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Abstract:	As the world becomes increasingly interconnected, digital technologies impact the way humans experience places and spaces in (smart) cities. To some extent, these smart technologies are intertwined with the urban living enabling the augmentation of the city's space and creating new opportunities for playful urban engagement. Moreover, touristic cities are becoming the arena of novel hospitality services, emerging from the widespread of digital technologies and internet-based platforms. At the same time, visitors look for increasingly "authentic" travel experiences that provide meaningful interactions with locals. New business models, such as those emerging from the sharing economy, flourished in response to these fresh needs and opportunities. However, establishing points of dialogue that bring benefits to both residents and tourists is a complex task that still needs inquiry. Here we extend on previous efforts by proposing a playful immersive experience that focuses on creating an aesthetically engaging environment for direct information exchange between locals and visitors. We investigate how technology can mediate and augment such information sharing, engaging tourists in a playful and immersive experience. Results of an experiment with 15 users are analyzed and presented to provide new insights to the HCI community

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Augmenting emerging hospitality services: a playful immersive experience to foster interactions among locals and visitors

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Augmenting emerging hospitality services: a playful immersive experience to foster interactions among locals and visitors

As the world becomes increasingly interconnected, digital technologies impact the way humans experience places and spaces in (smart) cities. To some extent, these smart technologies are intertwined with the urban living enabling the augmentation of the city's space and creating new opportunities for playful urban engagement. Moreover, touristic cities are becoming the arena of novel hospitality services, emerging from the widespread of digital technologies and internet-based platforms. At the same time, visitors look for increasingly "authentic" travel experiences that provide meaningful interactions with locals. New business models, such as those emerging from the sharing economy, flourished in response to these fresh needs and opportunities. However, establishing points of dialogue that bring benefits to both residents and tourists is a complex task that still needs inquiry. Here we extend on previous efforts by proposing a playful immersive experience that focuses on creating an aesthetically engaging environment for direct information exchange between locals and visitors. We investigate how technology can mediate and augment such information sharing, engaging tourists in a playful and immersive experience. Results of an experiment with 15 users are analyzed and presented to provide new insights to the HCI community.

Keywords: VR; 360° VR panorama; emerging hospitality services; tourism

Introduction

As the world becomes increasingly interconnected, new and emerging technologies shape the landscape of tourism and hospitality (Momani, 2012; Azouri et al., 2016). The hospitality sector core competency is all about creating connections (connecting people, places and cultures), and emerging trends in information and communication technology (ICT) can play a crucial role (Hughes & Moscardo, 2019; Sharma et al., 2021). Indeed, the widespread diffusion of mobile devices has provided new opportunities to access multiple sources of information in a ubiquitous, location-based and continuously connected fashion, changing the way we experience tourism-related services (Karanasios et al., 2015; Kim & Kim, 2017; Cuomo et al., 2021). All this information exchange is leveraged by a participatory culture that underlies practices such as user-generated content, social media sharing and creation, and crowdsourcing (Briciu & Briciu, 2020; Phi & Dredge, 2019; Tomaž & Walanchalee, 2020). The digital exchange of information not only impacts how people plan a trip, but also provides

emerging opportunities in accessing tourism services (Cuomo et al., 2021). In this light, the tourism and hospitality sector is embracing extended reality and immersive technologies, including virtual reality (VR) and augmented reality (AR), offering innovative services and playful experiences, both in situ (exploiting location-based technologies) or remotely, providing virtual representations of touristic places, with the final aim to increase the likelihood to physically visit such sites in the future (Dionisio et al., 2018; Jarratt, 2020; Kwok & Koh, 2020; Chirisa et al., 2020; Škola et al., 2020; Loureiro et al., 2020; Rahimizhian et al., 2020). Extended reality can, in fact, facilitate tourists in accessing valuable information and increasing their knowledge regarding a touristic destination while enhancing the tourist experience with different level of entertainment, such as playfulness, inspiration, liveliness, collectivity and surprise (García-Crespo et al., 2009; Kounavis et al., 2012; Olsson et al., 2013). While such immersive technologies have been strongly exploited in the Cultural Heritage context, they have not been explored as extensively in the context of hospitality services.

In this context, we investigated the possibility of taking advantage of mobile computing and extended reality to provide visitors with the possibility to enjoy "authentic" travel experiences, mediated by locals. "Authenticity" is a concept that has been introduced by MacCannell in the 1970s to investigate tourist motivations and experiences (MacCannell, 1973). MacCallen argues that most tourists seek authenticity but are frustrated in their attempts because the tourism industry, in the endeavour to exploit this desire, creates inauthentic environments as set up frontstages. Re-enacted folklore dances or themed restaurants, for example, mimic authenticity instead of being genuine (Pearce & Moscardo, 1986). Thanks to the widespread use of digital and networked technologies, locals today are taking the matter into their own hands, communicating directly with the visitors, proposing meaningful interactions, as well as, authentic and experientially oriented opportunities (Paulauskaite, 2017).

Our research effort embraces the opportunity to design and evaluate participatory hospitality services as playful urban experience, bringing together local hosts with visitors through a direct exchange of authentic information, proposing to foster connectedness and empathy through an immersive interactive playful experience.

Extending on the "SharePortugal" desktop-based web platform, based on a 2D flat visualization (Candido et al., 2020), the authors created ShareCities, a 360° mobile VR playful immersive tool to support hosts and visitors exchange of information about a touristic destination. Drawing on the idea of playable cities (Innocent, 2019; Nijholt, 2017; Nijholt, 2020), ShareCities exploits contemporary ubiquitous locative mobile technologies and 360° VR as means for creating meaningful connections between people and places (Clarke, 2020). Through the "playable cartography" concept, Clarke argues how "aesthetic and design methods can enhance a sense of community by placing an emphasis on personal, autobiographical location-based narratives as a means of capturing and sharing the multitude of emerging and individual identities of those who inhabit cities and township" (Clarke, 2020). Moreover, Desmet and Hekkert (2007) elaborate on the "aesthetic experience" as "a product's capacity to delight one or more of our sensory modalities". Inspired by these ideas, we designed ShareCities, exploiting playable cartography and the aesthetic qualities of the system to favour a visitor's playful encounter of an urban touristic destination. The graphics and colourful aspect of the VR 360° rendition are supposed to positively engage users through a virtual representation of the hosts' rooms and messages, inviting users to enter the virtual space. Such a virtual space is personalized by the local and should engage the visitors in playful treasure hunts for clues and suggestions left in the room for them to find. Hence, by engaging

with ShareCities, visitors can playfully interact with authentic and unmediated information provided by locals and distributed in their virtually rendered apartments. Moreover, visitors can use the platform to respond to messages, ask for further information and asynchronously initiate a dialogue[1] with locals.

Considering previous findings, establishing meaningful points of dialogue and sharing opportunities that bring benefits to both residents and tourists still needs inquiry. In this study, we took a first step, necessary to achieve this overall goal, by focusing on visitors' experience. We initiate this exploration by evaluating and comparing two distinct visitors' approaches (with different degrees of immersion). Our research aims to answer the following research questions: RQ1: *In the visitor experience of the ShareCities hospitality service, how does an immersive 360° VR visualization contrast with a 2D visualization?* RQ2: *What implication for the design of playful information sharing hospitality platforms can we draw from the study conducted on visitor experience of ShareCities?* To answer these questions, we tested the two solutions with 15 participants, collecting quantitative and qualitative data about usability, engagement, and immersion (declined in the interface, motivation, involvement, mobility, and reality constructs as detailed in Kim, 2013). Our findings show that ShareCities elicited engagement and immersion and an overall positive impact on the user experience of the VR system, increasing the possibility to foster a playful interaction and foster information exchanges between locals and tourists.

Related work

In the following, we present some studies that inspired our work and research study.

Creating connections between tourists and locals through technology

Nowadays, tourists aim to experience the authenticity of the place they visit. One way to feel it is to get in touch with the local people, feel the human contact and experience their lifestyles. Paulauskaite (2017) demonstrated, through a qualitative analysis based on some interviews with Airbnb guests, that co-created experience, thanks to the sharing of spaces or local information between the local and the tourist, leads to feeling the authenticity of the travel and increase the tourist's immersion in the experience. In the attempt to understand how to make this experience more authentic and memorable in the context of in-situ guided tours, Zatori et al. (2018) also used a qualitative analysis through a questionnaire. In particular, they found that the interaction between tourists and local guides is positively related to the authenticity and memorability perceived, as they reflect the local culture. This insight is accentuated by Richards (2013), who reasoned on the concept of being or living like a local,

[1] We use the term dialogue to refer to "a *conversation* between two or more persons" (source: https://www.dictionary.com/browse/dialogue); and we refer to a conversation as "an informal interchange of thoughts, information, ideas or opinions about a particular issue, etc., by spoken words or other nonoral means of communication" (source: https://www.dictionary.com/browse/conversation).

which states that tourists want to become involved in the daily life of the visited place. Such condition is reachable through the exchange of culture, knowledge, and so on.

