

Through the Loupe:

Visitor Engagement With a Primarily Text-Based Handheld AR Application

Merel van der Vaart
ASHMS / Allard Pierson Museum
University of Amsterdam
Amsterdam, the Netherlands
m.j.vandervaat@uva.nl

Areti Damala
Computer and Information Sciences
University of Strathclyde
Glasgow, UK
aret.damala@strath.ac.uk

Abstract—The use of Augmented Reality (AR) in a museum or heritage setting holds great potential. However, until now, introducing AR into their buildings has been prohibitively expensive for most museums. On the one hand, programming the AR application could not be done in-house and would be rather costly. Secondly, the time-consuming production of high-quality digital visuals, often used in AR installations, needed to be outsourced. With the arrival of several AR engines, creating the actual experience has become easy, relatively fast and cheap, meaning the costs and skills associated with content creation might be the prime reason for particularly small and medium sized museums to not engage with the use of AR. This begs the question: Can other, simpler, types of content, such as texts, also be used to create a valued AR interpretation tool? This paper will discuss a study that has made a first attempt to answering this question. In addition, it explored the role AR can play in improving engagement between visitor, the object and its related information. The Loupe is a handheld AR application that was designed and tested as part of the meSch project. For this study, content, mainly consisting of text, was created for the Loupe at the Allard Pierson Museum. The tool was then tested with 22 participants who were asked to use the Loupe, either alone or together. Through questionnaires, observations and interviews, participants' engagement with and response to the Loupe were analyzed. This paper will discuss the findings of that study, focusing on the way the Loupe influenced the relationship between visitor and object, as well as the value of textual content as part of such an AR tool.

Index Terms—Augmented Reality, Exhibition Texts, Museum, Distraction, Visitor Behavior, Visitor Study

I. INTRODUCTION

These days, many museums aim to enhance the visitor experience through the use of on-gallery digital installations. One of the returning challenges when developing these installations is the issue of competition between digital exhibits and exhibits containing physical objects [1], [2]. Although digital installations are often intended to enhance visitors' understanding of, or engagement with a museum's collections, visitors often find themselves in a position where they have to choose whether to focus their attention on the digital offer, or the physical object itself [3]. Augmented

Reality (AR) can bring object and information more closely together, as it visually surrounds objects or exhibits with additional digital content.

Though historically [4] the first AR applications were developed mostly for outdoor Cultural Heritage sites, [5], [6], [7] and were cumbersome and bulky, the recent, mass adoption of mobile, personal, multimedia-capable devices led to a whole new generation of mobile AR applications for museums and galleries [8], [9], [10]. The MEandertal application, developed by the Smithsonian National Museum of Natural History (Washington, USA) allows visitors to examine what they would look like as prehistoric humans through a powerful morphing application. The Museum of London (London, UK) Street Museum app allows visitors to overlay images from the museum's photography collections on present day London street scenes [11]. The Van Gogh Museum (Amsterdam, the Netherlands), used AR to assist visitors visualize x-rays, infrared and ultraviolet captures on top of original paintings [12]. More recently and within the framework of the CHESS EU project, museum visitors at the Acropolis Museum (Athens, Greece) were able to visualize the original colors of archaic Greek sculptures, using portable devices [13]. There is a wide range of potential uses of AR for museums and Cultural Heritage settings [14], using as a point of reference, the real, physical object that can be augmented with different types of media: 2D images and animations, 3D visual overlays and animations, text, audio and of course hyperlinks to relevant online content [15].

Until recently, creating AR experiences required advanced programming skills, forcing most museums to outsource the development of these types of experiences, resulting in relatively high production costs. Today, creating AR experiences has become easier, because of the arrival of various AR engines or creators, such as Layar, Aurasma, InstantAR and Metaio Creator.¹ These engines facilitate the production of an AR experience by asking users to simply digitally link images of the objects that need to be augmented

¹ <http://humanorigins.si.edu/resources/whats-hot/meandertal-mobile-app-0>, <https://www.layar.com/>, <http://www.aurasma.com/>, <http://instantar.org/>, <http://www.metaio.com/creator/>

with the required AR content, for example through the use of a drag and drop interface. By using an off-the-shelf AR engine, creating and updating AR experiences has become feasible and affordable for many museums.

However, the creation of the actual experience is not the only costly element related to the use of AR in the museum environment. AR installations are generally perceived as reliant on high-quality visual content. This content cannot be made in-house by most museums. Its production is time-consuming, and therefore costly, especially when outsourced. If the availability and production costs of high-quality visual content has been prohibiting heritage organizations to embrace the use of AR, it is relevant to ask whether simpler, cheaper forms of content could be a suitable alternative. For example, textual content can be, and is being, produced in-house by most heritage organizations. If simpler forms of digital content can prove to be a suitable content-type for meaningful, object-centered AR experiences, creating these type of experiences could become feasible for many smaller and medium-sized museums across the world; it could also allow them to experiment and become familiar with AR applications prior to engaging in long-term projects, which are often demanding in terms of budget, infrastructure and human-resources.

