Experiencing the Presence of Historical Stories with Location-Based Augmented Reality

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Abstract. In the SPIRIT research project, a location-based Augmented Reality (AR) storytelling application has been developed with the goal to support the imagination of lively historical events at places of cultural significance. We describe a showcase scenario and report on its quantitative and qualitative evaluation, conducted at the Saalburg Roman fort, an outdoor museum site near Bad Homburg in Germany. 107 random voluntary visitors were observed using the app, before filling questionnaires that were then analyzed with SPSS. Specifics of the app include a novel interaction pattern that uses positioning sensors of mobile devices and image recognition to trigger content, featuring transparent videos as ghost-like overlays on the camera image of the environment. Results presented in this paper show that in general, the app was effective and fun to use. Further, there have been differences in the experience of presence concerning the AR representation, as well as in the comprehension and appreciation of the story's content. Concluding, we discuss influencing parameters on the results and draft hypotheses for future work.

Keywords: Interactive storytelling · User experience evaluation · Location-based storytelling · Augmented Reality · Interaction design

1 Introduction

Augmented Reality (AR) systems enable the seamless integration of 'made-up' digital impressions in the perception of everyday real environments. Therefore, since their first appearance, tourism [9] and cultural heritage [24] have been considered as application areas. Ranging from simple information to gaming and storytelling, varying philosophies for interaction have been explored [3, 13, 14]. Differences still lie in the degree to which a concept is readily applicable. Thus, AR systems often introduce unfamiliar user interaction styles due to hardware developments [4]. Within the last three to five years, personal handheld devices have been getting ubiquitous as platforms for gaming and entertainment, including mainstream concepts for museums or tourism. With reasonable screen sizes, a variety of sensors and increased computational power, hopes and expectations are now also raised for storytelling with mobile AR.

We report on a user evaluation of a complex prototype enabling location-based AR storytelling. It has been developed within the applied research project SPIRIT, with the goal to explore the applicability of location-based AR on off-the-shelf hardware for a

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museum environment, as well as boundaries for storytelling and design. In this project, in order to develop a full experience, several aspects had to be tackled by an interdisciplinary team. These include (i) the development of a new location-based AR player app (running on Android tablets and smart phones), (ii) a formalized content structure as XML dialect to be authored by storytellers or game designers, (iii) a plot engine parsing the content structure, managing the presentation in time and in relation to contexts and variables, (iv) the conception of sensor-based interaction patterns, tested with users in formative evaluation cycles, and (v) a case study production for an outdoor museum site, integrating the experience of a historic drama on the spot with factual information to be acquired in context. During development, iterative formative evaluations with preliminary content have supported design hypotheses concerning interaction with and staging of the story content. Many of these test persons in about 20 design cycles were media-savvy. However, we expected to achieve different results within the real environment.

We evaluated the resulting prototype within regular operations of the museum. 107 visitors filled questionnaires after using our tablets during a tour of about 30 to 40 min, being accompanied and observed by two researchers. In the following, we report on the insights gained by this evaluation. First, we describe our intended interactive story experience, as well as design hypotheses and constraints. We also relate our approach to the state of the art. After explaining the setup of the empirical investigation, we report on the most significant results relating to design parameters for interactive dramatic experiences with AR.

2 Interactive Storytelling with the SPIRIT Prototype

One of the first visions of this project, which was inspired by possibilities of location-based AR, was to realize the metaphor of ‘meeting the spirits of history’ right at the place where they lived their lives – ideally, with no profane GUI elements that remind at a technical operation system. Consequently, several aspects of interaction design and storytelling had to be combined during conception: location scouting including local facts and visual perspectives as backdrops for action, suitable ideas for fictional characters and drama with connections to historical facts, and finally, interaction design that caters to the functional constraints, which are intricately interwoven with the achievement of the novel enabling technology. The result is a novel interaction pattern that new users need to learn at the start location of their first walk with the app. After that, the interaction pattern repeats at all further locations. For simplicity and to avoid over-complex interactions in the first instance, the prototype tested here works with a linear story, although a developed plot engine would enable the management of non-linear and conditional content.

2.1 Content Description of the Evaluated Experience

Visitors (as subjects) at the outdoor museum site of the Saalburg Roman Fort [22] started with a tutorial that explains the interaction with the SPIRIT app. The goal is to find spirits

that appear at specific historical places. The spirit ‘Aurelia’ is introduced. She provides us with memory images that we can use as visual stencils (Fig. 1, center) to find views of places that had been meaningful for her. Step-by-step, the tutorial guides us to visualize spirits, holding the tablet vertically in front of these backdrops. Users can also follow lateral arrows to turn the tablet to the left or to the right, visualizing further spirits in the space around (Fig. 2). The menu is pointed out as well, consisting of buttons for listing met ‘spirits’, ‘facts’, ‘progress’ and a ‘map’ (Fig. 1, left).