To foster this exchange, several companies have exploited the use of crowdsourcing, developing web-based and mobile applications that put visitors in direct contact with locals. This contact can happen directly through questions and answers as in "The Loqal"[2] mobile app or "Spotted by Locals"[3], also built on the same rationale. Both services provide tourists with an offline guide to locals' favourite places, avoiding the touristic ones. Similarly, applications such as "Traveling Spoon"[4], "Withlocals"[5], and "Cool Cousin"[6] aim to put tourists and locals in direct contact, offering walking or guided tours, culinary experiences, disclosing interests and even the jobs of the locals, to give the visitors the opportunity to get to know them better.

Moreover, Locavores (Yuan, 2019) mobile application provides tourists with authentic food and experiences, facilitating the encounter with locals and exchanging information about their respective cultures. Locals register their profile on the platform, and, based on that, they will be matched with the tourists' preferences (Yuan, 2019).

In conclusion, regardless of the exploited device (web platform or mobile application), the flourishing of these commercial applications demonstrates that tourists care for meaningful and authentic experiences and finds them through the connection and direct information exchange with locals.

360° VR to foster playful interactions

In the last few years, 360-degree virtual reality (360° VR) has gained more and more attention in the travel and leisure industry, both from the academic and business domains. Quite often, 360° VR is designed to work with head-mounted displays (HMD) to make the experience more immersive. However, recently, the 360° VR technologies gained attention in the mobile ecosystem, thanks to the fast and vast diffusion of smartphones. In this context, some studies investigated the use of 360° VR technologies in the tourism sector. For example, 360° VR has spread in tourism-related applications to attract tourists and let them experience the chosen destination even before their actual travel (Rahimizhian et al., 2020). Some studies were conducted in the tourism context to understand if mobile 360° videos and soundscapes, and HMD VR could positively influence the user experience concerning new travel destinations and heritage sites, which can lead to enjoyment and amusement (Kelling et al., 2017; Kim et al., 2011; Dueholm & Smed, 2014).

Moreover, Dionisio et al. (2017) investigated users' perception in a mobile application that uses location-based storytelling and mobile VR to enhance the tourists' experience of the urban destination, providing them with an entertaining way to explore some of the locations and learn about the local culture. Similarly, Yasmine's Adventures lets users playfully

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[2] https://loqal-app.com/

[3] https://www.spottedbylocals.com

[4] https://www.travelingspoon.com/

[5] https://www.withlocals.com/it/

[6] https://www.coolcousin.com/

experience a Berlin inner city neighbourhood, through mobile 360° VR panoramas and local anecdotes (Nisi et al., 2018). In their preliminary study, the authors also confirm that the application improves the relatedness and the playful exploration of the surroundings. These systems are inspiring examples of successful tourists' engagement through urban playful interaction.

With the COVID-19 pandemic, most tourism companies and agencies have moved their activities online, offering virtual experiences to mitigate the monetary loss, since tourism was one of the most affected industries (Gretzel et al., 2020). Lots of museums have created virtual exhibitions using 360° VR so that users could watch them from the couch at home during the lockdown (Samaroudi et al., 2020). The COVID-19 outbreak has increased concerns and anxiety among tourists, and the use of VR could mitigate them (Neuburger et al., 2020).

Finally, virtual 360° environment are also exploited for commercial use. For example, the IKEA virtual reality experience[7] lets the users see and experience a kitchen with the help of an HMD. The application offers some playful and useful interactions, when through a simple click, the user can change the colour of cabinets and drawers. Another commercial example is InmobiliAR[8]. InmobiliAR is an app that allows the clients of a real estate agency to see the apartments and take a virtual 360° VR tour, directly from the street.

These applications were an inspiring start for our adaptation of the existing application (Candido et al., 2020), exploring the playful benefits of immersive technologies and evaluate the impact of such technologies in contrast with the 2D application.

User studies in the touristic 360° VR contexts

Several studies investigated the user experience of VR in tourism (Han et al., 2018; Lo & Cheng, 2020; Lee & Kim, 2021). In our project, we narrow the focus to the evaluation of 360° VR environments. A virtual 360° environment is often used in tourist contexts to engage and to immerge the potential tourists in their destination before and during the actual trip. Hence, Rahimizhian et al. (2020) intended to understand if 360° videos could positively influence the tourists' attitude and behaviour towards the destination. After conducting an online questionnaire, they found out that the 360-degree videos about Hong Kong could affect the tourists' satisfaction and, therefore, their trip and the electronic word of mouth about the destination. Moreover, in the literature, some studies that compare 360° VR in mobile devices and HMD both in private and public context are presented to understand how target users perceive them. For example, Kelling et al. (2017) showed that 360-degree videos positively offert a new travel destination or experience. Still, the participants in their study preferred to enjoy it in private contexts due to social and cultural background. The same conclusion was drawn by Dionisio et al. (2017), as they found out through questionnaires and interviews that 360° VR was positively perceived by the participants of the study, as it can create an enjoyable experience.

In conclusion, the 360° VR improves the attitude of tourists towards the destination, especially if it can also be used in private contexts. In this context, as a novel contribution, we

[7] https://www.ikea.com/ms/en_JP/this-is-ikea/ikea-highlights/Virtual-reality/index.html

[8] http://www.inmobiliar.com.mx/

investigated the possibility to explore 360° VR together with aesthetic experiences and playful interaction to engage tourists in looking for information in virtual rooms.

The ShareCities platform

ShareCities has been conceived as a case study to investigate the possibility to exploit aesthetic experience to establish meaningful points of dialogue and sharing opportunities that bring benefits to both residents and tourists. We initiated such an investigation by designing and implementing SharePortugal, a desktop-based web application, described in (Candido et al., 2020).

The desktop-based web application provides the following functions:

- Tourists and locals need to register to become part of the community and enjoy the services. The created account can be used both in the desktop-based web version and in the mobile app.
- Once logged, it is possible to select a city to explore; each city has a homepage presenting, in a virtual fashion, the monuments, buildings, and peculiarities that characterize such a city, explorable through a horizontal scroll, as shown in Figure 1 (left side). Moreover, it is also possible to change the background style of the image (night or day), and vice versa.
- Images representing the local's avatar or photos are visible in the city building windows. By selecting the picture in the window, tourists can see the customized virtual room of a specific local, together with information about the person and the provided touristic services, authentic information about the city, and read and leave messages in the room.
- Locals can customize the virtual room, adding personal information, photos, posters, messages that the visitors can find, information about the city, changing the wall colour and pattern, and so on.

As anticipated, the local's virtual room includes not only visual elements to reveal the personality and interests of the person but also textual information, such as the telephone number and the email, the possibility to leave messages on a visible communication board. Through the playful experience to leave messages in the room and receive answers, the host and visitor have the possibility of initiating a conversation leading to a virtual or face to face dialogue. This information exchange would benefit both residents and tourists. The residents will benefit by having an opportunity to meet new people from different cultures and initiate a connection, and eventually, dialogue, with them before deciding to host them or to meet them face to face. A visitor, on the other hand, by getting to know the host, could develop a closer sense of their hosts, fostering empathy and facilitating the exchange (which can be beneficial to the local in several manners: cultural of goods, of information, etc.).

When navigating a virtual room using such a system, the user can only see a static 2D image of it.

FIGURE 1

ShareCities mobile

To enhance visitors' playful interaction with locals through information sharing and asynchronous message exchange, we extended the SharePortugal 2D-based visualization web system into the 3D ShareCities mobile application. The new mobile app explores the smartphone 360° VR potential about interacting in real-time with the urban and digital space of the city and provide tourists with aesthetic immersive experiences. The mobile application has been implemented in Flutter[9], a mobile UI framework that allows building native apps on iOS and Android from a single codebase. The app features several functions.

- Log in - once logged in, tourists (as well as locals) will see the list of available cities, ordered by the distance from the user who is navigating the app, taking advantage of the built-in GPS sensor. We also exploited the smartphone time zone to change the city background, from day to night (and vice versa), which should also privilege the information shared (if happening during the day or at night).
- (Selected) City Home - considering the city homepage (same as the desktop-based web app), the user is presented with the graphically rendered facade of several iconic buildings of the selected city (Figure 1, right side). The visitor can enter a room of the building by touching the avatar/picture of a host, which is visualized on the windows of the buildings (as depicted in Figure 1). In the mobile ShareCities, we exploited the location-based nature of the smartphone to order the avatars on the windows by their proximity to the user; the same approach is used when selecting the "See all hosts' rooms" button, which shows all the available rooms, ordered by their proximity.
- Room view - inside the rooms, visitors can read messages and reviews left by other tourists who came in contact with the same host, including scores (i.e., "stars"). To visualize such details (public messages and reviews) and other host's information, such as the touristic services/places s/he recommends, the user can touch the buttons on the left side of the screen, as presented in Figure 2. To create an immersive experience, we implemented the local's room as a 360° VR panorama representing the local's room (see Figure 3). Exploiting the smartphone built-in gyroscope sensor to map the user viewpoint, the tourist can look around the virtual room by simply rotating the smartphone, feeling to be "inside" the room. To generate the 360° image sphere, we used the viewer provided by the Panorama plugin[10].

