

Smartphone app as a museum guide. Testing the Open Art application with blind, deaf, and sighted users

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ABSTRACT

In this article, we report on the results of a usability study on the Open Art mobile application conducted in a museum with blind, deaf and sighted/hearing people. The Open Art application was created following the principles of Universal Design to give all types of users the opportunity to use the app on equal terms. The main goal of the study reported here was to assess how the application is used in museum space. We tested 13 people: 1 blind, 5 partially sighted, 3 deaf

and hard of hearing as well as 4 sighted/ hearing participants. The results show that the app was generally well received and that its use has a positive influence on museum visiting experience.

KEYWORDS

Universal design, accessibility, mobile application, museum.

1. INTRODUCTION

Visitors with disabilities can pose a great challenge to museums and cultural institutions. In recent years, however, an increasingly growing number of museums have embraced the possibilities offered by new technologies to create a better experience for patrons with disabilities (Scopigno *et al.*, 2014). Some institutions provide tactile exhibits for the blind and partially sighted (Anagnostakis *et al.*, 2016) and offer large print materials for visitors with sight impairments (e.g. National Gallery or Tate Modern in London). Others organise special guided tours with sign language interpreting or with audio description. A host of institutions (Prado, Guggenheim, MOMA, Centre Pompidou, Louvre, Musée d'Orsay, Andy Warhol Museum, Washington's National Gallery of Art, National Museum in Warsaw to name just a few) have developed mobile apps for their permanent or temporary exhibitions to foster the museum visiting experience for diverse groups of visitors. Some organisations offer apps or websites dedicated especially at visitors with sensory impairments (e.g. The *Czytanie obrazów* 'Reading paintings' app for people who are blind or partially sighted by the Polish NGO Fundacja Kultury bez Barrier or the *iSztuka* 'E-art' - an online encyclopaedia presenting the works of art from prehistory to present times created by Fundacja Audiodeskrypcja).

In this article, we report on the results of a usability study on the Open Art mobile application conducted in a museum with blind, deaf and sighted/hearing people. The main goal of the study was to assess how the application is used in museum space. In particular, we wanted to see if the app meets the needs of diverse groups of potential users, how they perceive the accessible content and whether using the app changes their museum visiting experience.

2. OPEN ART APPLICATION

Providing accessibility can be a costly expense for museums, particularly if it has not been included at the design stage and has to be retrofitted at a later stage (Ellis, 2016). The Open Art application was created following the principles of Universal Design (Connell *et al.*, 1997; Story, 2011). In line with these principles,

all types of users should be able to use the app on equal terms. Therefore, the two fundamental characteristics of the Open Art application are: accessible technology and accessible content. The app contains descriptions of works in the form of short video clips (2-3 minutes) presenting selected works of Polish modern and contemporary art. The clips contain visual material, such as photographs, video footage, artists' portraits, and other archival documents, accompanied by narration in two languages to choose from: Polish and English. The text is also available as subtitles (in Polish and English) and/or in Polish Sign Language. The app is developed in such a way that other languages can be easily added. For detailed information about the app, see Szarkowska *et al.* (2016). In this paper, we present results of usability tests with different types of users in a museum.

Currently, the Open Art application contains descriptions to selected works of art in three major museums in Poland: The National Museum in Kraków, the National Museum in Warsaw and the Museum of Contemporary Art in Kraków (MOCAK). The app can be accessed both at home and in the museum. Users who are in a museum can use Bluetooth connectivity (beacon devices) to detect user's location and be informed about the exhibits nearby.

In the Open Art project we opted for the participatory design approach (Baek *et al.*, 2007; Ladner, 2008; Metatla *et al.*, 2015). In the course of the app construction, we conducted a number of studies with potential end users (Jankowska *et al.*, forthcoming), including a needs analysis study, an evaluation study on sample multimedia descriptions, a qualitative reception study of the accessible content (see Szarkowska *et al.*, 2016) as well as usability tests of an interactive high-fidelity mock-up application created via the Proto.io platform. The application was developed based on the participatory design framework, taking into consideration the results of these studies.

However, until now, all the studies tested selected features of the application separately, for instance content and duration of the video clips, or the interface. As a final step of the project, described in this paper, we carried out a usability study to assess how the Open Art app as a whole is used in an ecologically valid setting: a museum.

3. RESEARCH GOALS

The main goal of the study was to assess how the Open Art application is used in real world, i.e. in a museum space. In particular, we wanted to see if the app meets the needs of end users: sighted/hearing, deaf and blind people. We wanted to find potential ways to improve the app so that it caters for these needs even better.

As for the research setup, we tried to create a natural setting in which the participants would interact with art pieces and the app while visiting an exhibition in a real museum. Such research environment allowed us to see how well the app integrates with the entire art exhibition experience, especially to what extent it

helps or disturbs in understanding art pieces, navigating through exhibition and immersion into art experience. We also wanted to test whether the Open Art application provided sufficient help for the blind without being patronising for the sighted participants at the same time.

