THE PERSONALIZED AUDIO TOUR

The personalized audio tour based on gaze detection and micro narratives.

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Abstract

In the last two decades the use of technology within museums has increased, the use of audio tours and communication through screens is common in almost every large institute. But what more does the future hold for technology inside of museums? Sensors that can detect gaze patterns or other signs of engagement are getting smaller and easier to use, these sensors can enhance and personalize the museum experience. In this research gaze detection will be used to personalize an audio tour based on the areas of interest of the user. User tests will be done to test whether the set of micronarratives of each user differs, indicating that the information that is given to the visitors is personalized. Finally, the system will be improved based on the findings that are made in the user test.

Acknowledgements

I would like to thank all of the people that helped me. My supervisors Nienke Bierhuizen and Mannes Poel for guiding me throughout the process. I also would like to thank my colleagues Marissa Mul and Simone Luiten for their enthusiasm and inspirational insights. We all started with the same research question: “how can we improve the museum experience” and it was so nice to see how the three of us all found different approaches to tackle this problem. I also want to thank Maurice Markslag who was the client of this project, he gave us the complete freedom to develop “The future museum experience” and he always motivated us to realize it.

I finally want to thank all of the friends, family and acquaintances that helped me during the user testing phase. In the last 5 weeks of this project everything came together beautifully, and by using my own art during the user tests I think that I not only developed as a student but also as an artist. Because of this project I found new meanings within my own artworks and the project also made me think about the story that I want to tell with them. I stepped out of my comfort zone and exhibited the artworks that I was most proud of. I am happy that I got the chance work on a project that connects so well to my passions and goals.

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1 Introduction

Museums are institutes with the difficult role of balancing between educating the public and making exhibitions that are fun and suitable for a large target group. In the last decades, the goal of museums was to cater to people that are intrinsically motivated to understand art. This has shifted to a place where the general public can come and learn about art in an entertaining way. One of the incentives for museums to expand their target group is due to the reduction in museum budgets, and the need to expand the number of visitors to compensate this with revenue (Chan, 2009). The research of Cerquetti (2016) suggests that despite changes in society that began in the 21st century, museum visitors are still upper education, upper occupation and upper income groups. This raises the question if museums still need to evolve their ways of communicating to address a broader public, and if a personalized experience is needed to cater to the variety of museum visitors.

VidiNexus is the client of this project, the company develops interactive touchscreens for museums and other events. Their EXPO Matic screen has different functions that can be used in a museum context, the screen is depicted in figure 1. The screen is able to fulfil basic information tasks, but also has the ability to show the social media pages of the museum. The screen can serve as an interactive floor plan of the museum, that gives visitors direction. There are also numerous possibilities to use this screen for different other purposes. The screen has a small processor inside that make it possible to perform small computing tasks. The screen is also able to read Near-field communication (NFC) chips and can be fitted with a camera if the client wishes to use it in this way.

Figure 1: Vidinexus EXPOmatic

There are different ways to create a personalized museum experience, for example the article of Francisco (2015) describes how a personalized database was created to increase the awareness of art history and themes amongst the visitors of the Rijksmuseum. Visitor information was gathered by letting museum visitors fill in their preferences with the use of a star-ranking system. The system gave recommendations about routes and artworks that came close to the interest of the visitor based on these rankings. This method for personalization takes some time and effort from the museum visitor and can be improved with the use of brain computer interfaces (BCI). One of the objectives of this research is to find out how brain computer interfaces can play a role in the personalization of a museum visit.

The use of the personalization that is mentioned in the research of Bohnert, (2015) could make the museum experience more accessible to a broader audience, which could lead to an increase of visitors. The acquirement of sensory data from museum visitors can work in a beneficial way for both the museum and the visitor. The article of Shettel (2001) states that since the 60's user studies have enhanced the effectiveness of exhibitions to convey stories. The gaze sensors that will be used during this study have the ability to enhance productivity and generate large databases of information that could be used for research.

The goal of this project is to use BCI inside of the museum environment to improve the experience of the visitor. Research that tries to combine these elements like the one of Walker et al.,(2017) or Cruz-Garza et al., (2017) are mainly focused on statistically analysing the information that can be captured with the use of BCI sensors. The research Walker et al.,(2017) and Cruz-Garza et al., (2017) try to see if the given technologies can function within a museum and not if the experience of museum visitors can be improved. Research within this field is relevant because can give insight into the interaction's museum visitor have with artworks.

The main research question that is proposed is very general and will probably be narrowed down when specific sensors can be chosen based on their ability to perform in the right context. The following research question will act as a guiding line for the exploratory research of the literature review and state of the art.

RQ: how can the museum experience of a visitor be enhanced?

To answer this main research question three sub-research questions are made. The sub questions can be seen as steps that will guide the exploratory research.

- What are the aspects that make up the museum experience?
- What is the most effective way to convey personalized information to museum visitors?
- What kind of museum can benefit the most from a personalized experience?

After the background research and literature review a product will be made with the use of Gaze detection, and personalized micro narratives. This product will be evaluated in chapter 7, to test whether the content of the personalized information differentiates between test subjects. Finally, a different set of research questions will be used in the second part of the research. The main research question: how the museum experience of a visitor can be enhanced is too broad to use for user testing but was very useful for an exploratory background research. The sub-conclusion after the background research will state the final set of research questions and will explain the reasoning behind them.

2 Background

Within the background research multiple tools will be used to find answers to the questions that are proposed in the first chapter. This will be done with the use of different methods, a literature review, interviews with experts and a state of the art. The literature review will focus on how the museum experience can be improved, with or without the use of sensors. In this initial research the focus will lay on how the experience enhancements work in the context of different museums. In this research no exclusions are made based on target group of museums. To find out how a museum experience is put together a section of the literature review will focus on this topic. The background research will also consist of Interviews with experts to validate the findings of the literature review and to see if they are in line with their personal experiences. The interviews also serve the purpose of getting a more detailed picture of how exhibitions are put together, and what type of practicalities should be taken into consideration when developing such a museum information system. The interviews will be held with experts in the field of art and technology. The background research will consist of a state of the art, the goal is to find out what research already has been done on the subject of using sensors in museums. In this part there is no requirement to only look for papers that try to enhance the museum experience with the use of sensors. It does focus on what type of sensing equipment is available in a real-world context.

2.1 The museum experience

To find out what curatorial practice entails, it can be useful to look back and see which developments were critical and formed this field of practice to what it is today. To get a better understanding, multiple articles are compared and summarized to get acquainted with how art can form curational practice. A case study from Miles (2007) of a Natural historical museum in England is used as an example on how formative evaluation has shaped its exhibitions from 1981 onwards. The article described how the museum changed its concept from being a private owned collection to being property of the state. To make this change it was necessary to go from a curatorial/collections focus to a visiting public focus. Qualitative research can shape exhibitions to be more engaging for visitors, this statement is made by Miles(2007) and Shettel (2001). Shettel (2001) argues that it is often not known if an exhibition is misunderstood or not. The paper gives an example of adolescents that are enthusiastically turning a wheel to make bubbles in a whale feeding display. What became clear during the study was that none of the adolescents could relate this interactive object to the story that was about the cooperative feeding behaviour of whales. This example shows that not only engagement or time spent at one object shows if people can relate to the story. The article of (Shettel, 2001) and (Miles, 2007) both state that through extensive user studies these kinds of experiences can be reshaped to eventually improve the museum experience.

Exhibitions are not only formed by stories that connect artworks, but artists also have a say in how their work is positioned inside the museum. This enables the creation of new types of exhibitions that feature new mediums and other ways of storytelling. According to Papadaki (2019) it is argued that during the 1960's exhibition discourse moved away from the analysis of works of art as autonomous objects. This followed with the start of focussing on contextual characteristics and the space of an exhibition. It opened the way for curators to experiment, but also made it necessary to be aware of the medium in which the artist works as much as the work itself. This new way of curating is difficult, especially with the introduction of new art that employs technology as part of their creation and/or final exhibit output. Examples of this are VR installations, Interactive art, virtual art and new media art (Papadaki, 2019).

To conclude it can be said that there are many stakeholders that are involved in shaping exhibitions, and the most important stakeholders should be taken into account during the design phase of the product. The final system should be able to help curators communicate stories about art, and the system should also be able to adapt to different types, shapes and mediums that are used to create the artworks of the future.

Information alongside artworks.

The first step in designing an information system to enhance the experience of museum visitors, is knowing what type of information can have impact on their visit. One of the discoveries was that providing narrative enhancements during the museum visit can have beneficial effects on engagement (Dasu et al., 2021) (Allen, 2004). The book of (Allen, 2004) described the effect of nature connections, it be described as the ability of visitors to relate the content of the artwork to emotions and feelings of their own life. The book of Allen (2004) describes that narrative enhancements reduced the ability for visitors to experiment with their own thoughts. The article of Dasu et al., (2021) supports this claim and suggests to implement free choice learning to increase the ability of museum visitors to explore the information that is available.

Narrative enhancements are one way to improve the museum experience. It is also possible to change the environment in which art is being displayed. The article of Baños et al., (2004) concluded that the environment in which the art is shown has impact on how the visitor perceives the artwork. This research was performed by making a 'neutral' and 'emotional' environment in which test subjects experienced different artworks. The neutral environment was created by using a park, a space that was found very common for most of the participants. The emotional environment was created to specific conditions with the use of sad music and colours. The paper of Baños et al., (2004) concluded that the emotional environment was more engaging, natural and believable compared to the neutral environment. To conclude it can be said that a narrated story about the exhibit can have a beneficial impact on museum visitors. The article of Allen (2004) discovered that using video to illustrate the importance and social meaning of the artwork engaged visitors.

What type of art benefits the most from information?

From the last paragraph we have learned what type of information can lead to a higher engagement of museum visitors. Different articles are used to point out what kind of art can benefit from an information system, and what are pitfalls for designing such a system. One of the most concrete answers came from the article of Yanulevskaya et al (2012), which performed a statistical analysis on how abstract paintings can be selected to see if they evoke positive or negative emotions. The emotions of the test subjects were captured using a Likert scale of 1-7 and classification machinery is used to determine which part of the paintings evokes what emotions. The paper concluded that the emotional reaction on paintings primarily depends on the tone of the colours. Bright colours evoke positive emotions and dark colours negative emotions. It also suggests that emotions that museum visitors experience in front of abstract paintings are often pre-determined (Yanulevskaya et al., 2012). This may imply that capturing these emotions through sensors will yield little data that can be used to redefine the information that is shown.

Although the use of abstract art in the remainder of this project could come with difficulties. The book of Allen (2004) suggests that exhibitions that include artworks which are closely related to human concerns in terms of content are likely to benefit from information systems. Another research that is done on how information systems can benefit the experience of museum visitors was done by Grech et al (2020). The research consisted out of a case study at Saint Paul's catacombs in Malta, where 3d visualisations in virtual reality were used to enhance the experience of the visitors. The research concluded that with the use 3d models the visitors gained a better understanding of how the place looked originally. This system makes it possible to remove barriers between the story and what can be seen by the public. To conclude, the use of 3d models or other visual enhancements of can help visitors to engage with art.

Artworks that will benefit from such an information system are works that are close to human concerns in terms of their content. Also, historical objects that suffer from extensive degradation can benefit from additional visual information that help with conveying the story.

How can information be communicated to visitors?

This paragraph will focus on how information can be displayed with the means of digital technology. The article of Baños et al (2004) states that the most effective way of communicating with the environment is by using a big screen. This research also experimented with the use of VR technology, although this provided a more immersive experience, museum visitors felt negative effects like nausea. The article also stated that the use of VR systems in this way was not practical to use in a museum environment. There are two articles that both did research on how to incorporate narrative enhancements into the exhibition space. The article of Dasu et al (2021) suggests that the most effective way of conveying information is to use free choice learning. In the context of the museum this means that visitors make a decision about what information they want to acquire for a specific art piece for example. The book of Allen (2004) had a more fundamental approach to see what type of information lets museum visitors engage with artworks. The book concluded that visitors that watched narratives are more likely than baseline visitors to say that the exhibition was engaging. There is also enough evidence to say that visitors that got narrative enhancements through text where more engaged in terms of imagination. Incorporating narrative in the form of videos or other media can be beneficial for the engagement museum visitors experience.

2.2 Sensors and the museum

Chapter 2.1 described what museum visitors find interesting when coming to the museum. The main finding was that the museum experience can be enhanced by giving the visitors information about artworks that relate to their individual concerns. This information can be given in different ways but the most promising is micro narratives and the concept of free-choice learning. The purpose of chapter 2.2 is to learn from research that has been done about the use of sensors within a museum context. Although it is preferable that the research also describes how sensing can enhance the museum experience it is not a necessity. This section will focus on research that uses brain computer interfaces to measure the experience that museum visitors have. The goal of this chapter is to find out what information can be sensed during a museum visit, and how this information can be translated into data that can be used to enhance the museum experience.

2.2.1 MuMIA

The first article that was found was the article of (Raptis et al., 2021). In this article a multimodal system was created to improve the accessibility and to attract a wider audience for cultural heritage museums. The goal of the application is to identify areas of interest of museum visitors. The application communicates learned interests back to visitors. The MuMIA system tries to be fully immersive, and visitors do not notice the data collection of the system. Only when the user makes voice commands to ask the system for more information about artworks it will interact.

The Mumia system tries to acquire personalized information with the use of Gaze detection and location monitoring. With this data the system can point out areas of interests (AOI) of visitors, and these AOI's form the basis of the information that is provided during the visit. In the research of (Raptis et al., 2021) the Eye tribe tracker is used to see where the visitor is looking at, and when a pattern of interest is detected this AOI is stored in a repository. The eye tribe tracker that is used in this research is very similar to the Tobii eye trackers that is available in the BCI lab at the University of Twente. Both of the sensors can be mounted next to a screen to see what the user is looking at on the screen. This is the most basic type of Gaze detection, but this leads to one of the biggest limitations of this research. It is hard to implement this exact system in a real museum where visitors rather look a real artwork than looking at pictures of artworks on a screen. This type of gaze detection can be seen as the first generation but is also the most reliable since it has been used for studies for a long time. The article also looked at the use of gaze detection in the form of wearable glasses but determined that it was too hard to use in a real museum setting because of the extensive calibration that is necessary.

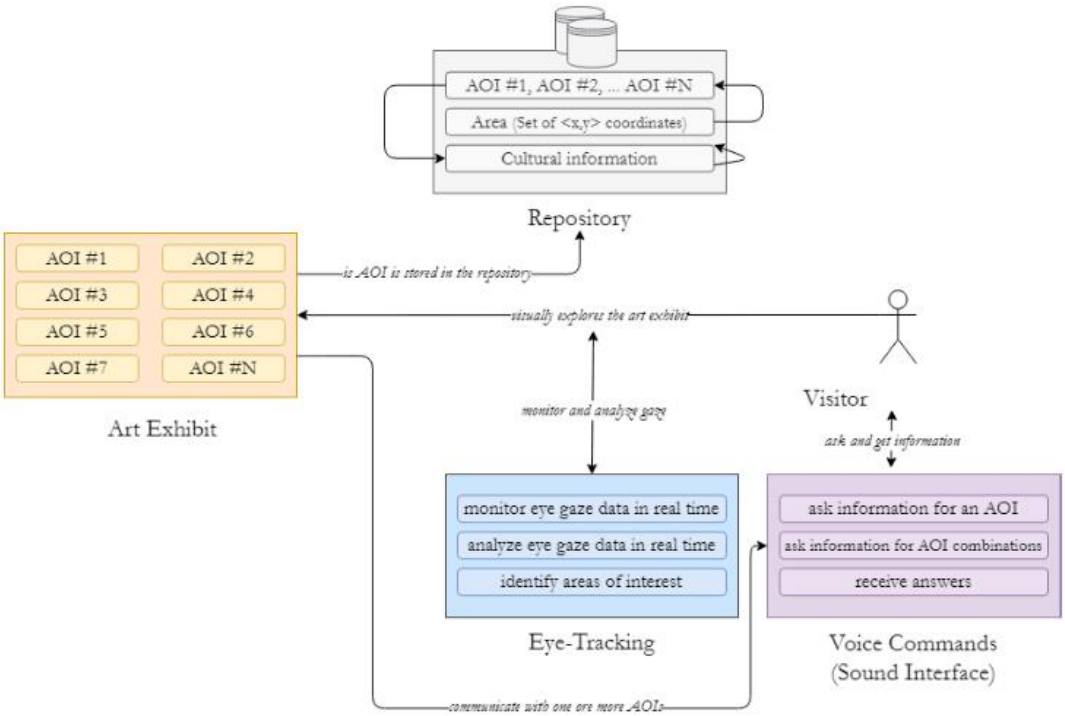

Figure 2: architecture of the MuMIA system (Raptis et al., 2021)

User interface

The way the MuMIA system interacts with the user is with the use of a sound interface. This interface is activated when the user asks a question verbally. This system has been chosen to minimize the amount of effort the user has to do to interact, which leads to a more immersive experience.

