



A Mixed Reality neighborhood tour: Understanding visitor experience and perceptions



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ABSTRACT

Museums are increasingly turning to technology to improve their offerings. This presents an opportunity to surrounding neighborhoods to take advantage of the museum in order to connect with visitors and offer them a glimpse into their community. The work presented in this article contributes to advancing the state of the art in designing Mixed Reality (MR) entertainment experiences by presenting and discussing *Yasmine's Adventures (YA)*, a mobile application aiming to extend the museum visitor's experience into the surrounding neighborhood. YA demonstrates the potential of MR in engaging visitors to explore neglected urban areas. This is achieved by incorporating the opinions of community members, and other contextual information, into a fictional storytelling journey, delivered through a MR entertainment experience distributed in real space. Consequently, users are provided with opportunity to connect with enriched portraits of these spaces. Results from a quantitative and qualitative evaluation showed that participants' perception of the neighborhood was positively affected by the experience, which fostered curiosity and willingness to explore the neighborhood both at the spatial and social levels. By taking the tour, participants increased their interest in interacting with locals and fostered greater knowledge of the area, which they were willing to share after experiencing it.

1. Introduction

Mobile and social technologies are now enabling people to explore, record and inhabit their surrounding spaces in novel and enhanced ways [1]. Despite the recent economic crisis, the tourism and travel industry is still growing [2] and so are visitors' demands and expectations for novel experiences. The design and staging of meaningful and pleasurable experiences is a pressing need for many touristic destinations [3]. In this context, technology-mediated experiences can play a role in sensitizing tourists towards key societal issues. We envisage that such experiences have the potential to create meaningful connections with local communities instead of the plain exploitation of local resources. The spreading and rapid uptake of various types of digital media and personal devices provides the opportunity for new technology-mediated experiences. These new types of media can be associated with urban locations and work with online and virtual channels, providing rich entertainment and educational experiences.

However, the emergence of mobile technology-mediated experiences creates a number of challenges for leisure businesses that rely solely on the exploration of physical space. Museums today embrace

technology in order to attract visitors and provide engaging and tailored events for their audiences [4,5]. For instance, Hume et al. [4] examined 12 museum techniques and operations towards customer satisfaction, concluding that museums need to shift their strategies and incorporate technology to create more interactive experiences in their experience-based services. In other words, museums should personalize their offerings using techniques such as free-form customized tours, wayfinding or space-guided navigation, bookmarking, or through social media technology [5]. These techniques are developed by combining virtual layers of digital information within users' experiences to specific points of interests within exhibitions.

Mixed Reality (MR) is defined as the combination of virtual computer graphics objects and real-world elements into a virtual environment. Recent studies suggest that MR is increasingly becoming our contemporary social reality [6]. It forms a continuum extending from the completely real through to the completely virtual with middle spaces that include augmented reality and augmented virtuality [3]. MR modifies the way we interact in public and private spaces [7] creating new meanings of "realness" that change as people move through the physical world while using their mobile devices to

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communicate with their counterparts through the virtual/digital world.

Through the design and evaluation of *Yasmine's Adventures*, this paper provides evidence of how MR can be used to extend the experience of museums outside their premises, supporting a more positive perspective of the spaces and communities surrounding it. Throughout a real-world case study, we present how MR technologies could be used to suggest new ways for people to reason and interact with their physical surroundings [8]. Unlike other conventional Human-Computer Interaction (HCI) contexts, the engagement and feedback from audiences become crucial for the improvement and refinements of these technological interventions.

The main contribution of this paper is advancing the state of the art in the design of MR entertainment experiences, and how they could be used in the context of digitally mediated neighborhood tours. We accomplish this by presenting and discussing the combination of a quantitative and qualitative evaluation of a real-world case study of MR entertainment experience deployed in a major museum in a European capital. Overall, our findings suggest that MR experience successfully stimulates museum visitors to explore the surroundings of museums spurring links with local communities and their interests.

The rest of this paper is structured as follows: Section 2 describes related work and outlines the research questions. Section 3 describes the design of the MR application. Sections 4 and 5 present evaluation procedures and main findings. Section 6 discusses the study's insights and outcomes; Section 7 discusses the limitations and future work. Finally, in Section 8, we present conclusions.

2. Related work

Mobile MR experiences are inherently impacting how we perceive reality by enabling participants to inhabit the physical and virtual environments simultaneously [8]. These technologies raise multiple questions, concerns, and research challenges. Some authors argue the negative effects of mobile MR on social interactions (i.e. people engage with screens more than with surrounding people) [9]. Others highlight the power of MR in bringing people into physical proximity to each other, facilitating more natural interactions [10]. In several projects, Cheok et al. [11–13] provide evidence of how MR experiences actually push people to become deeply involved in social and physical interactions. MR technologies have the power to conceptually change the nature of a public physical space and the social interactions that occur in them [14]. The research conducted in this field is extensive and multifaceted. The related work is divided into several subsections, although much of the work cited could fall under more than one.

2.1. Mixed Reality and location based technological challenges

As a large number of mobile devices today are equipped with GPS, cameras and multiple sensors (accelerometers, gyroscopes, and compasses), they are extensively used to craft and deliver digitally-mediated storytelling and gaming experiences. Mobile devices enable associating digital content with physically-located products, objects and/or locations. Several recent projects explored how to design MR experiences that facilitate the transition between the physical and the virtual world [14]. One approach, common to some early locative media projects, was to augment the physical environment with content available through radio frequency tags (such as RFID or iBeacons) [15–17]. For example, in *Hopstory* [18] a character-driven story is digitally delivered inside the Dublin's Guinness Hopstore. While exploring the physical space, the audience collects content through interactions with sculptures equipped with iButtons. Further, with the spreading of GPS technologies, the association of digital stories and memories to locations was taken outdoors. Several projects experimented with the potential of combining stories with urban streets and locations. Pioneering research was conducted through projects such as *'34 North by 118 West'* in Los Angeles, USA [19] or *'Media Portrait of the*

Liberties' in Dublin, Ireland [20]. Both projects use space as a navigation strategy for story content, depicting the place at a different point in time. However, the inaccuracies in early GPS systems negatively affected the user experience in some reports [21,22] and prompted the adoption of different approaches to locate content in the real world. Some authors combine different techniques and technologies such as position self-reporting [21], visual markers [22], Bluetooth technology [23], or QR codes [24]. An early example of a story-driven location-aware experience, which combines the use of GPS sensing and Bluetooth technology to augment tourist experiences, is the *'History Unwired'* project in Venice [23]. The application accompanies the audience through a walking tour of Venice's hidden neighborhoods, meeting local characters (in the form of pre-recorded interviews) in their natural settings. The authors report on several good practices highlighted through their project, in particular how users appreciated tales told by local characters and hidden surprise content (referred to in gaming jargon as "Easter Eggs"), which worked as powerful rewards for the audience. Altogether, these different techniques facilitate the relationship between physical artifacts (i.e. products and objects or locations in everyday life) with emotionally charged personal tales. For instance, Karpiscek & Michahelles [25] reported positive engagement of the public with a mobile application that connected social content with physical objects/products. Ballagas et al. [26] report GPS shortcomings identified in the initial evaluation of the *'REXplorer'* system (a location-based game working with GPS alone) and propose the integration of GPS with further locative technology including WLAN, and GSM cell data. Such idea resonates in part with some of the existing practices around "geocaching", as reported by O'Hara [27] wherein certain caches participants are directed to look at particular features in the environment in order to find the cache, encouraging them to look at places in different ways than if they were not caching.