4. RESEARCH METHOD

The study was designed and conducted to answer the research questions and test the Open Art application in natural settings. It took place at the Gallery of the 20th Century Polish Art of National Museum in Krakow on 13-16 December 2016. The study followed ethical rules of empirical research with human subjects. The data gathered during the study were summarized with the qualitative analysis of observed behaviours and interview answers as well as with statistical tests of questionnaire data. The statistical analyses were conducted with the use of authors scripts in R computational language (R Core Team, 2017).

5. STUDY DESIGN

To answer the research questions posed above, the empirical usability study in natural settings with elements of ethnographic and qualitative interviews methods was used. The main independent variable grouping participants was their level of their sight impairment (none vs. partially or fully blind; all deaf participants were sighted). The measurements were taken from two online questionnaires (before and after the visit into the Gallery), observations during the art exhibition visit and post-visit semi-structured qualitative interview.

5.1. SAMPLE AND SAMPLING PROCEDURE

Thirteen (N=13) participants (8 female and 5 male), aged between 23 and 66 (M=31.69, SD=11.57) took part in the study. Seven people had no visual impairments, one was partially sighted and five were blind. Participants with and without visual impairments did not differ significantly in their age, $t(8.96)=0.50$, $p>0.1$ (participants without sight problems: M=33.14, SD=14.8; participants with sight problems: M=30.00, SD=7.21). There were more female subjects among sighted people (N=6) compared to male subjects in this group (N=1). Among visually impaired participants, the proportion of males and females was more balanced (2 female and 4 male). Ten participants claimed that they have no hearing problems and three that they were deaf since birth. Participants from these two groups did not differ significantly in terms of age, $t(10.997) = 0.76$, $p = 0.47$ (for no hearing problems M = 32.9, SD = 13.14; for deaf M = 29, SD = 3.46).

Participants volunteered for the study in the exchange for a gift card to Empik, a major Polish chain store selling multimedia and books. They were recruited by the Seventh Sense Foundation through advertising on its social media and newsletters. Before taking part in the study, participants received detailed information about the procedure and signed a consent form. They were also instructed that they may withdraw from participation in the study at any stage. All the data gathered during the study were anonymized.

5.2. RESEARCH PROCEDURE

The research procedure was similar for each of the participants and consisted of three stages. Exhibition visiting was adjusted for visually impaired participants to allow them to fully experience the exhibition: they were accompanied by a research assistant and their path of the art exhibition was more structured in comparison to those who reported no sight problems.

- 1) Stage 1: a preliminary stage of the study before visiting the Gallery lasted for about 20 minutes. During this stage participants were familiarized with the study procedure and the Open Art application (sighted participants watched a short instructional video, whereas blind and partially blind were instructed orally). After that, participants completed a short questionnaire containing questions on their socio-demographic profile, computer and mobile usage and museum visiting habits (for full questionnaire see Appendix 1). After finishing the questionnaire, participants were handed a 19.7" iPad with the Open Art application. Then they familiarised themselves how to use the application on this device during the further stage of the study.
- 2) Stage 2: during the second stage, i.e. the visiting stage, sighted participants were asked to visit the gallery with the Open Art application. They were given 25 minutes to explore the gallery on their own. All of the participants were requested to listen to the description of the painting *Temptation of Saint Anthony* by Stanisław Ignacy Witkiewicz (for the text of the description see Appendix 2) and other descriptions of art works of their choice. The participants with visual impairments visited the exhibition with a sighted assistant from the Seventh Sense Foundation who helped them navigate through the exhibition. They listened to the multimedia descriptions of three works of art: *Temptation of Saint Anthony II* by Stanisław Ignacy Witkiewicz (painting), *Dance* by Maria Jarema (sculpture) and *Kraków Sarcophagi* by Andrzej Pawłowski (installation). We made sure that all participants saw/listened to the description of Witkiewicz's work because at the final stage of the study, a memory test related to this work was conducted (whose results will be reported elsewhere). In this study, we want-

ed the participants to walk at their own pace and stop at the works which were interesting for them. This is why there were no special instructions or route designed for the sighted participants. Because of this dose of independence, the visit was more natural for participants, however this “naturalness” may have meant something different for each of them.

- 3) Stage 3: the last stage of the study lasted approximately 20 minutes. It consisted of the memory test on Witkiewicz’s painting, a post-visit online questionnaire and a semi-structured post-visit interview (see Appendix 3).