Finally, the sound interface of MuMIA is able to give micro narratives based on the interests of the user for specific artworks. As has been mentioned in the literature review, narrative enhancements can improve the visitor's engagement and overall experience. The article of Raptis et al., (2021) added that the use of micro narratives in this form is able to improve cognitive and learning response when exploring art. It states that participants of the study could build connections between interesting parts of exhibitions in a concrete and easy-to-follow way. As stated in the introduction of this study, such a system could greatly benefit people that do not have the ability to make these connections themselves.

When developing the micro-narratives, it is important to keep in mind that the content does not have a specific order. The use of micro-narratives could work in conjunction with the normal audio tour, this would make it possible to have different systems inside of the museum. To summarize, the use of micro narratives can enhance the museum experience and is able to help people make connections between different exhibitions in an easy-to-follow way.

2.2.2 BLE beacons IOT based smart museum

In the research of (Spachos & Plataniotis, 2020) localization technology is tested to see how well it can function inside of a museum context. The technology that is tested are Bluetooth Low energy (BLE) beacons. These beacons can measure proximity towards other beacons. This means that the system in general cannot determine the exact location of visitors, but rather measures distance between an object and the visitor. The information that the BLE beacon gives can be used to make trigger zones, when a visitor steps in one of these zones the system knows that the visitor is paying attention to the given artwork. This information is collected and the time each visitor spends at an art piece is measured.

The article states that the time each visitor spends at a given artwork is used to provide the museum visitor with recommendations for a future visit. The use of BLE beacons within a real museum context has been tested and the following limitation of the system were discovered. First the BLE beacons need an accurate path loss model to perform well, this means that every time that the exhibition changes engineers need to recalibrate the system. The article also mentions that if the number of BLE beacons in an exhibition room increases the detection estimation accuracy decreases. This implies that exhibitions with a lot of different objects are not able to use such a system in an effective way. The article does suggest that future research also need to focus on Wi-Fi beacons, because this technology could minimize errors. This article did conclude that BLE beacons can improve the interaction within a museum at a low cost. This can be done without interferences with other wireless connections that are normally present inside a museum.

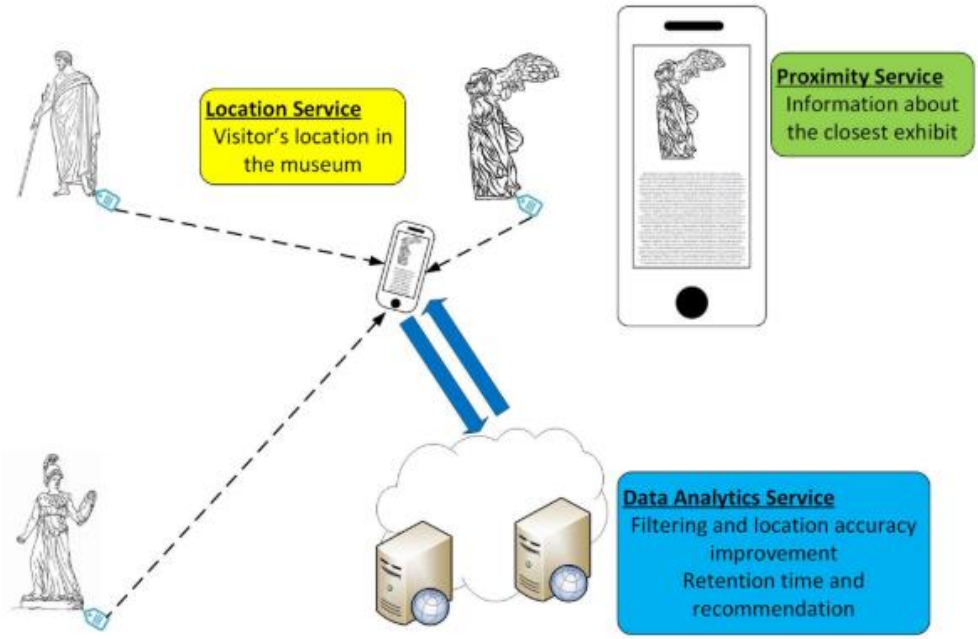

Figure 3: schematic overview of the BLE system (Spachos & Plataniotis, 2020)

User interface

The user of this system needs to interact with his mobile phone to see information that is provided. The system uses the proximity of the user with regards to museum pieces to give the user information about the exhibition that is in front of him. This information is not personalized yet when walking through the museum, but when the user leaves a recommendation will be made for the next visit. This recommendation includes pieces of art that could be of interest or could also simply be exhibition rooms that have not been looked at by the user. To conclude it is not probable that BLE beacons alone will serve as a sensor to measure the personal likings of museum visitors, but it can work hand in hand with other sensors because of its portability and low cost. The user of this system needs a mobile phone to interact with the system and read the information that is given.

Table 1: positives-negatives BLE

Benefits	**Negatives**
Cheap and small detection of location with the use of BLE beacons.	Extensive path loss models need to be made to reduce errors within the system.
The interaction within the museum can be improved with this technology.	
The beacon has a low energy consumption and can therefore be used for extensive periods.	

2.2.3 Automatic speech recognition

The article of Li et al., (2021) did research on how the museum experience could be improved with the use of location sensing and artificial intelligence. One of the goals is to make a system that does not distract from looking at art, and therefore vocal communication was chosen as one of the interfaces for the system. The system personalizes information based on the location of the user. It has a lot of resemblance with the MuMIA application with the main difference being the way user preferences are sensed. This system has the ability to learn from locational information and is actively encouraging visitors to ask questions based on what they are looking at. The system uses chatbots that can conversate with the museum visitor. In figure 4 a system overview is given; in this overview you can see the way the location of the visitor is tracked via Ultra-Wideband (UWB) radio technology tags. The tags are given to each of the museum visitors at the entrance and during this time the visitors are also asked to download the corresponding mobile application. The UWB tag should be paired with this specific application and stay connected in a reliable way during the visit. UWB tags have the advantage over BLE tags that they do not have interference when multiple tags are next to each other. This makes this type of sensor more reliable in a museum setting.

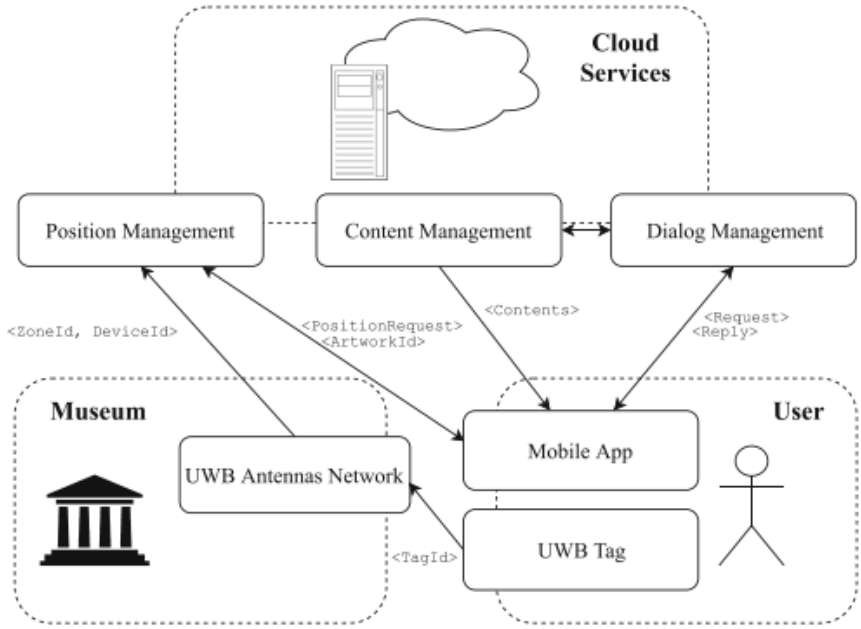

Figure 4: System layout of A vocal museum

User Interface

The research described that not only a vocal interface was used, because of possible unwillingness of museum visitors to interact in this way. The solution that was proposed is to let the system also work with text input, while using the same system for interaction only in chat form. The text input will be done on the phone of the visitor, this type of interaction breaks the immersive feeling of the system, but it will increase the number of users that are willing to use it. The article does state that vocal interaction with the system was identified as the most natural and user-friendly interface. It is therefore something that should be taken into consideration in the ideation phase of this project. The research has been performed only with IT experts, it therefore hard to decide if this system would also work in a real museum context. Possible limitations for the use of this systems are the target group of elderly people who are not capable of working with mobile phones. One of the limitations of automatic speech recognition (ASR) is that it can struggle with noisy environments, and with specific accents of users. This is not preferable when trying to create a system that should enhance the accessibility of a museum. To conclude the following benefits and negatives of using UWB technology and ASR:

Table 2: positives negatives ASR

Negatives	**Positives**
Automatic speech recognition (ASR) can endure a negative impact through noisy backgrounds, users age and accent.	The system can proactively encourage users to ask questions about specific artworks through the location tracking with UWB.
It is not sure whether UWB radio technology is compatible with other wireless systems that are sometimes placed within museums.	
This article only tested the system with IT experts in a testing environment, making it hard	

to gauge how general public would perceive such an application.

2.2.4 The use of EEG inside museum context

In the research of (Cruz-Garza et al., 2017) an extensive overview is given about the use of mobile Electroencephalography (EEG) within a museum environment. Focussing on the difference between gel-based and dry electrode systems. Also, an array of different EEG devices was used to test the effectiveness and ease of use. The test subjects needed to stare at a white wall for one minute as baseline test, and in total 432 people were tested during this study. The subjects had complete freedom to look at whatever art piece they wanted. This approach is very different to that of a laboratory setting, and experiments with the use of EEG sensors inside real museum settings is not common. The biggest tasks of the researchers were creating protocols that could lead to high quality recordings of brain responses. That are also capable of capturing other physiological and environmental signals associated with human experiences and behaviours in natural complex settings. Some of the biggest signal contaminations comes from non-physiological and physiological sources, these interferences include power-line interference, electrode pops, ocular motions like eye blinking and fixations, muscle activation and cardiac activities. One of the protocols that was taken in use during the research was the use of Bluetooth location technology, but this was not effective enough for good data segmentation. Another method that was used instead was RFID trackers that test subjects needed to scan when they started to look at a painting. This also gave the users the ability to interact with the system whenever they wanted to. The different mobile EEG devices that are used are depicted in figure 4. The M4S system is very similar to the Muse EEG sensor that is available in the BCI lab on the University of Twente. The BCI lab also has a sensor that is very similar to the BPD sensor that is depicted in Figure 5. During the test Dry electrodes are used, these pads are also available for the Emotive sensor and comes standard on Muse systems.

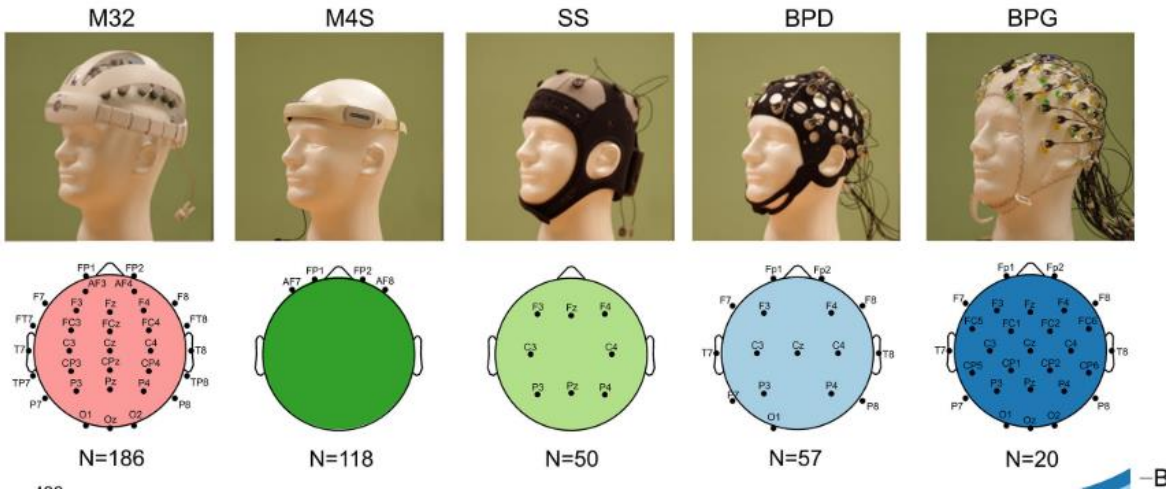

Figure 5: mobile EEG devices

The M4S system that is also depicted in figure 5 suffered from the issue of electrodes that snapped loose when a minimal load was exerted upon the headset, this caused a bad signal in these cases. In general, users tried to adjust the cap during the experiments which caused the electrodes to pop. Five distinct non-physiological artifact types were observed during user testing which were electrode pops, poor electrode contact, digitization errors resulting from low signal amplitudes, data loss

during wireless transmission and no signal relative to the reference. These artifacts cannot simply be removed but to limit electrode pops for example a threshold of 300 µV was set to identify high amplitude bursts. Automated artifact rejection (ASR) was also used to clean the data stream. Finally, the M4S used a Bluetooth connection to stream the data to the user interface which was a tablet in this case. As mentioned before the Bluetooth connection sometimes led to data-loss, but in general was easy to use and setup.

The methods and protocols that were used during this research can be used as the baseline for user testing in the future, it can also be concluded that the M4S sensor was seen as the most practical because of the ease of putting on and off. The limitations of this research where that it did not focus on what the measured data means regarding the preferences of museum visitors.

2.2.5 What is easthetic appreciation?

The article of Leder et al., (2004) makes a psychological model for the aesthetic appreciation and aesthetic judgements of art. Within the article, Leder proposes that the aesthetic preferences are affected by familiarity. The research also found that familiarity through repetition increases the affective preference for a stimulus. This means that people that regularly see art will experience more joy because they can sense familiarity. It is also stated that these non-Naïve viewers can get a self-rewarding cognitive experience by being able to successfully classify the style of a painting.

The research focusses on the aesthetic experience of modern art, it is stated that modern art has the need for personal interpretation and when this is found can be experience as emotionally positive. The research makes a clear distinction between how art is experienced between experts and by more “naïve persons”. The research described people that do not have the knowledge base to recognize features of artworks as naïve persons. The research states that experts are challenged by a more cognitive reception while naïve persons are having a more direct emotional mode of reception.

It is also stated that an aesthetic experience is often pleasurable but can also result in displeasure. When for example certain concepts of an artwork are hard to understand, and no information about this specific concept is available. The displeasure that is caused by the lack of information can also cause an negative aesthetic judgement. Finally the research states that museum visitors often stop the information processing that can happen in front of an artwork due to a low level of interest. This causes them to stop looking before the development of possible displeasure. In a museum context this type of interaction is very common due to the sheer offering of paintings. To have a real aesthetic experience it requires sufficient time to allow the museum visitor to fully process the painting.

2.2.6 The embodied gaze

The article of Garbutt et al., (2020) did research on the use of gaze sensing technology inside of the MET museum. The research lead to the result that gaze does not transisiton smoothly across and image. This was an insight that was long supposed by artitsts and theorists. It was found that the eyes make a series of rapid movements that are described as seccades. The MET museum did the research with the purpose to acquire information about their collection that was more objective than data collected by human observers. The feasability of doing large scale research was reduced by a wide range of factors. For example the measuring equipment are very expensive and have an obtrusive and often-challegning calibration process. The research states that newer measuring equipment like the Tobii pro glasses 2 have overcome these technical concerns.

Within this research the Tobii pro lab software was used to analyze the gaze of subjects. This software was used to map fixations and saccades onto static digital images of paintings. The average viewing time of a painting was 32.73 seconds, what became apperant during this user study was that looking at art is often not focussing on one piece alone. The test subjects were looking around at other paintings that were also inside of the exhibition room. This means that a linear way is not possbile in a real world situation. One possibility that is suggested is to give museum visitors a protocol to observe a single paitning for one minute for example. The research also stated that the size of a painting really matters for the viewing time. So when comparing these values it is not possible to say that one painting was more engaging only because of this measure.

2.2.7 Eye movements patterns of children and adults in the Van Gogh museum.

The final research that will be included inside is the one that is written by Walker et al., (2017). The research was performed to see what the impact is of relevant background information effects the gaze patterns of museum visitors. The research was setup In the Van Gogh museum and made use of the eye tribe eye tracker. Special software was written for this experiment that enabled the glasses to analyse the gaze in real time. The conclusions of Walker et al., (2017) were in line with findings from other researches, which stated that expertise, culture, personality traits, and physical salience of featured can influence the eye movement patterns.

The research also concluded that the observers of the van Gogh paintings quickly extract the gist of the scene. But details of objects and true appreciation of the picture are only available when the visitors subsequently scans the painting. The research in the Van Gogh museum concluded that the average viewing time of a painting was 27.2 seconds.

During the tests of the system test subjects were asked to look at a selection of 6 van Gogh paintings. While wearing the gaze detection glasses. After the test was performed the subjects were interviewed by showing one of the paintings on a digital screen. The questions was asked: “what struck you about this painting”? a testing group of children and adults was used to test if there was a different in the way that they perceived the van Gogh artworks, and if this could be measure with the use of Gaze detection. The research finally concluded that adults rely much more on top down processing than children when viewing the paintings. Top down processing can be described as how methodical an artwork is viewed, and suggest that children sporadically choose where to look at.