The study described in this paper explores how visitors respond to and engage with an object-focused AR installation, called the Loupe, which was developed as part of the meSch project. This paper will explore how visitors engaged both with the content of the Loupe and the objects that were included in the AR experience. The content of the Loupe was almost exclusively created in-house by the Allard Pierson Museum (APM), the archaeology museum of the University of Amsterdam, the Netherlands, with support from Waag Society within the framework of the EU meSch project [16]. The goal was to see if simpler forms of digital content can be effectively combined with AR. Consequently, the content included in the Loupe consisted mainly of small chunks of text, two 2D animations, three images and one audio file. During content production, as well as data analysis, this study relied on existing research on the behavior and text-reading habits of visitors in object-centric museum spaces.

For decades, academics and museum professionals have studied the behavior of museum visitors inside the exhibition space, including the way visitors interact with museum text. The outcomes of this body of research and the best practices that arose from it, however, rarely directly influence studies focusing on visitors' interaction with text-based, digital, in-gallery installations. Rather than referencing existing knowledge of visitor behavior in a similar context, the museum space, these studies often refer to research on the use of similar media, such as touch screens or mobile apps, mostly conducted in the field of Computer Science. This paper will give an overview of the museological research that has been carried out over the past decades, analyzing visitor behavior in relation to objects and texts, with an emphasis on museum displays of archaeological or historic collections. It will then give a description of the Loupe, including information about the way requirements for 'good museum text' informed the

content development for the Loupe. In addition, it will analyze if and how the findings of previous research on visitors' on-gallery behavior correspond with the outcomes of this specific study. This might be a step towards better understanding how the restrictions and possibilities of a chosen medium, text label or handheld AR device, can influence the way visitors engage with the textual information it provides, as well as the objects the text refers to. Finally, this paper will reflect upon the potential of text-based object-focused AR content as a relatively cheap yet meaningful complement and alternative to rich visual AR content for medium sized and small museums that are dependent on in-house content creation.

II. VISITORS: WHAT DO THEY READ?

Traditionally, museum professionals communicated with their audiences through only a limited number of media, of which objects and text, apart from face-to-face interaction with a member of staff, were the most prominent. This triangle of visitor, object, and textual information still often forms the basis for visitors' interaction with object-centric museum displays. Of course, this interaction triangle forms only a part of visitors' experience in the museum [17], [18], [19], but when exploring the use of digital media on-gallery, the relationship between visitor, object and information should certainly be taken into account.

In the 19th century, the main museological narrative, particularly in non-art museums, explained the world to museum visitors through a story of progress, order and hierarchy. This story was told primarily by grouping objects in certain ways, and only limited additional textual information was provided [20]. In the 20th century, the taxonomic display of objects fell out of fashion and museums instead favored more complex messages and storytelling [21]. At the same time, the use of text in museum exhibitions increased significantly [22]. This medium being so ubiquitous has led to a considerable body of research on the way visitors engage with and use museum texts [23], [24], [25], [26], [27], [28], [29]. Consequently, it has inspired a series of best practices that, although not always applied in museums, are considered to facilitate optimal use of texts by visitors during their museum visit. These best practices, as well as the findings related to general visitor behavior on-gallery, have informed the creation of both concept and content of the Loupe as described in this paper.

III. VISITOR BEHAVIOR

Many studies that have analyzed visitor behavior in traditional museum settings have identified an important discrepancy between the way museums convey messages through the display of objects and text, and the way most visitors use an exhibition space. Often, museums design their exhibitions, be they chronological or thematic, as a linear experience, similar to reading a book. Most exhibitions, therefore, have a beginning, a middle consisting in various chapters, or themes, and an end. However, visitors rarely follow this linear approach and move through the space in a seemingly random way [17], [24], [30]. Within this general

behavior pattern, several researchers have identified behavioral differences within two, often small, subgroups of visitors.

The first subgroup distinguishes itself by spending a comparatively large amount of time engaging with the exhibition's physical or textual content. Serrell refers to these visitors as 'diligent visitors' [24], Bitgood and Patterson describe them as 'motivated' [25]. Their research implies that these visitors are somehow more intrinsically motivated than other visitors, for example because of a personal interest in the subject matter. The second subgroup of visitors that show alternative behavior are called 'skilled visitors' by Rounds [30], whereas Falk and Dierking use the word 'experienced' to describe this type [17]. Their behavior is described as more efficient and focussed [17], and one could argue that as a consequence their visit is more satisfactory [30]. These studies imply that, over time, people who visit museums can develop certain skills that can help them make sense of the museum environment and optimize their use of it. Understanding visitors' on-gallery behavior can inform our analysis and expectations of their use of digital installations. For example, does this use seem to match existing visiting patterns, or does it move visitors to use the exhibition space in a distinctively different manner? Both motivation and experience seem to have impacted the outcomes of the Loupe study, as will be discussed in section VI. Furthermore, for this study one specific aspect of visitors' behavior in the museum space requires further examination, namely their use of on-gallery texts.