Figure 1 A screenshot from a film with *Temptation of Saint Anthony*

The memory test was constructed as online jigsaw puzzle depicting *Temptation of Saint Anthony*. The completion and time of completion were taken as main indicators of the memorization of this art piece. Because visually impaired participants were not able to undergo the jigsaw puzzle task, they were asked to orally describe the painting. The post-visit online questionnaire concerned participants’ experience of the gallery visit, their evaluation of the Open Art application as well as the interaction with the application. The questionnaire also included questions of user experience questionnaire adopted after Bednarik, Gowases and Tukiainen (2009). We adopted Bednarik *et al.* (2009) questionnaire to evaluate *museum visiting experience*. During this part of the questionnaire participants evaluated easiness, naturalness, pleasure and immersion of museum visiting experience with the Open Art application, on 21-points Likert-type scale (from -10 to +10, i.e. 21 items altogether including “0”). Separately, we asked five additional questions to evaluate the user experience during interaction with the Open Art application per se. These questions concerned usefulness, ease of usage, help in sightseeing, aesthetics of design and immersion. This stage of the research pro-

cedure ended with the short semi-structured qualitative interview. During the interview the following topics were discussed: overall evaluation of the museum visit with the Open Art application, advantages and disadvantages of using the app, evaluation of descriptions, subtitles, Polish Sign Language interpreting and evaluation of the duration of films. Participants were also asked about ideas and concepts regarding new functionalities of app.

After finishing the last stage of the research procedure, participants were debriefed by the research assistant. During the debrief, we presented again the goals of the study and summarized its procedure. We also made sure that the momentary well-being of all the participants did not lower due to the research procedure.

6. RESULTS AND DISCUSSION

Given the large amount of data collected and the limited scope of this article, below we present results obtained during the pre- and post-visit stages, excluding the memory test.

6.1. DIGITAL PROFILE OF PARTICIPANTS

To establish the cyber potential of the research participants, we asked them “What devices you use to go online?”. The participants said they mostly use desktop computers (including laptops) and smartphones to access the Internet. Only three participants did not use a smartphone to go online, whereas ten (10) use smartphones to access the Internet every day. Among three (3) of the participants who declared not to use smartphones, two (2) participants were blind and one with no sight problems. Tablets turned out to be less popular among the research sample. They were used for Internet on daily basis only by two (2) participants and six (6) of the participants did not use tablets at all. These results are in line with the global statistics of mobile, desktop and tablets devices internet market shares (StatCounter, 2017).

We also asked the participants how they use the Internet in their mobile devices. Not surprisingly, web search, emailing and social networking were the most popular. None of our participants declared to use mobile phones or tablets for online gaming. Only one participant declared to use mobile phone and tablet for visiting galleries or museums websites (see Figure 2).

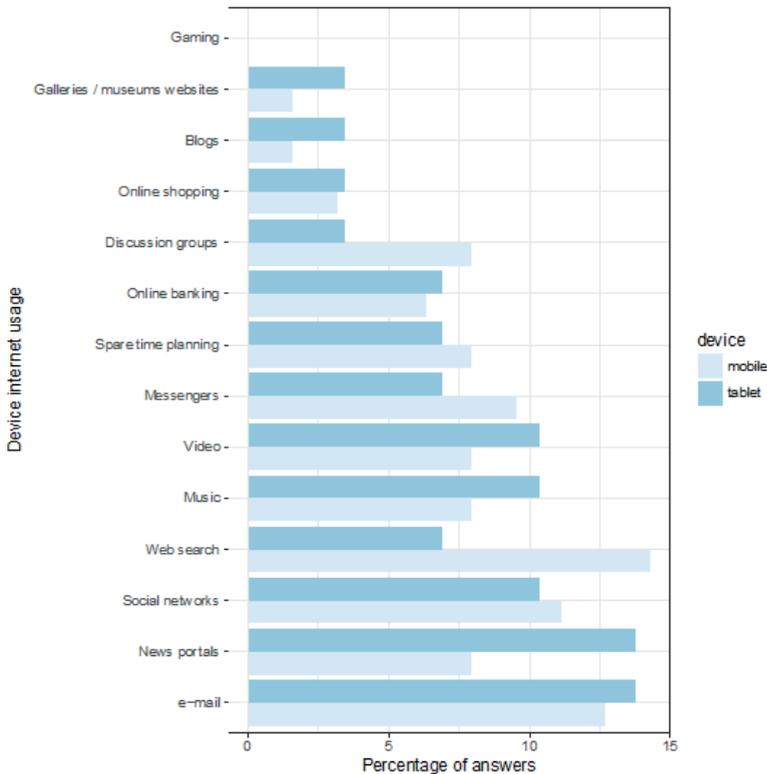


Figure 2 Internet use among study participants by mobile device.

6.2. CULTURAL PROFILE OF PARTICIPANTS

To find out about participants' habits related to visiting museums and art galleries, we asked them how often they visit such places. Most participants said they visit museums or art galleries several times a year (54%). Nearly one quarter (23%) declared to go to art exhibitions once a month or more often. None of the participants said they had never been to an art gallery or museum.

When asked about their visiting habits, participants stated that museum visiting is very often a social event for them. Most participants (61%) go to museums and galleries with friends, 23% go with their families and only 8% visit museums and galleries only by themselves. Most participants (69%) usually spend between 1 and 2 hours in the exhibition during one visit and 15% spend between 2 and 3 hours. Participants tend to visit the museums or art exhibitions either with a leaflet or no guide at all. Only about one in four people said they used mobile apps as assistive technologies (see Figure 3).