2.3 interviews

In this section of the background research interviews are held with experts that have done work or have information about the experience within museums. Different types of museums have been approached to gain a broad understanding of how experiences are formed. The first interviews are mostly exploratory, this is why the topics that will be discussed during the interview are not set beforehand. This should help with finding information or opportunities that could not have been found when only doing literature research. The general theme of the research question should be: how can the museum experience be enhanced from your point of view?

2.3.1 Interview The museum Fabriek.

The first interview was held with the technical director of the Museum Fabriek, this is a ANBI institution with a collection that came mostly from donations of people throughout the province of Twente. The technical director told us that he was not only interested in beautiful art but was more interested in the historical information that is shown on the painting or object. He started the tour around the museum in a hall that he had curated, where almost all of the paintings were hung up on one side of the room. He positioned the paintings in a way that was visually appealing, but also in chronological order. He made the decision not to place any information directly next to the paintings, because this would interfere with the composition of the wall. Instead, he chose to have the information inside of a folder that guests could also take with them. The curator told us that he did not have complete freedom while designing this exhibition, because of the room it was in. This room was also rented out for large presentations and conferences, because of this flexibility he didn't have the ability to show all the works he wanted to. And therefore, stories that could have been told are now lost in storage. This is something that curators of the museum Fabriek has to deal with often because there just is not enough room to show everything, and hard choices have to be made about what is most important. The next thing that was mentioned was that the "importance" of a work is of course subjective and that not only the historical importance plays a role in selecting the items. During the design process of making an exhibition he was thinking about three target groups that all have different needs. First of all, the families with kids, that normally come to the museum on Wednesday afternoon and in the weekends. Secondly the elderly people that are retired which are spread out throughout the week. And finally, a small group of experts that come to the museum to find more information about artifacts that are displayed or are in storage. The curator mentioned that that he wasn't able to cater to all these groups, because the families are normally just looking for a fun experience in which they can all learn something new. Every time that there is too much text, or the meaning of the exhibition is somewhat hard to understand they lose interest and move on. While elderly people usually take the time to read everything if they find the object interesting enough. And finally, the experts who can handle and sometimes need a large amount of information about objects. The museum Fabriek also has voluntary researchers that study most of the pieces that are coming in, therefore there is no lack of information but there is just no appropriate way to include this information into the exhibitions. Therefore, the experts miss out and this is where one of the opportunities lays inside of natural history museums. A system that knows in which group you belong, and what your information needs are could solve a large part of this problem. And make the experience of the museum more enjoyable and easier for everyone since the amount and the kind of information has always been a trade-off.

2.3.2 Interview with Concordia

The second interview was held with Concordia, this is an institute that has a very diverse focus. On the one hand they have theatre that focusses on art films. And in their other building they show visual arts, this building is also split up into different segments. The curator mentioned that one of the exhibition rooms was created for art lovers while other rooms had the intention of giving an easy-to-understand experience. It was interesting to see how diverse the target group of Concordia was, and that they tried to cater to everyone by sub-dividing the museum. The museum Fabriek did not differentiate their exhibitions for different target groups. The curator also said that they try to approach the different target groups in different ways. More experienced museum visitors know 'how to look' this is something that the curator also wants to teach to less experienced visitors. The curator mentioned that there were different ways to teach how to look, for example having a video about the artists within the exhibition can give viewers some context about the methods that were used to create the artwork. But these videos can also give background about the meaning of the artwork. One of the most important things was that visitors should really invest their time in artworks, also when the picture doesn't strike you as beautiful when you first look at it. During this conversation it was mentioned that there was a philosopher at the University of Twente that has written a book about how to look at art. Finally, the curator talked about how they measured if an exhibition was successful or not. She stated that the museum only counted the number of visitors at any given day, but that there were no statistics on how long people looked at the different artworks of exhibitions. She said that it could be useful to have this information, but that there rarely is a need to change exhibitions. Something that Concordia does, is letting artists themselves have the ability to show the works in the way they want and help create the exhibition. Also, the exhibition rooms are open for public while the artist is working on this new exhibition, this is done with the goal to let the artist interact with the public and to hopefully come to new insights for both of these groups. As mentioned earlier the next interview will be held with a philosopher of the University of Twente that has written the book about looking at art. This final interview will hopefully give more insight on how to improve the experience of looking alone, and which emotions are connected to a museum visit. T

2.3.3 Interview philosopher University of Twente.

Mieke boon is a philosopher that works at the university of Twente, a couple years ago she started writing articles in Trouw about the philosophy of looking. One of her critical remarks about the art world is that there is a consensus that you have to be art historian or an expert to have an opinion or a feeling about artworks. Mieke states that museum visitors feel clumsy because of this prejudice, and therefore don't get the most out of their experience with the artwork in front of them. One of the social norms is also that upon seeing the artwork it should give direct emotion, otherwise it is not good. She said that social media has a big influence on the way people look at pictures. In our visual culture we are used to images that evoke direct emotions. In order to gain a good experience from artworks it is necessary to throw away the expectations of getting emotional, but instead the viewer really has to work to get connected with the artwork that is in front of him. This is also where technology could possibly help the visitor. When talking about how to look Mieke gave a lot of examples that were very similar to how people meditate. One of the tactics that she used incorporated questions that the spectator should ask himself. For example, when looking at a landscape portrait of an old master, the spectator can ask himself what type of weather it could have been on that day or what the season was at that time. These questions can help the visitor to relate to the artist and can give a deeper meaning to the works. After these questions Mieke suggests that the spectator should look at the materials the artist used to convey this feeling of spring for example. After these assignments the spectator has probably spend about 5 minutes in front of the artwork and has made their own assumptions about the meaning. Finally, it is possible to share your experience with fellow museum visitors. It is critical not directly communicate your own feelings about the art-piece upon arrival, since this can influence the experience of another in a negative way. These types of exercises can be personalized based on gaze detection, Or EEG could be used to measure if the spectator is really focussing on the painting and help with the meditative experience.

Mieke also said that linking experiences outside of the museum is important to find relation to the artworks. For example, it could be interesting to listen to jazz music before visiting a Piet Mondriaan Exhibition. One of the particular things about Piet Mondriaan was that he was inspired by jazz music to make his artworks. When these cross-connections between different fields of art can be made, the experience will also cater to a larger public because some people have just had more affinity with one or the other fields. One idea that was mentioned during the interview was that the screen of VidiNexus has NFC incorporated into the device. When a personalized experience is created during the museum visit, and the data of the most engaging art pieces is stored it is possible to make some kind of take-home message. For example, when my preference was to look at works of Piet Mondrian, the museum is able to give me background information about other things I could visit next, or music that I could listen to after my museum visit.

2.4 conclusion

To enhance the experience, the methods can be sub divided into three different things. First the kind of information that is shown to the visitor. The use of narrative in the form of video, and virtual environments engages museum visitors and can have beneficial effects. The second part that makes up the museum experience is how to position the information system in a museum environment. It is recommended to incorporate such an information system when the artwork is closely related to human concerns. In this last case a narrative enhancement could make the experience better for visitors. Also, historical sites or objects that are degraded over time can benefit from visual information about details that are not visible anymore. The third aspect of the system is conveying the information in a way that is most effective in a museum environment. As stated earlier free-choice learning can have a large impact on the engagement and interest the museum visitor feels. It is also recommended not to use virtual reality environments inside of exhibitions since it has proven to be not practical.

The second part of the background research concluded that there are a lot of sensors able to sense interest, engagement and looking behaviours of museum visitors. From the articles of section 2.2.5 – 2.2.7 it became clear what the capabilities are of gaze detection. The choice is made to move forward with gaze detection as primary sensor. But the possibility is always there to have a multimodal system that is able to combine two streams of data. The research question that is before the background research was: how can the museum experience of a visitor be enhanced? This question is answered in the background research by giving answered to the following sub questions:

1. What are the aspects that make up the museum experience?
2. What is the most effective way to convey personalized information to museum visitors?
3. What kind of museum can benefit the most from a personalized experience?

The answer to the first sub-question is very broad, but from the background research and the expert interviews it came forward that the information that the museum gives together with the right selection of art make up most of the museum experience. From the expert interviews it also became apparent that the time a visitor spends in front of the painting, and the mental effort that is done to understand a given art-piece have a big influence on how the experience is perceived. When the viewer is assisted in their needs in terms of information next to an artwork the experience of the visitor will be positive, but when this information lacks the right information to understand concepts of an artwork this can be demotivating.

For the second sub question several things came forward during the background research, but a trend was visible that audio is often used to convey information to museum visitors. During user tests of the Mumia system of section 2.2.1 and the automated speech recognition application of section 2.2.3 it came forward that the use of narrative enhancements in the form of audio and micro narratives can be useful to explain concepts of paintings.

The third sub-research question was hard to answer, but a common factor across all types of museums can be found. Every museum has the need to tell a story and this can be done in different forms like audio, text and video. From the background research it is not possible to conclude that one museum is more in need of personalized information than others. The main concept of personalization is well defined in section 2.3.1 in the interview with the curator of the museum Fabriek. In this interview it is described that every piece of art that is collected comes with a huge amount of information, and that the museum needs to cater to different user groups without having the ability to personalize the information for these different groups.

Finally the main research question of the background research can be answered: how can the museum experience inside of the museum be enhanced? The answer of this question does not directly relate to the sum of the three sub-research questions. It is hard to define a single way to improve upon the existing museum experience, because this experience varies a lot across different types of museums. The background research did conclude that personalization based on the likings of the museum visitor can improve the museum experience. The data with which this personalization happens differentiated between researches, but ultimately it always resulted in a system that is able to select certain artworks, or parts of artworks that are of interest of the user. Personalization could also solve the problem that was brought in by the curator of the Museum Fabriek, the goal is to let visitors of the museum guide themselves through a big amount of information. This should be done by letting the information that they get correspond to the objects or parts of the painting that they find interesting.

3 Ideation

During the ideation phase it is necessary to step away from the solutions that are provided in the state of the art, and come up with a set of requirements based on user studies. It is also necessary to experiment with the different types of information that can be given to the museum visitor. The following sub research question will be answered: **What is the most engaging way to use gaze detection to provide personalized content for the museum visitor?**

3.1 Design vision

In this first paragraph the design vision will be stated, the goal is to start the ideation phase with a clear vision that is based on the background research. In the following section the choices will be motivated based the information that was found.

3.1.1 Sensor choice

After extensive testing with the Tobii pro glasses 2 and the analysis software that is included, the choice has been made to focus on this sensor for the remainder of this project. During this exploratory phase the emotive EEG sensor was also tested, but the use of EEG devices inside of the museum context is very complex. The main reason for this is that during movement the contacts of the EEG sensors can disconnect, this could lead to interrupted data streams. It is also hard to determine when excitement levels are measured for one individual painting. The research of Garbutt et al., (2020) stated that looking at art in practice is not a linear activity, meaning that visitors often compare artworks that are next to each other. The choice is made to use Gaze detection as the primary input for data. The output should be personalized content that is activated by the gaze pattern of the museum visitor.

3.1.2The Tobii pro glasses 2

The tobii pro glasses 2 is a high end gaze detection sensor that is wearable. The glasses are depicted in figure 6, only the headset is displayed but to let it function a small battery pack should also be worn by the user. The glasses are available in the BMS lab, which makes it convenient to use this system. The Tobii glasses have a good python API that will help analyse and capture the gaze data, this will make the final design of the system easier. The Tobii glasses have a build in camara that can be used to identify the painting that the visitor is looking at.

Figure 6: Tobii pro glasses 2

The article of Li et al (2021) stated that the use of narrative enhancements in the form of audio is the most intuitive way to convey information inside of a museum context. One example that was given is that visitors could ask questions to their mobile phone and receive information through spoken micro narratives. The article of Li et al (2021) stated that the vocal system was identified as the most natural and user-friendly interface, this leads to believe that this is a good option for direct feedback

to the museum visitor. Another reason to work with an audio information system is because museum visitors are used to this kind of interaction. The Vidinexus screen will serve as the start screen of the complete experience, this is where the glasses of the visitors will be calibrated and instructions are given on how to use the system.

Finally the experience of the museum visitor will be enhanced by using gaze data to detect areas of interest (AOI's) of the museum visitor. There are different options to translate this data into personalized information. These options will be further explored in the ideation phase.

3.2 Stakeholder analysis

The project has a large amount of stakeholders who can be divided into different categories. The categories are explained in the following section. A list of all the stakeholders can be found in table 3 together with their influence and interest in the project.

Museum Visitors

The museum caters to a diverse target group that ranges between experts that come to the museums to study artworks to families that come to enjoy the experience of the museum. The system needs to be able to enhance the experience for both of these target groups. The type of information that is necessary to enhance the experience for the different groups may vary, and identifying the target group before the experience may be essential.

Museum Professionals

Museum professionals are the group of people that are responsible for running the museum. This group ranges from the receptionist to the museum director. Museum professionals can use the Vidinexus system to enhance the experience within the museum. The information that the system will provide to the visitor needs to be created by the museums themselves therefore staff also needs to able to manage and edit the system. Finally the use of the system needs to be managed by the museum, this entails the maintenance on the sensors and periodically checking if the system functions properly. In table 3 external parties that influence the museum are mentioned, these stakeholders are museum donors, public funding and artists that collaborate with the museum.

Researchers

The system that will be installed inside of museums will provide large quantities of data about the experience that museum visitors have. This data can be used to optimize exhibition layouts and look for new ways to make the museum experience more engaging.

Developer:

The information system will be developed primarily by the main researcher Leon Groothaar, assistance will be provided by the client Vidinexus. The assistance will primarily be given during the final phase of the project, when the system needs to be integrated into the product of the client. In the evaluation phase of the project Curators will be used as experts to give feedback about the system, and therefore will help with the development process.

Decision makers:

There are different decision makers during this project, first of all the client that initiated the project can be seen as the most important decision maker. The contact person of Vidinexus is Maruice Markslag, he will receive monthly status updates and within the company he is responsible for the interface and user-interaction of the VidiNexus screen. This Graduation project is also supervised by Mannes Poel and the critical observer is Nienke Bierhuizen. Their role within the project is to give feedback and support, Nienke Bierhuizen helps with the use of sensors that can be borrowed from the BMS lab at the University of Twente. Nienke has a lot of experience with the use of different sensors and can therefore be a decisionmaker when there is doubt about feasibility or implementation of sensors.

Table 3:interest and influence of stakeholders.

Stakeholder	**Category**	**interest**	**influence**
VidiNexus	Developer/decision maker	high	high
Leon Groothaar (developer)	Developer/decision maker	high	high
Mannes Poel (GP coordinator)	Decision maker	high	high
Nienke Bierhuizen (Critical observer)	Decision maker	high	high
Museum Donors	Decision maker	low	high
Public funding	Decision maker	low	high
Artists	User	medium	low
researchers	Decision maker	medium	medium
Curators	User/Developer /Decision maker	high	high
Museum marketing	Decision maker	medium	medium
Museum Visitors consisting of:			
Art experts	user	medium	low
Art enthusiasts	user	high	medium
Families	user	high	medium

3.3 User needs

To find out what the needs are of the different type of users of the system, personas are written that will describe the different interactions that will be made with the system. The complete personas can be found in Appendix 1, The three different personas are summarized inside of the point of view table. This table helps to identify the needs of each of the users, and gives some clarification about the role of the user. Personas were written for three user groups: experts, families and curators, the biggest

Table 4: Point of view table

User	**Need**	**insight**
Art experts	- New things to learn. - Experience new things every visit.	Experienced visitors have the need for interesting information every time they visit the museum. In a museum that is setup in a traditional way, the texts and information that is provided does not change often. The personalized system could help with the amount of information that is available to these visitors. But access to this information depends on the way visitors look, and new information is therefore not guaranteed.
Families	- An experience that works for the whole family - Information that is exciting for children. - a quick setup process	Families that come to the museum are there to have a nice day with each other. A system that gives personalized information based on your own data could make the experience more individual. The calibration of the glasses could also take a lot of effort for a whole family, this can be experienced as negative.
Curator of the museum	- System that is easy to use - System that enables the curator to reach specific target groups - A system that brings the visitor closer to the artist	Curators want to have a system that caters to a diverse group of people that go to the museum. Personalization is key to make the experience of a museum better and this is something that is liked about the system. A feature of the system that is less effective is that the amount of information the system requires to operate is rather large. Also the curators have minimal control over how the story is told, since the micro narratives react to the gaze data.

3.4 Brainstorm

3.4.1 Individual brainstorm

First an individual brainstorm will be done to generate ideas about the use of the gaze data. A star bursting brainstorming technique will be used for this session. The main goal of a star bursting session is to come up with questions about how the product should function. These questions will be answered in section 4.5 where the preliminary concept will be described. The star bursting method used for two sub-categories of the project, First questions will be formulated about the user experience and after that questions will be made for data collection.