A. Reading Text

Much research has been dedicated to understanding how visitors use textual information on gallery and how they decide what to read. As a consequence, numerous descriptions of best-practices have emerged. This paper will try to identify those findings related to reading behavior and 'good writing practices' that are not related to the physical text label as such, but that refer to reading and textual interpretation more generally, expecting they might also hold true for digital museum texts.

As discussed earlier, visitors rarely follow an exhibition narrative as is intended by the exhibition designers. Most visitors tend to stop at a limited number of exhibition elements, such as objects or text labels [24]. Rounds [30, pp. 391] describes visitors as "strategic agents – as people who are up to something, and who tailor their behavior to fit their present goals and situations". Understandably, the fewer texts visitors read, the less likely they are to capture the main narrative of an exhibition or exhibit. Bitgood points out two aspects that influence whether or not visitors read texts: Firstly, visitors have a preference for looking at 3D objects and therefore are more likely to read texts that refer directly to an object. Secondly, reading a text requires attention. Attention has focusing power, it helps visitors focus on a specific exhibit or exhibition element. However, attention is also selective, a person can only pay attention to one element at a time, and the total amount of attention a visitor can pay is limited [26].

The limited amount of time and attention visitors bring to an exhibition force them to make decisions as to which texts to read and which texts to ignore. Visitors are more likely to focus on objects or texts that are salient, or distinctive [26]. They are less likely to spend time on displays or texts that do not provide near-instant gratification [24]. If information is provided as a series of shorter texts, more visitors are likely to read them than when the same text is provided on a single text panel [25]. Texts can be made easier to read by using short, uncomplicated sentences without sub-clauses or jargon [26], [28]. Other techniques that could increase 'cognitive-emotional arousal' are asking questions, identifying high-interest content, using mental imagery, advising visitors what to look for in an object, and providing a clear message [26]. A study by Bitgood and Paterson showed that visitors who engaged in reading text labels also spent more time looking at the objects the labels referred to [25]. This would suggest that, rather than being distracting, museum text can encourage or facilitate object-visitor interaction.

IV. DESCRIPTION OF THE LOUPE AND THE TOUR

The Loupe is one of the prototypes that have been developed within the meSch project [31]. It has the form of a wooden magnifying lens in which an iPhone is enclosed. The visitor uses the Loupe to examine museum artifacts and exhibits more closely. The camera of the iPhone runs an image recognition algorithm that recognizes the objects for which content is available. When one of the objects included in the application is recognized, digital content, such as text, images or animations, appears on the Loupe's display. Several types of intuitive interaction metaphors have been developed for the Loupe (i.e. shaking the loupe, tilting to the left or to the right, or zooming) and can be mapped with different functions. Currently, an easy to use authoring tool is being developed that allows museum professionals to create their narratives for the Loupe, among other devices, using "recipes" [32]. The Loupe could be used in two ways. Firstly, it could facilitate visitor-led exploration of individual objects, providing additional information about an artifact upon request. Secondly, the Loupe could offer visitors a thematic tour. For this study, AR content could be developed for only a limited number of objects on display. Previous studies at the Allard Pierson Museum where AR content was available with a limited number of objects had shown that many visitors found it challenging to identify the 'augmented' objects, despite the use of clear indicators and markers. Therefore, it was decided to develop a dedicated tour as part of this study, guiding visitors from one 'augmented' object to the next.

A series of validation studies of the Loupe with museum visitors and museum curators alike, had been conducted in three museums; Museon (the Hague, the Netherlands), the APM, and the National Museum of History (Sofia, Bulgaria). One of the recurring research questions that emerged during these studies was related with the issue of attentional balance of the visitors. More specifically, the museum curators encouraged us to further explore how the attention and focus of visitors is distributed between the Loupe and the physical

objects included in the Loupe's offer. The validation studies at Museon and the National Museum of History had used children as their target audience. During these studies it became clear that children were easily distracted by the challenge of finding the object, paying little attention to either the content or the physical objects as a result. Because of this, and because the main audience of APM consists of adults, this study focused on the use of the Loupe by adults instead. Alongside this question about attention balance, the APM wanted also to experiment with simpler forms of digital content, to be delivered through the Loupe (text, 2D images and animation, audio). Particular emphasis was given on the role of text when combined with a mobile AR application.