Fig. 1. Searching methods ‘map’ and ‘memory stencil’ for finding active areas and triggering spirits.

Fig. 2. One active area with three viewing directions. After triggering the house of the spirit ‘Titus’ in the central view, he urges us to go into the fort. Turning about 90° to the left points into our walking direction, where we see Aurelia and Aliquander leave after their discussion with Titus. Turning back to the right reminds us that some strange guys follow us.

After the tutorial, Aurelia’s memories begin in her former village – now only visible as low-rise mural remains – outside the main gate of the Roman fort (Fig. 1, center). We witness her parents, who try to rescue villagers into the fort, because of an announced attack of Germanic tribes. She also remembers that after the attack, two girls show her a piece of wood, which expresses a call for help from a kidnapped carriage. Together with her friend Aliquander, with whom she seems to share neighborly friendship as well as a beginning romance, she follows the cart to the eastern gate. Figure 2 shows the second location of the tour, at which their friend Titus gives them hints that the cart might contain stolen weapons, together with a kidnapped armorer. Titus urges Aurelia to warn her father, the Centurion of the fort.

Following Aurelia's memories, the visitor then has to pass the eastern gate to get into the fort. After these two meetings with other spirits, we learn that a Germanic ruler uses corrupt auxiliary soldiers to get hold of Roman weapons, only to beat the Romans with their own means. Following Aurelia's warning, the Romans try to stop the cart, thereby getting into another attack. Aurelia fears that Aliquander's life gets jeopardized, when she realizes that she cannot think of a life without him. Back at the main gate, her memories reveal to the visitor that after this incident, they had married and started a family. With the feeling of a happy end, they died in their old age, long after the fort had been abandoned by the Roman Empire as a consequence of the attacks.

In summary, two fictional threads are contained in the story – a tentative romantic love story of young adults in the village, and the complex political plot of Germanic assaults and corruptibility of auxiliary cohorts. Some story events trigger notifications in the facts menu (see Fig. 1, right), indicating that there is some brief factual information related to the situation. Users can read this at their convenience in between fictional scenes. For example, the village was indeed attacked in the year AD 233, and we learn details about the situation of women and auxiliaries during the Roman occupation.

2.2 Technical Constraints Influencing the User Experience

The functionality underlying the SPIRIT player has been described elsewhere [8, 12] and is not in the focus of this contribution. However, in order to use the system, some knowledge of it has proven useful, in order to develop a suitable conceptual image of successful interaction. The visual recognition is based on the ORB algorithm [21], searching camera images for matching pixel patterns in a set of reference images. These reference images are photographed backdrops for spirit scenes, prepared during authoring. The 'memory stencil' images have no direct function in the process, only indirectly, as mere support devices for users to find places with backdrops and point at these with low speed. The recognition works sufficiently reliable, especially as the system supports ad-hoc adding of current photographs in advance of a tour. However, on days with frequent changes in lighting conditions, the system might still have difficulties, resulting in recognition failure as well as in false positives.

The triggering of new video content, after the tablet is turned to the left or to the right, is accomplished by the gyroscope sensor, which works incrementally. Apparently, for novice users, the proper momentum and degree of turning is hard to guess, unless the movement is demonstrated by someone. Therefore, the tutorial, which shows an animated modelled action, has been considered as necessary by most novice users. After adopting the movement, this interaction works reliably.

The augmented content consists of prepared video sequences with live-acting characters. Bluescreen production and chroma-key postproduction let them look like floating in thin air on top of the device's camera image of real surroundings. After their appearance, characters seem to stay at their 'place' within the image of the real environment – as expected for AR content. This is a crucial feature for the user experience of presence, but nevertheless, it can lead novice users, who are inexperienced in AR, to missing the visualization when they move the tablet too fast, while the audio continues.

Concluding, issues due to the technicalities of the prototype did partially influence the assessed user experience in our test.

2.3 Goals for the Interactive Story Experience

Through dramatic staging in front of the ruins and reconstructed historical buildings, the actors stay 'in character', re-enacting fictional personal memories with emotional content. Associated facts exist, however, our design demanded to avoid situations, in which characters also adopt the role of modern museum guides. Therefore, brief text summaries of factual knowledge can only be consulted separately on demand of the user, anytime in between.