2.2. Mixed Reality Games

Games are a well-exploited area of application for MR technologies. These games, called by Sousa et al. "Hybrid Games" [28], imply extending gamification elements and co-opting the players' sensory experience beyond the screen into the physical world. The real-world elements become part of the storytelling experience, mixing the physical and virtual to create an immersive hybrid game world. After the pioneering work *'Uncle Roy All Around You'*, [29] others followed the trend of mixing reality in gaming experiences [30]. In *'Mosaic'* [31] the authors attempt to create a hybrid space through the gamification of real objects in a museum following a storyline. In *'Mentira'*, [32], a site-specific game teaching Spanish within the context of local neighborhoods in Albuquerque, New Mexico, surprising positive results demonstrate how MR mobile experience can deepen the understanding of place and transform it into a personalized learning experience. Likewise, the Location-Aware Mobile AR game *'The Final TimeWarp'* [33] explores the relationship between presence and game design factors. Results from the user study show that content including moral dilemmas, strong narratives, as well as using real locations effectively and applying simple physical behavior within virtual characters to improve embodiment, have a positive impact on the player experience. More recently, Rossitto et al. [34] presented a qualitative study of *'Maryam'*, an interactive audio drama facilitated by a location-based application. In *'Maryam'*, audience members trigger audio scenes as they walk through pre-defined city areas. The authors explore creative imagination and open interpretation as audience members traverse places and establish inter-relations with locative media. Results showed that audience members attempted to develop their own meaningful associations between elements of the locative media and elements of place. This is a clear illustration of how embodiment and emplacement are central to the interpretation of the story.

2.3. Mixed Reality in curated spaces

As Neuhofer [35] points out, innovative technologies provide the potential to differentiate destinations and create unique experiences valued by tourists and visitors. Museums and other culture-related curated spaces are competing for people's time, so they must be appealing and offer individual experiences to draw people's attention. For instance, 'Pure Land' [36] mapped a virtual reality digital model of the UNESCO World Heritage cave. The exhibition space was set up at the same scale as the real cave and enables visitors to explore sculptures and wall paintings through their mobile devices acting as "windows" to the virtual reality. 'CHESS' (Cultural Heritage Experiences through Socio-Personal Interactions and Storytelling), crafts personalized and adaptive museum guides [24]. The 'Collect' mobile phone application enables users to retrieve content from a data matrix code placed on physical sign posts, and allows them to review the collected content as they tour the zoo. For each situated marker/location, 'Collect' proposes a mix of audio, video, and text files about the animals in that particular enclosure [24]. The use of markers within a curated space adds a tangible element to the experience of a Location Aware Multimedia Story and ensures that participants observe and take in the physical and architectural elements of the desired location before consuming digital content, avoiding the problem of looking at the mobile device screen all the time [22]. A similar approach was used to support meaningful visitor engagement at a heritage site in the project 'Reminisce', [37] wherein the participants can enrich their visit to a series of buildings with a set of digital auditory "memories" narrated by fictional characters associated with the sites. The presence of "memories" was indicated by QR-markers placed in different parts of a building that could be scanned with the phone. The system worked well in fostering engagement with the heritage site. Authors report that, although the actors impersonating characters in costume connected to the building's history, the visitors found it hard to connect the buildings and the real-life scenarios re-enacted in front of their eyes. After all, the QR codes seemed a more effective way to revive the past in the audience's mind. 'Luostarinmäki Adventure' [38] is a MR adventure game that yielded valuable findings on using MR technology in curated spaces. It shows the life in a city of the past 19th century, by combining the physically existing contemporary buildings and digitally created characters. The project demonstrated how experiences could seamlessly combine physical and virtual pieces of content, be highly interactive in real-time, and allow users to experience the content with free movement in the real world 3D space.

The above-cited projects provide evidence of the value and potential of MR technologies when applied to cultural spaces, namely, enhanced user demand of exhibit-related information and a more self-guided approach during the MR experience [32,33]. It is particularly interesting to note how MR can provide realistic experiences of impossible events, such as bringing dinosaurs to life [39], or a high-resolution experience of an artwork located elsewhere by using 360° videos, thanks to Google Arts and Culture and The Natural History Museum collaboration [40].

2.4. Research challenges and opportunities in Mixed Reality and locative entertainment

MR experiences can connect information with material reality, making the invisible visible in-situ and thus helping build connections between the space, its history and community, and visitors to the place. As MR technologies mature, its potential applications in hybrid spaces increase and become widespread. However, research in this area is still early stage, and hence highlighting operable insight and guidelines could help practitioners and researchers progress the field. In addition, comprehensive frameworks for evaluating these novel experiences in their multiple dimensions of adoption, usability, engagement, immersion, presence and physical awareness are rare. Therefore, the research

challenges concerned with the design and evaluation of MR experience are a growing area of interest for the HCI community. For instance, Bach & Scapin [41] identified various obstacles for evaluating the usability of MR systems. The authors concluded that there is a lack of common testing platforms and benchmarks. In the light of the reported related work, this paper aims to address the following research questions in order to evaluate the YA as a MR entertainment experience:

RQ1: How does the *Yasmine's Adventures* MR entertainment experience help visitors of a museum perceive the surrounding neighborhood?

RQ2: How is the *Yasmine's Adventures* MR perceived as an entertainment experience?

This MR experience was designed as an entertainment experience to enrich the visitor experience stimulating the exploration of the surroundings of a popular museum in a European capital. *Yasmine's Adventures* was evaluated using a selection of evaluation methods from qualitative to quantitative (shadowing and semi-structured interviews and a variety of validated scales) summarized using thematic analysis [42]. Finally, we discuss the general benefits of this MR experience for the local community, i.e., benefiting a disadvantaged neighborhood by reshaping the interaction between locals and visitors. In the following sections, we describe the design and evaluation of *Yasmine's Adventures*.