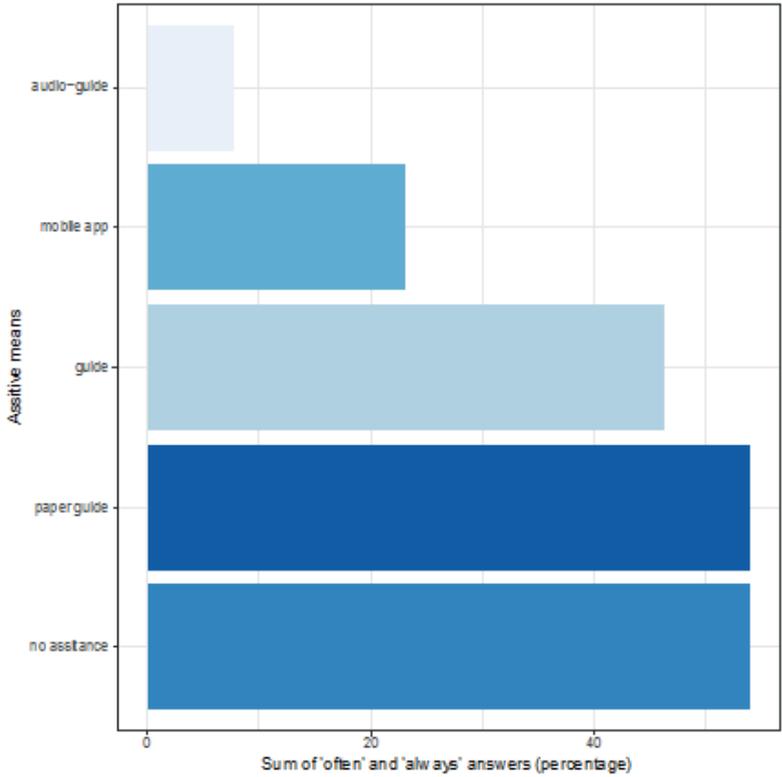


Figure 3 Assistive means during art galleries and museums visiting (top 2 boxes).

All in all, the profile of our study participants was in line with a typical profile established in previous studies (Szarkowska et. al, 2016).

7. APP EVALUATION

Below we present the results of the post-visit studies that included: (1) an in-depth interview during which the participants evaluated the content of the app and its accessibility and (2) questionnaires regarding museum visiting experience and app usability. The results of the study presented below reflect this mixed-method approach as we present both quantitative and qualitative data, including participants' feedback.

7.1. EVALUATING THE CONTENT

Below we present the results of qualitative study regarding the content of the app. Discussed aspects include: length of the descriptions, attitude towards visual cues and interpretation in the descriptions.

Each video in the app lasts for about 2-3 minutes and contains, among other things, a short description of the visual elements of the work. One of our main research questions was whether these descriptions are sufficient for the visually impaired users and whether they are not patronising for sighted people. We addressed this issue by combining the spontaneous statements of participants with the direct questions about assessment the length and form of descriptions.

None of the sighted participants said they found the visual description of the work of art unnecessary or patronising. Instead, they stressed the fact that this type of description helps them notice some elements of the work. For instance, in the case of Witkiewicz's painting *The Temptation of St Anthony II* one sighted man when commenting on the figure of a man next to St. Anthony, who is wrestling with an ox, said: "it's interesting, because I may not have noticed this". One sighted woman noted that: "In the case of the works of art that are more abstract, these descriptions with the visual elements in the beginning are really helpful". One sighted man even declared: "You could just close your eyes, and you could simply imagine it all. It just inspires your imagination". Another sighted person said:

I think the amount of information was good: there was some description of the painting, but not only focussing on the visual description, but from time to time there was also extra information which allows you in a way to distance yourself from analysing the painting, to rethink something, such as a short bio of the artist and then to come back again to the painting, to the description. It was really nice, not just focussing only on the painting.

On the negative side, one sighted person felt irritated by the information about the size of the work, which he found unnecessary given that he was standing in front of the work. However, because the app can be used outside of the museum and also by blind people, the information about the size of the work is essential.

As opposed to sighted people, with blind people we wanted to establish if the amount of description was sufficient to them. We were expecting that some blind and partially sighted viewers may think that the amount of description is not enough. However, none of our participants stated they would have wanted more detail; they were generally pleased with the duration of the descriptions. One blind woman explained that she likes short descriptions because "they don't strip it down to minute component parts, which I really hate: I then feel like... as if someone took a PC apart and told me to put it back together. I really find it very tiring". Another person noted the amount of the description necessary depended on the work of art and its complexity. One blind person said: "I believe it was enough. It was just right and not too long. It didn't make me feel impatient." An-

other person stated that the description should enable viewers to imagine what the work looks like and “get the meaning and say whether you like it or not”.

