



# A comparative study of VR and AR heritage applications on visitor emotional experiences: a case study from a peripheral Spanish destination

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## Abstract

VR (virtual reality) and AR (augmented reality) applications are increasingly being implemented in the heritage and cultural tourism sector, generating immersive and engaging visitor experiences. Taking into account the gaps in the literature concerning the topic, the objective of this study is to compare the emotional impacts of VR and AR applications on the visitor experience in two heritage sites in the peripheral town of Ulldecona (Catalonia, Spain). Through a qualitative real-world study, combining participants' self-reports and participant observation, the analysis will be conducted by examining visitors' reactions across five dimensions of emotions identified in the literature (Soon et al. in *Psychol Mark* 40(11):2387–2412, 2023) and adapted to this context: the cognitive, affective, physiological, motivational and expressive dimensions. Both positive and negative effects are explored to provide a comprehensive understanding of the visitor experience. Results reveal that what visitors express does not always match their sensorial and physical behaviour during the experience. Additionally, VR and AR applications elicit different reactions among visitors due to their varying degree of immersivity. This research provides valuable insights to the literature on VR, AR and heritage tourism, emphasising the need for a mixed-method approach to further explore advanced technologies' impacts on visitors at heritage sites.

**Keywords** Virtual reality · Augmented reality · Heritage tourism · Visitor emotional experience · Comparative study · Participant observation

## 1 Introduction

Virtual reality (VR) and augmented reality (AR) applications have been widely implemented in the tourism sector (Fan et al. 2022; Kim et al. 2020) transforming products,

services and tourism destinations (Loureiro et al. 2020). These immersive technologies provide added value to the tourism sector and modify visitors' experiences (Bec et al. 2019; Jung et al. 2016; Rainoldi et al. 2018; tom Dieck and Jung, 2018; Tussyadiah 2014). They allow tourists to play a more dynamic and autonomous role (Flavián et al. 2019).

VR and AR create powerful 3D interactive visual experiences (Yung and Khoo-Lattimore 2017), generating emotions among users, stimulating visitors' senses and immersing them in the visit (Nayyar et al. 2018). VR can be defined as a computer-generated three-dimensional environment that constructs a virtual world where users can navigate and interact (Guttentag 2010). On the other hand, AR enriches real environments using computer-generated voices, images, and other virtual data (Gaberli 2019) through devices that provide a lower degree of immersion compared to VR (Yung and Khoo-Lattimore 2017).

These immersive technologies have been mostly developed in the field of heritage and cultural tourism, where

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tourists' experiences are particularly relevant (Bec et al. 2019; Han et al. 2018). Heritage tourism offers experiences that involve visiting places or reliving activities from the past, and these immersive technologies not only allow heritage to be preserved and managed, but also integrate history into heritage (Zhu et al. 2023). They engage with history at the heritage site, recreate the places or events as they were originally, and offer additional enriching information that renders places more attractive, entertaining and educational (Yung and Khoo-Lattimore 2017). All this increases the level of visitor immersion in the application experience, generates emotions and greater engagement, and enriches the tourist experience (Bec et al. 2019; Mura et al. 2017; Soon et al. 2023).

Most studies on VR and AR applications in heritage tourism highlight the advantages offered by these technologies such as the added value they bring to heritage sites and museums with more innovative, interactive and exciting information (tom Dieck et al. 2016; Yung and Khoo-Lattimore 2017).

Numerous academic studies examine the role of VR and AR as marketing tools in tourism and the users' acceptance and use of these technologies (Chung et al. 2015; Huang et al. 2013; Huanget al. 2016; Li and Chen 2019). However, there are still few empirical and theory-based studies on the tourist experiences, and even less on tourist emotional experiences (Jung and tom Dieck 2017; Jung et al. 2016; Tavakoli and Mura 2015; Wei et al. 2019). In addition, emotional experiences are generally studied from the focus of enjoyment, but further analyses encompassing all dimensions of emotions generated by VR and AR experiences are needed (Soon et al. 2023).