3. The design of *Yasmine's Adventures*

Yasmine's Adventures (YA) is a MR entertainment experience designed with the goal of engaging visitors with a neglected neighborhood around a well-known museum in a capital city of Europe. YA was conceived to encourage visitors to explore the area around the museum, highlighting the point of view of the local community. The application and the initial idea was inspired by "Pinpointing Meringplatz", a workshop organized by the design research group at Berlin University of the Arts involving the local community. In the workshop, community members identified features of the neighborhood they considered attractive and unattractive and potential issues, marking them as pleasing, disagreeable, or potentially transformational. Consequently, these features of the neighborhood highlighted by the community members served as a backdrop for the story. Afterwards, we designed a trail through the neighborhood that would bring the audience to visit the points of interest highlighted by the community. We did so by creating a fictional character, a young girl called Yasmine, who moves through the neighborhood touching on locations identified during the workshop. In order to pinpoint the presence of content to the mobile audience, we augmented the physical environment with visual markers [22] positioned in the different places where the story unfolds. Hence, the audience was required to find and capture these markers with their mobile phone cameras in order to follow the progress of the story of Yasmine. Once detected, the markers would trigger multimedia content on the mobile phone. This was done reconstructing the surrounding environment in 360° VR navigable landscapes. This allowed us to place the markers in the vicinity of the Point of Interests (POIs) but still in a safe and accessible place for the visitors to stop, capture and view the content (Fig. 1a,c). The actual story of Yasmine was told with 2D animation clips, each one corresponding to a finite episode of the story. These 2D story fragments are placed inside the 360° VR navigable landscapes, overlapping the virtual landscape with the multimedia content. In order to find the story fragments the user needs to use the phone to navigate the landscape (Fig. 1b). The story was designed to be experienced sequentially, so the visual markers should be captured in the correct order following the predefined trail (Fig. 2). Yasmine's story ends after all highlighted locations on the map interface have been visited. The user then returns the device to the museum. The whole tour of YA lasts approximately 20 min.

The audience experience unfolds in three layers. The first layer corresponds to the interaction with the real world where the markers are placed and then found in the neighborhood surrounding the



Fig. 1. *Yasmine's Adventures* Tour: (a) Capturing Visual Marker; (b) Scanning the environment; (c) Story visualization.



Fig. 2. Users Physical World Trajectory.

museum. The second layer corresponds to the MR world where the stories of *Yasmine* can be found by exploring the 360° VR model of the surrounding physical space, which is loaded up upon capturing the marker. Interacting with the VR environment and looking for content implies users exploring the 360° VR model by means of moving around in real space. Finally, once the 2D content is found and loaded into the VR space, the video animation of *Yasmine* plays. This leads to the third layer corresponding to *Yasmine's Adventures* fictional story or fictional world delivered as a sequential journey through the 2D animation clips.

3.1. *Yasmine's Adventures* fictional story

Yasmine is a fictional character, a curious and adventurous seven-year-old girl from the local neighborhood. She starts her adventure by escaping from a school trip to the nearby museum and going back home by herself. Along the journey, she stops in various places corresponding to the POIs highlighted by the local community. These include recognizable places such as the school where hip-hop classes are offered (Fig. 3), or the popular street murals where she talks to the mural painter at work. Places that the neighborhood dislikes are also shown, such as the center of the neighborhood square, which looks like an abandoned construction site. The story illustrates real neighborhood features such as the fun activities taking place at the hip-hop music center, or the history of the authored murals near the main square. These issues highlighted by the community are used as informative

background for *Yasmine's* journey, illustrating the concerns and pride of the community, through the pleasurable moments and challenges that *Yasmine* must overcome to reach home. For example, the community members appreciate the painted murals since they bring life to the neighborhood. In *Yasmine's* stories, these are featured and enhanced by a metaphor where the bird of the mural comes to life and flies away. *Yasmine* follows the bird into the nearby construction site, a neglected and scary area full of abandoned machinery and tools. While the character of *Yasmine* is completely fictional, the world that she inhabits is grounded in community opinions and feelings.

3.2. Experience design and markers

The YA application is designed to provide an experience in the physical environment, namely the neglected area surrounding the museum. In order to use the MR application, the visitors to the museum are provided with a smartphone or instructed on how to download the application to their own device and briefly instructed in how to use it. The visitors then go outside the museum to look for visual cues or markers that signal the presence of the fictional story of *Yasmine*. These visual markers serve as portals between the physical and the virtual worlds. They are placed in strategic POIs in the real world indicating the presence of the content from the story world of *Yasmine*. These markers are A5 postcards (Fig. 1a) depicting scenes from *Yasmine's Adventures* and are easy to see and access. Visitors can discover a total of five visual cues, using a map interface to guide them through the area.

3.3. Mobile phone application

The mobile application delivering YA includes information from both the fictional story world and the real physical world corresponding to the different layers of reality. The mobile application supports the Mixed Reality experience (Fig. 4). Once the users in the physical world find the visual cue, they point the camera phone at it to capture the marker. At that point, a 360° VR reconstruction of the surrounding environment loads and is displayed on the screen. The user is then prompted to scan around using the mobile phone in the real environment looking for additional story content. Using the phone's accelerometer and compass, the 360° VR reconstruction of the environment follows the user's movements, updating the screen with a 360° VR version of the surrounding landscape. This composition is an interpretation that brings together elements from the physical world with elements of the fictional world. The chosen real locations are modeled and textured according to the visual style of the animation. The entire surrounding landscape is then rendered in shades of grey except for the exact location where the story happens, highlighting the presence of additional live content.

The story fragments are highlighted within the 360° VR landscapes by an orange circle (Fig. 1). This circle is a loading cue, meaning the story content related to that specific point is loading. The users wait



Fig. 3. Stills from *Yasmine's Adventures Story*.

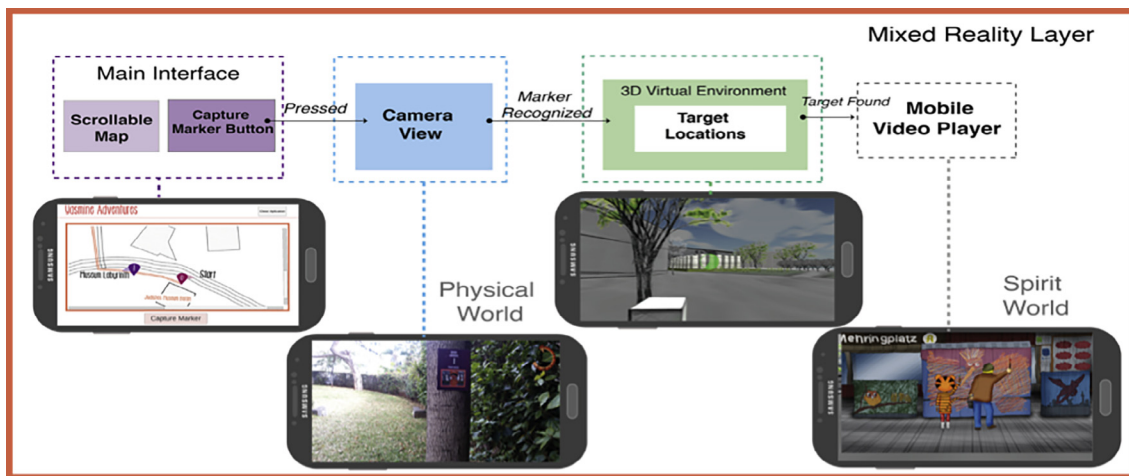


Fig. 4. *Yasmine's Adventures* Components' within the Mixed Reality Layer.

until the video animation is fully loaded and the animation then plays automatically. The animation depicts *Yasmine's Adventures* in that specific location from the story world.