Having these two questions in mind and after carrying out a series of tests in the APM, a final selection of objects to be included in the tour was made. Limitations of the object recognition software were also taken into consideration at this stage. For objects to be easily recognized, they have to be well distinguishable from their surroundings, for example through contrast and clear lighting. In addition, it is important that the camera image that is offered to the AR software is unlikely to change from one moment to the next. Changing reflections or shadows, for example from sunlight, and showcases that have glass on all sides, providing the possibility of other visitors stepping into the picture, should be avoided. To facilitate identification of the objects that were part of the tour, it was decided to choose objects that could all be found in the same showcase. From this case, themed 'Ancient Greek gods and heroes' (Fig. 1a) a series of six objects, four ceramics and two statuettes, was chosen. The AR tour highlighted an additional story within this showcase, which contained eighteen objects in total; the story of the "Children of Zeus". For each object approximately five to six chunks of text were available. One audio file, two 2D animations and three images (Fig. 1d) were also included in the tour.

Though the Loupe is a prototype mature enough to accommodate any type of digital content with which a museum artifact can be augmented – including a powerful zoom-in feature that allows visitors to zoom-in museum artifacts' details – all by allowing the use of different interaction metaphors that can be coupled with different functionalities for the museum visitor, such as tilt left, tilt right, tilt backwards, tilt forwards, and shake, in this study our aim was to keep the interaction metaphors as simple as possible and experiment with types of digital content usually widely available to museums and Cultural Heritage institutions.

A stand where visitors could pick up the Loupe and read instructions on how to use it was installed next to the showcase. Study participants were asked to approach the showcase and read the instructions. They would then pick up the device. When the Loupe was held upright for the first time, a small introductory text appeared on the screen. This informed visitors that an outline, matching the shape of the object the visitor had to look for, would appear on the screen. Once the outline appeared (Fig. 1b), the visitor had to detect which object matched the outline displayed on the Loupe.

Visitor validated their choice by trying to match and align the virtual outline with the object on display. Upon a successful match, the outline would pulse and then fade out (Fig. 1c), to be replaced by the digital content for that specific object. For each object, at least 5 to 6 short chunks of text and sometimes images of objects with iconographic parallels were available. To navigate through the content, visitors could tilt right to go forward in the narrative or left to go back. After the last piece of content for a specific object had been shown, a new outline would appear, prompting visitors to identify the next object in the tour. For a visitor going through all the content, the tour lasted approximately 15 (+/- 5) minutes.

V. EVALUATION PROTOCOL

The study described in this paper took place over a period of seven days. In total 22 participants were recruited through the Friends of the APM, among the University of Amsterdam library staff and through the use of social media. Some of these participants were single visitors, others were part of a visiting couple. The study consisted of four phases. First, participants were given a verbal introduction to and explanation of the study, after which they filled out a pre-visit questionnaire consisting of questions related to demographic data, as well as questions about their general preferences in relation to museum visiting and the use of technology. Secondly, participants were observed using the Loupe in the museum. After using the Loupe, each participant filled out a second questionnaire, which focused on their experience of and appreciation for using the tool. Finally, a semi-structured interview with each visiting entity, either the individual or the couple, was conducted, mostly focusing on the relationship between the participants, the object and the content of the Loupe. Unfortunately, it was not possible to conduct this interview with all participants to the study. In total, fifteen interviews were conducted with twenty individuals; five interviews were double interviews, with interviewees who had used the Loupe together. As described previously, the emphasis of this paper will lie on participants' engagement with the objects and the Loupe's content, specifically the textual content that was provided in the tool.

VI. OUTCOMES

A. Participants' Profiles

The characteristics of the recruited participants, as collected through the pre-visit questionnaire, mostly matched those of the museum's regular visitors. The higher age ranges were well represented, with twelve participants aged between 45 and 64 and an additional three participants over 65. In addition, six participants were aged between 18 and 24 and the age of one individual lay between 25 and 34. The 35 to 44 age bracket was not represented. Fifteen women and seven men participated in the study. Twelve participants took part in the study together with a partner, which resulted in six couples and ten individual users taking part. All participants were frequent museum-goers, with sixteen of them visiting a museum four

times a year or more and the other six visiting a museum two or three times a year. Fifteen participants confirmed that they would usually visit a museum together with friends or family. The others generally visited museums alone. Nineteen participants indicated they were interested or very interested in Greek mythology.

All participants could be described as digitally literate, with nineteen out of 22 indicating they used the Internet on a daily basis and twenty saying they felt confident of very confident in using digital applications and devices, such as smartphones, tablets and PCs.

Of the 22 participants that took part in the study, seven were a member of the Friends of the Museum, all of whom were 45 years or older. Friends of the museum are known to be familiar with the museum's collections. Among these seven Friends, the gender balance was more equal, with three men and four women taking part, in comparison to four men and eleven women among those who were not a Friend of the museum.



Fig. 1a-1d: The Loupe and the study set-up.