The goals we wanted to achieve with the specific design have been (i) the experience of 'presence' of the spirits in the real environment, which is associated with a sense of 'genius loci', (ii) motivation and interest to learn more about the Roman world through an emotional story, and (iii) the freedom to use the menu at the individual user's convenience for appreciating the connection of the story to historical facts. One important design parameter, which distinguishes our prototype from other solutions, is the inclusion of the 90° turns. With this interaction pattern, we can stage different characters surrounding the user, and can prompt the user to look into specific physical directions. Our hypothesis is that this aspect supports a sense of place, together with the appreciation of the presence of the events within the real locality.

3 Related Work

Location-based Augmented Reality is an emerging topic, especially in application areas in the realm of storytelling, education, and historical information connected to geographic places. Blurry lines exist between location-based gaming and storytelling, and between serious applications and entertainment [3, 13, 20, 25]. Recent evaluations addressed learning outcomes and experiential qualities [7, 15]. The results of these support our design goal to not focus on stories for the acquisition of knowledge, but for motivational aspects, such as gaining empathy with the past. Additionally, AR does not yet rely on standardized user interaction styles, as different hardware approaches lead to unfamiliar systems that have to be learned by novice users in the first place. There is still a lack of evaluation with non-technical target groups, as a majority of subjects used to be recruited within the academic field [2] or higher education settings [1]. In our project, we created a novel and unique interaction style that we have not found elsewhere yet. We evaluated it with regular museum visitors, spanning a great diversity of people including families. Besides testing the usability, the experience aspired by design relates most to the feeling of presence [16, 19], sense of place [6] or aura [17]. In other projects, these factors have been evaluated with applications that so far do not resemble our integration of the search for places, turning around and rendering through video-based storytelling. Still, there are outcomes in line with those of our study, concerning the necessary distribution of attention focus between media and the environment.

4 Empirical Analysis

4.1 Survey

The empirical survey was carried out by students of Hochschule RheinMain on 5 days in May/June 2017 at the Saalburg Roman Fort [22]. The interviewers randomly invited regular museum visitors to participate in the testing and survey. Single and pair visitors, as well as small groups and families constituted subjects to participate most likely. That way, a total of 70 groups of visitors could be acquired to walk the tour with the app. 2 researchers accompanied each tour, one for support and one observer taking notes of situational reactions and remarks. 107 subjects from these test groups completed the post-tour questionnaire and answered additional qualitative questions. The form included 26 groups of questions with 40 single questions, of which – besides the topics of demographics, usability and learning – 20 items were related to 'storytelling' in the broader sense. For answering most questions, a 5-step Likert scale was used.

In this paper, we focus on these 20 storytelling-related questions. Further, we take into account 3 questions addressing potential disturbing or interference factors. In the following, we analyze the results in terms of their reliability and validity. Based on this, various correlation and regression analyses are carried out [10, 11]. Before detailing the statistical analyses, we summarize basic facts:

- Out of the 107 subjects, 62 were female and 45 male. The numbers per age groups are as follows: <20 (34), 21–29 (16), 30–39 (13), 40–49 (19), 50–59 (18), >60 (7). The average experience with similar apps (e.g., Pokémon GO, Ingress, Geocaching, AR) is "low" (2.1 on the Likert scale, with 1 for "not at all" and 5 for "very much" experienced).
- The users rated the experience mainly positive (average grades of 4.0–3.8, where 5 is highest degree of approval), based on the questions "I had fun using the app", "I wish the app would be available also in other museums with fitting content", "I recommend the app".
- 88.8% of the users confirmed that there have been 'any' disturbing factors while using the app. Grades for single causes fell between 2 (low influence) and 3 (medium influence). Thus, most troublesome was "Holding the tablet" (2.8), "Technical problems" (2.7), "Long dialogs" (2.7) and "90 degree turns" (2.6).
- Regarding the questions (a) "Through the app, I could immerse myself into the Saalburg's history" and (b) "I got the impression that the characters were present like ghosts in the environment", the users responded between rather positive and neutral, i.e. average grades of 3.5 for (a), and 3.1 for (b).
- Out of factors for a potential perception of historic 'aura', the aspects "Scenes relating to locations", "Historical characters", "Search for locations" and "Map" received the highest degrees of approval (average grades of 3.7–3.6).
- Concerning parameters for the "Motivation to continue", all items were ranked rather positive ("Search for locations" 3.8, "Novelty of the app usage" 3.7, "Suspense of the story" 3.2).