When the video ends, the user is returned to the 360° VR landscape screen to scan the environment for more stories. If no new stories are available, the interface suggests the user to go back to the 2D map and follow the indications to reach the next POI. The application presents novel content in five different POIs, all embedded in 360° VR reconstructions, so to match the physical surroundings. Several 2D animation clips of *Yasmine's Adventures* can be found at each location.

Through the act of scanning the environment in 360°, the user becomes familiar with the surrounding peripheral space. She can then lock the motion in the direction of the detected content, which is the same precise spot in the 360° VR environment. After viewing the content, the user can resume looking around and checking the real surroundings to reflect on what she just saw. The replication of real space in 360° VR is designed to evoke a sense of wonder and contrast between the real, mixed, and fictional world and to provide additional precision to enhance the connection between physical space and the placement of virtual content. GPS alone would not have given us enough precision to support the connection between *Yasmine's* stories and the places pinpointed by the community. At the same time, the real space around the user still acts as a reference, since the 360° VR world depicts the same setting.

4. Evaluation and methodology

We designed *Yasmine's Adventures* to understand how MR entertainment experiences could be used in the context of digitally mediated tours around museum neighborhoods. To achieve it, we collected qualitative and quantitative data from users taking the tour and evaluated their experience against this potential entertainment experience. In the following sections we list the measures used, the study setup and sample. We finish by summarizing our findings.

4.1. Measures

To evaluate YA as an entertainment experience we used the quantitative measures listed in Table 1. These measures were integrated into a questionnaire composed of several items: (i) demographic data, (ii) compared experience with similar applications and (iii) selected items from the Narrative Transportation Scale [43], the Flow Short Scale [44], Positive and Negative Affect Schedule scale (PANAS) [45] and the AttrakDiff™ questionnaire [46]. Each measure is described in the following paragraphs. The final questionnaire included a total of 16 questions (some containing multiple items, for instance, Flow Scale alone contained 10 items).

The Narrative Transportation scale (NTS) was applied to assess participants' ability to be transported into the experience's narrative

Table 1
Quantitative measures result summary.

| Measure | Reliability of the scale | Mean scores/Standard Deviation |
|------------------------------------|--------------------------|--------------------------------|
| NTS (11 items) | $\alpha = 0.47$ | M = 43.44 SD = 6.54 |
| Flow Short Scale (10 items) | $\alpha = 0.71$ | M = 48.80 SD = 8.12 |
| PANAS Positive Feelings (11 items) | $\alpha = 0.80$ | M = 31.85 SD = 6.65 |
| PANAS Negative Feelings (7 items) | $\alpha = 0.88$ | M = 9.40 SD = 3.96 |

[47]. It consists of 11 items that evaluate immersion aspects such as: emotional involvement in the story, cognitive attention to the story, feelings of suspense, lack of awareness of surroundings, and mental imagery ($\alpha = 0.47$). All items were measured on a seven-point scale anchored by very much (7), and not at all (1) where higher scores represent greater transportedness (considering M = 35 as an average value of transportedness).

Replicating previous work using the NTS scale [47,48] we applied a principal component analysis (PCA) to extract the main factors. Our PCA analysis (varimax rotation) revealed a two-factor structure: emotional involvement (8 items; $\alpha = 0.49$) and story involvement (3 items; $\alpha = 0.37$). As the subscales generally did not differentially predict relevant outcomes, therefore we decided to report results using the NTS full scale following the originally developed scale. The two factors: emotional involvement and story involvement were only used to explore the possibility of correlations among the different sub-factors of NTS and other collected measures (Flow and neighborhood perception), the results from that are described below.

The Flow Short Scale [44] was used to evaluate the individual's ability to be absorbed by the activity and fluency during the experience. It is composed of 10 items and its internal reliability was high ($\alpha = 0.71$). Emotional involvement (measured by NTS) was correlated with Flow where results indicated a large and positive correlation [49] ($[r = 0.533, n = 20, p = 0.023]$) in which high levels of Flow (mean scores) were associated with high levels of emotional involvement (mean scores).

The PANAS scale [50] measured feelings about the story. This scale measures the experienced affect and it uses 20 verbal descriptors for both positive affect (alert, attentive, determined, enthusiastic, excited, inspired, proud, strong and interested) and negative affect (afraid, scared, nervous, jittery, irritable, hostile, guilty, ashamed, upset and distressed). The internal reliability for this scale was high (Positive $\alpha = 0.80$ and Negative $\alpha = 0.88$).

In addition, we applied the AttrakDiffTM questionnaire (28 seven-step items) developed by Hassenzahl [51] in an attempt to assess *Yasmine's Adventures* in terms of the overall user experience and its potential as an entertainment experience. Increasingly, services stand out for their user experience, the AttrakDiffTM questionnaire is a product evaluation questionnaire that focuses on both the usability and the pleasantness of the experience. It records the perceived pragmatic quality, the hedonic quality, and the attractiveness of an interactive product [51,52]. Through the AttrakDiffTM questionnaire users indicated their perception of YA on different dimensions: Pragmatic Qualities (PQ), Hedonic Quality (HQ), Hedonic Identification (HI), Hedonic Stimulation (HS), and General Appeal (GA) [51]. PQ describes the usability of a product and indicates how successful users are in achieving their goals using the product. HQ refers to the aspects of a user interface that appeal to a person's desire for pleasure and avoidance of boredom and discomfort. HI indicates to what extent the product allows the user to identify with it in a social context. HS indicates to what extent the product can support those needs in terms of novelty, interesting and stimulating functions, content, interaction, and presentation-style. And finally, GA includes attributes that examine the beauty and how well does the product fits the user's desired goals [51].

We asked if the MR experience helped users to learn about and change their neighborhood perception, a single question, participants indicated ratings with an average score of 4.5 (on a 1–7 Likert scale). This perspective modification was correlated to transportation (NTS), a large and positive correlation [49] between the two variables ($[r = 0.702, n = 20, p = 0.001]$), with high levels of transportation (NTS Mean Scores) associated with high levels of changing the neighborhood perspective.

To assess Presence, a single item was included in the questionnaire: "In the video narrative I had a "sense of being there". Presence is defined as "a psychological state in which virtual objects are experienced as actual objects in either sensory or non-sensory ways" [53] and there seems to be a connection between presence and enjoyment (e.g., [54,55]) where "presence can intensify existing media effects such as enjoyment" Wirth et al. [56]. In addition, the results suggested a strong and positive relationship ($[r = 0.505, n = 20, p < 0.05]$) between transportation and presence with high levels of transportation associated with high levels of presence. We opted for a single item, being a multidimensional concept for the particular purpose of this study, presence associated with physical presence seemed the most adequate to be assessed with our participants. Furthermore, this decision was also based on the condition of making the questionnaire as brief as possible, since it contained other measures and following previous research indicating that a single item would suffice [57]. Overall, preliminary analyses were performed to all scales to ensure no violation of the assumptions of normality, linearity, and homoscedasticity (also referred to as homogeneity of variance).