FIGURE 2

FIGURE 3

[9] https://flutter.dev/

[10] https://pub.dev/packages/panorama

Evaluation

Methodology

This study's primary intent is to shed light on the use of mobile 360° VR strategies to support playful information sharing between locals and tourists. To better frame our goal, we defined the following research questions: RQ1: *In the visitor experience of the ShareCities hospitality service, how does an immersive 360° VR visualization contrast with a 2D visualization?* RQ2: *What implication for the design of playful information sharing hospitality platforms can we draw from the study conducted on visitor experience of ShareCities?*

With the main focus to answer our RQs, we designed an experiment to collect qualitative and quantitative data. We exploited a within-subjects study and questionnaires as a self-report method. In particular, we were interested in comparing the visitors' user experience as they visualize the local's virtual room using a 360° VR immersive panorama (gyroscope-based view) with the 2D approach, which uses a flat image. Both the approaches were tested using the ShareCities mobile version, using a smartphone; we developed two versions of ShareCities mobile: one presenting the virtual room with 2D flat images, the other one exploiting 360° VR panoramas.

To statistically validate the outcome, we defined our overall null hypothesis (H_0) as follows: "*no difference is perceived between using a 360° VR versus a 2D visualization of the hosts' room while experiencing emerging hospitality services through the mobile app*".

Since the RQs and H_0 revolve around the concept of "immersion", we designed the questionnaire considering measuring immersion, and related constructs, such as flow and presence. Moreover, usability as a measure of how comfortable the users felt with the system and interface design. And finally, engagement to understand if we had succeeded in fostering playful interactions among users of the system. Existing literature abounds in validating scales to measure the above constructs. In the following, we describe the validated scales we adopted for our study and discuss the motivation behind the specific selection.

The questionnaire

The questionnaire scales

Usability. Usability is a core term in HCI and a relevant property of a system that could impact the user experience of the evaluated software (Hornbæk, 2006). For this reason, we opted for including a few questions to measure the system usability of both the 2D and the 360° mobile VR ways to explore a virtual room. Among the vast literature on usability evaluation (Lund, 2001), ASQ (Lewis, 1995), SUMI (Kirakowski & Corbett, 1993), we opted for the System Usability Scale (SUS) (Brooke, 1996) composed of 10 simple questions so not to overload the participant. Although it is a very discussed and controversial approach (Borsci et al., 2009; Bangor et al., 2008; Bangor et al., 2009), it is widely used by HCI practitioners, and researchers are still confirming its validity in comparison with other scales (Lewis, 2018; O'Brien & Cairns, 2016).

Focusing on this dimension, the H_{0U} we test if: "*no difference in usability is perceived between using a VR versus a 2D visualization of the hosts' room while experiencing emerging hospitality services through the mobile app*".

Engagement. Engagement, which can be defined as the ability to engage and sustain user's engagement in digital environments, is crucial to foster the dialogue between locals and tourists. Analyzing the existing literature (Lalmas et al., 2014; O'Brien & Cairns, 2016), we decided to focus on self-reporting scales since such a strategy allows participants to describe their own experiences (Jacques, 1996; Webster & Ho, 1997; O'Brien & Toms, 2008; 2010), and, finally, we opted for the short form of the User Engagement Scale (UES-SF) (O'Brien et al., 2018), using only 12 items to investigate four dimensions: focused attention, aesthetic appeal, perceived usability, and reward factor. The short version encompasses all of our evaluation needs in measuring user engagement while reducing the study participant's fatigue (as recommended in O'Brien et al., 2018).

Focusing on this dimension, the H_{0E} we test is: "*no difference in engagement is perceived between using a VR versus a 2D visualization of the hosts' room while experiencing emerging hospitality services through the mobile app*".

Immersion. Immersion is a multidimensional concept that has been extensively investigated when designing and evaluating virtual environments (VE). Immersion can relate to interaction with the technology itself (Slater and Wilbur; 1997) or to the users' feelings when immersed in the system (Witmer & Singer, 1998). Considering the former one, immersion can be defined as a psychological state of being enveloped by and interacting with an environment that allows users a continuous stream of experiences (Witmer & Singer, 1998). In VE, immersion has been achieved using wearable devices such as HMD and/or large displays and caves environments that isolate the users from the real context (Bowman & McMahan, 2007; Jennett et al., 2008; Salomoni et al., 2017). While the concept of immersion has been analyzed in web browsers contexts (Scuri & Nisi, 2020) and smartphones (Kim, 2013; Choi et al., 2018), the relevance of context while using a smartphone is just starting to be explored (Bala et al., 2017; Choi et al., 2018; Dionísio et al., 2017; Kim, 2013; Nisi et al., 2018). Kim coins the concept of "contextual immersion" (Kim, 2013) which keeps into account the context-awareness typical of mobile systems (Kim, 2013). Despite our study not being focused on AR, but rather on 360° VR panorama, we adopted Kim's framework since it allows us to investigate different properties valuable in measuring immersion in our mobile scenario. We relied on Choi et al. (2018) to investigate the interactive and immersive experience of using 360° VR content on the mobile platform by selecting some items (i.e., 3, 17, 20, 30, 80, 81, 82) from (Tcha-Tokey et al., 2016). While the Tcha-Tokey et al. (2016) questionnaire was designed for a head-mounted display game study, nonetheless, some items can be adapted to a smartphone-based 360° VR scenario, as proved by Choi et al. (2018).

Focusing on this dimension, the H_{0I} we are testing is: "*no difference in immersion is perceived between using a VR versus a 2D visualization of the hosts' room while experiencing emerging hospitality services through the mobile app*".

The comprehensive questionnaire

In the end, the questionnaire was comprised of 45 items, divided into four groups: 10 items to

measure the app usability using SUS (Brooke, 1996); 12 items to investigate engagement using UES-SF (O'Brien et al., 2018); 23 items to understand immersion as a multidimensional concept, including 16 items extracted from the framework for context immersion in mobile augmented reality (Kim, 2013), and seven from the questionnaire presented in Tcha-Tokey et al. (2016. Table 1 details the selected items for each framework. Since the experiment was conceived as a within-subject study, we created the final questionnaire considering 45 as the maximum acceptable number of questions to minimize the respondent fatigue (Ben-Nun, P., 2008).

TABLE 1

To evaluate immersion, we grouped all the items into six constructs: *interface*, *sensory, involvement*, *motivation*, *mobility*, *reality, and sense of comfort* (as presented in Table 2).

TABLE 2

Participants answers followed a 5-point Likert scale (1 - Strongly disagree; 2 - Disagree; 3 - Neither agree nor disagree; 4 - Agree; 5 - Strongly agree). At the end of the questionnaire, three open-ended questions concluded the study: "*What were the positive aspects of the experience? What were the negative aspects of the experience? Could you share some suggestions for improvements?* (i.e., 80, 81, 82 in Tcha-Tokey et al., 2016). All the items were translated into Italian to facilitate participants (regarding SUS, we used Borsci, 2009), and adapted to our case study, when possible. The questionnaire was pilot tested for content ambiguities on a small sample of users (three) with different backgrounds. After the pilot test, a few items were reworded (or supplemented with comments).

The study protocol

To design the evaluation, we tested ShareCities for mobile devices in two versions, one with a 360° VR immersive panorama of the host's virtual room and the other showing just a static image of it (the 2D-based version). Each participant tried both versions, so as to eliminate individual differences between experimental conditions. To avoid ordering effects, we applied a counterbalancing strategy, asking half the participants to start with the 360° immersive version and the other half with the 2D version. Moreover, since the sense of immersion is a personal experience, we opted for using a questionnaire - recognized as a well-exploited self-report instrument - to evaluate it.

The experiment was performed in September 2020, in Cesena (Bologna, Italy), following the COVID-19 recommendations and restrictions both at the national and regional levels. We engaged one participant at a time, and the two researchers and the participant wore the mask all the time. To avoid participants installing the two versions of the app, we used one of the lab smartphones, and we sanitized the device (and the desk) at the beginning of every new session. Each session lasted 30 minutes, including: a brief introduction to the study and to the app goal, the two app evaluations, and the related two questionnaires. In particular, each participant evaluated one app and, afterward, they answered a questionnaire, then, they repeated the two activities (evaluation and questionnaire) for the other version of the app. To answer the questionnaire, we provided students with two QR-codes to allow them to answer using their device in a small room outside of the lab (to avoid putting pressure or influence them with the researchers' presence). Considering the method, one researcher was

assisting the participant, while the other was transcribing the participants' comments and recording the hidden transcript (facial expressions) and user interaction issues that were experienced.

Participants

We engaged digital natives, and in particular, students attending the "Mobile Programming" course, during the third year of the bachelor's degree in Computer Science (Cesena campus, University of Bologna). The call for participation was shared online using the course mailing list and the participation was voluntary.

Due to COVID criticalities, access to users was limited. A total of 15 students (5 females and 10 males), ranging from 21 to 32 years old (avg = 23), answered our call, still allowing us to collect relevant data (Preece et al., 2015; Caine, 2016). All the participants were informed that participation in the study was voluntary, and they could refuse or discontinue their participation at any time for any reason.

Findings

In the following subsections, we present the results and findings from the study. In describing the findings, we call "2D" the version of the visualization that makes use of the 2D static/flat image, while "VR" is the one using 360° VR panorama, to represent the virtual local's room. To answer our H_0s, we also computed the Wilcoxon Matched-Pairs Signed Ranks Test nonparametric statistical test, that compares two paired groups to establish if they are statistically significantly different from one another, exploiting the median values (MacFarland & Yates, 2016).