4.2 Reliability and Validity

Reliability is a measure of the formal accuracy of surveys. It is that part of the variance that can be explained by differences in the characteristic to be measured, and not by (measurement) errors. Reliable results must mainly be free of random errors (i.e. reproducibility of results under the same conditions). We use Cronbach's Alpha to measure the reliability, where values higher than 0.7 represent a good reliability. Accordingly, the concepts and data collected are to be considered as reliable (see Table 1).

Table 1. Cronbach's alpha and validity analysis

Questions related to the concepts of ...	Cronbach´s Alpha	KMO	Bartlett-Test	Cumulative Variance
Fun / Recommendation (a)	0.887	0.799	$p < 0.000$	74.832%
Interference Factors (b)	0.711	0.712	$p < 0.000$	41.680%
Presence (c)	0.878	0.849	$p < 0.000$	64.374%
Appraisal of the Story (d)	0.836	0.770	$p < 0.000$	61.527%

Validity refers to the consistency of an empirical measurement with a logical measurement concept. Based on literature, a significant Bartlett test ($p < 0.050$) indicates a valid data collection. This is supported by the Kaiser-Meyer-Olkin test (KMO), which indicates good validity by a value higher than 0.7. For a good explanation rate, the cumulative variance has to be higher than 50%, i.e. if a large part of the variances of the collected data can be explained, the collected data are valid. Thus, nearly all presented results in Table 1 support validity, but the cumulative variance for the questions related to interference factors, which is lower than 50%. This means in this case that 41.680% of the variances of the collected data can be explained.

Examples for questions of each concept are: (a) "I enjoyed using the app" (3 items), (b) "The following factors bothered me while using the app" (6 items), (c) "I got the impression that the characters were present as ghosts in the real environment" (9 items), (d) "I liked the story" (5 items).

4.3 General Correlation Analysis

The correlation coefficient analysis determines the degree of linear relationship between two individual variables (however, not the degree of dependence). A correlation of 1.000 shows a 'perfect' relationship, and a value higher than 0.500 is classified as a 'good' relation [5]. Between all our relevant 23 variables/questions, 253 correlation coefficients exist. We identified 65 correlation coefficients that are significant ($p < 0.050$) and have a value over 0.500. For the sake of brevity, we list here only relationships with correlation coefficients higher than 0.700:

- Relation between variables "I wish the app would be available also in other museums with fitting content" and "I recommend the app" (coefficient 0.765).

- Relation between the variables “I was motivated to continue by the suspense of the story” and “I liked the story” (coefficient 0.755), which supports strongly the results of the regression analysis.
- Relation between the variables “I had fun using the app” and “All in all, I rate the app concept …” (coefficient 0.718), which shows that the overall rating of the app is mostly related to the ‘fun factor’.
- Relation between the variables “I gained knowledge of the Saalburg through using the app” and “I liked the story” (coefficient 0.708), which shows that the gaining of knowledge is strongly related to the level of appraisal of the story.

4.4 Regression Analysis on Presence Factors

Regression analysis explains relationships between a dependent variable and one or more independent variables. Beyond general correlations suggested by the collected data, we are especially interested in criteria to achieve the perception of ‘presence’ of the historical scenes in the environment through AR. Therefore, we performed regression analysis for the dependent variables “Through the app, I could immerse myself into the Saalburg’s history” (Table 2) and “I got the impression that the characters were present as ghosts in the real environment” (Table 3).

Table 2. Regression analysis – dependent variable “Through the app, I could immerse myself into the Saalburg’s history”

Independent Variables/Questions	Regression Coefficient	Significance (p)
“Characters were present as ghosts”	**0.203**	**0.009**
“Perception of historic aura fostered by ...”		
Image overlay	0.083	0.342
90 degree turns	0.129	0.116
Historical characters	0.195	0.073
Scenes relating to locations	**0.218**	**0.047**
Search for locations	0.189	0.055
Map	**-0.203**	**0.046**
Audio	0.112	0.168

Table 3. Regression analysis – dependent variable “Characters were present as ghosts”

Independent Variables/Questions	Regression Coefficient	Significance (p)
“Perception of historic aura fostered by ... ”		
Image overlay	0.177	0.181
90 degree turns	0.152	0.218
Historical characters	0.208	0.202
Scenes relating to locations	0.031	0.850
Search for locations	0.062	0.678
Map	0.038	0.805
Audio	**0.257**	**0.036**

The dependent variable "Through the app, I could immerse myself into the Saalburg's history" is

- significantly positive ($p < 0.050$) influenced by the variable "Impression that the characters were present as ghosts in the real environment" (coefficient 0.203),
- significantly positive ($p < 0.050$) influenced by the variable "Perception of historic aura fostered by scenes relating to locations" (coefficient 0.218),
- significantly negative ($p < 0.050$) influenced by the variable "Perception of historic aura fostered by the map" (coefficient −0.203).