4.2. Participants and study setup

For this study, a total of 20 users (15 females) were recruited using a snowball sampling method and completed the tour. Regarding the participants' age ranges, 11 participants were between 25 and 34 years, 5 participants between 35 and 44, 2 participants between 18 and 24, 1 participant between 45 and 54 and finally 1 participant also between 55 and 64. Their native languages were German (11 participants), Spanish (3), French (2), Portuguese (1), Swedish (2), and Romanian (1). All participants were, however, pre-screened for their fluency in English. Participants were all currently living in the European capital of Berlin.

Participants were asked to complete the tour of *Yasmine's Adventures* as it is described previously in the paper (Fig. 4). The tour started at the entrance of the museum where the researchers handed in the mobile phone running the YA application. At the beginning of each user study, the researchers informed the participants that they would be taking notes during their experience (shadowing), emphasizing the fact they would not interfere with their experience. The subjects were also informed they could give up the experiment at any time by returning the device to the researcher. On average, each tour lasted around 20–25 min. Once the tour was completed, participants were asked to complete the questionnaire described in the previous section. Additionally, researchers conducted semi-structured interviews to probe participants' impressions about the overall experience. The interview guide included individual questions based specifically on participants' tour shadowing and observation notes. Interviews lasted around 15–20 min, these were audio-recorded and transcribed for analysis. The resulting data was analyzed with the support of Nvivo [58], using a thematic analysis approach to collect user's impressions concerning the MR experience [42]. The team conducted a bottom-up data analysis reviewing in an iterative process. Firstly, researchers used open coding, where each researcher selected quotes and created high-level categories, reviewed and merged or divided into new categories. Secondly, affinity diagrams were used to explain the relationships between categories. Thirdly, researchers organized the most frequent concepts and insights, followed by the description of each one with illustrative quotes given by users in the interviews.

Table 2
Thematic analysis results with user quotes.

| Research Questions | Themes | User quotes |
|--|--|---|
| RQ1: How does using a MR entertainment experience help visitors of a museum perceive a surrounding neighborhood? | Enjoyment and knowledge | <p>"I felt I learn something new, I did not know they organized hip-hop classes at KMA or about the artists who painted the artwork" (U12 ref. 3) "Getting an insight of this place (...) where it was explained that the spaces shown are important places for people who live here and this was the most interesting thing for me, to have an insider's view of it" (U15 ref. 2) "It was a very nice experience, I got to find out more about the area, some details I did not know about, it was very interesting" (U19 ref. 1) "I think it was fun! (...) it was nice to look around and see the street art" (U7, ref. 1)</p> |
| | Physical space enhancement/attention to details | <p>"I could see the area in a different and more intimate way, it made me look more in detail to places" (U11 ref. 1) "I felt like since I know the area I have not been noticing the details and the surroundings. I know the area, which is why I usually do not look for details. I only started looking for the details when I was looking for the markers (...). It helped to put focus on surroundings' details" (U16 ref. 1)</p> |
| | Physical space exploration | <p>"I don't think it could replace a documentary about the space but I think it is one of the best ways if you are short on time and you want to explore the neighborhood in a different way" (U5 ref. 1)</p> |
| | Challenge social conventions | <p>"I do not like pointing at places and people, because they do not know what I am doing" (U17 ref. 2) "For a moment, I felt funny holding the phone as it seems like I am taking pictures of the kids" (U9 ref. 3) "Especially here people are very aware about cameras, especially mobile cameras (...). and you stop at somebody's face for example and the place [referring to where the story is located] it is when I feel a little uncomfortable" (U2 ref. 4) "If I was alone I would not probably do it I would feel awkward to walk around with a smartphone like this" (U16 ref. 3)</p> |
| | Distracting and limited exploration | <p>"You are very focused on the app and it does not give you an opportunity to really see the neighborhood. I can see it through the augmented reality but you are not really paying attention to how it really is. I would like more reasons to look at the real things" (U10 ref. 1)</p> |
| | Share the learned experience with others | <p>"I feel more connected because I am here I have seen the people in the street. It is a geographically placed experience, I would be comfortable and it is nice to present the neighborhood to other people" (U15 ref. 4)</p> |
| | Reveal the real hidden stories | <p>"I think it's a first step in a good direction I would make it more complex, the story more complex and deeper, and also longer. A more engaging story and more intriguing" (U13, ref. 1) "I would rather have the little stories of what happened there, or what happened here to make me more curious about the area (...). it's just the story I find a bit too poor (...). or some more history or even the feeling of why is it cool here?" (U1, ref. 1) "I would maybe think more about the stories that you tell through the app either make them real stories about real persons or testimonials" (U10, ref. 1) "It would be good to have more content that is specific to the location" (U8, ref. 1) "Not my personal story but more historical facts" (U16 ref. 1)</p> |
| | Empathy and identification | <p>"I think for when we go to a place we do not know, in this way, we can figure out the place and the problems of a living area that you did not think before. So, I would just have walked by the building/construction site I would not reflect on what and why and for how long it's going on" (U7, ref. 1) "I really enjoyed her and how as a child I was a bit like her. I would sneak out to find things" (U10, ref. 1)</p> |
| | Enabled walking and exploration | <p>"I really like just taking the tour and looking around (...) feeling lost and finding my way around again (...) your curiosity is open in a way" (U11 ref. 1) "In this area, there are many more things around, there are many interesting locations it would be cool to have a longer walk" (U16 ref. 1) "I think it is a good idea to walk around, in a way you have to interact with the objects and you have to look around" (U7 ref. 2) "For me it's a nice presentation of Mehingplatz that nobody knows" (U18 ref. 2) "I walked through a path of the city that I have never been" (U7, ref. 1)</p> |
| | Innovative, creative and inventive | <p>"A mediated journey through the neighborhood (...) I really like the path and the story, I would like to know more about it" (U11 ref.1) "I really liked it, a story in an app" (U10 ref.1)</p> |
| RQ2: How is the Yasmine's Adventures MR perceived as an entertainment experience? | Enhanced the local experience | <p>"The funniest part was finding the markers and the scavenger hunt; it turned the experience into a game" (U14 ref. 1) "It was fun to follow the adventure, to watch the videos, it worked well (...). It was fun to follow. I could have done a couple more [markers]" (U9 ref. 1) "The funniest part was finding the markers and the scavenger hunt; it turned the experience into a game (...) it was a different way to move in the space" (U14 ref. 1)</p> |
| | Treasure hunt | <p>Enjoyable experience "This connection of a device that guides me and how looking at the site and the street worked very well, it was nice (...) having the reality and seeing what I'm seeing at the map I enjoyed this a lot. This hyper reality worked very well for me" (U9 ref. 2)</p> |
| | Interface | <p>Feedback cues "I really appreciated the fact that it tells you there are no more videos [referring to markers] (...) you do not need to look for more" (U10 ref. 2)</p> |
| | | <p>360° VR Environment "I like the details (360° VR) you have captured the environment very well" (U10 ref. 3) "I really liked the 360° VR environment. It is really cool, it is fun to see something through different media and kind of hand drawn I think it works really well" (U12 ref. 3)</p> |
| | | <p>Problematic map "The map I can not control it, it keeps coming back to the beginning. It would be good to have a GPS so I know when or where to walk and if I'm close to it or not" (U12 ref. 1) "I should, jump to the current location so I do not have to scroll again in the map" (U9 ref. 4) "The technical stuff, it did not match the directions or some places while walking (...) maybe another feedback when it is enough to hold your hand" (U4 ref. 1)</p> |
| | | <p>Conflicting information "I do not know if I am on the right side of the street, it is confusing for me" (U4 ref. 1) "I'm confused here because the picture is in this side of the road but the application shows the opposite way. I feel disoriented" (U15 ref. 8) "I feel a little stupid" (U15 ref. 6)</p> |
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5. Findings