B. Museum Interpretation preferences and the Loupe

Before discussing the potential for the Loupe to strengthen the visitor-object-information triangle, this paper will briefly look at the general museum interpretation preferences of the visitors involved in the study and their appreciation of the Loupe as an interpretation device. One of the questions in the pre-visit questionnaire inquired after people's preferences with regards to museum interpretation tools by offering a list of options of which one or more could be chosen. Interestingly, paper-based textual media, such as text guides, books and brochures were favored most. Half of the participants, eleven out of 22, chose at least this interpretation type from the list. Audio guides proved to be almost as popular and were chosen by ten participants. Besides these two most popular interpretation tools, the preferences of Friends and non-friends diverged. The third most popular tool with Friends was the guided tour, with three out of seven friends favoring this type

of interpretation. In contrast, non-friends seemed to be more favorable towards onsite interactive kiosks and displays. This option was chosen by six non-friends, but only two Friends of the museum also liked this option.

Both the interview results and the questionnaire data clearly show that participants were positive about the Loupe. In thirteen of the fifteen interviews, it was stated that the Loupe as a tool had added value for the museum visit. Twelve interviews had it confirmed that the content provided by the Loupe offered added value. In the questionnaires this general positive attitude towards the Loupe was supported by answers related to gaining knowledge and understanding. Eighteen out of 22 individuals confirmed that using the Loupe helped them better understand the museum objects included in the tour, while nineteen said the Loupe helped them better understand what was depicted on the objects. Also in the questionnaire, despite the high level of existing interest and knowledge on the subject of Greek mythology, all participants but one indicated they had learned at least one new thing about Greek mythology they didn't know before, and twenty had recalled at least one thing they had learned in the past.

C. Information, Visitors and Objects

When analyzing the triangular relationship between the Loupe, the visitors and the objects on display, it becomes clear that this relationship is both complex and highly personal. In the questionnaire participants were asked to what degree they agreed or disagreed with the following statement: Using the Loupe distracted me from the original works of art. This question received mixed responses. Almost half of the participants, ten out of 22, agreed, while one person strongly agreed with this statement. However, seven gave a neutral response, while four strongly disagreed with the statement. The fact that many participants appreciated the Loupe as a tool, suggests that the sense of being distracted from the original objects is not necessarily viewed to be negative, or can at least be counterbalanced by other factors, with a positive experience as a result.

A more detailed view of this seeming contradiction between being distracted from looking at the objects, but nevertheless valuing the use of the Loupe, arises when taking into account the interview data. Of particular interest are those participants who describe the Loupe as distracting them from the objects. When asked whether they felt the Loupe invited them to look at the objects, five out of seven interviewees from this group responded positively, or partly positively. This indicates that the Loupe could be experienced as both a distraction, as well as a tool that helps one look at objects, at the same time. Several of these interviewees reflected on the role of the different types of textual content that were offered by the Loupe. Some content offered mythological narratives related to the characters depicted on the various objects. Some content consisted of questions, actively referring to the visual qualities of an object. These questions were described by interviewees as inviting visitors to look at the object more closely and helping them reflect on the related narrative they had just read. Some also described the Loupe as a tool that

could be used to access extra information, but that is easily ignored whenever a visitor has more subject knowledge.

When asked whether they felt they had looked at the objects enough, only one individual was completely negative and said the textual content was distracting. One individual described how using the Loupe interfered with the usual first, perhaps aesthetic, encounter with the object. Instead of first looking at the object and questioning its physical appearance in order to gain understanding of the artifact, one could simply read the provided text. Reading, this individual claimed, was easier and as a result a visitor would become lazy. However, this same individual also expressed a desire to use the Loupe with every object. Here an echo of Bitgood's attention model can be heard, in which he describes how attention is limited and gets depleted over time, suggesting visitors would benefit from an efficient, what one could call lazy, use of the available attention [26]. Other individuals mentioned how they had to get used to the Loupe first, before having attention for the objects again, or reflected on their personal experience and skills which meant they found it easy to look at objects and get information from that experience, whereas others might need help doing this. One couple reflected on their usual interaction with objects. One of them explained she would usually spend more time looking at objects, but knowing less about them, while the other person said he would usually look at objects briefly, unless he knew and liked the story that was related to it.

As part of the interview all participating visitors were also asked whether they would have spent more time, less time, or the same amount of time looking at the objects, if they would not have used the Loupe. Only in three interviews participants confirmed they would have spent more time looking at the objects, if they would not have been given the Loupe. One of these interviews was conducted with a couple, who stated they would have looked at the objects and discuss what they remembered of the depicted characters and the myths related to them. In six interviews, representing eight individuals, the interviewee(s) stated that they would have spent less time looking at the objects and in five interviews, seven interviewees highlighted they would have looked at the objects in a different way. In one interview, which was part of this latter group, the interviewees described how the Loupe highlighted visual elements that they would not have noticed themselves. Interestingly, six of the interviewees who indicated they would have spent less time looking at the objects, or would have looked differently at the objects without the Loupe had confirmed they found the Loupe distracted them from looking at the objects when filling out the questionnaire. This seems to signal that shifting the attention balance in the visitor-object-information triangle is not necessarily experienced as being negative.

