no and if yes to elaborate.

Earlier, the basics of a t test were explained, and an example with a smaller sample of participants was given. This part will include the T-test calculations added to the results from the final experiment. The T-test used for these results is a two one-tailed T-test, because the goal of the information is to check whether an interactive artwork can increase interest compared to a similar motionless image, therefore we are looking for a positive difference in results. The one tailed T-tests are paired since we use two samples from the same group and compare them.

The first T-test made, was for the Likert scaled statement “I was entertained by the product”, here, a comparison between the motionless and interactive artworks is made. The t value of the results from this statement is 7, and when looking at the t table, also featured in the appendix, the closest value with 36 participants and the degrees of freedom being 70, hence they answer for both prototypes questionnaires (APPENDIX T-table), is t= 0.0005, we can see in the figure below the t table used with this number. The section called one tail is selected because this is our focus, and since the cumulative probability we have chosen is 0.05, which is 5%, the specific vertical part is selected. This means that if the t value is higher than the t values from 0.05, the null hypothesis can be rejected and the alternative hypothesis will be accepted.

**t Table**

| cum. prob | $t_{.50}$ | $t_{.75}$ | $t_{.80}$ | $t_{.85}$ | $t_{.90}$ | $t_{.95}$ | $t_{.975}$ | $t_{.99}$ | $t_{.995}$ | $t_{.999}$ | $t_{.9995}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| one-tail | 0.50 | 0.25 | 0.20 | 0.15 | 0.10 | 0.05 | 0.025 | 0.01 | 0.005 | 0.001 | 0.0005 |
| two-tails | 1.00 | 0.50 | 0.40 | 0.30 | 0.20 | 0.10 | 0.05 | 0.02 | 0.01 | 0.002 | 0.001 |
| df | | | | | | | | | | | |
| | ... | | | | | | | | | | |
| 60 | 0.000 | 0.679 | 0.848 | 1.045 | 1.296 | 1.671 | 2.000 | 2.390 | 2.660 | 3.232 | 3.460 |
| 80 | 0.000 | 0.678 | 0.846 | 1.043 | 1.292 | 1.664 | 1.990 | 2.374 | 2.639 | 3.195 | 3.416 |

**Figure 77 – Sections of a t-table**

The second T-test was for the statement “I found the product interesting”. The t value is 6.3, which also ends up having the same outcome as the one mentioned before. Therefore, it is possible and considered valid to reject the null hypothesis and claim that “An interactive painting is more interesting than a static painting”.

## 7.5 Sub-Conclusion

The objective of our testing is mainly to confirm the Final Problem Statement. There are different objectives for the final experiment and for the pilot experiment. The pilot experiment was done mainly to practice for the final experiment so that we knew what to do when we did it. It also indicated what final changes we could make to the prototype in order to have the best product possible. The pilot test showed us that we needed to make the visuals more aesthetically pleasing since the pilot experiment participants found it disturbing. We also learned that the observer shouldn’t be used which is why we chose to record instead of observe with a person. This was for the better since none of the experiment participants mentioned the recorder to be creepy.

The within-subject experiment makes it possible to compare the results of the answered questionnaires, where the participants were exposed to both of the rooms. The participants where then asked to answer a questionnaire after each prototype. This makes it possible to compare the results of the participants that went in to the room with the static painting first, with the participants that were exposed to the interactive prototype room as their initial room. As well as to see if, any noticeable answers existed. Depending on which initial room the participants were exposed to.

The within-subject experiment worked out fine and the within-subject experiment, made it possible to compare the results from the two questionnaires. Therefore, it was possible to get a clear result if one prototype was liked more compared to the other prototype or if there is any difference at all. Thus giving the framework the ability to prove or disprove the Final Problem Statement.

# 8. Discussion

In this section the execution and results of the final experiment will be discussed in relation to the FPS, in order to estimate if the FPS can be declared solved. This will be achieved by evaluating of the way the experiment was performed and thereby the validity of the collected data.

## 8.1 Experiment issues

First off, before taking a look at the results, the execution of the final experiment will be evaluated, so as to ensure that the results to some degree are in fact valid.

## 8.2 Participants

There were certain factors, regarding the final experiment subjects, that could have affected our results:

The vast majority of participants were students of the same education (Medialogy). When participants have the background and same technical knowledge as us and therefore the participants might have higher expectations of the prototype than other students that might not have the same knowledge.

When working with art, there are many aspects that are not taken into account. The gender of our participants is one of these aspects. In our experiment we did not have both genders equally represented. We do not know how this influence the results, but ideally we could have represented the gender equally.

It would have been ideal for us to have conducted sampling including all ages from 18-40 and with different professions so that our participants represent a large section of the population. Instead of this we conducted accidental/convenient sampling, only gathering participants from a very preliminary area.

The majority of the participants knew us prior to the experiment. This could cause bias in the sense that the participants answers, might be sugarcoated because they did not want to be too harsh.

With the combination of the points above, we can hardly argue for the entire ideal target group having been represented. This could be deducted from obvious reasons, such as: There are many other individuals interested in art and/or technology than Medialogy students, we cannot assume the majority of these people are male or within the overall age range of 20 to 24 years, and the majority of people were bias, as they were our fellow students. This decreases the validity of our results.

## 8.3 Experiment

The conduction of the experiment contained several issues:

The introduction can be found in the appendix, and the first two participants did not get this precise introduction. At the time of the experiment with the two first participants, the introduction was not finalized so they did not get the exact introduction as the one in the appendix.

A way of avoiding this problem would be to have two additional people participate in the experiment, and have avoided using their responses.