In this section, we outline the findings according to our main research questions. For each question, we provide dominant themes, and within each of the themes, we provide the combined results from the quantitative (see Table 1) and qualitative analysis. The qualitative data, using user statements that support the findings, is displayed in Table 2, together with a sample of the most representative quotes found through thematic analysis. A discussion and reflection of the key findings are presented in Section 6.

RQ1: How does the Yasmine's Adventures MR entertainment experience help visitors of a museum perceive the surrounding neighborhood?

(1) YA generated positive feelings and further exploration

Participants appreciated the overall experience. Quantitative results showed high scores when associating positive feelings with the experience, and low results for the negative components (Table 1 – PANAS Results). The tour in the neighborhood, supported by YA, was considered to enhance the experience in physical space. The experience enabled users to focus and notice specific details in space. Participants considered the experience to be very effective in fostering exploration of the space. In their interviews, participants emphasized the exploratory aspects of the experience that incentivized walking and wandering, where curiosity would make them withstand an even longer walk. For others, the walk enabled a greater degree of interaction (Table 2 - U11 ref. 1; U16 ref. 1).

(2) Using the application in public felt like defying social conventions

Several users reported feelings of uneasiness while walking with a phone visible in their hands (for example: see Table 2 - U16 ref 3) and even more while scanning the environment for content. Participants reported feelings of discomfort and awkwardness when interactions with YA involved pointing the mobile phone towards other people. Some users reported YA as being unpredictable and isolating (Fig. 6 - Right Side). This isolation feeling relates to what some participants mentioned in the interviews, the application was making them focus on the phone screen instead of the neighborhood physical features. Interestingly enough, a few users even felt constrained by the application, and that it limited their exploration of the neighborhood at their own leisure and pace (Table 2 - U17 ref. 2; U9 ref. 3; U2 ref. 4.).

(3) Learning about the neighborhood through the application led to willingness to share

The NTS scores reveal a certain degree of transportedness into the narrative, highlighting opportunities for enhancement, as mean score values are only slightly above average, See Table 1. The feeling of transportation into the narrative might have allowed for users to better connect with the neighborhood. In the questionnaire, we asked if the experience helped users to learn about and change their perception of the neighborhood. Participants indicated ratings with an average of 4.5 (on a 1–7 Likert scale), which is rather positive. This perspective modification was correlated to transportation, a large and positive correlation [49] between the two variables ($[r = 0.702 \ n = 20, \ p = 0.001]$), with high levels of transportation associated with high levels of change in the neighborhood perspective. Moreover, emotional involvement (measured by NTS) was correlated with Flow, where results indicated a large and positive correlation [49] ($[r = 0.533, \ n = 20, \ p = 0.023]$), in which, high levels of Flow were associated with high levels of emotional involvement. In addition, participants mentioned YA increasing their knowledge about the neighborhood, as they learned new facts or became aware of “local’s concerns”. This knowledge modified their previous perspective about the neighborhood, and

users even referred to specific locations, such as the hip-hop center (KMA) (Table 2 - U12 ref. 3). As a result, users revealed their willingness to share their knowledge about their own neighborhood and related to facts, namely historical facts (Table 2 - U16 ref. 1).

(4) Story mapping to the Real World and hidden stories

In the interviews, users expressed the wish to have a more complex story indicating that *Yasmine's Adventures* could be expanded, by adding more complexity and more facts to it. Some users mention that the content could be further shaped and enriched by local individual’s testimonials rather than simply woven around a fictional character (Table 2 - U13 ref. 1; U1 ref. 1). Others remarked how they enjoyed the factual anecdotes about the place more than the fictional character itself. Upon experiencing YA, those participants who already knew the place were prompted to remember several further anecdotes. Additionally, some users reported that they would have liked to prolong the journey, to discover more locations and markers (Table 2 - U16 ref. 1).

(5) Uncovering the story enabled empathy and identification

The *Yasmine's Adventures* were tightly linked with the physical journey of the place. The fictional and fantasy elements of the story were positively perceived by most users and, overall, helped visitors to learn about local places. The content led some users to reflect on current community issues (see Table 2 - U7 ref. 1).

The main character generated empathy in users through a number of ways, contributing to their engagement and enjoyment. For example, several audience members connected with the character and participants’ childhood memories emerged (Table 2 - U10 ref. 1). Moreover, the participants’ perception of the story revealed that their attention was captured by specific elements of the story. For instance, the main character caused participants to notice not only its physical characterization but also, more detailed psychological traits such as her curious and well-disposed personality (Table 2 - U10, ref. 1). The art style was perceived positively, while some users observed that the style was more appropriate for a specific audience such as children.

RQ2: How is the Yasmine's Adventures MR perceived as an entertainment experience?

(1) Yasmine's Adventures as an entertainment service for the museum

The results from the AttrakDiff™ framework show YA with average score values in terms of pragmatic qualities and hedonic qualities (Fig. 5). Firstly, it is important to highlight that the confidence interval is small, meaning that users are in agreement in their evaluation of the experience and ratings in both of the dimensions. The dimension values (P) lie in the “character-region” classified as “neutral”, signifying that there is still room for improvement both in terms of usability (pragmatic quality) and stimulation/attraction (hedonic quality). Nevertheless, it is encouraging to see that the dimension values (P) are already quite close to reaching the “desired” “character-region”.