Throughout the interviews two recurring discussion topics brought forward by interviewees could be identified. Firstly, there was the fact that the narrative text did not invite interaction with the objects the way the questions did. The second topic that was often touched upon was the way both personal knowledge and museum-going experience influenced

the way the Loupe was used and appreciated. The way the second issue in particular was discussed by various interviewees, for example by reflecting on their personal experience of looking at objects, or on their knowledge of and interest in Greek mythology, echoes the description of skilled or experienced visitors by Rounds [30], Falk and Dierking [17] and that of diligent or motivated visitors by Serrel [24], Bitgood and Paterson [25]. As Rounds [30], Falk and Dierking [17] describe, skilled or experienced visitors are more efficient and focused during their museum visit, this matches the way some of the participants reflected on their own visiting behavior, saying they were very experienced and knew how to gain knowledge by looking at objects, or indicated they were familiar with the Greek myths and the characters depicted on the objects, making it easier for them to 'read' the objects as it were. While diligent and motivated visitors were described as spending a relatively large amount of time engaging with objects and associated text [24], [25] some participants to this study similarly described how they would spend time with objects, move between reading text and looking at the object, or would go back to certain objects several times in order to get a better understanding of them.

Reflecting on the relationship between Loupe, visitor and objects it becomes clear that visitors with different visiting behaviors, including diligent or motivated and experienced or skilled visitors appreciate the Loupe as an interpretation tool, but used the tool differently. It also shows that an interpretation tool, such as the Loupe, can shift the balance, particularly for diligent and skilled visitors, between time spent interacting with the objects directly and time spent with related interpretation materials. However, in the case of the Loupe this shift in balance, noticed by visitors, is not often experienced as negative. Indeed, visitors highlight how the Loupe provided unknown information and encouraged them to look at objects longer, or in new and different ways.

D. The Use of Text in the Loupe

As described earlier, the Loupe primarily contained textual content and this study aimed to better understand how visitors responded to this type of content, particularly as part of an AR tool. In the interview participants were asked how much of the text in the Loupe they had read. In nine out of fifteen interviews it was confirmed the interviewee(s) had read all the text. In three cases most of the text was read and in three more cases some of the text was read. As said before, when asked whether they felt the content of the Loupe added value to the visit, in eleven out of fifteen interviews participants either agreed or strongly agreed. One individual was of the opinion that the Loupe added some value and two individuals did not answer this question. One person suggested the value added by the content depended on an individual's personal knowledge or experience. As well as several questions in the interview focusing on interviewees' response to the textual content, participants themselves also often commented on this emphasis on text. Some made positive remarks about the narrative nature of some of the text and several interviewees said that, although there was more text than would generally be presented on a

text label, the fact that the text was broken up in small sections meant they were more inclined to read all the text. Some also mentioned being driven by curiosity to read more after each short section of text. A number of them referred to what they called their own impatience with regards to reading traditional texts in the museum space. The challenge to find the objects and the fact that information was divided in short sections helped them overcome this impatience. A few participants mentioned how they believed the texts were suitable for people with various levels of pre-existing knowledge, because they combined a summary of mythical stories, which could be an entry-level introduction or a brief reminder for those with more knowledge, with texts that directly related to the specific objects that invited participants to look more closely. The ease of combining reading the texts and looking at the objects was also mentioned.

These responses seem to indicate that indeed text can be a suitable alternative to high-quality visual content for AR tools. What they also emphasize is the fact that, at least regular museum-goers, not only respond well to texts that are written according to best practice suggestions, but can also identify some of the elements that are considered to be best practice without invitation. Short sentences, easy language, referencing the object and dividing the text in several shorter sections have all been identified as generally making museum texts easy to read [25], [26], [28], and were all mentioned by at least one, but often several of the interviewees. This does not mean, however, that visual content does not have a very strong role to play as part of AR experiences. When interviewees were asked to share the most memorable object or piece of information they had seen, ten mentioned content that had included an animation and three identified content that included a sound clip. When asked what their favorite object was, again nine interviewees mentioned an object for which an animation was available. Here it is important to mention, however, that both animations consisted of simple .gif images. This seems to indicate that even fairly basic visual content can have a positive impact on visitors' experience, which is something museums with a limited budget could certainly benefit from.

VII. CONCLUSIONS AND DIRECTIONS FOR FUTURE WORK

We can conclude that, when engaging with a specific exhibition element, visitors divide their attention, among other things, between the physical objects and the accompanying information. Previous research [24], [25], [26], [30], as well as the responses from some of the participants of this study all suggest that text labels are often not thought to be attractive interpretation tools, and most visitors have a bias towards interacting with 3D objects [26]. When given the opportunity to use an AR device, such as the Loupe, visitors' attention can shift towards this device. However, as the Loupe study has shown, textual content can actively encourage users to also pay attention to the object. In addition, this study suggests that spending more time looking at a specific object does not necessarily enhance the visiting experience. The most positive museum experience seems to combine interaction with the object itself with time spent engaging with information

associated with the object. This information should provide visitors with specific information about the object, giving them a fuller understanding of the object itself. This result of the Loupe study matches findings of Serrell [24] and Bitgood [26], among others.