Although all the regression coefficients do not exceed the desired 0.500, based on Brosius [5] the values (higher than 0.200) can be classified as sufficient. In the particular case in question, where the change of the dependent variable is explained by only one or a few independent variables, explanatory rates (=regression coefficients) higher than 0.2 can already be regarded as worthwhile to be considered as indications. (The R-square of 61.9% shows, that descriptive variables reach a good explanation rate, i.e. dependent variables can be explained to a high degree with the independent variables.)

This means that if a user gets stronger impressions by the named variables ("Characters were present as ghosts" and "Perception of historic aura fostered by scenes relating to locations"), he or she will feel more strongly immersed into the history of the Saalburg. Remarkably, the variable "Perception of historic aura fostered by the map" influences the immersion negatively, i.e. the search actions with the map seem to tend to hinder rather than to promote the immersion into the history of the Saalburg.

The dependent variable "Characters were present as ghosts" is significantly positive ($p < 0.050$) influenced only by the variable "Perception of historic aura fostered by Audio". The coefficient 0.257 is higher than 0.200 and can be classified as sufficient [5]. (The R-square of 34.1% shows that descriptive variables reach a good explanation rate.) Due to the fact that only one significant independent variable could be identified, a stepwise regression analysis is performed to analyse each of independent variables more specifically. The stepwise regression leads again to a significantly positive ($p < 0.050$) influence of the variable "Perception of historic aura fostered by Audio" (coefficient 0.393), as well as to a significantly positive ($p < 0.050$) influence of the variable "Perception of historic aura fostered by 90 degree turns" (coefficient 0.293). Again, the regression coefficients (higher than 0.200) can be classified as sufficient [5]. (However, the R-square of 19.1% shows that descriptive variables reach only a poor explanation rate.)

From the quantitative data, "Audio" has the strongest influence on the extent to which users of the app feel the 'presence of ghosts'. Also the aspect of "90 degree turns" seems to support the 'ghost feeling'. However, due to the low explanatory rate of the stepwise regression, it is recommendable to look into the qualitative analyses for other indicators to the aspects of presence.

4.5 Regression Analysis on Story Appraisal

As shown in Table 4, the dependent variable "I liked the story" is

- significantly positive ($p < 0.050$) influenced by the variable "Motivated to continue by the suspense of the story" (coefficient 0.634),
- significantly positive ($p < 0.050$) influenced by the variable "Motivated to continue by the search of locations" (coefficient 0.328),
- significantly positive ($p < 0.050$) influenced by the subject's age (coefficient 0.129).

Table 4. Regression analysis – dependent variable "I liked the story"

Independent Variables/Questions	Regression Coefficient	Significance (p)
"Age"	**0.129**	**0.005**
"Motivated to continue by ..."		
Suspense of the story	**0.634**	**0.000**
Novelty of the app usage	0.073	0.317
Search of locations	**0.328**	**0.000**

The coefficients higher than 0.200 can again be classified as sufficient. The R-square of 68.3% shows that the descriptive variables reach a good explanation rate. All in all, the factor "Suspense of the story" has a very strong influence (coefficient 0.634) on the extent to which users liked the story.

4.6 Qualitative Analysis

Next to the quantitative data collection, we acquired qualitative data, in order to also get input on open aspects that the questionnaire did not cover. The accompanying researchers in each tour filled an observation form, to mainly note spontaneous remarks or reactions of users to situations. The observer also registered who (of a group) used the tablet, an own account of the subjects' initial motivation, how much support was required, and what different parts of the interface were used. Further, after their tour, subjects were asked a last open question concerning the story contents they remember, and how they liked certain aspects of it. If they agreed, this short conversation was audio-recorded. Afterwards, all filled forms and audio tapes were transcribed verbatim, and then sorted by the method of structural content analysis [18], building categories, and developing hypotheses from these. Thus, for some aspects that can hardly be explained with the statistical data at hand, we got further insights, as users partly provided explicit verbal explanations. Here, we only briefly summarize selected key insights to complement our statistical results, especially regarding the concept of presence and interactive story appreciation. Any quotes are translated from German.