User experience:

- Who
    - Who will be responsible for the operation of the system?
    - Who will make the content that the system uses?
- What
    - What will be the impact on the experience of the museum visitor.
    - What should the device look like?
    - What happens when the user wants to stop with the experience?
    - What will the user of this system remember from his experience?
    - What kind of information will be given to the museum visitor?

- Why
    - Why is this system better than a normal audio tour?
    - Why would people pay to use this system?
    - Why would people feel comfortable with giving this type of data to the museum?
- Where
    - Where can visitors pick up the glasses?
    - Where do users go when they have questions about the use of the system.
    - Where will the system be used? (For every painting or just a few)
- How
    - How much money would people pay for this experience?
    - How does the system interact with the user?

Data collection:

- Who
    - Who is responsible for the security of the data?
    - Who will help when the system has errors?
- What
    - What can the Tobii pro glasses 2 measure?
    - What other methods are there to collect this data?
- Why
    - Why is this expansive technology necessary to personalize the museum experience?
    - Why is it not possible to use other (cheaper) gaze tracking technology
- Where
    - where does the system process all the data?
    - Where Is the data stored?

- How
    - How will the data be analysed in real time?
    - How is the system able to detect the painting that the visitor is looking at?
    - How will the system interact with the database of the museum?
    - How does the curator add narrative to the system?
    - How will the system communicate that there is an error?

3.4.2 Group brainstorm

A group brainstorm was executed with friends of the researcher. This was done to gain information from people who visit the museum less frequently and to see what their opinions are on the experience that can be given when the gaze sensor is used. The focus of this brainstorm is to find out what type of information can be seen as engaging and how this should be implemented inside the system. The protocol and questions that are asked during the brainstorm are described in appendix 4

Conclusion

Many of the participants of the brainstorm were hesitant to share their gaze data with the museum since it was hard for them to grasp what kind of data they would actually be sharing. The test group was however willing to use a personalized system like this when they would come to the museum to learn new things. This indicates that there is dilemma between privacy and having the ability to improve the experience. The participants were interested in the idea of personalization and what this would entail inside of a museum. Multiple participants of the group stated that the time that a visitor spends looking at an artwork is a good indication of how interested they are in it. Personalizing information based on this data could work according to the test group. One participant mentioned that personalization could also entail skipping information inside of an audio tour that has already been told. For example when a user of the system is visiting an exhibition that displays a lot of work from the "Cobra" movement. In this case it would be nice if the system knows what type of information was already given about this topic and that it would generate an audio tour with information that is always new.

3.5 Preliminary concept

A list of possible features is made from the information that is gathered in the literature research brainstorms and interviews. The following list of requirements is given:

- The system should be able to give micro narratives based on gaze data of the visitor.
- The curator should be able to change the information that the system provides without the help of an engineer.
- The system needs to be able to analyse the gaze data in real time.
- The story that is told should adapt to different target groups.
- The users should be able to wear the device during the complete museum visit
- The user should be able to calibrate the system themselves with the help of the VidiNexus screen.

4.5.1 User experience

The aim of this project is to personalize artwork information based on gaze data that is generated by the Tobii pro glasses 2. The micro narratives that the user receives are based upon the data that comes in from the sensors.

The system differs from a normal audio tour in a way that the information that is given directly relates to the way the visitor is looking at a painting. The information that is given needs to be pre-determined for each of the museum's paintings, it is therefore necessary for the developer of the system to work closely with curators to develop a set of micro narratives that work well. The development of this database will come with trial and error testing, and therefore it is recommended that the database is easy to manipulate by the curator.

The device itself will look like the Tobii pro glasses 2 or any newer version that is also capable of connecting to python. Tiny speakers need to be added to the glasses to let it communicate with the museum visitor. The speakers that are used on the glasses must be open-ear. This implies that the speakers are not directly 'plugged' into your ear, and therefore leave some room to communicate with other museum visitors. It does have the drawback of not removing background noise during the visit, this may distract from the story that is being told by the system.

The museum will be responsible for managing the system. The way that the system is used inside of the museum is very similar to that of the audio tour with devices being rented at the cashier. The biggest difference is that the system requires an information point that will explain what the visitors have to do during the experience, this point will also serve as calibration screen. The interaction with the screen will work as follows:

Table 5: System protocol

1.	The visitor is first told to put on their glasses and to check if the system is turned on.
2.	A calibration circle pops up on the screen and the visitor is asked to focus on the middle of the dot.
3.	If calibration was successful the screen will turn green.
4.	The system will require the museum visitor to type in their name and age to further personalize the experience.
5.	Finally when the visitor walks away from the screen the system starts explaining how it works through audio. The system will mention that the visitor needs to focus on a painting for at least 30 seconds, and when there are questions the visitor needs to ask this to museum staff.

3.5.2 Data collection

Data collection is a critical part of the system, in this paragraph it will be explained how data is collected and how it will be sent from the sensor to the processing unit. Additionally the data is managed by the museum is also explained in this section.

The Tobii pro glasses will be connected to a processing unit that runs python to analyse the real-world footage and gaze data. Different methods of detecting gaze are possible but the glasses are picked because of their ability to let the user walk around freely. Personal information of the visitors will not be stored by the museum, unless consent is given by the user to use this for research purposes.

The sensor is connected with a LAN cable to the processing unit that is able to analyse the data in real time. The processing unit will be a laptop that has enough processing power to analyse the Tobii footage. The audio will be provided by a headphone that is connected to the laptop; the laptop therefore needs to stay close to the user of the device. It is recommended that the user will carry the equipment inside of a backpack. This setup is very similar to the setup that is used during the research of Walker et al., (2017).

3.5.3 Data analysis

For research purposes the Tobii glasses are often used together with the Pro analyser software, this software is able to make heatmaps according to recorded gaze data. As mentioned previously in the list of features it is necessary to do this step in real-time. It is required that the system is able to

interpret the direct data that comes from the glasses and that it will output a set of micro narratives according to this. In the following paragraph this process will be explained.

The data that the processing unit will acquire from the Tobii headset is the following:

- Video livestream of the front facing camera.
- Gaze data coordinates for every frame
- Audio from the glasses

Identifying objects:

To identify the painting that the visitor is looking at different methods could be used. In the research of Walker et al., (2017) QR codes were hung next to the painting, to let the system identify the borders of the paintings. The QR codes also gave the gaze system a clear plane on which to project the final heatmap. For this project no QR codes will be used, instead an internal package of python will be used which is called OpenCV. This package enables python to detect objects from live video footage. The database that recognizes objects can be modified to detect paintings. The high contrast backgrounds and good lighting that is present inside the museum environment help the object detection to perform well.

After the painting is detected, the system will start to analyse the gaze patterns of the visitor. This part of the program needs to be written completely by the developer. The data that is necessary before analysing is a string of coordinates of gaze data that fell within the boundary boxes that are set by the object identifier. This string will have to be interpreted with the use of a grading system that counts the time that the user is looking at one specific trigger box.

Finally, the trigger boxes with the highest scores will be activated after the user has looked at the painting for 30 seconds. How much micro narratives will be activated depends on the scores of the trigger boxes. When these scores are higher than a certain threshold they should be activated. What this exact threshold will be needs to be tested in the evaluation.

3.6 Conclusion and preliminary requirements

3.6.1 Conclusion:

The ideation gives a rough outline of what is expected from the final system, within the scope of this project it is necessary to focus on the most valuable interaction the museum visitor will have with the system. This interaction can be described as the feedback the system will give to the museum visitor after their gaze is analysed. In part 4.5.3 it is described how the system will classify the right information for the specific museum visitor, this method will be further explained and specified in the next chapter.

3.6.2 Preliminary requirements

After the ideation a final list of requirements can be set up. The requirements will be classified into different categories Must, should, could and won't have. This type of organization is called the MoSCow method, finally all of the requirements will be labelled with Functional requirements (FR) or Non-Functional requirements (NFR)

Must have

- FR1: The system must be able to track the gaze of the museum visitor.
- FR2: The system must run on a normal laptop.
- FR3: The system must be designed for python.
- FR4: The system must play a sequence of micro narratives after a period of 30 seconds.
- NF5: The system must be intuitive for different kinds of users.
- FR6: The system must have calibration option.

Should have.

- FR7: The system should be able to give different micro narratives to different visitors.
- FR8: The system should give visitors the feeling of personalized information.
- FR9: The system should give the users an indication when their gaze is being measured.
- FR10: The system should have the precision of tracking gaze within 1cm of the target.
- FR11: The system should be Compatible with a VidiNexus screen.

Could have

- FR12: The system could make data visualizations to show the AOI's of the museum visitor.
- FR13: The system could have the function to let the visitor choose the artworks he wants to view.
- FR14: The system won't have the ability to analyse gaze data of the Tobii pro glasses 2 in real time.
- FR15: The system won't be able to personalize information according to a target group that the user has to specify before the experience starts.

4 Specification

The goal of the specification phase is to get a better overview the functionalities of the final system. Within the specification phase the system will be referred to as the Vidi-look. The result of the specification should be a set of requirements that will be taken into account during the realisation phase of the project. The specification will start off with a FICS analysis and will be followed with a specification about the scope and timeframe of the software development.

In the ideation phase the expectation is set that during this research the Tobii Pro glasses 2 will be used to evaluate the system. After extensive testing, and efforts to write a program that is able to analyse the gaze data in real time it became apparent that the use of this sensor was difficult. The interactions that are mentioned in the ideation phase are possible but due to time constraints and lack of knowledge in programming It has been chosen to work with a different gaze detection sensor. The sensor that will be used during user testing is the Tobii 4C sensor, it is also able to detect gaze, but it is not able to make use of the tobii pro analyser software. The Tobii 4C was the only laptop mounted gaze detection sensor that was available for the remainder of this project.

4.1 FICS analysis

First a FICS analysis will be done to get insight into the functioning of the system. The analysis will give an optative service description of the functionalities in the form of four different categories: functions and events, interaction and usability, content and structure and style and aesthetics.

4.1.1 Functions and events.

The final interaction will be made in two different phases, in the first phase the participant will look at paintings on a laptop screen. During this phase their gaze will be analysed, and this will result in a list of triggered micro-narratives. After the participant has seen several paintings the first phase is done. In the first phase the paintings are only analysed and the micro-narratives that are activated by the gaze of the participant are saved. In the second phase the participant will have the ability to walk around in a small exhibition room with the same paintings that are analysed in the first phase. In the second phase the participants will receive a series of micro narratives that are activated by the researcher when they stand in front of the right painting.

The system will have the following functions:

1. The gaze sensor that will be used needs to be calibrated to the user.
2. The system will not collect raw gaze data but keeps track of the time each participant spends at specific trigger box on a painting.
3. A list is made for each of the analysed paintings that contains micro narratives of all the trigger boxes that have been looked at for longer than 4.25 seconds.
4. The participant will hear the selected micro narratives when they are standing in front of the real painting.

4.1.2 Interactions and usability

The participant will first be asked to calibrate the laptop mounted Tobii 4C sensor. The researcher will help with this step, after it is completed, the researcher will start the python program that contains the different artworks. The user is asked to follow the gaze target with their mouse while looking at the artworks. After the participant is done the program will automatically shut down. The user will walk to the exhibition room and is asked to look at any painting they want. After the user stands in front one of the paintings the researcher will activate the micro narrative that correspond

with the ones that were selected. The order in which these micro narratives are played is chronological according to their numbers. For example, if micro narrative 1 and 4 are selected for the participant, first micro narrative 1 and then micro narrative 4 will be played after each other.

4.1.3 content and structure

Input

The system will receive input from the mouse locations on the laptop screen. While the participant is interacting with the system an external application that is made by Tobii is connected to the Tobii 4C sensor. This input will be used to display a circle on the screen that is controlled by the gaze of the participant, this blob is depicted in figure 9. The circle does not get recognized by the python program, but rather serves as conformation for the researcher that the participant is following their own gaze with the mouse.

Output

The system outputs the wav files that correspond with the trigger boxes that are activated. The raw gaze data of the Tobii 4C sensor will not be saved because the 4C is not a Tobii pro sensor and therefore cannot make use of this functionality.

4.1.4 Style and aesthetics

The program in python should show the artworks with a white background. The white background is chosen because it will not distract the participants from the painting that is in front of them. The paintings that are hung inside of the exhibition for the second phase of the user test will also be hung on top of a white background if possible.

The full screen size of laptop will be used, and the size of the paintings will be optimized so that they are as big as possible. When the paintings will be depicted smaller the sensor will be less exact, this could cause measuring errors.

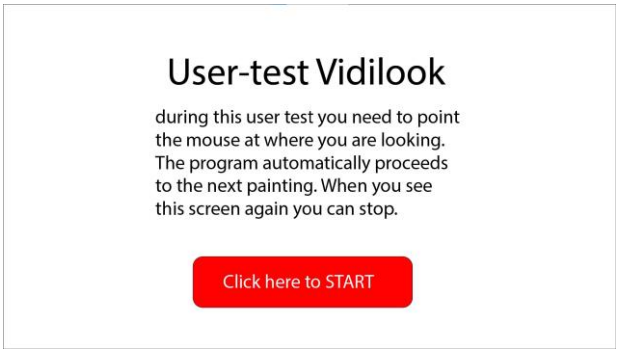

Figure 8: introduction screen Vidilook user-test

Figure 7: painting with gaze circle

4.2 System architecture

To let the system, work different components need to work together. In this section the inputs and outputs of the system will be described, and later in this chapter the black box that is now called “system” will be further explained. The first system that will be described in figure 9 is called the level 0 system. The system can be seen as the program that needs to be made in python to connect all of the sensors and outputs.

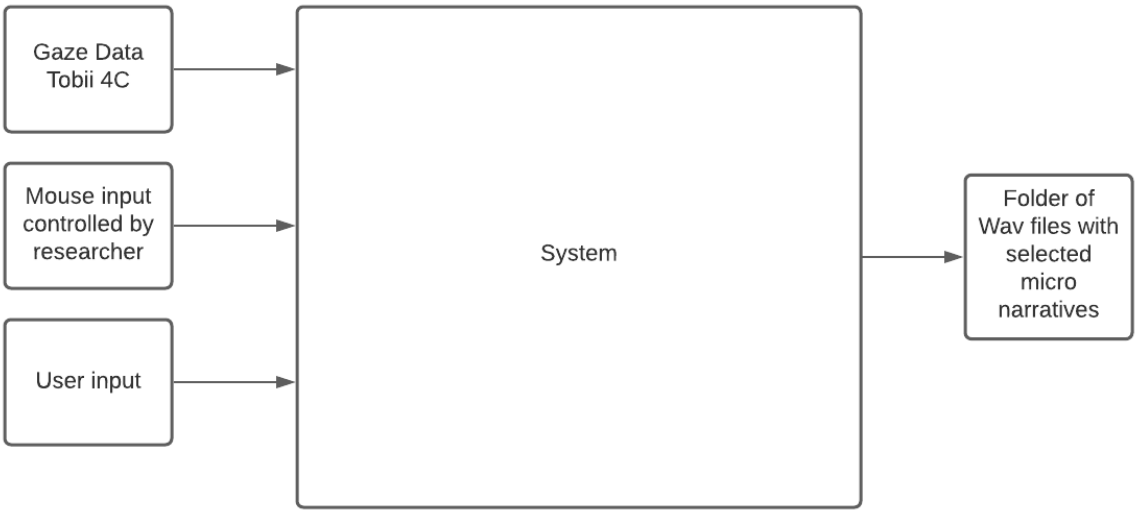

Figure 9: level 0 system

4.3 System specification

The system can be seen in the physical world as a laptop that connects the different inputs and outputs. The following sub sections will define the different aspects of the system like the sensors, the functioning of the system and the design of the micro narratives.

4.3.1The Gaze sensor

The Tobii 4C sensor was chosen because of the inability to acquire any other laptop mounted gaze sensors from the BMS lab. The sensor is normally used to assist in gaming so that interactions with your mouse feel more stream lined. Because the sensor is not a Tobii pro sensor it cannot be connected to the Tobii API, and therefore it was not possible to use the real-time data output of the Tobii-sensor. This limitation was circumvented by using the gaze circle of the Tobii 4C, and by letting the test subject follow his blob with their mouse. The x and y coordinates of the mouse are easy to implement in python and therefore this option was chosen. This type of interaction can have a big impact on the complete user experience, this will be taken into account when writing the limitations of this research.