In the final prototype there were still issues with a delay from the sound input being analyzed which then altered the objects on screen. When the participants made a sound it took a few seconds for it to register, and make changes accordingly. This could have caused some participants to be confused as to how they are manipulating the interactive artwork.

The noted time for each individual participant might be flawed, due to inconsistent precision in regards to starting and stopping the stopwatches. Ideally it would be possible to have a timer that begins as soon as the first sound is said and recorded by the microphone.

Some of the participants might not have understood the introduction, as they may have missed a point when introduced to the prototype. This lead to some of the participants being confused towards what the objective of the experiment was. Some of them did however not understand that they could leave the room whenever they wanted, which might have led to them using a larger amount of time in the room than the average, resulting in biased results.

The time of the day, being around lunchtime, might have led to certain participants rushing through the experiment survey to go eat. Ideally the testing phase would be outside the lunch time. This was however not possible, due to time limitation.

These flaws and shortcomings most likely colored the answers of the participants to some degree, leading to further decreasing the validity of our results.

## 8.4 Interpretation

Some of the data could have been incorrectly interpreted by us, in terms of comments and quotes gathered from certain aspects of the final experiment.

Firstly, the data gathered from audio recorded participants at the final experiment.

Since we chose to use a dictaphone instead of having an observer in the room we have not gotten any visual feedback from the experiment. This means that we are only able to discuss the interaction that the participants had with prototype that included sound.

Secondly, the answers provided for the open (text field) questions of the questionnaire. When reading the response from the participants, the feedback was very straightforward, but some of it could have been misinterpreted.

With certain collections of data having been created based on our interpretation of comments and sound recordings, the data could be flawed, as this data proceeding for collecting data is subjective.

## 8.5 Has the research been sufficient?

Overall, the research was sufficient in that, it was possible to create a prototype to experiment the final problem statement, however, what is really important to discuss is, whether this research has been sufficient when talking about an ideal result. It is believed that, it would have been a better approach to have more information regarding sound and the sound features that can be implemented in a technical way. These features should have in depth description and examples of how these can be implemented in order for these to be recognized by the program used. We have noticed that the information regarding the sound features was useful and it was necessary to create the ideal design, however when we reached the implementation chapter, it was not possible to implement the features researched into, even though this would have meant creating a better prototype.

Another research that has been made was regarding the grid design; this was a good point to have when creating a product which required the user to pay attention to certain places. We could have used this research and information wiser, by putting the most animated and easiest influenced object in the user's visual focus and make the animations follow the Fibonacci spiral focus, therefore not letting the users lose sight of the objects they are moving on the screen. In general, the research gathered should have been better written in the requirements used in the Design.

## 8.6 Evaluation of the Final Problem Statement

The final problem statement that this project sought to solve was:

*How can a user intuitively interact via sound with a 2D dynamic artwork if they are controlling it and how will this influence their interest compared to equivalent static art?*

We expected our results to have a somewhat more interested and entertained value than what we ended up getting. The results that we got suggest that the experiment participants did not agree with the statements saying that the interactive prototype is entertaining or interesting.

From our results we can see that the interactive prototype is more interesting than the static prototype, but without comparison the interactive was not interesting.

# 9. Conclusion

From the initial problem statement it was possible to go further in depth with research on art and sound, in order to reach a final problem statement. In the pre-analysis we learned that there are some already existing products which combine visuals with audio. These played an important role when looking for inspiration on how to reach a narrowed down research. Art was also defined and research in sound art and art installations helped build towards the final problem statement. After the pre-analysis had been done, the analysis included further research on subjects such as, art terminology, golden ratio and sound theory with sound features. From the analysis it can be concluded what interaction is, and how it works in regards to art and sound. In the analysis, the available programs were presented and the ones that were used when creating the product were further explained. The requirements from the analysis worked as guidelines for the design of the prototype. Everything described in design contained an ideal prototype that would be implemented; this design would have been implemented if more resources, time and experience would have been available. The design also gives a good idea of how to implement knowledge gained from the analysis in both the hardware and software parts of the prototype. Before the implementation was started, a delimitation section was required since, due to experience and resources, it was not possible to implement the ideal design described in the chapter. Therefore, the delimitation section was where our final product was described and it made clear which aspects of the design were possible to implement, which means it was chosen which features to implement and to use. After this was finished, the implementation chapter became the focus, where the features described were implemented. From the implementation, it became clear how some features have been used to create the product, in regards to both the code in Java, Max 6 and the drawings. The first implementation of the product was a simple representation of the design, where we drew the lines through code in Java. After doing a usability experiment it became clear that the experiment participants were unable to interact with the artwork and one of the reasons for this was that the artwork was not aesthetically pleasing enough, so the participants could not overcome the 'ugliness' of the artwork. Therefore during this, a lot of small changes were done and the experiment phase was performed. During the experimenting phase, a lot of feedback was gained from the participants. Using this feedback we improved our product from the pilot experiment to the final experiment. Statistics had been done on the results from the final experiment, using the theory that is presented in the experiment chapter.

Even though there were various issues with the final experiment, the results generally indicated that the augmentation of motionless art in fact did increase the given artwork's value of interest in the eyes of the users. As the majority of users were confused by the concept, and what it aimed to accomplish, the product should have its interactive functionality developed further so as to accommodate the users' expectations and be more intuitive overall. However, as the interactive artwork did in fact get better results than the motionless artwork, it could be argued that with further development it would be possible to successfully create a piece of art that would appeal to a larger audience than that of a typical painting.

In conclusion we deem the final problem statement somewhat a success, due to the results showing a positive increase in interest in regards to comparison of the interactive- and static artwork. However, these results were only vague.

*"How can a user intuitively interact via sound with a 2D dynamic artwork if they are controlling it and how will this influence their interest compared to equivalent static art?"*

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