Studies on heritage virtual applications often focus on either VR or AR or treat the two technologies together (Bogicevic et al. 2021, 2019; Flavián et al. 2021). However, there are hardly studies that compare the experiences generated by the two technologies (Verhulst et al. 2021). In addition, there are practically no *real-world studies*, carried out with real visitors to heritage sites, without prior involvement or planning by researchers (Verhulst et al. 2021). Moreover, the vast majority of studies are quantitative and based on self-reports from participants collected through questionnaires and analysed using quantitative methods (Disztinger et al. 2017; Jung et al. 2016; Tussyadiah et al. 2018; Wei et al. 2019), while the physiological emotions generated by the applications have been largely understudied (Gaberli 2019).

Taking all these shortcomings into account, the objective of this study is to compare the impacts of VR and AR heritage applications on visitors' emotional experience across five dimensions identified (cognitive, affective, physiological, motivational and expressive) (Scherer and Moors 2019; Soon et al. 2023). Additionally, the study aims to explore

the potential influence of the cognitive, affective, physiological and expressive aspects on the visitors' motivation. Finally, it seeks to verify whether what visitors report and value through interviews (here considered as the expressive dimension) align with their actual reactions, captured through participant observation (PO). These objectives will be accomplished through a qualitative *real-world* study. The study starts with a literature review chapter about the emotional impact of the two technologies on visitors, and detected gaps identified in literature. The following chapter, the methodology, provides an overview of the territorial context, the two technologies of the case study chosen for the analysis, and it develops six hypotheses to corroborate through the combination of two qualitative methods (participant observation and in-depth interviews). The sample used for the study is also detailed in this section. In the results' chapter, the findings will be split according to the five dimensions of emotions considered, after results' triangulation. The concluding chapter will include the main contribution of the study and a discussion for future research about the topic.

## 2 Literature review

### 2.1 Detected gaps in the AR and VR visitor experience literature

VR and AR are different technologies. While VR provides visitors with a real illusionary experience in the virtual world, AR creates the illusion of virtual elements in the real environment (Fan et al. 2022). However, despite the differences in experiences generated, Yu et al. (2023), there are few comparative studies comparing the experiences and emotions they elicit (Verhulst et al. 2021). In fact, many studies analyse the experience generated by these technologies together (Trunfio et al. 2022), often under inclusive concepts such as Mixed Reality (MR) (Fenu and Pittarello 2018; Flavián et al. 2019; Trunfio et al. 2022), Augmented Virtuality (Gaberli 2019), or Virtual Exhibition (VE) (Peroularakis et al. 2023) technologies, defined as a variety of technological solutions with different interactions and immersive styles. Bretos et al. (2023) wrote a comprehensive literature review on AR and VR.

Aslan et al. (2019) compared the experience generated by different AR devices, while Loizides et al. (2014) by different types of VR devices. Voit et al. (2019) found that AR generates less immersion than VR. On the other hand, Verhulst et al. (2021) later compared the two technologies at the same tourist attraction (i.e., a gallery in Verona). They analysed enjoyment, presence, cognitive, emotional and behavioural engagement through a survey (self-report).

Additionally, they analysed the negative emotions generated by these applications, such as nausea or feelings of discomfort. They found enjoyment to be present in both technologies, although more pronounced in VR due to its higher level of immersivity (Voit et al. 2019). Furthermore, Verhulst et al. (2021) found a low number of reported negative effects across both VR and AR, demonstrating that both technologies generate an overall positive visitor experience. However, given the distinct features of VR and AR (Flavián et al. 2019), there is a need for further studies to delve into the different experiences and emotions generated by each technology (Bretos et al. 2023).

Moreover, most studies on the impact of VR and AR on visitor experiences and emotions are quantitative, while there are very few qualitative, mixed methods or experiments (Jung et al. 2017). Studies are usually based on visitors' self-reporting through surveys (Disztinger et al. 2017; Jung et al. 2016; Tussyadiah et al. 2018; Wei et al. 2019). Very few have applied in-depth interviews (tom Dieck et al. 2019) or focus groups (Han et al. 2018). However, it has been shown that a self-report methodology does not fully capture the sensorial and physiological emotions of users (Larsen and Fredrickson 1999). Consequently, studies are beginning to emerge that take the physiological aspects into account by applying neuroscience and psychology techniques (Beck and Egger 2018; Kim and Fesenmaier 2015; Li et al. 2012; Marchiori et al. 2017). Along these lines, some studies analysed skin conductance responses (Kim and Fesenmaier 2015) and others heart rate variability (Beck and Egger 2018; Marchiori et al. 2017; Li et al. 2012). Additionally, studies on visitor experiences have recently begun to take into account the physiological impacts along with the cognitive and affective ones (Gaberli 2019; Kim et al. 2020; Li and Chen 2019); however, they are still in a very incipient stage and do not take into account all the dimensions of emotions.