Interestingly, one partially-sighted participant, who could see the contours of the works of art, stated that he prefers to watch the works of art together with the descriptions in the application, as they “walk us through different visual elements of the work of art and help us see what we should be seeing and what is really there.” The descriptions were not overwhelming or unnecessary for him, because they confirmed the visual information he could see. One may therefore generalise that in the case of partially sighted people, descriptions can play a confirmatory role. According to this participant, the descriptions are not an obstacle in experiencing art, but quite the opposite: they “sensitize us and sharpen our perception”. The descriptions draw the viewer’s attention to the details, but also, as stated by this participant, “clear our perception”.

During their visit participants usually watched 2-3 movies, about 3 minutes each. The opinions on the duration of the videos among the sighted participants were divided: three people said the descriptions were too short, two stated they were optimal, the rest thought they should be slightly shorter. Many people suggested the descriptions should last up to 2 minutes. Most blind and partially sighted participants agreed that the duration of the descriptions was appropriate. One person even suggested descriptions could be half a minute shorter in order not to bore the listener.

One of the objectives of the project was to create descriptions that would be easy to understand. This goal was achieved by using plain language with short and simple sentences as well as avoiding jargon. Long, winded sentences can make the listener feel lost and cause a strain on working memory (see Wong *et al.*, 2012; Brünken *et al.*, 2002). All participants thought that the language used in the descriptions was appropriate, understandable, and written “in accessible way for ordinary people” as one person said. One of the blind participants was particularly outspoken about that and suggested that sentences should be short and succinct, not very syntactically complex.

When the Open Art project was carried out, there were no guidelines regarding AD for museums. AD was created following general principles of AD which at that time followed the objectivity paradigm. The descriptions in the Open Art app differ from these ADs in the sense that they do not only contain information about the visual aspects of a work of art, but they also include a degree of interpretation. We were also interested in whether people appreciate having interpretation interwoven with the visual description. In general, participants seemed positive about the fact that interpretation was provided. One of the participants even said that: “the app adds to the experience, because it provides us with some interpretation of these paintings.” Another person noted that:

the app contains information that a person who autonomously visits a museum lacks, unless she or he studies art. A person without such knowledge just visits the museum

and sees what is presented there, and does not understand much. And this application offers some points that direct the visitor towards what is important.

One person stated:

I prefer to have the interpretation given to me maybe because I don't have the history or artistic knowledge. Sometimes you need to know history, or some art period, to be able to interpret the work. Not everyone has this knowledge, so it's good to have in the app. It would be good if it was marked, so you can skip it if you don't need it.

One blind man suggested that he would like to divide the description into two separate parts: description and interpretation. This would allow viewers to decide – after listening to the description – if they are interested in this work and to continue listening to the interpretation, or to move on. Overall, these results are in line with results from the needs analysis studies (Szarkowska *et al.*, 2016) where participants compared modern art to a riddle that can be solved only with a guide.

It can be concluded that the descriptions help notice more details, see the work of art as they really are without deformations resulting from personal interpretations or impairments.

7.2. EVALUATING ACCESS TO THE CONTENT

During the qualitative study we also asked the participants to evaluate the ways in which content can be accessed, namely Polish and English narration and subtitles as well as Polish Sign Language Interpreting. Below we present issues that were raised regarding different ways of accessing the content, including sign language interpreting, voice-quality, text versions, the availability of multiple language versions, and the “bring your own device” approach.

Although the number of deaf and hard of hearing people who took part in this study was limited, they nevertheless expressed some interesting opinions about the app functionality, particularly when it comes to the sign language interpreter. Some people voiced their concern about the quality of signing. Among the issues raised was the fact that the interpreter was not dynamic enough, showed little emotions and did not follow the image.

Participants also stated they would prefer to have sign language interpreting in-vision, that is embedded in the film, instead of a screen split between the film and a separate figure of the signer (see Fig. 3), stating it would be easier for them to focus on the film and the signer simultaneously without having to divide their attention between the film and the signer.