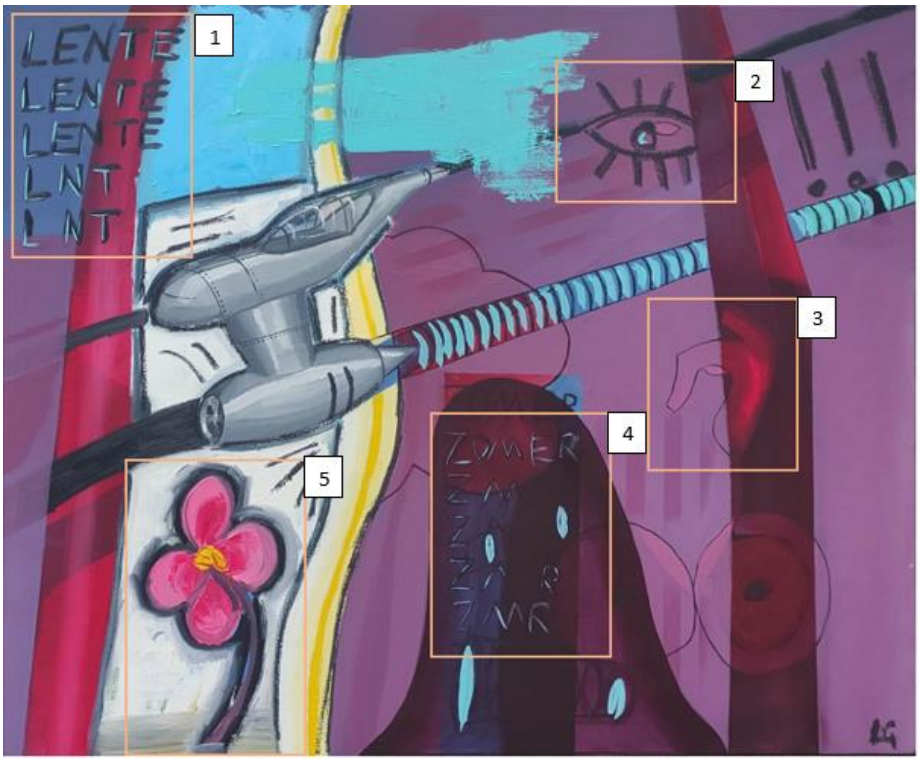

Figure 10: painting with trigger boxes

4.3.2 The system

The system that is described in figure 8 has multiple functions. It captures the location of the mouse and counts how long the mouse is hovering above each of the trigger boxes. The trigger boxes are described in figure 10, The edges of the trigger-boxes are square and cover the complete object that the micro narrative describes. When the mouse hovers over one of the triggers boxes the score of this trigger-box is increased. The score of the trigger-box is saved for the 30 seconds that the participant is looking at the picture. The score of the trigger-boxes is increased every time the screen refreshes, the refresh time of the screen is 60 times every second.

The micro narratives are activated when the score of a trigger box is higher than 255. This means that that a test subject needs to spend at least 4.25 seconds focussing on one trigger-box before it activated the narrative. The time that is required to activate is the same for each of the trigger-boxes, although the size of the boxes do vary. During the evaluation it will become clear which trigger boxes are activated the most, and changes can be made after the first round of testing. The baseline of 4.25 seconds is chosen on the basis of functional testing with the system while developing the software.

4.3.3 Micro narratives

The interaction with the museum visitor will come primarily from the micro narratives that will be told during the museum visit. The micro-narratives should therefore be made in a singular style that is easy to follow for museum visitors. In this section the rules for making the narratives are formed, these rules need to be followed during the realisation phase where the actual micro narratives are created. The complete list of narratives for each painting can be found in appendix 5.

The list of micro narratives will be made by the system, but the researcher will have to manually activate them. This will cause a small delay in between the different micro narratives. No effort will be made to make a smooth storyline between the micro narratives since the order in which they will be played will vary. This will be one of the key differences between the information that is given through a normal audio tour compared to the Vidi-look system. The contents of the micro narratives are created to give specific information about small parts of the artworks, this is unconventional in normal audio tours and therefore marks the second difference.

The contents of the audio tour are made by the researcher, and the art that is used during testing is also made by the researcher. In a normal use-case the contents of the system would be created by a museum curator in collaboration with the developer of the Vidi-look and possibly an artist. The quality of the content that will be created by the researcher will be lower than is expected inside of a real museum. The contents of the micro narratives are also really dependent on the artworks that are shown. To make some structure for the contents of the micro narratives the following rules are created:

Micro Narrative rules:

- The location on the object that the micro narrative describes should be uniform and follow this example.” On the down right corner” followed by “a description of the object” follow by the micro narrative.
- The micro narrative should include information that directly relates the object by which it is activated. Information can range from meaning of the object within the composition to materials and mediums used to make the object.
- Micro narratives should not be longer than 3 sentences, this will ensure that the information that is given is concise.
- The micro-narrative should not contain information about general aspects of the painting but rather focus specific information about the objects that are depicted.

4.4 Final requirements:

A final Moscow analyses is done in which the preliminary requirements that are set after the ideation phase are revised. The biggest change to the final system was that the researcher was unable to implement the Tobii pro glasses, this has a big impact on the user interaction that will be experienced during user testing. The following list of requirements is made for the final prototype that will be used during testing.

Must have

- FR1: The system must be able to track the gaze of the museum visitor.
- FR2: The system must run on a normal laptop.
- FR3: The system must be designed for python.
- FR4: The system must play a sequence of micro narratives after a period of 30 seconds.
- NF5: The system must be intuitive for different kinds of users.
- FR6: The system must have calibration option.
- FR7: the micro narratives that are created for the final system should comply with the rules that are made in chapter 5.3.

Should have.

- FR8: The system should be able to give different micro narratives to different visitors.
- FR9: The system should give visitors the feeling that the information they receive is personalized.
- FR10: The system should give the users an indication when their gaze is being measured.

Could have

- FR11: The system could proceed to the next painting when the user provides confirmation that he is done looking.
- FR14: The time that the user spends to look at each artwork could be used to indicate the number of narratives that he should receive.

Won’t have.

- FR15: The system
- FR16: The system won’t be able to personalize information according to a target groups, like children, experts and amateurs.
- FR17: The system won’t be able to use the Vidi-nexus screen for calibration or any other interaction.
- FR18: The system won’t be built with the touch interactions of the Vidi-nexus screen in mind.
- FR19: The system won’t have the ability to be tested on a VidiNexus Screen.

5.Realisation

This chapter will describe the process of creating and developing the Vidi-look that will be used during user testing. In the first section the development of the software will be described, details about the personalization method will be described here. In the second section the museum pieces that will be used for user testing will be analysed, and the micro narratives that will be told during user testing are described here.

5.1 Development process

The development process of the Vidi-look system is an iterative process, within this research a first LO-FI prototype will be created. The parts that work from this system will later be used as the basis for the HI-FI protype. Both of the prototypes will be evaluated in the evaluation chapter, the final changes that are made to create the HI-FI prototype will be based on the findings of the first round of user-testing. The reasoning behind these final changes will be described in detail in the Evaluation chapter, but the final system will be explained here.

5.2 The prototypes:

The LO-FI prototype was created to perform user testing. The most important feature of the LO-FI prototype was that it was able to analyse the gaze of test subjects, and that the interaction with art, while the participants are receiving their personalized audio tour felt as if they are in a real museum. The HI-FI prototype will inherit most of the features of the LO-FI prototype and will try to incorporate additional features that will improve the experience of the user.

5.2.1 The LO-FI prototype

The LO-FI prototype was created to test how the basic functions of the Vidi-look system. The LO-FI prototype was created with the use of the Tobii 4C sensor. This eye tracker has the capability to plot a gaze “blob” on the screen of the researcher. To let the system, work the “blob” needs to be followed by the mouse to enable the system to track the gaze. The LO-FI prototype made use of 4 paintings that were made by the researcher. The location of the different trigger boxes was determined by the researcher based on what parts of the painting he found most interesting. The micro narratives that are created will be completely described in appendix 5, because the paintings remain the same for the HI-FI prototype these micro narratives will stay the same as well.

5.3 The HI-FI prototype

5.3.1 The software

For both of the prototypes the code is written in python, The code will be open source and can be accessed by using the following link: https://github.com/s2190206/Graduation-project-Vidilook. In figure 9 the UML diagram of the Vidi-look system can be seen. The different blocks stand for the different classes that were used. Each class consists out of standalone game program that has a draw () and update() function that gets controlled from the System operator class. There is no interaction between the different game classes. Only the system operator class is aware of the current state of the game.

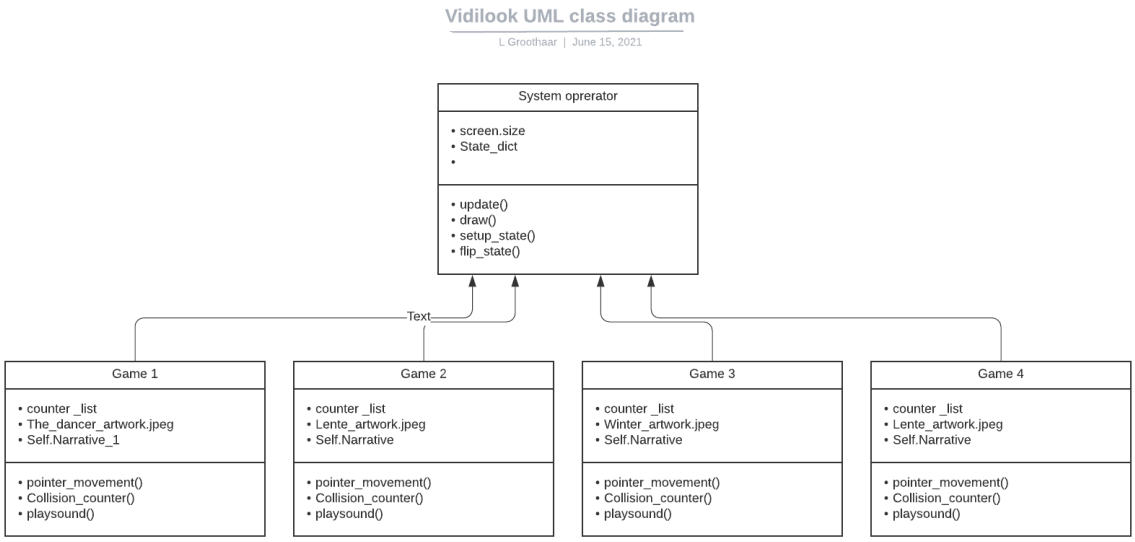

Figure 11:UML diagram Vidi-look

As can be seen in the UML diagram in figure 10 the program is structured around 5 different classes, the classes that are named game 1 through 4 operate in exactly the same way, with the only difference being the content that is displayed. The design choices that are made for each of the classes will be described in the following sections.

System operator:

The system operator is the organizing program that manages how the different games are started up and shut down. The system operator contains the global variable screen size and manages the order in which the different paintings are shown. The source code that was used to create this type of state machine can be found in source (Metulburr, 2016). The system operator also starts the draw and update functions that are used by all of the different states.

The game class:

The different game classes are completely the same with the exception that they contain a different list of micro narrative and pictures of paintings. The separate game classes do not sent information to each other, and only get the global variable screen size from the system operator. Each game class creates its own library of micro narratives and images that are only available in their own class.

The game class has the function movement () which moves an object that will be controlled by the x and y coordinates of the mouse. The object that is moved is described as the Eye_pointer, this object used to detect collision with the trigger boxes that are placed over specific parts of the paintings. After the game is done all the information that is used will be deleted and only the list of micro narratives will remain saved inside of the main folder of the python program. The scores of the individual trigger boxes will be cleared when the clean-up () function is called.

The trigger-boxes

The trigger-boxes are created by using the rectangle function of pygame, these rectangles have to be manually put in place by the researcher with x and y coordinates and sizes. The trigger boxes for the HI-FI prototype were placed according to the boxes that can be seen in appendix 2. Most of the paintings were fitted with 5 trigger boxes with the exception of one which contained only 4. The size of the trigger boxes was determined by the scale of the objects that were depicted on the painting. This causes each trigger box to have a different size.

Figure 12: Trigger boxes in python.

The analysis system

After the first round of user tests the analysis system was changed. After this first round it became apparent that some users did not focus for long enough on any of the trigger boxes. This resulted in users that did not get any information for some of the paintings. This interaction was experienced as negative and therefore a change was made in the system. During the first testing round the analysis system worked with timers that were placed on each of the trigger-boxes. An example of these trigger boxes is shown in figure 12. When the user pointed their gaze for longer than 4.25 seconds at one of these boxes they were activated.

The system that will be used for the second round should have the ability to always give at least one micro narrative for every painting. The narrative that will be given to the user is the one that corresponds to the trigger box with the highest score. The lines of code that will select the right narratives are activated when the program performs the Clean-up () function, this clean up happens after the participants has looked at the painting for 30 seconds. The score of each trigger box is then calculated and the narrative that corresponds with the high score is exported to the main folder.

The use of both of these systems at the same time can cause that both of the systems export the same micro narrative. For example when the user looks at 3 trigger boxes for more than 4.25 seconds, it is logical that one of these three also has the highest score of all the trigger-boxes, therefore 4 micro narratives are exported to the main folder while there are only three unique ones. The micro narratives are activated by the researcher during the second phase of user testing, and it is up to the researcher to only select unique micro narratives.

5.3.2 The sensors:

For the final testing setup, the Tobii 4C eye tracker will be used, this tracker is not part of the pro line-up of Tobii sensors and is therefore not able to connect to the pro analyser software. The Tobii 4C is an optical eye tracker that uses high resolution images and projectors to calculate the gaze point of the user (Tobii, 2012). During the user tests the accuracy of the sensor is checked by the researcher by asking the participants to look at the mouse. When the mouse is in the center of the Gaze circle the calibration of the sensor is complete. The Tobii 4C tracker can have difficulties with participants that wear glasses, this can affect the accuracy. Malfunctions of the sensor should be spotted during manual inspection of the calibration. If the eye tracker is not calibrated correctly the application that comes with the 4C sensor has an option to improve the calibration by clicking on "improve calibration" in the menu. Lighting could also have impact on the accuracy of the sensor.

5.3.3 The paintings:

The paintings that will be used during the final tests are made by Leon Groothaar, the choice to use these paintings was mainly done out of practicality. The exhibition room and the paintings were easy to access for the researcher, this eventually saved time when comparing it to sourcing artworks from the artworks program of the University of Twente for example. The second factor that played a role for choosing these specific artworks was that most of them had figurative elements. These figurative elements served as the basis for selecting the places of the trigger boxes. The four paintings that have been used during user testing are described in Appendix 5.

5.3.4The audio tour:

After the first round of user testing and after an interview with the curator of the University of Twente, it became clear that the users of the system want to get more information. The curator proposed during the interview that it could be beneficial to start with a normal audio tour. This proposal was made because the curator saw that not all of the information of artworks can be described by micro narratives of specific parts of the painting. The curator also made a proposition for including a question for each of the paintings that will initiate a deeper search about the meaning of the picture that is in front of them. When the question of the participant is answered by the personalized audio tour it can lead to an increase in engagement. The main objective for adding the additional audio tour was to rise the amount of information for every painting to see what the users like the most.

5.3.5 The micro-narratives

The micro-narratives that are created for each of the paintings are described in Appendix 5. The figurative elements were chosen by the artist of the paintings. One style element that was added to the requirements was that the micro narratives should be informative and use examples on specific parts of the paintings to inform the visitor about overarching themes within these paintings. One example of this can be found on the painting dancer, which is also described in Appendix 5. The overarching theme of this painting is "Freedom", and the micro narratives describe how the different elements of the paintings try to portray this feeling.

Not all of the figurative elements were used to make micro narratives, the paintings were first limited to 5 narratives each. This choice was made to balance the amount of information that was available for each of the paintings. The selection of figurative elements was now made by the artists, but this is a field in which the Tobii pro glasses could be useful. The pro glasses could be used to indicate areas of interest for different types of users. This information can be analysed and used to find the areas of interest that are looked at the most.

The micro narratives are placed on objects that contained a clear message, this clear message was harder to find on the painting that was called Winter. As can be seen in Appendix 5 Winter is a completely abstract painting with no figurative elements. The micro narratives of this painting were created to point out different painting techniques that were used to create the composition.

5.4 Functional Testing

After the system was completely built the researcher performed functional testing to see if all of the different components of the system work together. The researcher also tried how easy it was to follow your own gaze circle with the mouse, and this proved to be easy and accurate. Calibrating the Tobii 4C was easy and quick and no problems were found. During functional testing the researcher experimented with the values that make up the interaction of the system. Because the researcher made all of the narratives it was hard not to be biased to look at specific parts of the paintings to activate them. The researcher always activated at least 2 micro narratives for each of the paintings. And never activated none of the narratives. Therefore, the system was approved and ready for the first round of user testing.

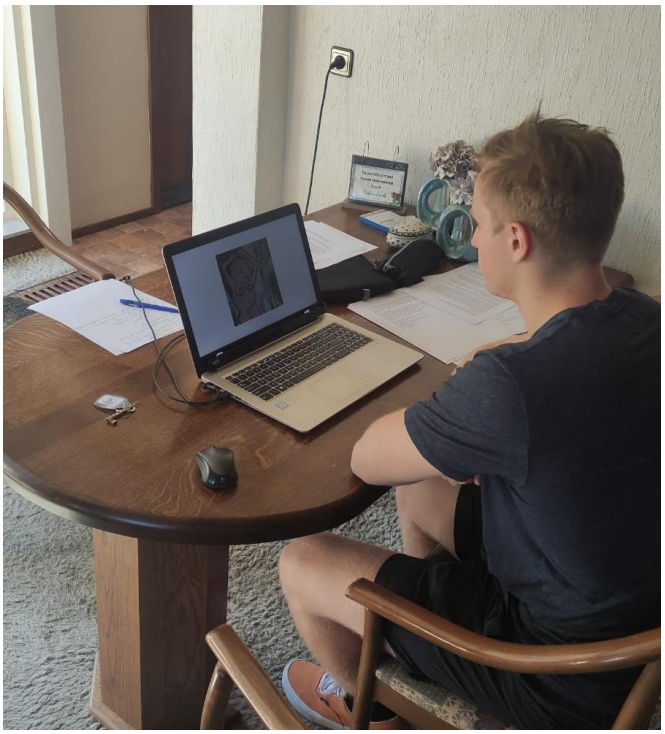

Figure 13: Prototype as used in functional testing.