Therefore, this qualitative study aims to analyse emotions in all their dimensions by comparing the self-reports resulting from in-depth interviews with participant observation (PO). Specifically, the self-report method corresponds here to the expressive dimension and is functional to investigate the cognitive, affective, physiological and motivational dimensions. However, part of the cognitive dimension, the affective and the physiological dimensions will be also corroborated through PO to verify whether visitors' verbal reports align with their observed behaviours. Additionally, this study seeks to explore the potential influence of the cognitive, affective, physiological and expressive dimensions on the motivational dimension.

Thus, there is a lack of comparative studies between the experiences generated by AR and VR (Yu et al. 2023), as well as a scarcity of real-world studies (Verhulst et al.

2021). Moreover, there is a lack of qualitative studies that also analyse the possible negative effects generated by these technologies across all dimensions of emotions (Suh and Prophet 2018; Verhulst et al. 2021). In fact, several literature reviews emphasise the need of investigating potential negative effects in future research (Loureiro et al. 2020; Fan et al. 2022; Bretos et al. 2023). For all of the above, this qualitative and real-world study, conducted with visitors at attractions on the day of the fieldwork, aims to analyse the different emotional impacts between VR and AR, considering also what influences the motivation of visitors. It encompasses both positive and negative emotional effects and compares qualitative self-reports with PO results.

## 2.2 Impact of AR and VR technologies on visitor emotional experience

Previous studies have shown that AR and VR applications at heritage sites generate positive visitor experiences, making destinations more attractive (Gaberli 2019). Although the visitor experience generated by VR and AR is still little researched (Jung and tom Dieck 2017; Jung et al. 2016; Tavakoli and Mura 2015; Wei et al. 2019), and the research that does exist sometimes even offers contradictory results (Fan et al. 2022), nowadays it is expanding, especially in the field of cultural tourism (Han et al. 2018). Some studies have focused on the impact of these technologies on the visitor experience (Falk et al. 2012; Ismagilova et al. 2015); others on the advantages and functionalities that these technologies provide to users (Li et al. 2022). Loureiro et al. (2020) compiled the existing literature on these immersive technologies in tourism in the last 20 years, although research dealing with the experiential impact is still limited.

Regarding their effects on experiences, some studies analysed the perceived advantage (Jung et al. 2016; Lee and Kim 2021; Yu et al. 2023), others, the perceived enjoyment, the satisfaction (Chung et al. 2018; González-Rodríguez et al. 2020). Zhu et al. (2023) analysed the perceived authenticity generated by the two technologies, demonstrating their impact on the visitor experience and their positive influence on tourists' satisfaction and visit intention. Similarly, Bogicevic et al. (2019) and Flavián et al. (2021) showed that VR can generate a visitor experience even before arriving at the hotel, generating positive mental imaginary and an enhanced brand experience (Bogicevic et al. 2019), creating more positive emotional reactions and higher levels of psychological and behavioural engagement (Flavián et al. 2021). Yu et al. (2023) have also analysed the possible limitations of these technologies in the experience of senior visitors. Yersüren and Ózel (2023) showed that VR experience quality influences perceptions and visit intentions.

Visitor experiences generate emotions that can be considered as a mental state of readiness that arises from cognitive appraisals of events and incorporates components like physiological processes, motor expressions, subjective feelings, and action tendencies (Bagozzi et al. 1999). Only in the last decade have studies begun to investigate the emotions generated by visitor experiences of these immersive technologies (Del Chiappa et al. 2014; Errichiello et al. 2019; Li et al. 2015; Moyle et al. 2017; Prayag et al. 2013). Some studies have focused on the information, learning and emotions generated by these technologies (Falk et al. 2012; Han et al. 2018; Ismagilova et al. 2015). Taking various socio-demographic clusters into account, Errichiello et al. (2019) analysed the emotional responses of VR users and found significant differences between them. Some studies have highlighted the importance of observation and active experimentation in influencing emotions, but few consider their impact on the overall experience (Flavián et al. 2019; Minocha et al. 2017).