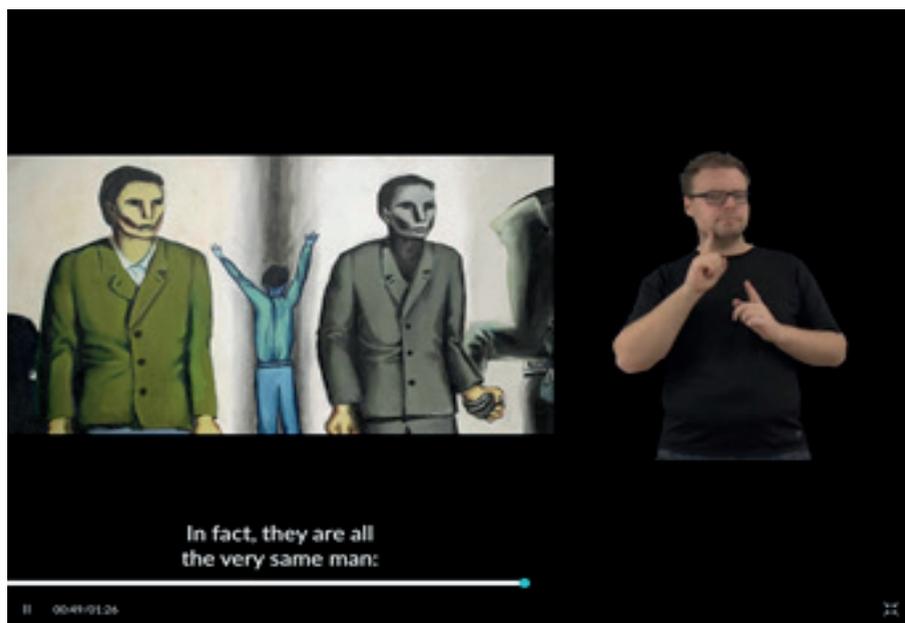


Figure 4 A screenshot from a film with subtitles and a signer.

One deaf participant noted that it would take deaf people longer to visit the museum compared to the hearing, as deaf people need to look at the sign language interpreting first, and only then can they focus on the work of art itself. This, however, might be true in the case of traditional audio guides which only contain the audio, but in the case of the Open Art app, both hearing and deaf people are supposed to look at the screens to watch the film. They can, of course, pause the film any time to look at the real work of art.

Some participants, especially the visually impaired, expressed their concerns regarding the intonation used by some of the voice talents while reading out the descriptions. One of the participants said that the voices sounded synthetic and that the description should not only be read in a more emotional way but also significantly faster. The speech rate was commented on by various visually impaired participants. All of them wished to have an option to manipulate the delivery rate or to have descriptions also available in a text format. As one of them said:

I think it would be useful if there was also a text version [...] Text can be read at the pace set in screen reader. I always set it at a very fast pace [...] If the text was available in the app one could listen again to the last line. And now I would have to listen to the whole thing again.

Participants generally noticed that the possibility of adding multiple language versions is a very useful feature. Some of them said that they would listen to the

descriptions in English. What is particularly interesting is that all the deaf and hard of hearing participants mentioned that International Sign version should also be made available.

Commenting on the usefulness of the “bring your own device approach” instead of a traditional audio guide, one blind woman said she prefers to use her own device because she knows how to use it. With traditional audio guides in museum, each time she goes somewhere, she needs to learn how to use it: she needs to familiarise herself with the type of the guide, whether it is touchscreen or has buttons, etc. Sometimes, during the visit, the battery runs out, so she said with her own device, she would be responsible for charging it, providing her with autonomy. One of the sighted participants also noted that this approach can be particularly useful for elderly users who may find it difficult to learn a new solution in every museum.

7.3. EVALUATING MUSEUM VISITING EXPERIENCE WITH THE OPEN ART APPLICATION

The user experience questionnaire provided the insight on pleasure, immersion, naturalness and difficulty levels associated with the use of the Open Art application while visiting the Gallery. On average, museum visiting experience with the application was evaluated significantly higher than 0 on pleasure, naturalness and immersion scales but not on difficulty scale. The experience was rated as not difficult ($M=1.92$, $SE=1.84$), immersive ($M=4.46$, $SE=1.83$), natural ($M=2.92$, $SE=1.85$), and pleasurable ($M=5.23$, $SE=1.42$), see Figure 5.

No significant differences were found between participant with and without visual impairment. The significance of differences were calculated with two-sample Welch’s t-tests. The results are presented in the Table 1.

At the end, we also asked participants to evaluate their enjoyment during the museum visiting experience on 21-point Likert-type scale (“I enjoyed visiting the museum with the Open Art application”). Again, on average they rated it very high ($M=6.77$, $SE=0.99$). The two samples t-test for differences in evaluation between blind and sighted participants did not reach the significance level, $t(9.1625)=0.38$, $p>0.1$ (for sighted participants $M=7.14$, $SE = 1.20$, and for blind participants $M=6.33$, $SE=1.74$). This means that for both groups, the visiting experience with the app was similar, which is in line with the Universal Design approach.