Usability

Following the SUS recommendations, we calculated the average total score for both applications. The outcome was positive ("excellent") for both versions: the 2D version obtained an average total score of 91.3 (out of 100), while the VR version got an average score of 91.5 (out of 100). Considering these scores, it seems that the immersive peculiarity of the VR version slightly influenced (positively) the perceived usability of the overall system, which was already high. Both apps were perceived as original, visually appealing, and simple to use, without requiring the users to perform complex tasks. This outcome is also confirmed by computing the Wilcoxon Matched-Pairs Signed Ranks Test, obtaining a p-value = 0.3869 > α = 0.05, meaning that we can not reject our H_{0U}.

Engagement

We calculated and then compared the UES-SF scores for both versions of the app. As detailed in O'Brien et al. (2018), an overall engagement score can be calculated by adding all of the items together and dividing the sum by twelve. The data had a high level of internal reliability with a Cronbach's α value of 0.82 and 0.90, respectively. As a result, considering a scale from 1 to 5, the VR version obtained a higher score (4.38) than the 2D one (3.88). Table 3 shows the score grouped by the four relevant sub-dimensions; it is possible to notice minimal differences

between the two versions, confirming the results obtained using SUS. While the 2D version scores slightly higher in Usability, the Attention Focus (FA), Aesthetics (AE), and rewarding Factors (RF) positively impact the user's engagement with the 360° VR version. FA (circa1) reports on the higher difference. Analyzing the data using Wilcoxon Matched-Pairs Signed Ranks Test, we have the confirmation that we can reject our H_{0E} (p-value = 0.01922 < α = 0.05), and we can assert that the introduced VR function impact (positively) the level of engagement.

TABLE 3

Immersion

To evaluate immersion, we exploited the six constructs presented in Table 2, i.e., interface, sensory, involvement, motivation, mobility, reality, and sense of comfort. Figure 4 presents an overall view of the obtained outcome. In the following, each construct is analysed in detail.

FIGURE 4

Interface. Regarding the interface construct, we evaluated how the interface can facilitate the acquisition of information. Its sub-dimensions were considered, in particular, three questions were analyzed: *finding the information requires me a lot of effort* (reversed for the analysis), *I was very efficient in finding the information*, and *navigating the room didn't require me any effort*, with a Cronbach's α value of 0.71 and 0.65, respectively. Comparing the two versions of the app, most users performed a better information acquisition with the 360° VR version, even though it required a higher effort for a few participants. In general, the VR version scored an average of 4.67 (var = 0.03) versus the 4.18 (var = 0.01) of the 2D (see Figure 4). Focusing on our H_{0I}, computing the Wilcoxon Matched-Pairs Signed Ranks Test proved that the interface construct positively influences the sense of immersion (p = 0.001904 < α = 0.05).

Sensory. To analyze the sensory construct, we considered two sub-dimensions: I exclusively used vision to survey or search the environment, and I extensively used a touch-sensing function to survey or search the environment. It emerged that participants were more prone to exploiting the touch-sensing function in the 2D version than in the VR one (an average value of 4.7 vs 3.3, with a variance of 0.20 and 1.69, respectively). This can be explained considering that touch was the only modality to navigate the 2D visualization. Considering vision to search the environment, both the apps obtained a similar result (3.3 vs 3.8, with a variance of 1.29 and 1.36, respectively), aligned with the fact that both the interfaces needed an extra sense (i.e., touch-sensing and movement, respectively). In both the sub-dimensions, the high computed variances between the scores tell us that, likely, participants interpreted the meaning of the question in different ways. Moreover, the statistical analysis using Wilcoxon Matched-Pairs Signed Ranks Test confirms that, in this case, we can not reject the null hypothesis (p = 0.1126 > α = 0.05). Accordingly, it seems that vision and touch do not discriminate the way the two apps are perceived.

Involvement. According to Kim's contextual immersion framework (2013), the involvement construct is composed of seven sub-dimension: the *sense of being involved*, the *real-time awareness of the virtual environment* and with the *local's identity*, *concentration*, the le*vel of interaction with information in the environment*, the *satisfaction with the displayed information*, the *engagement with the visual elements*, and the level of *immersion in the system in relation with the external environment*. Two other sub-dimensions, the *involvement*

of the visual aspects of the virtual environment and the level of *not awareness of things happening around* (items 3 and 17 of Tcha-Tokey et al., 2016), were added to better investigate the involvement provoked by an immersive virtual environment. To verify the internal correlation between these seven sub-dimensions we computed the Cronbach's α value, obtaining a sufficient internal correlation (0.61 for 2D and 0.79 for VR). Focusing on the 360° VR version, participants provided positive scores (on average, 4.32, var = 0.04) for 6 out of 7 questions. In particular, only one question, "*I become so involved in the environment that I was not aware of things happening around me*" (n. 17 in Tcha-Tokey et al., 2016), scored close to 3 (3.2, var = 1.62). We decided to include this question to investigate the extent to which the 360° VR panorama let users "forget" about the real environment. Since the smartphone mediates the VR experience, this result is rather positive since the real environment in the background was not invisible to the user, but still did not interfere with the experience. The 2D version scored lower (on average, 3.27, var= 0.58), with a lower score of 2.67 (var=1.29) in the "*sense of being involved in the virtual environment*". It is interesting to highlight the high variance value. At a second analysis we noted that those who tried the 2D version first were inclined to give it a higher score than those who tested it as the second option. Focusing, in particular, on the *real-time awareness of the virtual environment* and with the *local's identity* sub-dimension, we can report that the VR version obtained a higher score than the 2D one (average values: 4.33 and 3.53, variances: 1.29 and 0.91). The two aggregate construct average scores are presented in Figure 4. Moreover, the Wilcoxon Matched-Pairs Signed Ranks Test confirmed that the involvement sub-dimension positively impacted the experience of the app, as shown by the data (p-value = 0.003436 < α = 0.05).

Motivation. The motivation construct is composed of four sub-dimensions: *moving in the room I acquired information*, *I felt intimacy with the person*, *I really enjoy the visualization/navigation task*, and *I developed empathy towards the person in the room*. The average value obtained by the 2D version is 3.67 (var = 0.23), versus 4.23 for the VR version (var = 0.11). As a confirmation of this difference, we computed the Wilcoxon Matched-Pairs Signed Ranks Test obtaining p-value = 0.001784 < α = 0.05, allowing us to reject H_{0I}. This outcome corroborates the relevance of 360° VR environment in supporting the participant playful and meaningful interactions with the system.

Mobility. The mobility construct includes just one sub-dimension: *it was possible to see real-time situations while moving.* With this item, we wanted to measure if the user experienced any positive or negative issue due to real-time visualization of the digital room. We obtained the following average values: 4.6 (var = 0.37) for the VR version and 3.8 (var = 0.16) for the 2D version. To ascertain if the null hypothesis can be accepted or rejected, we computed the Wilcoxon Matched-Pairs Signed Ranks Test. The output p-value = 0.005576 < α = 0.05 proves that we can reject H_{0I}, in favour of the VR version.

Reality. The reality construct includes two sub-dimensions: visualizing the scenes helps me to acquire spatial recognition and information about the real environment, and I felt physically fit in the virtual environment. Since we used items from different frameworks (see Table 3), we computed Cronbach's α obtaining a good internal consistency (0.76 for 2D and 0.61 for VR). The VR version obtained an overall average score of 4.3 (var = 0.04) versus 2.5 (var = 0.25) of the 2D room based one. Also in this case, we can reject H_{0I} because, computing the Wilcoxon Matched-Pairs Signed Ranks Test, we obtained a p-value = 0.0006859 < α = 0.05.

Sense of Comfort. To investigate whether the user felt comfortable in moving the smartphone

in real space to navigate the VR room, we exploited item n. 30 of Tcha-Tokey et al. (2016): *I was not worried about what other people would think of me*. This sub-dimension is correlated with the concept of flow, the sense of being absorbed by a task in such a degree that one forgets about time and place (Csikszentmihalyi, 1990). The data shows that half of the users didn't care about other people's judgment (answering positively - agree and strongly agree), while two felt neutral and four felt worried (average value = 3.3, var = 1.69 versus average value = 4.73, var = 0.20 of the 2D version). Computing the Wilcoxon Matched-Pairs Signed Ranks Test, we obtained a p-value = 0.00596 < α = 0.05, resulting in the rejection of the H_{0l} but in favour of the 2D version.

Qualitative data

To collect qualitative data, we exploited three open questions, as detailed in "The comprehensive questionnaire". In the following, details about the outcome are provided.

Positive aspects. In general, both apps obtained positive feedback. Positive aspects of the 2D app are related to: visual aspects of the interfaces (5 mentioned this aspect out of 15 participants), ease of use (6 out of 15), the concept (5 out of 15), the possibility to navigate the host's room (1 out of 15). In particular, one user claimed that the navigation of the 2D version is more straightforward because the VR version was too slow in reacting to the user's inputs; another user reported that s/he prefers the 2D version because it is possible to navigate the room without "moving".