It is also observed that the majority of studies analyse emotions in virtual technologies as cognitive or affective responses to technology use during the trip, but do not take other dimensions into account like, for instance, the physiological or expressive ones. Moreover, previous research on emotions caused by information technology lacks grounding in emotion theories and primarily focus on concrete emotions exhibited by users, particularly enjoyment (Hornung and Smolnik 2022). Kourouthanassis et al. (2015), for example, analysed the emotional impact of adopting an AR travel guide, finding that pleasure and arousal feelings influence visit intentions. Hu et al. (2021) explored the impact of AR applications of theme parks on visitor's emotional experience. They took into account five dimensions of AR performance, but they identified only two possible emotional responses (nostalgia and arousal). Stangl et al. (2020) analysed the emotional perception of AR applications across different types of experiences. In concrete, they analysed the link between usability and emotional perceptions, considering only entertainment, playfulness and enjoyment.

Soon et al. (2023), however, have recently developed a conceptual model to analyse the role of emotions in AR experiences, grounded in the theory of Scherer and Moors (2019), and based on the mutual influence between five different dimensions of emotions: the cognitive, affective, physiological, motivational and expressive dimensions. In particular, Soon et al. (2023) seek to demonstrate how the motivational component is highly influenced by some of the other dimensions considered. Nevertheless, this model has not been applied to the tourism sector yet.

Other authors have specifically focused on the use of AR on the heritage and museum sectors. The adoption of VR and AR technologies in these sectors has been rapidly

accelerating, especially following the Covid-19 pandemic, significantly transforming visitor experiences (Gaberli 2022). Over recent decades, the role of museums has evolved substantially (McCall and Gray 2014), shifting from merely preserving cultural artifacts to becoming educational and entertaining institutions (Swartout et al. 2010). This shift has enabled museums to attract new audiences and inspire younger visitors to engage with cultural heritage (Göbel and Geelhaar 2008; Swartout et al. 2010). Additionally, several studies have examined the use of VR and AR in these sectors, highlighting their impact on visitors' emotions (Han et al. 2018; Döpker et al. 2013).

Therefore, despite the expansion of the literature, many gaps remain in the study of the visitor emotional experience generated by these immersive technologies in heritage sites (Verhulst et al. 2021).

### 3 Method, sample and hypotheses

Given the limited number of qualitative studies on VR and AR visitor experiences (Verhulst et al. 2021), qualitative methods were selected. Moreover, due to the complex and fragmentary nature of these technologies, and due to the low number of participants in the study, a qualitative approach seemed more appropriate than a quantitative one (Walle 1997) for exploring and attributing meaning, in-depth understanding and description (Geertz 1973), to avoid generalising while implying a high level of reflexivity.

#### 3.1 Territorial context of Ulldecona and two innovative tourist experiences

The two tourist experiences take place in Ulldecona, a small town in the province of Tarragona, in southern Catalonia. Its population is 6241 and is currently decreasing (Idescat 2023). Ulldecona is a peripheral area, distant from regional centres and characterised by limited transportation networks. However, to counteract its marginal status, the municipality has utilised advanced technologies, specifically VR and AR, to offer an alternative means of communicating cultural heritage. This has contributed to making the heritage more appealing and accessible to a broader audience, thereby increasing local community awareness and appreciation of the area as well as its tourist attractiveness.

Ulldecona was selected as a virtuous example of advanced technologies' adoption for the valorisation of peripheral heritage sites, contributing to increasing the tourist appeal and reputation of the area. Despite its small size, it stands out as a remarkable case for its use of both VR and AR in two of its main heritage sites.



**Fig. 1** Medieval castle of Ulldecona.  
Source: Photo by Irene Pinto



**Fig. 2** VR experience at the medieval castle of Ulldecona.  
Source: Photo by Irene Pinto

**Fig. 3** Abrics de la Ermita, Levantine style paintings.  
Source: Photo by Irene Pinto



The study analyses two heritage sites in Ulldecona that have integrated VR and AR to enhance tourist experiences and raise cultural awareness among local inhabitants.