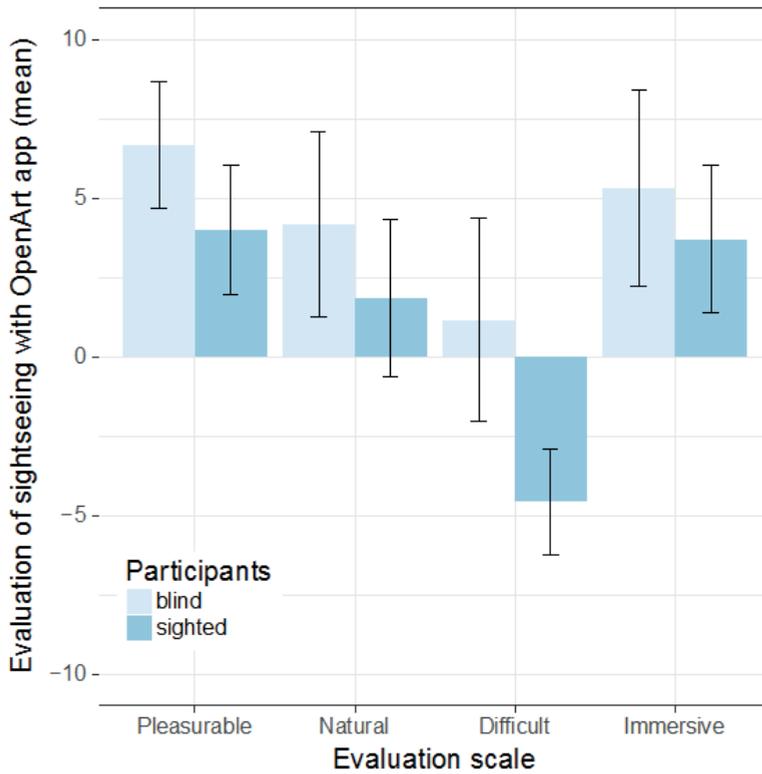


Figure 5 Evaluation of visiting with the Open Art app on four scales by blind and sighted participants.

Note that values -10 were labeled as “Absolutely not” and +10 as “Absolutely yes”. Error bars represent +/- 1 SE (standard error of the means).

Evaluation scale	t-test	Sighted participants	Blind participants
Pleasure	$t(10.936)=0.94$, n.s.	M=4.00, SE=2.02	M=6.66, SE=1.99
Immersion	$t(9.7003)=0.42$, n.s.	M=3.71, SE=2.34	M=5.33, SE=3.09
Difficulty	$t(7.5819)=1.59$, n.s.	M=-4.57, SE=1.66	M=1.67, SE=3.21
Naturalness	$t(10.329)=0.60$, n.s.	M=1.86, SE=2.48	M=4.17, SE=2.93

Table 1 The results of t-tests comparing the evaluation of the museum visiting experience.

We also asked participants whether the app makes the museum visiting experience different compared to the way participants traditionally visited such places. Many participants noticed that using the app enabled them to learn more and that it makes the visitor more conscious in a sense that they gain insight into knowledge they would otherwise not have. A sighted woman said:

Very often when we look at something, we are not aware of what it is that we are actually looking at. We may like it or not, but that's another issue. When we have a mention to the author's bio, then we start looking at the work from a different perspective. Then we know... this had an impact on that, this means that. And this is what's important. I find it an advantage of the app.

Almost all participants noticed that thanks to the app their visiting experience was deepened. One of the hearing impaired participants said that:

Application gives me information: details that I would certainly not pay attention to, that each element has some meaning. For example, without the app, I would look at the whole thing, and thanks to the app I can learn about the details.

Another participant said:

The app allowed me to pay attention to details which I would not have noticed otherwise. I would just have skimmed through the painting, and with the app I stop, I look... and I can approach the reception of the work more professionally.

One blind man noted: "To be honest, visiting the museum using this app is a bit of wasted effort. I might as well read those descriptions at home, without having to come here at all." Indeed, the functionality of the app makes it possible not to have to visit the museum in person: anyone who has access to the Internet and a mobile device can download the app and watch/listen to the descriptions anywhere. This is in line with the authors' intentions to make the works of art as accessible as possible, regardless of geographical limitations, just like in the case of the Google Arts & Culture app.

A few participants noted that visiting a museum with the app might be much longer and tiring if one wanted to listen to all the descriptions. One sighted woman noticed that, as opposed to visiting with a human guide, one can always just skip the exhibits one is not interested in.

7.4. EVALUATING THE OPEN ART APPLICATION USABILITY

We also asked participants to evaluate the application on five 21-points Likert-type scales (from -10 to +10) in terms of its usefulness, ease of usage, help in visiting, aesthetics of design and immersion. On these scales, the application obtained high scores on average. It was evaluated as very useful ($M=6.77$, $SE=1.72$),

easy to use ($M=3.62, SE=1.26$), making the sighting easier ($M=6.31, SE=1.44$), well-designed ($M=3.00, SE=1.32$), and very immersive ($M=5.77, SE=0.98$). Blind and sighted participants did not differ on any of these scales (see the Table 2 for t-test comparisons of means between sighted and blind participants).

The overall evaluation of the Open Art application (expressed in the reaction on Likert-type scale to the statement “I liked the Open Art application”) was relatively high ($M=7.35, SE=0.98$). Moreover, the two samples t-test looking at differences in the app evaluation between blind and sighted participants did not reach the significance level, $t(6.0991)=0.26, p>0.1$ (for sighted participants $M=7.57, SE=0.69$, and for blind participants $M=7.00, SE=2.07$).