6 Evaluation

Introduction:

The goal of the user tests is to answer the three sub-research questions that are stated in the next paragraph. This will be done with two rounds of user tests, after the first round the feedback will be implemented and a second round of user testing will be done to see if the changes had the desired effect.

The main research question that needs to be answered by the evaluation is the following:

- **How can the museum experience of a visitor be enhanced with the use of narrative enhancements and gaze data?**

To answer this main research, question the following sub questions are created. The sub-questions will be answered one by one in section 6.4.

1. To what extend can micronarratives be personalized based on gaze data of museum visitors?
2. How much information does a museum visitor want?
3. What are the main limitations of personalizing audio tours based on gaze detection?

6.1 Test procedure

To perform the user tests a script was created, this is necessary because the users are informed about how the system should function in a normal museum environment. If the script is not followed it is possible that the users have a different understanding of how the final solution would function. The script is added in appendix 6 and describes the different steps that need to be followed during the user tests.

In total 18 subjects will be tested to compare the two iterations of the Vidi-look system. The first round of user tests will contain 8 test subjects, the second round will have 10 test subjects. The test subjects are friends and family of the researcher. A selection is made by the researcher to recruit test subjects that have at least gone to the museum once. The researcher did not select on participants that often use an audio tour.

The test will be setup in two phases, where the participant will first look at the four different paintings on a laptop while their gaze is being tracked. The second part will be in the exhibition room where the participants can see the real paintings. During this second phase the micro narratives are activated by the researcher.

The questionnaire that the participants fill in after their experience consists out of open questions and Likert scale questions that are aimed to find out how different parts of the system are experienced. The full set of questions is stated in Appendix 7.

6.2 Experimental setup:

The testing location will be situated in an empty living room. One part of the living room will be intended for the test subject to fill in the consent form, the first survey and to use the Vidilook program. The second room is filled with the artworks that the test subject has seen while working with the Vidi-look program. Figure 14-16 show how the art is positioned on the testing location.

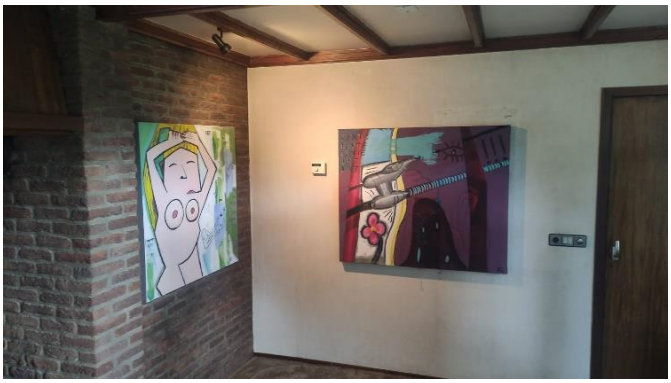

Figure 15:experimental setup

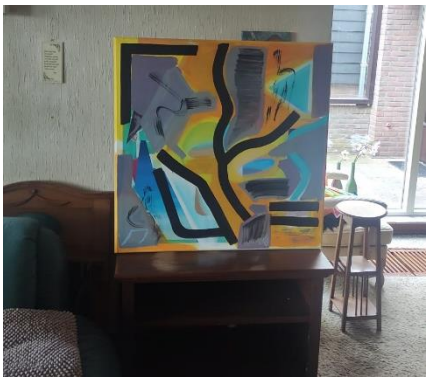

Figure 14: experimental setup

Figure 16: experimental setup

6.3 The second iteration of the system

After the first round of user testing the results were reviewed, it was very clear that the basic system needed to be improved on the amount of information that the participants are getting. From user testing it became clear that some participants only got a small amount of information for each of the paintings. Some participants did not receive any micro narratives for some of the paintings. During the first round of user testing the answer to the questions if the amount of information for each painting is the amount that they wanted can be found in figure 19 in appendix 8. The graph indicates that 75 percent of the participants answered the question with 2 on a Likert-scale with five options. A score of 1 indicated that the amount of information was too little, while a score of 5 indicated that there is too much information. This finding initiated the search for an addition to the system that is able to give at least one micro narrative for each painting, while still holding the feeling of personalization.

6.3.1 Expert interview

To evaluate how the system can be installed inside a museum, the curator of the University of Twente was approached. The interview was held inside of the exhibition space of the University of Twente. Different artworks were picked by the researcher to see how the Vidi-look system could be used.

Something that was apparent immediately was that the information that the Vidi-look is able to communicate is different than a normal audio tour. The information always needs to be based on visual aspects of the artwork. The curator mentioned that normal audio tours also contain background stories about the life of the painter. The conclusion was made that both types of information could work together, and that the Vidi-look system could benefit from having a normal audio tour while the user is being analysed. After 30 seconds the gaze data will be analysed, and the personalized audio tour will give additional information in addition to the audio tour. For the second round of user testing this system was implemented, and the exact information that is given to the test subjects is stated in appendix 5. The “introductive audio tour” will start immediately when the test participant is looking at an artwork.

During the meeting the curator also stated that it would be interesting to ask questions about theme of the painting during the audio tour. The curator mentioned that actively thinking about the theme or asking yourself questions about the painting could improve the experience. At the start of this research an interview was held a philosopher of the university of Twente, the complete results of this interview are described in chapter 2.3. But one of the findings from this interview was that actively asking questions to yourself about what you see can evoke a deeper relation to the artwork that is in front of you. This concept will be tested in the second round of user testing by incorporating a question inside of the introductive audio tour.

Finally, to give the users of the Vidi-look system more information the analysis of the looking behaviour was changed. The old trigger-boxes would still be in place but an addition to the analysis makes it possible that each user gets at least one micro narrative for every painting. How this system exactly works is described in section 5.3.1.

6.4 The findings:

In this section the results of the user test will be evaluated, the results that answer the sub research questions are divided into different sections of the evaluation. The quantitative data will be evaluated but since the user test is only done with a small sample group no statistically significant results are found.

6.4.1 The testing group:

As has been mentioned in section 7.1 the user tests have been executed with friends and family of the researcher. The researcher selected the participants with the minimal requirement that they had been to a museum once before. The age of the different participant ranged from 19 to 61. 10 out of 18 participants were younger than 26. Two out of the 18 participants indicated that they often make use of an audio tour when they come to the museum. 14 out of 18 people stated that they like to visit museums of modern art. This last question was important since in the exhibition that is used for testing abstract art is shown. When the participants do not have affinity with this type of art the experience can be misjudged.

6.4.2 To what extend are the micro narratives personalized?

To find out if the micro narratives are personalized the activated narratives for each user are compared. In the survey a question was asked about how personalized the complete experience feels. This question remained the same for both rounds of user testing, this indication is important because for the second round of user testing a different system was used to select the micro narratives. The answers on the survey could give an indication if this change in analysis made a difference for how personalized the complete experience feels.

The second indication of personalization is given by the uniqueness of each set of micro narratives that is given to test subjects. The complete set of data can be found in Appendix 3. To describe in what way the sets of micro narratives are unique an example will be given of participant 13 and 14. These two participants came to the user test together, and after they had did the test they were asked to tell each other what they had learned. In table 6 it is shown which micro narratives each participant received, the numbers correspond to the micro narratives that are stated in appendix 5. The participants could always tell something about the painting that other had not heard. This led to a fun experience where they could learn from each other. This table could be made for random participants and will result in the same findings.

Table 6: Micro narratives Participant 13 and 14

	LENTE	DANCER	NIGHT TALES	WINTER
Participant 13	1, 5	2	5	4
Participant 14	4	3,4	1	3

Questions about personalization were asked, the first question that was asked in the survey was: Did the micro narratives relate to the parts of the painting that you found interesting? The second question stated the following: To what extend did the micro narratives that were provided feel personalized. The first questions make the participant think about the micro narratives that he did get, and how well they were selected. The second question gives the participant the room to think about what he would have liked to hear in a personalized audio tour. The complete survey answers to these questions can be found in Appendix 8 figure 20-23.

The questions about personalization were asked in both testing rounds. To understand the findings first a hypothesis should be made about the causes of possible differences between the two iterations of the Vidi-look system:

- The number of micro narratives for every participant increased, and therefore the micro-narratives feel less personalized.
- The personalization decreased because trigger boxes with a high score could be picked instead of trigger boxes that have been viewed for longer than 4.25 seconds. A high score could also entail a value that is lower than 4.25 seconds.
- The introductive audio tour could lead to participants that were more aware of the meaning of the painting. This could give direction to find the visual expressions that conformed with this message. When the right micro narratives are selected the thoughts of the participant could be confirmed which makes him more aware of the personalization.

To conclude there is not a big difference between how personalized the audio tour felt when comparing the two iterations of the system. It is apparent that the changes of the system did not impact the personalized feel in a negative way, which is promising. An argument could be made about incorporating not-personalized content while viewing paintings could lead to a decrease in personalization. This is not apparent and therefore it can be said that the use of an initial audio tour could be beneficial.

6.4.3 How much information does a museum visitor want?

From the first round of user testing, it became apparent that the amount of information that was given by the system was insufficient. In the second round of testing the amount of information increased, in this paragraph the 2 testing rounds are compared to see which of the two systems had the best user feedback.

In the first round of user testing the average amount of micro narratives for every participant was 3.75, in the second round this number was 6.4. This number indicates the number of micro narratives that are given during the complete audio tour for four paintings. This means that the number of micro narratives increased with 70.6 percent.

In the survey 3 questions were asked about the amount of information that was generated. The answers of the first question: Did you receive the amount of information that you wanted? are described in figure 25 and 26 in appendix 8. This question was used to measure if the complete amount of information that was given came close to the required amount of each visitor. The results of the two different user tests did not differentiate enough to say that the increase of information made the system significantly better. Although the outcomes of the second testing round were slightly better, with 2 participants answering the question with 5. This indicates that they completely got the information that they wanted. None of the participants in testing round 1 gave a score of 5.

The second survey question that was asked is described in figure 27 and 25 in appendix 8. The following question was asked: What did you think of the amount of information that was generated for the individual paintings. This question was made to see what the overall experience was when it came to the interaction in front of the paintings.

The findings of this second question are that users found the amount of information that was given during the second round of user testing better. An answer of three on the likerd-scale indicated that there is not too much and not too little information. In the second-round 40 percent of the subjects answered with three where it was only 25% in the first round. In the first round 75% of the

participant answered the question with 2 indicating that they got too little information for each painting. In the second round the percentage of the user group that answered with 2 was 30%. Because the difference is not very big and only a small user group was tested it is hard to conclude that the amount of information that was generated in the second round is much better.

Finally, a question was asked in the second round of testing which stated: what did you think of the amount of information that was given during the complete experience? The survey answer to this question is stated in figure 28 in appendix 8. 70% of the subject responded to this question with an answer of 3 on a likerd-scale of 5. Three indicates that there was not too much, nor too little information given. The conclusion that can be made is that 70% of the second testing group was happy with the complete amount of information, indicating that the additional introductory audio tour did not cause an information overload.

6.4.4 What are the limitations of personalizing audio tours?

The answer to this question is given during the interview with the Curator of the University of Twente. The limitations that were mentioned by the curator during the analysis of the artworks were the following:

- The curator is not able to make micro narratives for different objects and artworks that were present in the exhibition. For example, there was a wall that displayed different portrait pictures of people. The curator did not see any possibility in which the Vidi-look system could enhance the experience by giving information about specific parts of these portraits.
- Within the exhibition there were sculptures position very close to each other. Although some of the sculptures had a unique element the Vidi-look system is not able to detect target area's in 3d space hence it is not possible to implement the system for sculptures.
- The curator pointed out that the information that can be given by the Vidi-look system is different from a normal audio tour. The information needs to relate to the target areas that it activates, it is therefore hard to incorporate background information about the artist.

6.4.6 User feedback

The users of the Vidi-look system answered several open-ended questions about the functioning of the micro narratives. The answers to these questions will be described in this section, quotes of negative feedback will be given to find out limitations of micro narratives.

In the first and second testing round an open-ended question was asked to see if it was clear where the participant needed to look while they received the micro narratives. Since the micro narratives remained unchanged over the two different testing rounds the results are combined. The results from the open-ended questions were positive. There was one negative remark about not getting any micro narrative for a painting in the first round of user testing, this does not relate to the ability of the micro narrative to let the user localize the area the micro narrative talks about.

Another question was asked if the micro narratives were easy to understand in terms of content. The reactions to this question were also positive in both rounds of user testing. This confirms that the method that was used to create the micro narratives is not confusing.

6.6 Discussion

The main goal of this evaluation was to see if micro narratives could be personalized based on gaze data. This goal was met with the use of the Tobii 4C sensor, the assumption can be made that this positive result also indicates that it is possible to use the Tobii pro glasses for the same purpose. The biggest differences between using the Tobii pro glasses and the laptop mounted sensor is that the user would be able to look at real art. The user is not able to see his own gaze when using the Tobii glasses. How these changes exactly have impact on the complete experience is still unknown. The results that were captured also did not show large differences between the two iterations, and therefore it is possible that the differences that are made only had a small impact on the complete experience of the user.

7 Conclusion and Future work

To conclude this graduation project an overview will be given of the goals and achievements. The sub research questions that are stated in the introduction are answered and thereafter the main research question will be answered. Finally, a recommendation will be made for future work based on the results of this research.

7.1 Conclusion

The main research question that is answered in this research was the following: To what extend can micronarratives be personalized based on gaze data of museum visitors? The final research question will be answered last, and the sub research questions will be answered first.

The first sub-research question for the system was: To what extend can micronarratives be personalized based on gaze data of museum visitors? The decisions that are made during the design process of the system resulted in a method in which target areas on the paintings were created that could be activated when the user focusses on them for longer than 4.25 seconds. This system was evaluated to see if the activation of the trigger boxes differed between test subjects. The complete set of data of activated micro narratives can be found in appendix 3. The conclusion can be made that each participant created a set of micro narratives that was unique.

In the second round of user testing changes were made to the way the gaze of the participants was analysed. These changed resulted in an increase of 70% on the average amount of micro narratives that were activated. The changes had no negative impact on how personalized the system felt for the users.

The second sub-research question was: How much information does a museum visitor want? This question is hard to answer with a user group of only 18 people that used different system and got different amounts of information. For the second round of user testing not only the number of micro narratives was increased but also an introductory audio tour was added to the experience. This resulted in the experience for the second round of user testing containing at least twice the amount of information compared to the first experience. This increase did not lead to significant changes in the way the amount of information was experienced.

The observations of the first round of user testing concluded that subjects want to have some information for every painting that they look at. The system was changed accordingly but no significant results indicated that this change made the participants more satisfied with the amount of information they got. The increase of information did not lead to disliking of the system, it can therefore be assumed that the total amount of information should be at least one micro narrative for each painting.

The third sub-research question stated the following: What are the main limitations of personalizing audio tours based on gaze detection? The answer to this question was found while doing an expert interview with a curator. One of the limitations of the system is the content that can be created for specific parts of paintings. Some of the important information of an artwork cannot be explained by describing specific parts of it. The curator therefore suggested to make a hybrid system that is able to tell a background story while the participants gaze is analysed. No specific questions about this new feature were asked or evaluated.

Finally, the main research question can be answered: How can the museum experience of a visitor be enhanced with the use of narrative enhancements and gaze data? The answer to this question comes in the form of a personalized audio tour that is able to activate micro narratives based on the areas of interest of the user. The information that is given in the audio tour is personalized therefore not all of the information that is available is given to the user. The assumption is made that the museum experience is improved when the information a visitor receives during their visit is personalized. This assumption is made based on the article of Bohnert, (2015). Personalization is a broad term, and the way in which it is used in this project has not been done before. Therefore, it is hard to say if this system really has the ability to Improve the museum experience, to test this extensive user studies need to be done inside of a real museum context.

7.2 Recommendations for future work

As a final remark in this graduation project some recommendations will be given for future work. The recommendations will be mainly based on the findings that were made in the evaluation and ideation phase.

First of all, within this research only gaze data was specified as data that could be used to personalize the audio tour. During the background research and the ideation phase it also became apparent that the time that a user stands in front of an artwork also gives an indication about how interested they are in it. This time can be measured with the Tobii pro glasses, and a recommendation is made to use this data in a multimodal system.

Secondly the method that was used within this graduation project to analyse the gaze data was very basic. With the Tobii pro glasses 2 it is possible to also measure the sequence in which a participant is looking at an artwork. The glasses are also able to identify areas of interest with more precision. This data could be used to optimize the location of the trigger-boxes, but also the first thing that catches the eye of the user can be measured. This is not possible with the current Vidi-look system.