Looking at YA as an entertainment experience through the AttrakDiff™ dimensions, (Fig. 6 - Left Side) we note that the Hedonic Identification (HQ-I) and Hedonic Stimulation (HQ-S) values are located in the average region, meaning that the user qualified YA as an experience in a social context (related to HQ-I) and thus meets ordinary standards in terms of being novel, interesting and stimulating (related to HQ-S). This is also reinforced by the Flow Short Scale results (Table 1), where we see average mean scores indicating that on average participants did get absorbed by the experience and some fluency occurred while undertaking the experience. However, in order to position YA as a service in this area, we must aim at motivating and stimulating the participants further. This would lead participants to feel strongly

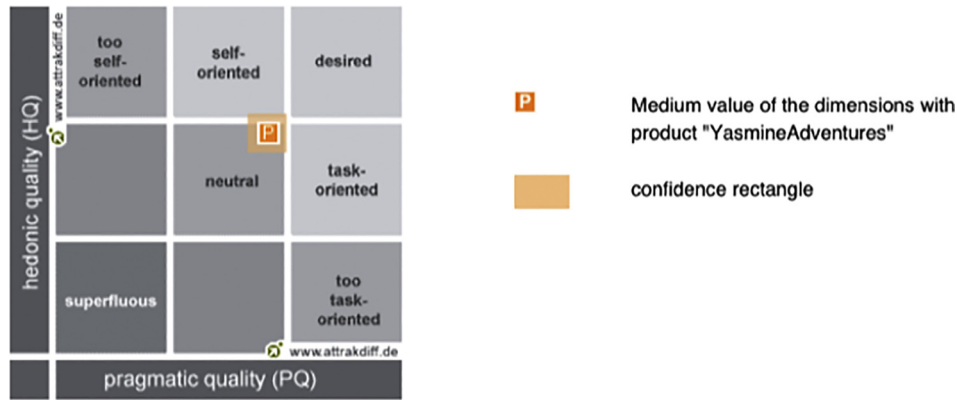


Fig. 5. Average value of the dimensions Pragmatic Quality and Hedonic Quality and the confidence rectangle of the product *Yasmine's Adventures*. Values of HQ are represented on the vertical axis (bottom = low value). The horizontal axis represents the value of the PQ (i.e. left = a low value).

bounded to YA as an experience. Nevertheless, it is also encouraging to see that the YA experience attractiveness value is located in the above-average region, signifying that YA is perceived as very attractive, as highlighted by participants in their interviews (Table 2 - U18 ref. 2; U19 ref. 1; U9 ref. 1; U18 ref. 2).

Furthering the analysis (Fig. 6 - Right Side) participants, in general, enjoyed the experience. None of the dimensions presents negative results, in fact, looking at the word-pair table we can see that most participants rated the experience to be “inviting”, “presentable”, “creative” and “simple”.

(2) Enhancing the local experience with Mixed Reality technology

YA was considered by most users to be a successful way to walk around the place and instill curiosity. Some defined it as unusual, innovative, and a different way to do it (Table 2 - U11 ref. 1). Most participants enjoyed the technology used and experienced a strong connection to the physical space, while some actually felt distracted by it. They highlighted that the connection with the neighborhood could be better by connecting the audience directly with the spaces and its historical facts, events or with local people for example (Table 2 - U10 ref. 1).

Participants associated YA to an engaging entertainment experience, comparing it to a treasure hunt. Finding the markers did not feel like a difficult task to perform, but enhanced the sense of search and discovery. Linking back to the AttrakDiffTM results (Fig. 5), the overall experience was not perceived as “task-oriented”. In fact, it was very close to a “desired experience”. As we mentioned before, participants highlighted YA as “innovative”, “creative” and “inventive” (Fig. 6 - Right Side). In addition, they mentioned in the interviews how they enjoyed the opportunity provided by the experience, to get to know the neighborhood and found that the tour allowed them to have fun and interact with the locals while walking and exploring (See quotes in Table 2 - U18 ref. 2; U7, ref. 1).

(3) Interface design and interaction glitches

In general, participants in the interviews reported positive feedback in relation to the interface and interaction design aspect of YA. These results were contrasted with YA user's interface rated in the “neutral” region (towards the higher side) for usability (Fig. 5 - Pragmatic Quality) indicating room for improvement. The interviews uncovered not only some of the positive aspects of the interface but also some of the required improvements. The feedback cues, which were used to tell users when to move to the POI, or how to move in the 360° VR environment were appreciated by the participants. On the other hand, the static map and the lack of GPS live feedback were perceived as problematic and the need for more detailed and responsive navigation aid

was brought up several times. In addition, participants mentioned feeling confused, disoriented, even “stupid” while trying to navigate the space (Table 2 - U15 ref. 8).

6. Discussion

Yasmine's Adventures was designed as a MR entertainment experience to invite visitors of the well-known Jewish Museum in Berlin to visit the surrounding neglected neighborhood. Findings from our study indicate that mixing storytelling with a physical journey of the area fostered users' curiosity and willingness to explore the neighborhood both at spatial and social levels (the place and people living in it). Regarding the design of YA as an entertainment experience provided by the museum, users reported the application to be simple, manageable and presentable. Additionally, they enjoyed the experience as it enhanced their exploration of the physical space and sense of discovery, making their journey through the neighborhood more meaningful and informative.

Furthermore, when prompted to find markers to uncover content, users compared *Yasmine's Adventures* to an enjoyable treasure hunt. Similarly to previous work by Goins [31], we also found that MR experiences can benefit from game design elements in order to increase entertainment, enthusiasm, and engagement. Specific aspects of the MR world, such as the 360° VR environments, were highly appreciated as they contained an extra level of interaction and exploration to delve into, making the experience more exciting and amusing. Nevertheless, it is interesting to note that some users reported social awkwardness and discomfort in interacting with MR environments in public spaces. Similarly to reports by DeSousa [14], the user's experience changes the nature of a public physical space and the social interactions that occur in them when interacting with a fictional story and a physical world through the MR application. These findings suggest support of the fluidity of the MR experience. However, attention should be paid to social norms and unspoken constraints at work in public spaces. A transparent interaction design is important to reduce any emotional or social distress when transitioning between the three different components of the experience: story, physical environment, and mobile application.

In line with previous findings [59], our research shows that the use of a MR paradigm facilitated users to become involved in social and physical interactions. Furthermore, as Bowlby indicated [10], MR experiences can help users regain natural interactions by enhancing the sense of presence and awareness. Interestingly, some reported the application was distracting them from the real facts and limiting their spontaneous exploration of the space, suggesting that a more self-driven approach of the space would provide more satisfaction, as observed in the work of Keil [60]. To support further social and physical involvement of users (as self-guided exploration), entertainment experiences