Positive comments regarding the VR app regarded: the visual aspects of the interfaces (4 mentioned this aspect out of 15 participants), ease of use (4 out of 15), the concept (4 out of 15), and the possibility to navigate the room through 360° VR (14 out of 15) which connects directly with our RQs. To give a better idea of the participants' feelings regarding the VR app, we report here some quotes from the users' interviews: "*I like a lot the possibility to explore the virtual room. In a way that is consistent with the movements made in the physical room*"; "*I liked being able to see a person's room from the inside*", "*I found the room that moves with you captivating, so as and the possibility of knowing in advance the person you are asking formation from*", and "*the ability to navigate the room in virtual/augmented reality is really interesting and gives the feeling of total immersion, and I find it very intuitive!".*

Negative aspects. Some negative aspects of both versions of the app were highlighted. Regarding the 2D app, the negative feedback was mostly related to: unclarity of some initial interface interaction (i.e., clicking on the hosts avatars to access the room, or scrolling down the city buildings, via the horizontal slider) (2 participants mentioned this aspect out of 15 participants); disappointment with the interaction, finding it too static (8 out of 15). Contrariwise, no negative issues were reported by 4 out of 15 users. The VR app collected a few negative feedback: unclarity of interaction with the icons on the windows (1 out of 15); gyroscope related technical issues - 4 out of 15 users noticed that if at the beginning of the navigation tasks, the smartphone was not perpendicular to the ground, the user needs to correct the spatial perception in the 360° scene; no possibility to interact (selecting or zoom in/out) with objects in the virtual room. Finally, no negative issues were reported by 6 out of 15 users.

Users' Suggestions. Analyzing users' suggestions for both the apps, we collected some interesting ideas, some more general and others more specific. One user suggested to include

the possibility to directly talk with the hosting person, maybe exploiting vocal messages (for both 2D and VR apps); one user suggested to have more than one room per host and to give the visitor possibility to navigate from one room to another (e.g., by clicking on the room door, the user can enter in another room) (for both 2D and VR apps); two users suggested to add interactive objects in the room (360° VR only); another user suggested to add hints to help users to understand how to interact with the city homepage (for both 2D and 360° VR apps); a user suggested to allow to choose the room visualization, if static or 360° (360° VR). Interestingly enough, one participant, after trying the 2D version as the first trial, s/he wrote: "*The system doesn't exploit at all the smartphone potentiality, but I have no idea how to improve it*". This comment indicates how young users' have expectations with smartphones.

Discussion and limitations

In relation to our RQs, the findings point out the positive influence of the 360° VR visualization on the visitor's experience of SharingCities. SharingCities, in fact, exploits VR immersive aesthetics, engaging the users through one or more of their sensory modalities, inviting them to experience the city and its hosts' suggestions in a playful and aesthetically pleasurable way. The graphics and colourful aspects of the AR renditions positively engage users; the virtual representation of the hosts' personalized rooms and the asynchronous messaging exchange invite visitors to enter the virtual space and immerse themselves in a playful treasure hunt for clues and authentic information on the hosting city. In the following section, we discuss the findings in detail against related work and each specific dimension of the experience.

Usability

Usability scored high across both apps (91.3 and 91.5 out of 100), even slightly higher with the 360° VR. The immersive peculiarity of the 360° VR version positively influenced the usability. We can hypothesise that the participants' age, which corresponds to our target users (digital natives), affects the positive results.

Digital natives rely on smartphones for many activities, including travel and tourism. Similarly, mixed reality is becoming an exciting and familiar mode of interaction. While in 2017 Nisi et al. (2018) and Dionisio et al. (2017) reported users feeling awkward in manipulating their phones in public to view 360° VR content, our study confirms that nowadays, the ease and comfort in performing these actions is growing (Hopf et al., 2020).

Engagement

Regarding engagement, the 360° VR app scored slightly higher than the 2D one, on all factors, except perceived usability (PU). To better understand this result that seems contradictory with the one above presented (SUS), it is worth mentioning that PU, framed in the engagement context, focuses on measuring the negative effect experienced as a result of the interaction and the degree of control and effort expended (O'Brien & Cairns, 2018). While a slightly lower PU score is understandable, as a 2D room interaction is simpler and requires less effort than a 360° VR one, we like to call the attention to one of our users' comments on the 2D app, mentioning that such an app seemed to miss the opportunity to exploit the smartphone capabilities. This expectation is aligned with recent studies investigating the increasing number

of mobile apps exploiting smartphone built-in sensors (e.g., GPS) and AR/VR to provide touristic services (Cranmer, 2019; Loureiro et al., 2020; Rahimi, 2020; Too et al., 2020). These recent studies confirm that, nowadays, digital native travellers have expectations about the possibility of interacting in mixed reality through mobile apps for tourism.

Moreover, regarding "immersive contextual" interaction (Kim, 2013), attention focus (FA) which is considered as "feeling absorbed in the interaction and losing track of time" (O'Brien et al., 2018), scored higher for the VR app. This is a positive result in itself as it confirmed our design intention to enhance playful "immersive" interaction.

Immersion

We analyzed the immersion dimension considering the context-awareness property of the smartphone ecosystem to measure contextual immersion (Kim, 2013). In doing so, we defined six constructs.

Interface

Both versions performed well regarding the evaluation of the interface, intended as ease of use in acquiring information. A slight majority preferred the 360° VR version, while a minority found it more cumbersome. This is understandable considering the effort needed to manipulate the smartphone to find the host's information placed around the room, in contrast with the 2D version, where the information is immediately visible and easier to retrieve. This result aligns with the perceived usability (PU) results (UEA-SF scale). On the other hand, 14 out of 15 users expressed positive feedback about the 360° VR navigation, confirming digital natives' comfort in using MR technologies, echoing recent studies in the education context (McGovern et al. 2020; Sepasgozar, 2020).

The visual aspect of the interface and its ease of use were considered positive aspects of both the 2D and the 360° VR versions.

Sensory

The scores obtained from the sensory construct analysis disclosed that vision and touch senses don't discriminate the way the two apps are perceived. The motivation can be three-fold. First, vision is highly exploited in both versions. Secondly, in both apps users can interact with the environment using touch albeit in a different way: in the 2D version the user mostly uses the horizontal scroll, while in the 360° VR the touch is used to zoom in/out. Thirdly, both the questions have high internal variance among the scores, probably suggesting that the participants interpreted the meaning of the questions differently, and consequently the data show inconsistency. Considering these motivations, we can conclude that further investigations are needed to better assess the sensory role in fostering playful interactions.

Involvement

The involvement construct allowed us to investigate relevant issues considering our goal to foster playful interaction among tourists and locals. The output confirms that users found the 360° VR app more "involving" than the 2D one (4.32 vs 3.27), with a difference of 1.05 in

favour of the 360° VR version.

The involvement construct includes, among the others, a sub-dimension questioning to what extent the app supports real-time awareness about the location, identities of people, objects, as well as environmental elements. The VR version obtained a higher score than the 2D one (4.33 vs 3.55, respectively). This is a relevant output considering that our design aims at fostering playful interactions among tourists and locals, and eventually build empathy between the two.

Moreover, one participant expressed the desire to start a live conversation with the hosts. S/he articulated that while visitors explore the room, the host could be available for questions, over a virtual phone line for example. While we only hypothesized this function, this user already expressed the desire for it. Other two participants claimed the interest in interacting with the objects in the room, to discover further information about the host's identity, while another would like to visualize more objects or details related to the owner. We believe these comments support the app potential to foster dialogue among the visitors and hosts.

Motivation

The analysis of the motivation construct highlighted that the 360° VR supports playful and meaningful engagement, confirming our intent. First, it confirms how 360° VR technologies can facilitate information acquisition. In fact, the item *moving in the room I acquired information* obtained an average value of 4.4 versus 3.3 for the 2D version. Secondly, the VR version fostered playful interaction. In fact, the item *I really enjoy the visualization/navigation task*, obtained an average score of 4.67 versus 3.35 for the 2D version. As a secondary effect, this result provides evidence that the 360° VR navigation didn't distract the user, but acted as an amplifier of the host information. Thirdly, on average, users felt intimacy with the room host, again confirming our design aim. In fact, the two items *I felt intimacy with the person* and *I developed empathy towards the person in the room* got an average value close to 4 versus 3.2 for the 2D version. Moreover, one participant reported, as a positive aspect, that s/he really liked the possibility of knowing a person in advance (thanks to the room exploration) before asking for suggestions about the city. This feedback reinforces our intuition to use 360° VR to design a system able to benefit the visitors through information exchange with the room's host.

Mobility

The mobility construct measures the possibility to access real-time information about the environment. The 360° VR version obtained an overall higher score than the 2D one offering its relevance for fostering playful interactions. The result was surprising, as both apps were experienced through a mobile device. Nonetheless, it is interesting to point out that some users perceived the 2D version as a good compromise to obtain real time information, without delay or inconsistencies, which on the contrary can be encountered by navigating the VR room using the built-in gyroscope. Accordingly, four users pointed out technical issues with the gyroscope as a negative aspect of the system. This outcome confirms the hight technological expectation of digital natives while enjoying a mobile immersive application.