In addition, this study suggests that AR tools can encourage visitors to read a larger amount of text than they would usually do, because of the ability to closely link text and object, because of the interactive element of finding the right objects and because the text can easily and playfully be divided in many smaller sections. It also shows that using relatively simple digital content, such as text and images, for AR handheld devices can still result in a digital tool that is highly appreciated by visitors. This potentially puts the development of AR experiences in the hands of museum professionals in small and medium sized museums.

Future research might compare the engagement and reading behavior of visitors when confronted with more traditional exhibition media, such as text labels, with the expected behavior as it was described by visitors themselves. This could be done by evaluating visitor engagement with either a touch screen application or a paper booklet, containing the same information as the Loupe AR tour.

ACKNOWLEDGMENTS

1. The research leading to these results has received funding from the European Union Seventh Framework Program (FP7/2007-2013) under grant agreement no. 600851.
2. The researchers would like to thank the staff of Waag Society, the Curator of the APM, Geralda Jurriaans-Helle, as well as all the contributing participants, for making this study possible.

REFERENCES

- [1] A. Woodruff, *et. al.*, "Electronic Guidebooks and visitor attention," in Proc. 6th Int. Cultural Informatics Meeting (ICHIM '01), Milan, Italy, 2001 available at <http://www.cs.cmu.edu/~akhurst/publications/2001-Woodruff-ICHIM2001-VisitorAttention.pdf>
- [2] E. Hornecker, "'I don't understand it either, but it is cool'" - Visitor Interactions with a Multi-Touch Table in a Museum," in *Proc. of IEEE Tabletop 2008*, 2008, IEEE, pp. 121-128.
- [3] A. Damala, *et. al.*, "Bridging the gap between the digital and the physical: design and evaluation of a mobile augmented reality guide for the museum visit", in *Proc. of the 3rd Int. Conf. on Digital Interactive Media in Entertainment and Arts*, Athens, Greece, 2008, ACM, pp. 120-127.
- [4] A. Damala, "An introduction to Augmented Reality and cultural heritage for curators, art historians and museum educators," in *La Cocina valenciana del Museo Nacional de Artes Decorativas: Una relectura a través de la tecnologiade Realidad Aumentada*, A. Cabrera Lafuente, I. Rodriguez Marco and C.V.F. Villar Frenandez, Eds. Madrid, 2013, pp. 120-133, available at: https://sede.educacion.gob.es/publiventa/descarga.action?f_codigo_agc=14591C&request_locale=en
- [5] T. Gleue and P. Daehne, "Design and Implementation of a Mobile Device for Outdoor Augmented Reality in the