Most our participants declared that they would like to use the Open Art application in the future ($M=7.15, SE=1.11$) and they would recommend it to their friends ($M=6.08, SE=1.55$). Again, there were no differences between blind and sighted participants for future use declaration, $t(6.0991)=0.26, p>0.1$, and for recommendations to friends questions, $t(6.4227)=0.04, p>0.1$.

CONCLUSIONS

In this paper, we presented results of a usability study on the Open Art mobile application conducted in a museum with blind, deaf and sighted/hearing people. The overall evaluation of the app was positive: most users were pleased with the content and duration of the descriptions. They also approved of the “bring your own device” approach, which they thought had many advantages over traditional guides. Most importantly, sighted people declared that the descriptions in the app helped them notice things in the work of art, which they would not have noticed otherwise. Participants also reported that their museum visiting experience differed with the app compared to visiting without it, for instance by offering them more autonomy and independence as well as insights into the works, their interpretations and trivia about the artists.

Thanks to participants’ suggestions, we found several aspects which could improve the app in the future. These include, for instance, speeding up the reading rate of the voice talents, using a livelier intonation, or slightly shortening the descriptions. Some suggestions would require further research and consultation, among them is having the sign language interpreter in-vision in the actual video frame.

- Anagnostakis, G., Antoniou, M., Kardamitsi, E., Sachinidis, T., Koutsabasis, P., Stavrakis, M., Zissis, D. (2016) "Accessible museum collections for the visually impaired", in *Proceedings of the 18th International Conference on Human-Computer Interaction with Mobile Devices and Services Adjunct - MobileHCI '16*, New York, New York, USA: ACM Press. pp. 1021-1025.
- Baek, E.-O., Cagiltay, K., Boling, E., & Frick, T. (2007) "User-Centered Design and Development" in *Handbook of Research on Educational Communications and Technology*. Ed. S. J. Michael, van M. M. David, M. Jeroen, & D. Marcy, London: Routledge, pp. 660-668.
- Bednarik, R., Gowases, T., & Tukiainen, M. (2009) "Gaze interaction enhance problem solving: Effects of dwell-time based, gaze-augmented, and mouse interaction on problem-solving strategies and user experience" *Journal of Eye Movements Research*, 3(1)(3), 1-10.
- Brünken, R., Steinbacher, S., Plass, J.L. & Leutner, D. (2002) "Assessment of cognitive load within multimedia learning by the dual task methodology", *Experimental Psychology* 49: 109-119.
- Connell, B. R., Jones, M., Mace, R., Mueller, J., Mullick, A., Ostroff, E., Vanderheiden, G. (1997) "The principles of universal design", https://www.ncsu.edu/ncsu/design/cud/about_ud/udprinciplestext.htm (last accessed 18/07/2017).
- Ellis, G. (2016) "Impairment and Disability: Challenging Concepts of "Normality" in *Researching Audio Description*. Ed. A. Matamala & P. Orero, Palgrave Macmillan UK, pp. 35-45.
- Jankowska, A., Kowalski, J., Krejts, K., Piasecki, A., Szarkowska, A., & Wichrowski, M. (forthcoming) „OpenArt - Sztuka współczesna dla wszystkich. Konstruowanie multimedialnych opisów dzieł sztuki współczesnej”.
- Ladner, R. E. (2008) "Access and Empowerment", *ACM Transactions on Accessible Computing*, 1(2), pp.1-5.
- Metatla, O., Bryan-Kinns, N., Stockman, T., & Martin, F. (2015) "Designing with and for people living with visual impairments: audio-tactile mock-ups, audio diaries and participatory prototyping", *CoDesign*, 11(1), pp. 35-48. <https://doi.org/10.1080/15710882.2015.1007877>
- R Core Team (2017) "R: A language and environment for statistical computing", R Foundation for Statistical Computing, Vienna, Austria. URL <https://www.R-project.org/>.
- Scopigno, R., Cignoni, P., Pietroni, N., Callieri, M., & Dellepiane, M. (2014) "Digital Fabrication Technologies for Cultural Heritage (STAR)" in *Proceedings of the Eurographics Workshop on Graphics and Cultural Heritage*, Eurographics Association, pp. 75-85.
- StatCounter (2017) StatCounter Global Stats. Retrieved from: <http://gs.statcounter.com/platform-market-share/desktop-mobile-tablet/worldwide/2016>
- Story, M. F. (2011) "The principles of universal design" in *Universal design handbook*. Ed. P. Wolfgang & S. Korydon H., New York, Routledge.
- Szarkowska, A., Jankowska, A., Krejtz, K., & Kowalski, J. (2016) "Open Art: Designing Accessible Content in a Multimedia Guide App for Visitors with and without Sensory Impairments" in *Researching Audio Description*. Ed. A. Matamala & P. Orero, Palgrave Macmillan UK, pp. 301-320.
- Wong, A., Leahy, W., Marcus, N. & Sweller, J., (2012) "Cognitive load theory, the transient information effect and e-learning", *Learning and Instruction*, 22, (6,) pp. 449-457.