Reality

With the reality construct, we investigated if the user felt the virtual environment as real. In this case, results strongly state that the 360° VR app was able to increase the acquisition of spatial recognition and information about the real environment, so as also the feeling to be physically fit in the virtual environment, obtaining an average score of 4.3 vs 2.5. This outcome is the confirmation that we designed an immersive system, able to create the psychological sensation of being in an alternate space, a feature VR technology should have by design (Bohil et al., 2009).

Sense of Comfort

The sense of comfort needs to be considered when designing a system that requires the user to perform physical movements in the public space. Indeed, this sub-dimension is clearly correlated with the concept of flow, the sense of being absorbed by a task in such a degree that one forgets about time and place (Csikszentmihalyi, 1990). The general result confirms that users seemed comfortable in using and waving their smartphone in a real public space to engage with the application. We like to connect this positive result with the changing habits of digital natives, and how the existence of mixed and extended reality applications for public space is becoming mainstream. Said that, a few users still declared that they are worried about other judgements, confirming that the sense of comfort can affect the ease of smartphone use and gesture performance in engaging with extended realities in public spaces. Echoing with (Nisi et al., 2018; Bala et al., 2017) we can conclude that this is an issue that needs to be considered while designing mobile 360° VR environments.

Summary

In summary, we can synthesize our lessons learned into the following points.

- The study results support concluding that today's generation of tourists rely on smartphones for many activities including travel and tourism, while mixed realities are becoming an exciting and almost familiar mode of interaction. Nonetheless, designing for 360° VR technologies is still in its infancy and guidance is needed to avoid discomfort while performing movements with the smartphone in the public space.
- The 360° VR version empowered the acquisition of information about the host's identity and personality, allowing the visitors to eventually build empathy and intimacy. Moreover, the 360° VR mobile app allowed users to create a mental image of the room, increasing the feeling to be physically in the virtual room.
- Direct exchange and potential dialogue are a welcome possibility for visitors exploring the hosts' environment. While we only hypothesized the possibility to provide synchronous dialogue between visitors and hosts through the exploration and annotation of the room, some participants clearly expressed the desire for it.
- Focusing on immersion, the *sensory* construct requires further investigation to understand its effects on fostering playful interaction through 360° VR technologies, while *interface*, *involvement*, *motivation*, *mobility*, and *reality* positively influence the user's perception of the VR version. On the contrary, we can confirm that the *sense of comfort* negatively influences the VR experience.

Limitations

The main limitations of this work are related to the experiment sample, in terms of size, background, and nationality. Size: we were able to engage only 15 participants due to the current COVID-19 pandemic and the related restrictions and lockdowns periods. This number can still provide valid results, as detailed in Preece et al. (2015) and Caine (2016), but, indeed, engaging a greater number of participants can strengthen the obtained results. The uniform background of the users might produce bias. All the engaged users were enrolled in the Computer Science bachelor's degree. Considering previous literature discussing the increasing diffusion of VR technologies in mobile applications (Loureiro et al., 2020), we can assume that this condition didn't affect the obtained results. Nationality: all the participants were Italian. Also in this case, we are confident in thinking that this condition did not strongly affect our study, due to the nature of the application. However, to validate our assumptions, a future experiment with a larger number of digital natives, with different backgrounds and nationalities should be performed.

Conclusion and future work

In this paper, we report on the design and study of a hospitality application driven by the following RQs: RQ1: *In the visitor experience of the ShareCities hospitality service, how does an immersive 360° VR visualization contrast with a 2D visualization?* RQ2: *What implication for the design of playful information sharing hospitality platforms can we draw from the study conducted on visitor experience of ShareCities?* As a case study, we designed and implemented ShareCities, a mobile application that extends on a previous effort (Candido et al., 2020) exploiting 360° mobile VR as a playful immersive tool to connect and engage visitors and locals alike, through the navigation of a virtual room. Engaging 15 digital natives, we performed a within-subject design experiment to investigate the tourists' perspective, exploiting two mobile versions of ShareCities to navigate the virtual room: one presenting 2D scroll-based images of the room, and the other exploiting 360° VR gyroscope-based navigation. The collected data allow us to positively confirm that the 360° VR version was perceived as more involving, engaging, motivating, real, mobile, and with an easier interface to acquire information, than the 2D one. Data shows that the 360° VR feature can be playful due to the high user's engagement and involvement it provoked. Moreover, curiosity about the host and its VR personalised environment was generated in the users, who asked for real-time interactions with the objects in the room and also the possibility to move across rooms, by simply opening the door. Ultimately, the desire to establish a dialogue between tourists and locals, emerged in the words of one user that expressed the desire to have a direct channel to talk with the host. Following these encouraging results, we are planning to continue investigating mobile 360° VR technologies focusing on supporting dialogue among locals and tourists (considering the locals' perspective), in emerging hospitality services. Moreover, we would like to investigate whether the role of the urban public space, as a space to facilitate social interactions, can play a relevant role in fostering such a dialogue.

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Table 1: Details about the composition of the questionnaire to evaluate the system

Dimension	**Scales/Questionnaires**	**Items**
Usability	System Usability Scale (SUS) (Brooke, 1996)	All items (#10)
Engagement	User Engagement Scale (UES), short version (O'Brien et al., 2018)	All items (#12)
Immersion	Framework for context immersion in mobile augmented reality (Kim, 2013)	*Interface* (1, 2, 4); *Sensory* (1,3); *Involvement* (1, 3, 5, 9, 10); *Motivation* (1, 2, 5, 10); Mobility (4); *Reality*: (2)
	Questionnaire to Measure the User Experience in Immersive Virtual Environments (Tcha-Tokey et al., 2016)	3 (engagement), 17 (immersion), 20 (immersion), 30 (flow), 80 (open question), 81 (open question), 82 (open question)
		Total items: #45

Table 2: Defined dimensions related to the immersion complex concept

Constructs	**Kim (2013)**	**Tcha-Tokey et al. (2016)**
Interface	*Interface* (1, 2, 4)	--
Sensory	*Sensory* (1, 3)	--
Involvement	*Involvement* (1, 3, 5, 9, 10)	3 (engagement), 17 (immersion)
Motivation	*Motivation* (1, 2, 5, 10)	--
Mobility	*Mobility (4)*	--
Reality	*Reality*: (2)	20 (immersion)
Sense of Comfort	--	30 (flow)

Table 3: The average score for both versions, obtained using UES-SF

Engagement sub-dimensions	**2D**	**VR**
Focused attention (FA)	3.09	4.07 (+0.98)
Perceived usability (PU) (reverse coded)	4.93	4.87 (-0.06)
Aesthetic appeal (AE)	3.78	4.44 (+0.66)
Reward factor (RF)	3.78	4.51 (+0.73)
	3.88 (overall value)	4.38 (overall value)(+0.50)

Figure 1: The desktop-based web app (on the left), and the mobile app (on the right).

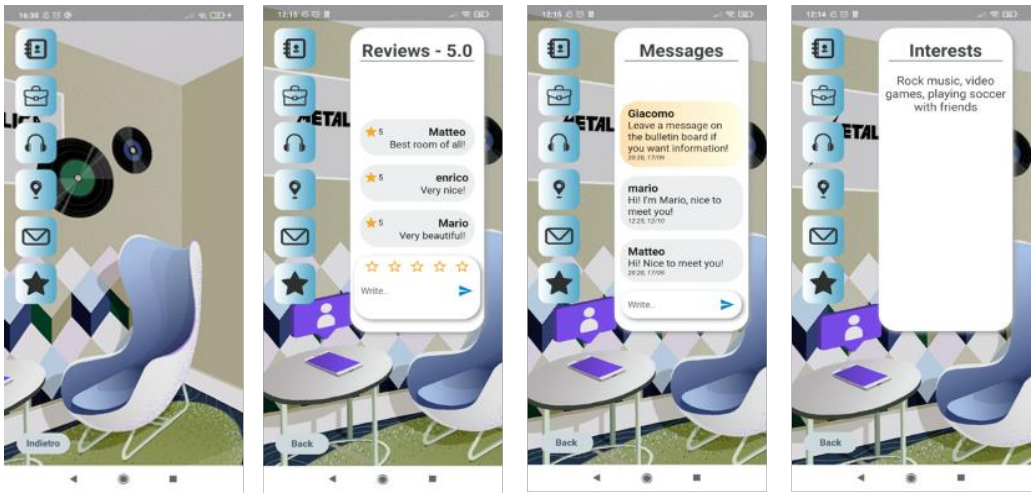

Figure 2: Screenshots presenting some of the room navigation functions

Figure 3: A representation of the 360° VR room experience with the Cesena city in the background