Most comments of users or peculiarities in their interaction that were noted down concerned the finding of locations (115 notes in this category), the story content (91 notes) and the 90° turning (66 notes).

Although in principle, our interaction concept has proven to be learnable, many users needed some time to grasp the 90° turns, before they managed after a while. Apparently, several users did not experience the AR overlay, i.e., (to try or manage) to perceive the video characters as floating 'in reality' at a location, visible through a magic window ("Where is he gone?"/"The head is cut off"). Thus it is comprehensible that those did

not get the point of having to turn around at all. ("I don't understand why turning around should be good"). Positive examples include a father managing it immediately, after the daughter demonstrated the movement to him, or "Now it's OK, I just needed to get used to the turning", or a family pointing to the direction of where the cart might be now in reality (after the video characters had pointed there). There were also many positive reactions to the first appearances of Augmented Reality ("Oh how cool", a girl trying to 'feel' the ghosts) and awareness that the real environment is seen through (friends/partners try to join the spirits in the camera image, "I can see you").

When asked to reproduce details of the experienced story content after the tour, given answers were very diverse. Some claimed not to remember anything ("I mainly paid attention to the app, that's the problem"). Only few presented a comprehensive account of almost all events. In these cases, the story elements were mixed in with the user's own journey report and attached to places.

Many reported at first to remember love story elements. However, although the majority thought of the romantic aspect as positive or neutral, about a quarter of the interview partners expressed negative remarks about it ("Amusing, but unnecessary"/"I was rather bothered by it, because it is […] not so much related to the Saalburg, rather a private story, appeared inappropriate to me.") Others indeed realized its relationship to the Saalburg ("Why not! I mean, when I just want to present how life was here in general, then it's probably just necessary"). Several people claimed their desire and expectation to learn "more facts" when they visit a museum. Very few users made use of the "Facts" button in the menu, though.

On the other hand, some mentioned having been influenced by the test situation ("If I would be here alone and would have time, I would probably sit down and read every fact"). The group aspect also influenced other interactions, such as the 90° turns. As a matter of fact, it is easily possible to watch the content on a tablet-size device as a group of three. However, 90° turns then require the bystanders to jump around in order to follow (a father giving commands "Now everybody turn back!").

The observers also noted several remarks of users who were bothered by having to walk back to an already visited location ("We want to see more of the Saalburg!"), although according to the story, it made sense to return. Actually, reducing the experience to a limited number of places was not part of our ideal concept, but due to prototype and evaluation practicality. However, the remarks also point to characteristics of designing progress structures in location-based AR, as its concepts of moving around differ from adventure games played at a computer. Especially museum visitors might expect a 'guided tour'.

5 Conclusion

With the SPIRIT project, we developed a system and prototypical content for a specialized form of location-based interactive storytelling with Augmented Reality. The prototype has been evaluated with end-users concerning some special design goals connected to the Augmented Reality experience, namely to feel a connection to a place and presence of spirits, as well as the appreciation of the form of storytelling. While the

interaction design and the presence have been pre-tested in iterative cycles with media-savvy subjects, showing promising results, this was the first evaluation with random museum visitors.

Based on the quantitative evaluation we found that overall, users liked the app and would recommend it. However, many users reported also disturbing factors interfering with their usage. Our mentioned goals, particularly the feeling of a connection to the place and the presence of spirits, have not yet been fully achieved; on average, the users rated these aspects only slightly positive to neutral. It is still interesting to look at the correlating items. For the "Perception of historic aura", the items "Scenes relating to locations" and "Historical characters" are the strongest supporting factors. The factor "90 degree turns", however, is interesting, as the majority of people had problems with it, due to usability issues with this unfamiliar interaction. Looking into the qualitative evaluation results suggests that those participants who did not report problems with the 90° turns, expressed indeed a connection of the story to the place. This aspect needs further investigation.

The statistical analysis shows that the majority of the survey's results are reliable and valid. The regression analysis suggests that the "Perceived presence of ghosts" has the strongest influence on the extent to which users of the app could immerse themselves into the history, "Audio" has the strongest influence on the extent to which users of the app feel ghosts present and the variable "Suspense of the story" has a very strong influence on the extent to which users like the story.

For future work, the results point out that the introduction of unfamiliar interaction patterns (together with technical insufficiencies of the prototype) influenced the experience of presence, however with prospects that further development can reduce the disturbing factors.

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