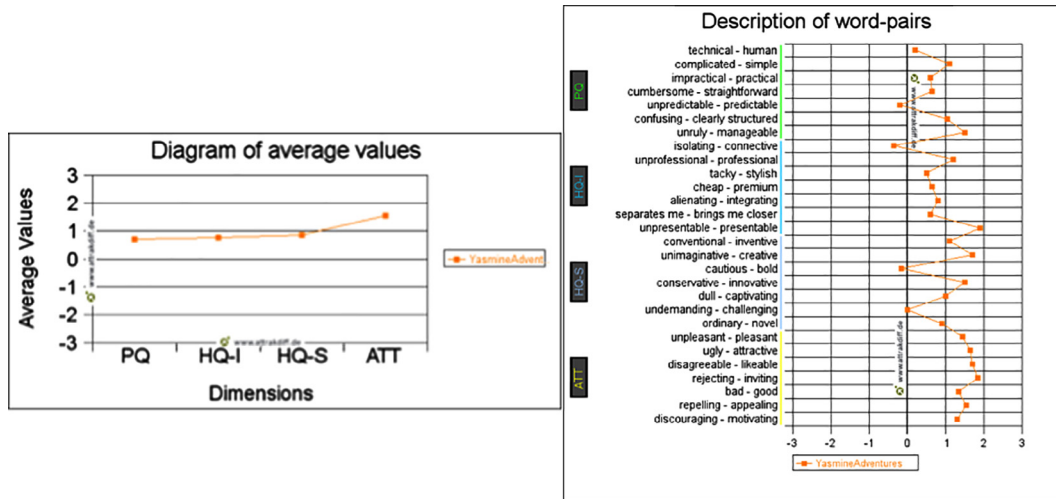


Fig. 6. On the left side we can see the mean values of the four AttrakDiff™ dimensions for the product *Yasmine's Adventures*: stimulation (HQ-S) and identity (HQ-I) and attractiveness (ATT). On the right side, we can see the mean values of the word pairs representing each category (Extreme values show which characteristics are particularly critical or particularly well resolved).

should be designed to accommodate users natural and spontaneous interactions with the space, such as taking a detour, or stopping and engaging in a specific location, beyond the scope suggested by the application.

Regarding the users' experience with *Yasmine's* fictional story, our quantitative results highlighted the low-reliability values in the NTS scale, indicating that items within the scale may not be measuring the same underlying construct. English was not the participants' native language, which may have interfered with the interpretation of some of the questionnaire items, as some participants reached out to the researchers asking clarification about the meaning of certain words while filling it. Likewise, this seems to suggest that language differences might have not only interfered with the questionnaire but also, participants might have misunderstood particular narrative sections, thus affecting their involvement in the fictional story. Nonetheless, a closer analysis on the qualitative data, suggests that participants empathized with the main character, as it reminded them of their own behavior as children, and inspired them to engage in exploring the neighborhood (as a child would). As a reflection on how transportation in the narrative could increase (NTS scores), in the interviews, users expressed the wish to have a more complex story indicating that *Yasmine's* story could be expanded, by adding more complexity to the plot and more facts to it. Users suggested transforming some markers into testimonials about the real people living in the area, or simply adding more content and making them into more complex and layered story artifacts. Nevertheless, it is satisfying to see that YA experience encouraged users connection and interest in the community and their neighborhood, hence fostering social involvement with locals. The increased involvement was perceived through the manifestation of interest from visitors in learning more about the local community, how they perceived their own space, and through the interests in knowing more about specific places charged with high emotional value for the community. Consequently, some users felt compelled to share their own stories, as found by Karpischek & Michahelles [25]. *Yasmine's Adventures* contributed to the visitors' positive engagement with the neighborhood, highlighting how MR storytelling applications can function as a catalyst for the audience, and foster participation and contributors from inside and outside the community itself.

From these results, we can state that MR entertainment experiences can function as connectors between users, locations, and their personal lives and memories. Furthermore, these can support an empathic connection of the audience with the social fabric of the physical space explored. By providing first-person narratives from locals, MR and

storytelling combined in an entertaining way can deepen visitors' connection, overcome distance and promote engagement with the community.

7. Limitations and future work

Through our study, we identified several limitations of the work. Firstly, some of the gestures needed to interact with the application promoted users feeling self-conscious, disconnected from the experience, or even misplaced. Such results indicate feelings of immersion, enjoyment, and comfort in the YA MR experience, were subject to the presence of social norms and self-awareness feelings in public spaces. For instance, users capturing a marker in a public space could not be disguised from the action of taking a picture with the mobile phone. On the same lines, users rotating on themselves while exploring the 360° VR models of the location, was interpreted as an intent to conduct filming on the premises. These actions generated some discomfort in users who were concerned about taking pictures or filming unknown and populated locations. This suggests that designing MR experiences should uphold transition between environments but also highlights the need to carefully think about the gestures and actions needed to explore the MR world when performed in public spaces. One further concern raised during the study was the transition between the digital content and the physical world and user's orientation in real space. Further work in this area includes considering interaction issues to fulfill users' expectations (scrollable map, GPS aid, spatial orientation icons).

In terms of evaluation methods used, we recognize that some of the adopted scales, although previously validated by their authors, they might not be the most appropriate within the MR application and linguistic contexts. Firstly, the NTS was developed to analyze transportation having in mind, a traditional narrative format. In the light of this fact, this scale would need to be adapted to new media formats, such as MR or VR. This issue highlights the importance of combining qualitative with quantitative evaluation methods, and skillfully combine and cross-validate results.

In terms of future work, we plan to refine the story construct through participatory design sessions involving community members. Although YA included the community's voice through pinpointing local problems, this study highlighted the visitors' desires in having real testimonies, coming directly from community members, instead of just relying on the current fictional character that was at times perceived as childish. We believe such sessions would help to strengthen the connection between visitors and locals. Moreover, community members

would help identify further testimonials that would portray the neighborhood in a more authentic way. We could then extend this study to include a broader sample of users and capture different cultural points of view on the area. Additionally, it would be valuable to evaluate the community's reaction to the visitor's feedback after participating in the experience. We believe this would help assess the long-term benefits if any of sharing such information to the welfare of the community.

8. Conclusion

This work described the design and evaluation of *Yasmine's Adventures*, a Mixed Reality entertainment experience designed to extend the visitor experience beyond an enclosed museum experience and guide them through the exploration of the neglected neighborhood surrounding the museum itself. The experience was evaluated in terms of the user's perceptions of the neighborhood, and in terms of a potential application to be developed as an interactive service for the museum to take advantage of. This evaluation was conducted using a mix of techniques, from qualitative to quantitative, to ensure the experience was thoroughly analyzed, and well captured from the user's perspective, and well translated in terms of a potential service.

Our findings demonstrated that such experience fostered users' curiosity and willingness to explore the surrounding neighborhood in the search for culturally enriching elements, at both spatial and social levels.

A closer look at YA indicates that transitions from a fictional story, application, and physical space or location need to consider constraints from all the design layers (storytelling or content layer, Mixed Reality or application layer, and architectural or physical space layer) in order to guarantee a smoother user experience. Our work indicates that Mixed Reality entertainment experiences, such as *Yasmine's Adventures*, have the potential to reshape people's opinion of places and possibly support more positive perspectives.

The work presented here contributes to advance the state of the art in the design of MR entertainment experiences by presenting and discussing results from both quantitative and qualitative evaluations of a real-world case study in a major European capital. In addition, current work demonstrates similar applications have the potential to be designed as services to enhance visitor interest and attendance.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at <http://dx.doi.org/10.1016/j.entcom.2018.04.002>.

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