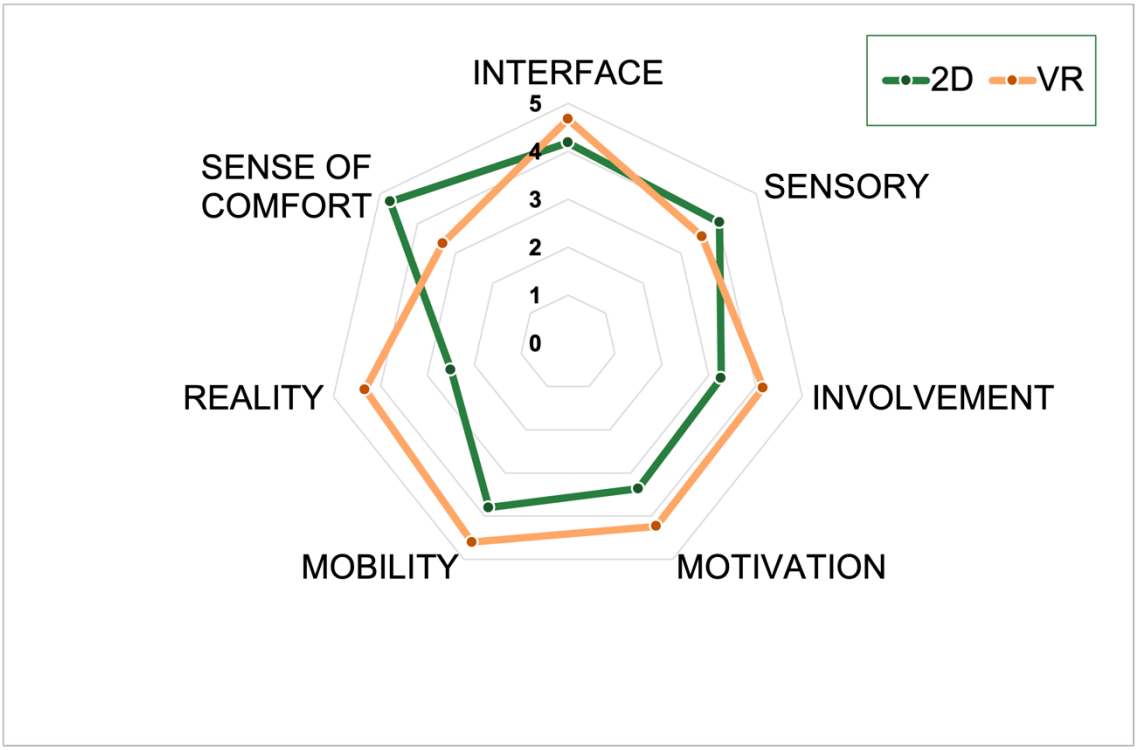

Figure 4: A radar chart presenting the average value obtained for each dimension composing immersion, for the two app versions (2D vs VR).

Ref: IJHC-D-20-00619

Title: Augmenting emerging hospitality services: a playful immersive experience to foster interactions among locals and visitors

Authors: C. Prandi, V. Nisi, C. Ceccarini, N. Nunes

Dear Editor, Dear Reviewers,

We are very grateful for your careful reading of our paper and for the constructive feedback. We have taken your comments and suggestions into consideration and we detail the way we answered to your feedback in the following document.

Table of Responses to IJCHI Editor's Comments

Reviewer Issue/Comment to Be Addressed	Response/Action Taken	Document Location
To fit within the special issue, I am really missing the playful aspects of the research study. They are not really discussed in detail. Could you please clarify the role of the research with respect to the concept of play.	To address the "missing playful aspects" of our work in the manuscript, we extended the Introduction to include a detailed discussion on playfulness and the city, referencing seminal work on playful cities (Innocent, 2019; Nijholt, 2017; Nijholt, 2020; Clarke, 2020). In this way, we better describe our solution's playful elements, according to recent literature. Moreover, references to the playfulness of our approach have been added and unpacked in the design and discussion sections.	In the "Introduction" section
In the opening paragraph of the introduction, you discuss that technology can build resilience in light of COVID…in tourism and then list a series of different tech – this doesn't really tell us how resilience is built using this tech. Can you give examples of how these tech solutions support resilience in tourism? Is it simply about sharing information as discussed in the second paragraph, or is it something more? In which case I am unclear about how this builds resilience in COVID era.	We improved the clarity of the Introduction by removing the paragraph related to the current pandemic and the resilience concept. In fact, although it has been proved that technological innovations can contribute to the creation of resilience tourism considering the post-COVID-19 scenario (see, for example, Sharma et al., 2021), we realized the reference is out of scope in the context of our publication and contribution, which indeed focuses on the relevance of AR and VR in the hospitality and tourism sector.	In the "Introduction", at the end of the first paragraph
The introduction should be much more specific about the use of AR and VR in the hospitality and tourism sector – but I am also missing in the third paragraph something about the why? Augmenting the experience – but why do this – what does it bring?	We revised all the Introduction content to focus on the central aspect of our study: AR and VR in the hospitality and tourism sector. In doing that, we also better clarify the importance to exploit such immersive technologies to offer innovative services and playful experiences, both in situ (exploiting location-based technologies) or remote, providing virtual representations of touristic places, with the final aim to increase the likelihood to physically visit such sites in the future. Extended reality can, in fact, facilitate tourists in accessing valuable information and increasing their knowledge regarding a touristic destination while enhancing the tourist experience with different levels of entertainment, such as playfulness, inspiration, liveliness, collectivity and surprise.	All the "Introduction" section has been revised
Please review the research question, at the moment it is rather broad and is a simple yes no question? "In the emerging digitally enhanced hospitality services panorama, can a mobile VR application foster playful connections, curiosity and, eventually, dialogue between locals and tourists?" I am not convinced of the playful connections or that the app supports dialogue, which I consider to be a conversation between two or more people. This needs clarification. I think what you are supporting is information sharing but not a true dialogue.	We narrowed the scope and rephrased the RQ as follows: RQ1: *In the visitor experience of the ShareCities hospitality service, how does an immersive 360° VR visualization contrast with a 2D visualization*? RQ2: *What implication for the design of playful information sharing hospitality platforms can we draw from the study conducted on visitor experience of ShareCities*? In order to clarify how our application supports dialogue in a playful way, we added a further paragraph to the introduction where we clarify our research goal as the exploration of the system qualities/features that could foster (asynchronous) dialogues or conversations between tourists and locals by means	Last paragraph of the Introduction section

	of messages and information the host leaves into the virtual room, and that the visitor can discover (playful aspect) and reply to (fostering dialogue or conversation). As it stands, we foster the start of this exchange; future work will evaluate if they can develop in a conversation, and eventually a dialogue. Our research presents a first step in this direction by comparing the experience of two different technological solutions (2D flat images-based vs mobile 360° VR), from the visitor perspective. We also added a footnote that clarifies the meaning of the two terms (dialogue and conversation).	
The related work sections -> for my taste this is too descriptive and would benefit from being more critical. For example in the section mobile applications to create connections between tourists and locals, you describe two systems but what features and design aspects really support the dialogue between visitor and resident – how successful are they. I suppose what I am missing is a discussion on the notion that information sharing supports authentic experiences. Given that is a key premise of the system – it merits a specific literature discussion. How is it, how has it been measured and evaluated in the part etc…	We revised the "Related work" section, and, in particular, the first sub-section (now named "Creating connections between tourists and locals through technology"), describing the cited studies and works with a more critical perspective.	The Related work section, and, in particular, the first sub-section
Likewise, for the 360 VR to foster playful interactions – again this is very descriptive and would benefit from some more critical evaluation and classification of the literature as it reads currently like a short list of projects. I am not sure what you mean by playful in this context of this sub-heading? Why does adding sound make a 360 video playful – perhaps more immersive? I wonder if perhaps you could classify the studies according to their immersive aspects and/or playful aspects. In fact, it could be useful to consider what aspects of VR support playful interactions?	We revised the subsection: "360 VR to foster playful interactions", including further details about the playful aspects of the presented solutions, framing the discussion around the playful concept we better developed in the Introduction.	The "360 VR to foster playful interactions" subsection, in the "Related Work" section
This section could also be improved by including a short review of the literature about user studies for VR /AR – given that this is the key to your research.	According to this comment, we added a subsection (titled "User studies in the touristic 360 VR contexts") in the "Related work" section. This subsection focuses on presenting the main result in the 360 VR context since this technology is primary in our study.	Added a new subsection ("User studies in the touristic 360 VR contexts") in the "Related work" section
I found the structure a little confusing as you talk directly about the design of the app after the section on related work perhaps this could be improved by providing a short summary of the user study at the beginning section that outlines the flow from brainstorming, questionnaires, design etc. . And perhaps noting the functions available in the desktop version – just to give a short overview.	We revised the paper structure to address the Editor comment, and we decided to remove the "ShareCities design" section. We agree it was not well-located in the paper, and, moreover, it was not highly relevant in the description of our study. Morevoer, we also revised the "The ShareCities Platform" section, to make clear the differences between the desktop-based system and the mobile app.	Removed "ShareCities" section and refined the "The ShareCities Platform" section
It is not clear to me where the residents fit in to the user study? How do they benefit – how does your design create a dialogue? Do residents want a dialogue with visitors? Can you clarify, please?	We clarified in the "Introduction section" the final goal of the research project is to design a system able to foster a dialogue between visitors and locals, by means of playful interactions. The study and results presented in this article are a first step toward this goal. We have clarified this point in the Introduction, and reshaped RQ1 and RQ2 to reflect this goal. The residents will benefit by having an opportunity to meet new people from different cultures and initiate a connection, and eventually, dialogue, with them before deciding to host them or to meet them face to face. A visitor on the other hand by getting to know the host could develop a closer sense of their hosts, fostering empathy and facilitating the exchange (which can be beneficial to the local in several manners: cultural of goods, of information, etc.). Following this line of thinking, we revised the text	In the "Introduction" section and in the "The ShareCities platform" section