7.3 Limitations:

The initial goal of the research was to examine how the experience inside of the museum could be improved with the use of Gaze detection and micro narratives. The assumption is made that the museum experience is better when the information that the visitor receives relates to areas of interest of an art piece. To test whether this personalized information actually improves the museum experience a large user test should be done that is able to significantly measure differences between a normal museum experience and an experience with the Vidi-look system. Because of the Covid-19 pandemic it was not possible to visit museums, this limited the researcher during the background research. It is hard to understand what an experience entails when the experience of visiting a museum is not possible. Observational studies could have helped with understanding how people look at art, and what are the most important aspects of the museum experience.

During the user tests the Tobii 4C sensor is used, to let the system work it was necessary to show a gaze circle. It became apparent that the participants of the user tests were often distracted by this circle. How this exactly had impact on the viewing behaviour of the visitor is unclear. This interaction together with the fact that subjects needed to look at art on a laptop made the user test very different from the intended final system.

During the user tests the researcher was constantly observing the participant, this is something that is not common in a museum context and could have impact on the research findings. As stated in the recommendations it would be better to test the system in a real museum setting.

Another limitation is that a big part of the test subjects of the user test were friends and family of the researcher. This made most of the visitors biased due to the relation they have with the artist they tried to put effort in finding out what the artworks mean. In a normal museum context users make a choice between paintings that are visually appealing to them, and only when they are visually attracted step in closer and try to understand the meaning.

The final user test was only held with 4 paintings that are all made by the same artist, The research would have been better when also different types of artworks were tested. Due to time constraints this did not happen.

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8 Appendix

Appendix 1: Persona's

Peter

Peter is a 30-year-old male that studied at the university and is now working in the field of media and communication. From an early age he was taken to the museum by his parents and because of this he developed an interest in art. Peter always goes to the museum with an open mind, and is not interested in the "blockbuster exhibitions". When Peter is in the museum, he normally first tries to figure out what the exhibition is about by himself before reading the information on the walls. When he stands in front of a painting, he asks questions to himself like, does this painting relate to my own life in any way and if anything brings up memories. After he has looked at interesting paintings throughout the room, he reads the thematic texts on the wall. Peter likes it when new innovations are brought to the museum, although he is often sceptical about the real gain it gives to the experience. He thinks that screens in exhibition rooms distract from paintings, and that audio tours only give general information and are boring because of that. When he heard that there was a new system that used Gaze sensing to give personalized information he was intrigued. He put on the glasses after he got them from one of the employees and walked to the Vidinexus screen to start his calibration. As instructed by the Vidinexus screen Peter walked to the first room and just started looking at the paintings he wanted to. Peter was instructed to focus for at least 30 seconds at one painting so that the system could acquire enough data to gain insights. After this period of time the system started talking and explained that peter has not focused on the upper right corner of the painting. The system told Peter that when you look closely you can see that the painter used a different kind of medium in this corner that made the finish of the oil paint more matt. Peter found this information interesting and once again looked at the painting to further analyse the techniques. Peter moved on to the next painting and the experience started over again. When peter wasn't interested in the painting he walked away before 30 seconds, in these cases the feedback was not given. Peter found the experience nice and enjoyed the personalized information that was given. One remark he did make was that although the information felt personalized, it did not bring information to him that he couldn't find inside of the brochure or thematic text.

Melissa

Melissa is a 35-year-old mother that likes to bring her family to the museum. She thinks that it is important that her children explore art and creativity, and that the museum also caters toward younger people. From previous visits she knows that her children like to have interaction with screens to learn about art in a playful way. This type of interaction is often not present in museums about modern art. Melissas discovered that one museum offered glasses that are able to personalize an audio tour, she found it interesting and now they are visiting the museum. She paid for three audio tours for her and her 2 children, together they walked towards Vidinexus screen to start their experience. The calibration process was not as easy as she hoped it would be, one of the glasses did not sit well on the face of one of the children and caused errors. She had to get a new one and that eventually worked. Together with her children she walked through the museum and looked at paintings. They were instructed to focus on one painting for at least 30 seconds before information could be given. Melissa herself did experience difficulty because her children were sometimes not so patient, and this caused her as well to lose focus. Eventually she just sometimes stepped away from her children to get the full experience. When she talked to her children about how they have experienced this new technology they both said that the system didn't talk much, and that they didn't know why they had to put on these glasses. In the end Melissa said that it was a fun experience for herself but doing it together with children is rather hard.

Agnes (Curator)

Agnes is 26 and just started her job as curator for a relatively small museum that displays modern art. Her goal is to attract a new group of people to the museum, and bring the joy of art to as many people as possible. When she heard that VidiNexus was developing a system that is able to personalize information for museum guests she directly got involved with the project. Agnes knew that implementing such a system would require good teamwork between the developer and the curator. During the development of the product Agnes already started with writing micro narratives about different paintings within the collection. She sent audio files to the developer and later on was also involved in testing the complete system inside of the museum. Agnes was one of the first people that could try this new experience, but she was not happy with it at first. The calibration of the system was fine and quick, but the information was not completely right, and did not show enough cohesion with the exhibition. After Agnes added more specific micro narratives the system worked better. After it was in use for 2 weeks Agnes closely monitored the troubles, the users had with the system. One of the things that stood out was that some visitors didn't like it to put on glasses during the museum experience and therefore returned the glasses before they were completely done with the tour. Agnes herself liked the flexibility of the system, when a new painting would come into the museum, she just scans the picture and makes the micro narratives herself. The system can pick up the image from the database and detects when a visitor is standing in front of it. Also changing around exhibition pieces does not change the way that the system functions, because the information is only given for single art pieces.

Appendix 2: Brainstorm ideas

The serpentine Galleries in London have recognised the central role a website can have in enhancing the experience of their visitors. This awareness led them to exhibit designs and re-designs of the website that are made by artists. By allowing this co-creation the galleries have redistributed power from the institution to the hands of the artist. This concept could also be used for personalized information systems. Where new artists can do an interview about the focus points of their artwork. And based on the gaze data of individual museum visitors these voice clips can be played.

With the use of Salience maps we can identify normal viewing behaviour of humans. This processing step will look at high contrast areas on paintings and will search for focus points. These salience maps can be used to determine if the museum visitor has a normal looking behaviour, and if this is not the case the visitor can receive additional information about the important features of the painting. It is also possible to teach new viewing behaviours to museum visitors by rewarding them when they try to focus on having an un-natural viewing behaviour.

For children it could be nice to make a game for looking at artworks. So, your painting level is complete when you have looked at all of the target boxes. Where the target boxes are exactly is unknown and eventually, they will be shown by a beamer. Children will learn to look at art when trying to complete the levels. They are forced to approximately look for 30 seconds at each painting.

Appendix 3: Complete results given micro narratives:

This is the complete set of activated narratives for the two testing rounds. In the rows the participant number is indicated and in the columns the number of the micro narrative that was activated is indicated. A red stripe indicates that the participant did not get any micro narrative for that specific painting.

LENTE					
Particiap	Lente 1	Lente2	Lente3	Lente4	Lente5
Subject1	1				1
Subject2	1				1
Subject3				1	
Subject4				1	
Subject5				1	
Subject6				1	
Subject7	1			1	
Subject8				1	
DANCER					
Particiap	DANCEF	DANCEF	DANCEF	DANCEF	Dancer5
Subject1	1				
Subject2	1				
Subject3				1	
Subject4					
Subject5					
Subject6		1			
Subject7	1				
Subject8					
NIGHT TALES					
Particiap	1	2	3	4	5
Subject1					
Subject2					
Subject3		1	1		
Subject4					
Subject5					
Subject6					1
Subject7	1	1			
Subject8				1	
Particiap	1	2	3	4	5
Subject1				1	
Subject2				1	
Subject3					
Subject4	1				
Subject5	1				
Subject6	1			1	
Subject7	1			1	
Subject8					

Figure 18:outcomes micro narratives Round 1 user testing.

LENTE					
Particiap	Lente 1	Lente2	Lente3	Lente4	Lente5
Subject 9	1				
Subject 10				1	
Subject 1	1			1	1
Subject 12					1
Subject 1	1				1
Subject 14				1	
Subject 1	1			1	1
Subject 1	1				
Subject 1	1			1	
Subject 18		1			
DANCER					
Particiap	Lente 1	Lente2	Lente3	Lente4	Lente5
Subject 9	1	1		1	
Subject 10			1		
Subject 1	1	1		1	
Subject 12			1	1	
Subject 13		1			
Subject 14			1	1	
Subject 15		1		1	
Subject 1	1				
Subject 1	1	1		1	
Subject 18			1	1	
NIGHT TALES					
Particiap	Lente 1	Lente2	Lente3	Lente4	Lente5
Subject 9		1			
Subject 10					1
Subject 11				1	1
Subject 12		1			
Subject 13					1
Subject 1	1				
Subject 1	1	1	1		
Subject 1	1				
Subject 17		1	1	1	
Subject 18		1	1		
WINTER					
Particiap	Lente 1	Lente2	Lente3	Lente4	Lente5
Subject 9	1				
Subject 10			1		
Subject 1	1				
Subject 12				1	
Subject 13				1	
Subject 14			1		
Subject 1	1				
Subject 1	1				
Subject 1	1	1			
Subject 18		1			

Figure 17: outcomes micro narratives round 2 user testing

Appendix 4:

Protocol:

At the start of the brainstorm the participants will be introduced to the Tobii pro glasses 2. They will be told what the device is capable of and how it can be used inside of a museum. The participants also need to know that the Tobii glasses consist of a front facing camera that can be used for different purposes and that the device is equipped with a microphone and speakers.

The following questions will be asked to the group:

- Are you aware of the content that can be measured by the Tobii pro glasses?
- What is would be the most compelling use of this data to personalize narrative?
- How could personalized micro narratives enhance your museum experience?
- Are there other methods to give the visitor feedback about his viewing behaviour?
- Would it be better to have one coherent story about art or personalized micro narratives that are put together by the computer?
- Why would a personalized information system be more engaging than a normal audio tour?
- Would you be comfortable with sharing your gaze data with the museum?

Appendix 5: Paintings with micro narratives

LENTE

Introductive audio tour:

This painting is called LENTE, this is one of the first paintings made by the artist Leon Groothaar. For him it denotes a breakthrough within his personal development. The different visual features of the painting are mostly sourced from pictures that are taken throughout the summer.

The question that you can ask yourself while viewing this painting is:

- What image makes you think of the summer?

Micro Narratives:

1. On the left side of the painting, you can see that the artists has written LENTE, This denotes the time in which the events that are depicted on the painting happened. The word LENTE is repeated as if it was a memory that kept on repeating, the word is synthesized until all the vowels were removed.
2. The eye that can be found on the right corner describes the sight of the artist while experiencing the events of his Lente. The eye is created with an oil stick and is left without any colouring exposing what is left in the layer below it.
3. On the right side of the painting a face can be seen beneath the red and purple planes. The face is not completely displayed and resembles an ancient mask.
4. On the dark purple plane, you can find the word zomer written down several times. The word is repeated and also synthesized into a word that doesn't contain vowels.
5. In the left corner of the painting a flower can be seen. The flower is painted with very thick impasto paint, this creates a different structure than the rest of layers of the painting that are flatter.
6. In the middle of the painting a spaceship painted, the artist created this spaceship to express a feeling of freedom.

Winter

Introductive audio tour:

The name of this artwork is Winter, this is the brightest painting inside of the exhibition and therefore the name of this painting can feel ironic. The layers that are built up on the canvas are made in a time span of 6 months. Every 2 weeks a layer was added this results in a painting that is full of different textures.

The question that you can ask yourself while viewing this painting is:

- Which layer came first? And why did the artist keep certain elements?

Micro Narratives:

1. The painting is built up out of multiple layers, an example of this is shown in the top left corner where you can see that the paint layer beneath has a rough texture that gives another dimension to the layer that is on top. These layers work together and make the painting feel more complex.
2. The painting consists out of a mixture of geometric shapes that are complimented with round and organic forms. This contrast is especially visible in the middle left part of the painting. Where a blue plane almost collides with a red geometric triangle.
3. The layers of the painting are formed in an iterative process, this can be seen clearly at the blue stripe on the right side of the painting. The painter tries to puzzle together the final composition by removing parts that don't feel right and adding new planes and colours on top.
4. In the lower right corner, you can see that there are 2 thick black lines placed parallel to each other. You can see that one of the black lines dripped down indicating that the artist has used very thin paint to make these marks.

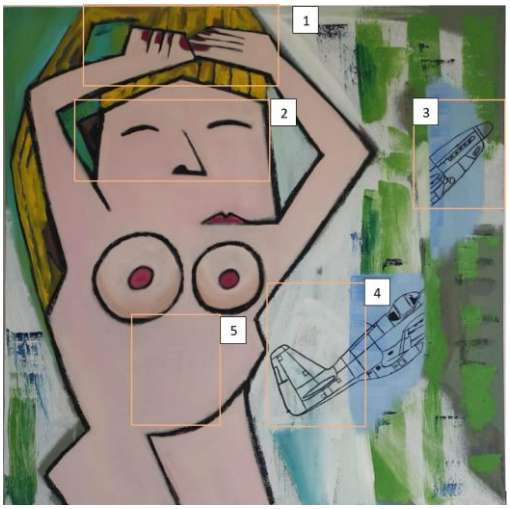
The dancer

Introductive audio tour:

The dancer is a painting that is created to express the freedom the artist felt. The facial expression of the dancer makes you feel as if she is confident about who she is, and what she is doing. The airplane that is painted next to the dancer also expresses freedom, to make the airplane the painter used a different painting technique with thinner paint.

The question that you can ask yourself while viewing this painting is:

- What kind of painting techniques are used to create this picture?



Micro Narratives:

1. With her hands, the figure is re-arranging her hair. The hands of the woman are crudely painted and have a painting technique that looks like early abstract impressionists.
2. The eyes of the woman are squeezed together. This facial expression exerts a feeling of freedom.
3. The nose of the airplane is cut off from the rest of the body. The airplane is pointing towards the sky, suggesting that it will fly away soon. In a broader sense the airplane also conveys the feeling of freedom that relates to the mood of the dancer.
4. Underneath the airplane the painter used newspaper that is glued to the canvas. Over time this newspaper will come loose. If you look closely, you can see that some of the edges are already coming loose.
5. If you look closely, you can see that the painter made a mistake by painting abs, and that this was later removed by the layer on top.

Night tales

The picture in front of you is called night tales, it depicts the emotions that the painter had during the winter. The colours and figures feel obscure and try to portray a feeling of loneliness. The inspiration for the figures that are depicted comes from science fiction movies.

The question that you can ask yourself while viewing this painting is:

- why are there so many different threes?

Micro Narratives:

1. The alien that is depicted in the upper left coroner looks as if it is shining because of the light purple glow that floats around him. The eyes are white and large, suggesting that the alien can see everything.
2. This small shed is a reference to the place that the artist calls home. From the window in his atelier, he is always able to see this shed, and he has chosen to depict it in a way that the shed looks mysterious and spooky.
3. The Three next to the shed stands out from the rest of the three like forms that are depicted on the top of the painting. This three represents the apple tree that is standing next to the shed at the atelier of the painter.
4. On the top right corner another alien is depicted. This one is without eyes and looks friendlier than the alien that is depicted on the left.
5. On the down right corner, you can see a figure of a small pig that seems like it gets captured by an object with a chimney. This image depicts the struggle the artist feels about eating meat.

Appendix 6: User testing protocol:

In this appendix the protocol is stated that will be used for both rounds of user testing. The protocol includes the different steps that should be done in this exact order but will also include the scripts with what the researcher exactly needs to say to the test participants.

1. The test subject should wash their hands with the hand sanitizer that is available, it should also be checked if the participant is wearing a face mask when entering the room.
2. The test subject is asked to sit down and is asked to read and fill in the consent form after reading the information brochure.
3. The researcher should ask the participant if anything is unclear, and if the concept of the Vidi-look is completely understood from the information brochure. If the answer to this is not the following script should be used to explain the goal of the research and the functioning of the system:
    - You are about the get a personalized audio tour from a system that is able to analyse your gaze and analyse this information. The experiment is setup as followed; you first look at four different artworks on the computer. After this analysing phase you will walk to the exhibition room and look at the real artworks, while you are watching the artworks the audio tour will be started by the researcher. The final Vidi-look system will have this same interaction, but the sensor will be different, The final system will work with glasses that can track your gaze. This means that the interaction with the audio tour will be more direct, and your own gaze plot will be invisible.
4. The first survey can be filed in on the laptop of the researcher, this survey contains questions of all the demographic information that is necessary.
5. Now the gaze sensor of the laptop needs to be calibrated, the researcher will help the test subject with this.
6. After calibration the researcher should as the participant to look at the mouse to confirm that the calibration was successful. If gaze blob Is dislocated another calibration sequence should be done.
7. After the gaze sensor is calibrated, the researcher will start the Vidilook program, The participant needs to look at 4 different paintings and this will only take 4 minutes. While the participant is viewing the paintings, the researcher will follow the gaze blob with the mouse.
8. After the audio tour is generated, the participant is asked to view the first painting in the exhibition.
9. After all of the micro narratives are activated and the participant has seen all the paintings, they are asked to fill in the last 2 sections of the survey.
10. A small interview will be done to ask how the participant has experienced the experience; the following questions can be asked in this part:
    - Which micro narrative did you like the most?
    - Which part of the painting did you find interesting but didn’t get a micro narrative for?
    - Is there something that you would like to improve about the current system?