- ARCHEOGUIDE Project,” in *Virtual Reality, Archaeology, and Cultural Heritage International Symp. (VASTO1)*, Glyfada, Greece, 2001, pp. 161-168.
- [6] D. Scagliarini, *et. al.*, “Exciting understanding in Pompeii through on-site parallel interaction with dual time virtual models”, *Proc. of the 2001 Conf. on Virtual reality, archeology, and cultural heritage*, Glyfada, Greece, 2001, ACM Press, pp. 83-90.
- [7] D. Pletinckx, N. Silberman, and D. Callebaut, “Presenting a monument in restoration: the Saint Laurentius church in Ename and its role in the Francia Media heritage initiative”, in *Proc. of the 2001 Conf. on Virtual reality, archeology, and cultural heritage*, Glyfada, Greece, 2001, ACM, pp. 197-204.
- [8] A. Angelopoulou, *et. al.*, “Mobile Augmented Reality for Cultural Heritage, in Mobile Wireless Middleware”, *Operating Systems, and Applications*, N. Venkatasubramanian, V. Getov, and S. Steglich, Eds. Berlin Heidelberg: Springer, 2012, pp. 15-22.
- [9] M. Schavemaker *et. al.*, “Augmented Reality and the Museum Experience”, in *Museums and the Web 2011*, J. Trant and D. Bearman, Eds. Toronto, Canada 2011, http://conference.archimuse.com/mw2011/papers/augmented_reality_museum_experience.
- [10] T. Chatzidimitris, *et.al.*, "Mobile Augmented Reality edutainment applications for cultural institutions," in *Fourth Int. Conf. on Information, Intelligence, Systems and Applications (IISA)*, Piraeus, Greece, 2013, pp.1-4. doi: 10.1109/IISA.2013.6623726.
- [11] E. Zolfagharifard, “Streets of London now... and then: Stand still and picture yourself in history with app that creates hybrid images of present and past”, in *Daily Mail London*, 26th of February 2014, available at <http://www.dailymail.co.uk/sciencetech/article-2567739/Streetmuseum-app-creates-hybrid-images-London.html>
- [12] W. van Eck and Y. Kolstee, “The augmented painting: Playful interaction with multi-spectral images,” in *Mixed and Augmented Reality (ISMAR-AMH), 2012 IEEE Int. Symp.*, Atlanta, GA, USA, 2012, pp. 65-69.
- [13] L. Pujol, *et. al.*, “Personalizing interactive digital storytelling in archaeological museums: the CHESS project,” in *40th Annu. Conf. of Computer Applications and Quantitative Methods in Archaeology*. Southampton, UK, 2012, pp. 77-90.
- [14] A. Damala and N. Stojanovic, “Tailoring the Adaptive Augmented Reality (A2R) museum visit: Identifying Cultural Heritage professionals' motivations and needs”, in *2013 IEEE Int.l Symp. on Mixed and Augmented Reality - Arts, Media, and Humanities (ISMAR-AMH)*. Atlanta, USA, 2012, IEEE. pp. 71-80.
- [15] A. E. Foni, G. Papagiannakis, and N. Magnenat-Thalmann, “A taxonomy of visualization strategies for cultural heritage applications,” *Journal on Computing and Cultural Heritage (JOCCH)*, vol. 3, no. 1, pp. 1-21, June, 2010.
- [16] D. Petrelli, *et. al.*, “meSch - material encounters with digital cultural heritage,” in *Digital Heritage. Progress in Cultural Heritage: Documentation, Preservation, and Protection, 5th Int. Conf., EuroMed 2014*, Limassol, Cyprus, 2014, pp. 536-545.
- [17] J.H. Falk and L.D. Dierking, *The Museum Experience*, Washington, D.C.: Whalesback Books, 1997.
- [18] Hein, George E. “The constructivist museum,” in *The educational role of the museum*, E. Hooper-Greenhill, Ed. London-New York: Routledge, 1999, pp. 73-79.
- [19] M. Csikszentmihaly and R. Robinson, *The Art of Seeing: An Interpretation of the Aesthetic Encounter*, Los Angeles, USA: Getty Publications , 1991.
- [20] E.P. Alexander and M. Alexander, *Museums in Motion: An Introduction to the History and Functions of Museums*, New York: Alta Mira Press, 2008.
- [21] S. Macdonald and R. Silverstone, “Rewriting the museum’s fictions: Taxonomies, stories and readers,” in *Representing the nation: a reader: Histories, heritage and museums*, D. Boswell and J Evans, Eds. London & New York: Routledge, 2005, pp. 421-434.
- [22] L. Ravelli, “Making Language Accessible: Successful Text Writing for Museum Visitors,” *Linguistics and Education*, vol. 8, no. 4, pp.367-387, 1996.
- [23] B. Serrell, *Exhibit Labels: An Interpretive Approach*, New York: AltaMira Press, 1996.
- [24] B. Serrell, “Paying Attention: The Duration and Allocation of Visitors’ Time in Museum Exhibitions,” *Curator*, vol. 40, no.2, pp. 108-125, June 1997.
- [25] S.C. Bitgood and D.D. Patterson, “The effects of gallery changes on visitor reading and object viewing time,” *Environment and Behavior*, vol. 25, no. 6, pp. 761-781, Nov. 1993.
- [26] S. Bitgood, “The Role of Attention in Designing Effective Interpretive labels,” *Journal of Interpretation Research*, vol. 5 no. 2, pp.31-45, 1993.
- [27] S. Bitgood, *Attention and Value: Keys to Understanding Museum Visitors*, Walnut Creek, CA: Left Coast Press, 2013.
- [28] M. Ekary, “Combating redundancy: Writing texts for exhibitions,” in *The Educational Role of the Museum*, E. Hooper-Greenhill, Ed. London & New York: Routledge, 1999, pp. 201-204.
- [29] C.G. Screven, “Motivating Visitors to Read Labels,” *ILVS Review: A Journal of Visitor Behavior*, vol. 2, no. 2, pp 183-211, 1992.
- [30] J. Rounds, “Strategies for the Curiosity-Driven Museum Visitor,” *Curator*, vol. 47, no. 4, pp. 389-412, Oct. 2004.
- [31] D. Petrelli, *et. al.*, “Integrating Material and Digital: A New Way for Cultural Heritage,” *ACM interactions magazine*, vol. 20, no. 4, 58-63, July and Aug. 2013.
- [32] M. Zancanaro, *et. al.*, "Recipes for tangible and embodied visit experiences," in *MW2015: Museums and the Web 2015*, Chicago, IL, USA, 2015, available at: <http://mw2015.museumsandtheweb.com/paper/recipes-for-tangible-and-embodied-visit-experiences/>