	throughout all the paper to better clarify this aspect. Our response to R1 (first comment) further clarifies this issue.	
The findings include descriptions of the questionnaire items – this might be better discussed in the section on the final questionnaire and how it was designed, what constructs were used etc. it might improve the readability of the paper.	We moved the description of the items (including Table 3, now Table 2) in the "Final questionnaire" subsection, sure that this would improve the paper's readability.	In the Evaluation section, and in particular in "The final questionnaire", in "Findings - Immersion" and in "Findings – Qualitative data"
Could you please be more explicit about the lessons learnt from your user study	We refined the discussion to better express the main contribution and the lessons learnt.	
There are number of proof reading issues and issues of sentence structure. I give just a few examples below. […]	We carefully proofread and revised the whole text.	The whole text
The paper needs to be put into the IJHCI format	Regarding this comment, we used the Word template available from: https://authorservices.taylorandfrancis.com/formatting-and-templates/ (version: Word 2016 & 2019 Windows), linked from the following page: https://www.tandfonline.com/action/authorSubmission?show=instructions&journalCode=hihc20#formatting . We carefully checked it, and it seems to match the original one. We hope to have correctly followed all the provided instructions.	--

Table of Responses to IJCHI Reviewers' Comments

Reviewer #	Reviewer Issue/Comment to Be Addressed	Response/Action Taken	Document Location
R1	I understand why tourists would like to use such an application. What is not clear to me is why would locals like to use it? What do they have to gain, other than being curious at the beginning, use it for sometime and then abandon it. You mention that the locals have an opportunity to decorate their room and show their personality, but I think this is not enough to keep them engaged in the long run. I believe these kinds of applications need clear motivation and sustainability planes to work. Otherwise, it would be a very interesting application that would not be used in the real world. What is missing, therefore, is also to ask participants to give answers from the side of the locals, not only the tourists. I suggest you change the focus of the paper to explicitly state that you are exploring the tourists' perspective. The locals' perspective could be explored in a future study but mention here that this will take place and that you will explore a motivational strategy to keep them engaged.	While the service is designed to benefit both sides of the communities (hosts and visitors), this paper focuses specifically on the study of the visitor experience. Nevertheless, in the introduction and in the "The ShareCities platform" we clarify that the host gains form the service a direct contact with a visitor, and the possibility of initiating conversation leading to a virtual or face to face dialogue. Furthermore, in the intro we make explicit that the tourism sector is moving towards more authentic, and technology mediated experiences, and the hosts can benefit from this system embodying such characteristics, exploiting mechanisms typical of the share economy paradigm and create a sense of belonging, connectedness, and trust in both visitors as well as residents (hosts) (e.g., Couch Surfing [1,2]). [1] Rosen, D., Lafontaine, P. R., & Hendrickson, B. (2011). CouchSurfing: Belonging and trust in a globally cooperative online social network. New Media & Society, 13(6), 981-998. [2] Molz, J. G. (2012). CouchSurfing and network hospitality: 'It's not just about the furniture'. Hospitality & Society, 1(3), 215-225 Moreover, we revised the Introduction, and the whole text, to specify that this paper presents a study focused only on the visitors' experience, as a first necessary step towards achieving our final goal: design a system that enhances the dialogue between hosts and visitors. Said that, we include such clarification in the "Conclusion and Future work" session that as a further step, we will investigate in detail the hosts experience through the system.	"Introduction" section and "The ShareCities platform" section
R1	You also have a rather small sample for the main study, N=15. In this case, you should not run parametric tests, like ANOVAs, but something like Wilcoxon rank sum tests instead. Please, change the analyses and use non-parametric	We conducted a new analysis computing the non-parametric Wilcoxon matched-pairs signed-ranks test that that compares two paired groups to establish if they are statistically significantly different from one another. The obtained results are presented in the "Findings" subsection.	"Findings" subsection

	equivalent tests appropriate for within subjects design.		
R1	Page 7, 1st paragraph, check paragraph formatting.	Thank you for the punctual comment. Done.	
R1	Page 8, you mention an 11 item questionnaire. Please, provide translated the actual questions used. The questions used might have affected the data gathered since I agree with the authors and it is not always clear what the participants would actually do in a real situation. This might not be easily reflected on their questionnaire answers.	We removed the overall section describing the design process, including the questionnaire we run before the study itself. In fact, we realize that it wasn't relevant considering our findings. We believe this decision improves the clarity of the overall manuscript.	Removed the "The ShareCities design" section
R1	Page 13: The questions used for the main study (presented in table 1), the user's attitude ones, are all suggestive. Thus, it is not surprising that most participants had positive attitudes towards interacting with locals (as reported in the results section). This is a serious methodological problem that I am not sure how you can overcome it, since data collection is now over. Perhaps you should drop the attitudes analysis altogether and keep the other scales that were based on standardized questions.	We agree with the issue pointed out by the Review and we decided to delete such an analysis since it was also not relevant for the discussion.	Removed the user's attitude analysis from the findings
R2	My major concern is that the paper is not really clear about its main goal and contribution. Does the system propose a new interactive system making use of AR to enhance dialogue between visitors and locals? Or does it seek to explore the added benefits of AR in an existing application and presenting findings from a user study? The introduction seems to focus on the first option, but the user study is rather providing insights for the second option. Unfortunately, because of this lack of a clear focus, there are many open questions related to the research methodology and it is also not clear how to understand and interpret the results.	We clarified the main focus of the study in the Introduction section and formulated as the study of the tourist experience with a hospitality service that makes use of mobile 360 VR features to share information and initiate communications between hosts and visitors. We revised the Introduction section and the RQ to better clarify the paper focus.	"Introduction" section, and "Evaluation" section
R2	The introduction is very broad. While it explains the motivation for using VR in tourism, I am missing more information about the context of this project and previous studies investigating the impact of VR features in touristic apps. How does the present work contribute to previous work done in the area?	According to this relevant comment, we revised the Introduction section clarifying the main focus of our study and framing it in the context of emerging hospitality services and immersive technologies, aiming to better clarify the contribution of this study.	"Introduction" section
R2	The related work section includes many commercial apps. I think it would be more relevant to focus on results from previous studies with similar apps.	We decided to include both research projects and commercial apps in the discussion of Related Work because we sought to present a whole panoramic of how VR features are exploited in touristic apps. Nonetheless, to the best of our knowledge, we included the more recent and interesting studies presenting similar apps.	--
R2	Websites should be added as footnotes or references, but not in the main text.	Done. We added footnotes for all the links.	In the whole document
R2	The research question is also not specific enough. Why not focuss on the user study and formulating the question around the impact of a 360° VR view in contrast to a 2D flat view?	We rephrased the RQ to better explain the motivation behind our study. Accordingly, we rephased the RQ as follows: RQ1: *In the visitor experience of the ShareCities hospitality service, how does an immersive 360° VR visualization contrast with a 2D visualization*? RQ2: *What implication for the design of playful*	In the whole document

		information sharing hospitality platforms can we draw from the study conducted on visitor experience of ShareCities?	
R2	The design process leaves many open questions. What exactly was the goal of the application? Why did you focus on digital natives? Why exactly was the survey done and how should the results contribute to the design? For instance, in case the design goal is to foster dialogue between locals and visitors, why did you ask if people were interested in fostering the dialogue? From the narrative of the paper, I would expect that this need was investigated already before starting the design process...	We removed the overall section. In fact, we realize that it wasn't relevant considering our findings. We believe this decision improves the clarity of the overall manuscript.	Removed the "The ShareCities design" section
R2	The system seems to be nicely designed, although it would be interesting to read more about the context of the application, i.e. why the first version was developed, was it part of a research project? However, the app does not seem very novel or innovative (which is not a problem in case the main contribution of the paper are the results from the study). In case there are some innovative features I am missing, they should be highlighted and compared to previous work.	We revised the Introduction section to include more details about the project context. Moreover, we included some other details about the overall research project in different sections of the paper. Considering the novelty aspects of the app, we exploited aesthetic experiences and playful interaction to engage tourists in looking for information in virtual rooms. We better explain this aspect in the "Introduction" and "The ShareCities platform" sections, in comparison with other approaches.	"Introduction" section, and "The ShareCities platform" section
R2	The discussion could be more focussed, in order to obtain better take-away messages. There is some summary, but which seems more like a general summary of the paper, and not a summary of the lessons learned from the user study.	We refined the discussion to better express the main contributions and the lessons learnt.	"The discussion" section
R2	A weakness is also the low number of participants, but this is explained by the authors.	We are aware of this issue and, for this reason, we included a brief discussion in the Limitations section (as pointed out by the Reviewer). Unfortunately, the COVID-19 pandemic didn't allow us to test the system with a greater number of participants: we were able to have only 15 participants, that, nonetheless, can still provide valid results, according to Preece et al., (2015) and Caine (2016).	--