- Would the final system be something that you would like to use in a real museum?

11. The participant is thanked for their time and effort.

Appendix 7: Consent form and information brochure.

The personalized audio tour.

Information brochure

Setup of the research
In the first stage of the experiment the user will have to look at artworks on a laptop. While the participants are looking their gaze is being analysed and translated into a personalized audio tour. In the second stage of the research the participant will walk through an exhibition and listen to the audio tour. One painting that will be shown in the exhibition depicts an abstract image containing mild nudity. Finally, the participant needs to fill a questionnaire about the experience they had. This research will be conducted to get insights into the gaze patterns of museum visitors, and how this information can be used to personalize audio tours. The final goal of this project is to develop new features for a product that is made by the company VidiNexus. The gaze data of the participants will not be shared with VidiNexus and can therefore not be used for commercial purposes. The findings that are made about the system will be shared with the company and can lead to the development of a new feature for their product.

Prerequisites for participation
To use the Tobii pro glasses 2 the participant cannot wear glasses. When the participant is not able to wear contact lenses the user experiment cannot be performed.

Potential risks and inconveniences
In the second stage of the test the user needs to wear the Tobii pro glasses 2, the glasses can be experienced as uncomfortable and can cause dizziness when worn for longer periods. The participant is allowed to put off the Tobii glasses at any time during the experiment if it causes discomfort.

What information will be gathered?
The gaze patterns of the participants will be measured by 2 different sensors, a camera bar in the first part and glasses in the second part. The glasses that are used in the second part will also record the audio of the participant. The gaze data that is collected will be stored and used in the research. The gaze data will be made anonymous, and thereby anonymously used inside the report. Finally, the participant needs to fill in a questionnaire about the experience they had, and observations of the researcher will also be stored.

Compensation
Participants of the user test will receive no remuneration. Participants need to be 18 years or older. There are no further limitations for participants.

Confidentiality of data
No personal data will be extended to third parties. When processing your data for the research, this data will be anonymized. In publication, anonymous data or pseudonyms will be used. The audio-recordings, forms and other documents that are used for this study, will be saved in a secure location at the University of Twente and on (encrypted) data carriers of the researchers.

The data will be anonymized, making it impossible to trace back to a person. The collected data will, when necessary (for control of scientific integrity, for example), only be available in anonymous form, when extended outside the research group. For this reason, the anonymized data will be deleted after a period of 5 years after the final publication of the paper.

Voluntary participation
The participant may discontinue the user test at any moment,
which will have no negative impact for the participant. After a participant withdraws, the data. that is already gathered will be removed completely. The participant also has the right to withdraw from the research within 24 hours after the interview.
For objections regarding the design or execution of the research, you can also contact the secretary of the Ethical Committee of Computer & information Science
at the University of Twente via *ethicscommittee-cis@utwente.nl*

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Tel: +31534893920

“The personalized audio tour.

Consent form

In this study the participant will look at different paintings on a laptop while their gaze is monitored by sensors. The data will be used to personalize the audio tour that the participant will hear in the second phase of the research.

‘I hereby declare that I have been informed in a manner which is clear to me about the nature and method of the research as described in the information brochure. My questions have been answered to my satisfaction. I agree of my own free will to participate in this research. I reserve the right to withdraw this consent without the need to give any reason and I am aware that I may withdraw from the experiment at any time. If my research results are to be used in scientific publications or made public in any other manner, then they will be made completely anonymous. My gaze data or answers to the questionnaire will not be disclosed to third parties. If I request further information about the research, now or in the future, I may contact Leon Groothaar.
Check this box if you have read the declaration:

☐

If you have any complaints about this research, please direct them to the secretary of the Ethics.
Committee of the Faculty of Electrical Engineering, Mathematics and Computer Science at the
University of Twente, P.O. Box 217, 7500 AE Enschede (NL), email:
(*ethicscommittee-cis@utwente.nl*).

Name researcher: Leon Groothaar
Address researcher: Burgemeester M van Veenlaan 313
Tel: 0631387339
E-mail address: *l.groothaar@student.utwente.nl*

Signed in duplicate

	name	Signature	Date
researcher			

I have provided explanatory notes about the research. I declare myself willing to answer to the best of my ability any questions which may still arise about the research.

subject			

Appendix 8: survey Questions

Questionnaire section 1:

1	What is your age?
2	what is your gender?
3	how many museums do you visit on an annual basis?
4	what type of museum do you like to visit?
5	Is it usual for you to go to a museum alone?
6	do you often use the audio tour option in a museum when it is available?

Questionnaire section 2-3-4:

7	How much did the experience of the Vidilook resemble that of a normal audio tour?
8	What where the main differences you experienced between the Vidilook and a normal audio tour?
9	Did the micro narratives relate to the parts of the painting that you found interesting?
10	Did you look at specific parts of the painting because of the question that were asked to you during the audio tour? (This was on the computer)
11	What did you think of the amount of information that was given during the complete experience?
12	What did you think of the amount of information that was generated for the individual paintings?
13	Did you experience the time the system required you to look at a painting too short or too long?
14	where the micro narratives easy to understand? if not please try to indicate which narratives were unclear.
15	was it always clear where you should look when a micro narrative was activated?
16	To what extend did the micro narratives that were provided feel personalized?
17	how did the question that was proposed during the audio tour impact your viewing behaviour?
18	how many micro narratives did you recieve in total? (Ask the researchere if uncertain)
19	Did you recieve the amount of information that you wanted?
20	Which painting did you find most interesting?
21	How much did the experience you just had resemble that of a normal museum visit? Please indicate what you think was different.
22	Do you have any suggestions that could improve the user experience of the system?
23	Would you be comfortable with sharing your gaze data with the museum?
24	Are you still comfortable with sharing your gaze data if it is used for marketing purposes?
25	Would you be comfortable with sharing your gaze data if this data is sold to third parties like other museums or marketing firlms?

Appendix 8: Graphs from the survey:

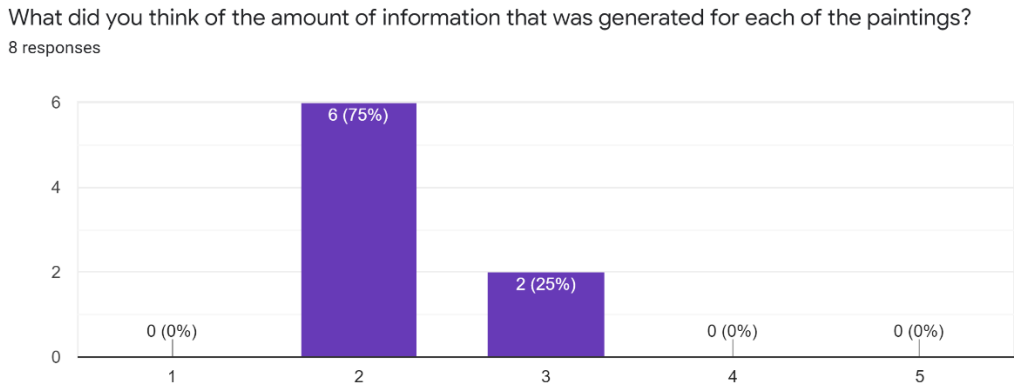

Figure 19: user testing first round (score 1: too little information - score 5 too much information)

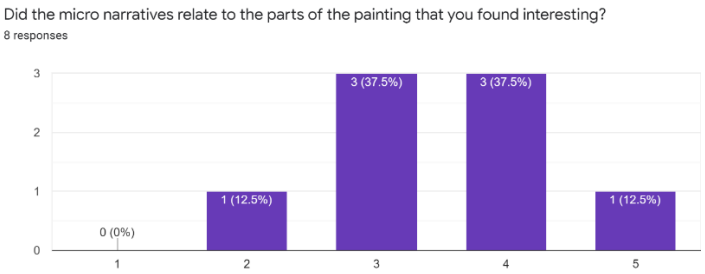

Figure 20: answer to survey question round 1 (score 1: definitely not– score 5: yes totally)

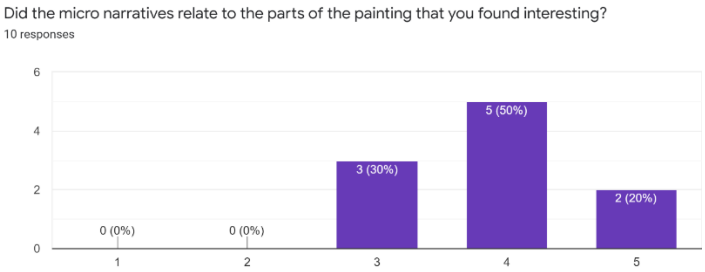

Figure 21: answer to survey question round 1 (score 1: definitely not– score 5: yes totally)

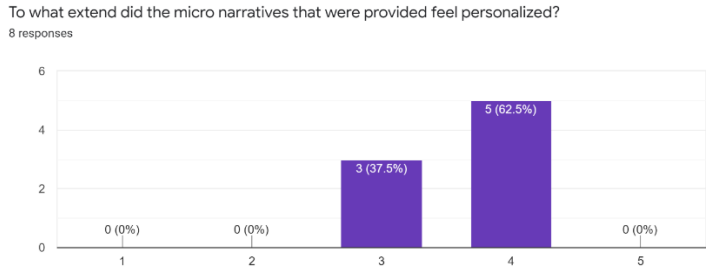

Figure 22: answer to survey question round 1 (score 1: totally not personalized– score 5:completely personalized)

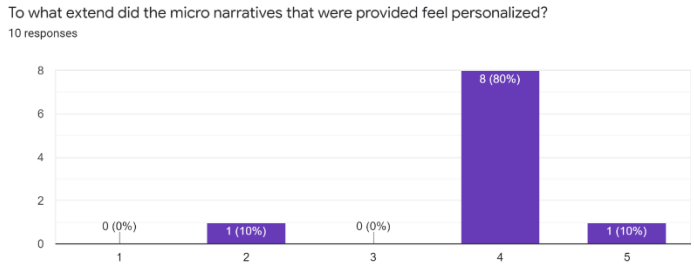

Figure 23: answer to survey question round 2 (score 1: totally not personalized– score 5:completely personalized)

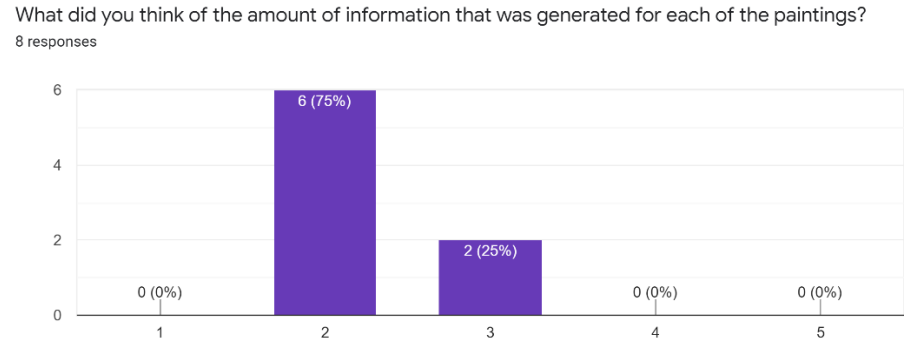

Figure 24: answer to survey question round 1 (score 1: too little information – score 5: too much information)

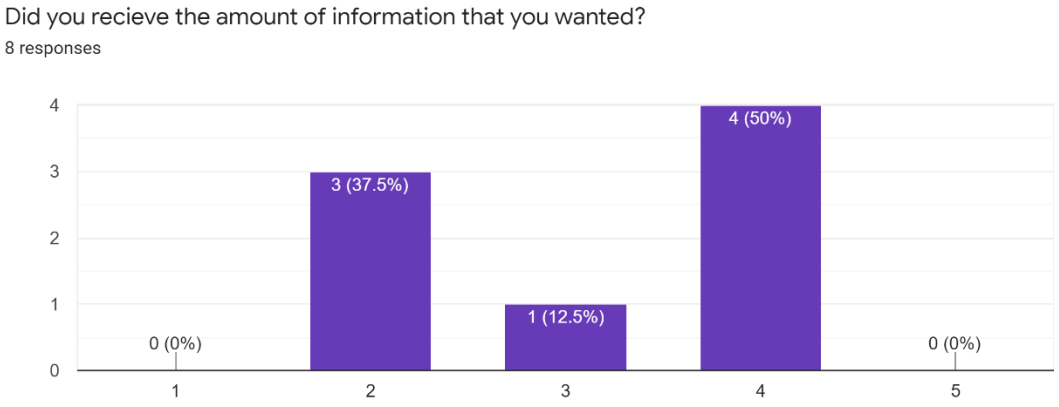

Figure 25:Figure 26: answer to survey question round 1 (score 1: totally not – score 5: yes completely)

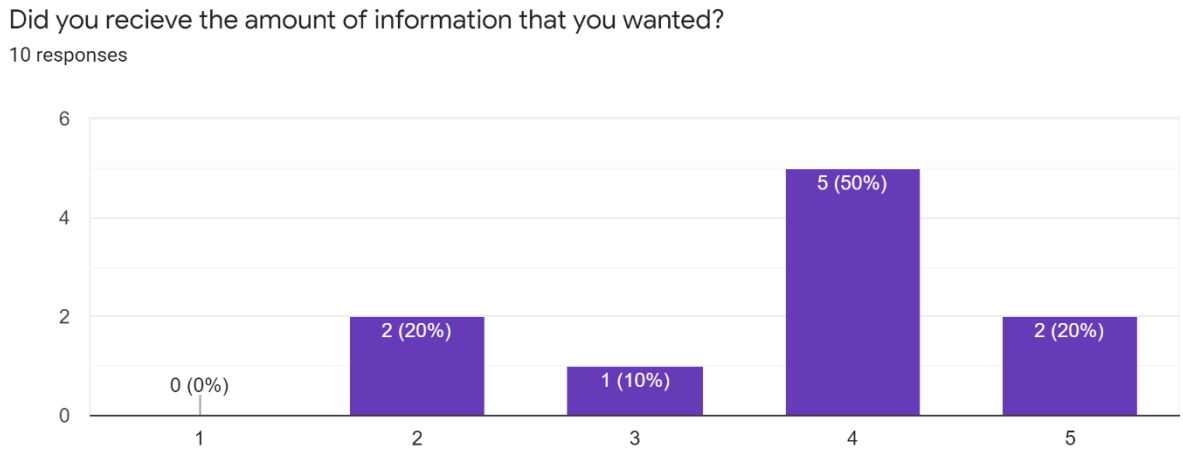

Figure 26:Figure 25: Figure 26: answer to survey question round 1 (score 1:totally not – score 5: yes completely)

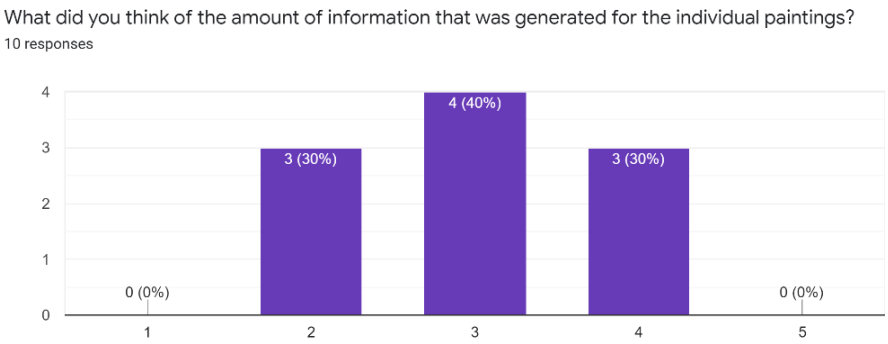

Figure 27:answer to survey question round 2 (score 1: too little information– score 5: too much information)

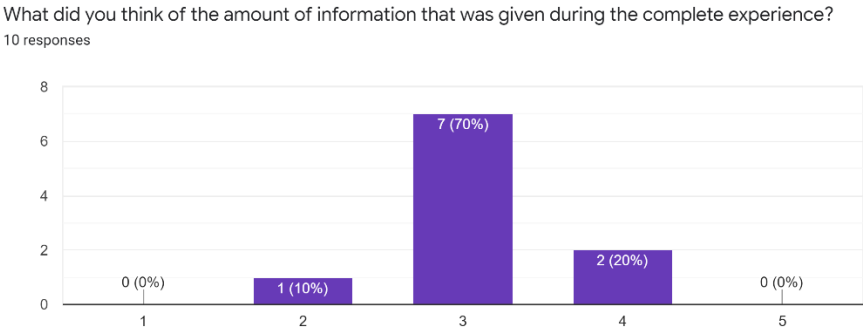

Figure 28:answer to survey question round 2 (score 1: totally not personalized– score 5:yes totally)