The first site is the mediaeval castle, a key component of Ulldecona's heritage. Dating back to the twelfth century, it currently comprises two towers, a sixteenth-century church, the remains of some demolished buildings and a perimeter wall. Recent restoration works have brought to light architectural remains from different eras (Fig. 1).

Building on these discoveries and recent developments of 3D scanning, the municipality conceived the idea of a non-standard museum inside the empty castle, namely a virtual reality (VR) tour. The objective was to offer an immersive experience using 3D glasses, consisting of a virtual exploration of all the different historical epochs through five different perspectives (Fig. 2).

The second site is the cave paintings of the Abrics de la Ermita, depicting the first signs of human settlement in the area. Designated as a UNESCO World Heritage Site since 1998, it comprises a series of thirteen shelters containing the most important collection of Levantine-style paintings in Catalonia (Fig. 3).

Since 2013, a preventive conservation programme employing 3D scanning techniques has facilitated an AR initiative for visitors. This initiative, accessible through a downloadable app, the official website and now via a tablet held by the guides during the visit, provides detailed information to enhance the visitor experience.

Although the VR and AR applications analysed were applied to different heritage elements, they were selected as representative examples of each technology. As previously outlined, we chose to compare these two technologies as they use different types of devices and have different degrees of immersivity, generating potential distinct emotional impacts on visitors. Specifically, while AR constitutes a virtual extension of real environments, being only partially immersive, VR generates a 3D virtual world where

users can move and interact with virtual objects, providing a fully immersive experience. In these specific cases, the VR experience utilises 3D glasses that transport users to a totally virtual world inside the castle, whilst the AR experience enables an improved visualisation of the cave paintings through a tablet positioned in front of the painted wall. The collection of data from the two experiences allowed us to compare the results and observe similarities and differences between the multifaceted emotional impacts generated by the two technologies on visitors (Fig. 4).

### 3.2 Hypotheses development and methodological approach

This study aims to examine VR and AR experiences and compare their positive and negative emotional impacts on visitors, readapting the five dimensions' model proposed by Soon et al. (2023) to our context. More specifically, we interpret the cognitive dimension as the level of understanding of the technology as well as the awareness and knowledge it raises. The affective dimension encompasses the deeper feelings provoked by the experience, while the physiological dimension seeks to identify the body's physical reactions. The motivational dimension explores the perceived added value provided by the technology to the physical visit, the desire to repeat the experience, and the willingness to recommend it to others. In summary, the motivational dimension corresponds to the visitors' overall evaluation. The expressive dimension corresponds to the interviews and is thus considered as a method, providing insights into the cognitive, affective, physiological and motivational dimensions.

Our hypotheses are built upon previous studies on emotions (Del Chiappa et al. 2014; Prayag et al. 2013; Soon et al. 2023) where attempts were made to relate the different

dimensions of emotions. We aim to extend these findings by investigating correspondence, in our two case studies, between the motivational dimension and all other dimensions considered. Therefore, our hypotheses are the following:

- (H1): The cognitive dimension influences the motivational dimension.
- (H2): The affective dimension influences the motivational dimension.
- (H3): The physiological dimension influences the motivational dimension.
- (H4): The expressive dimension influences the motivational dimension.

We used a mixed-method approach, combining a non-self-report method, namely PO during the visit, and a self-report, consisting of in-depth interviews. The fieldwork, entailing two full days in the town, helped us become more familiar with the main project stakeholders, the geographic context and the local community. On the first day, the researcher interviewed the person in charge of Ulldecona's heritage. This interview helped establish context regarding the use of VR and AR in the town's heritage. Subsequently, on the second day, the researcher conducted PO during the two different visits and held in-depth interviews with the visitors present on that day, immediately after their visit. During interviews (expressive dimension), visitors were asked about their understanding of the technology and the knowledge gained from it (cognitive dimension: e.g. Has the experience increased your knowledge about the castle's history? and the destination history? Did you understand how the glasses work?), their deeper emotions (affective dimension: e.g. Has VR generated excitement, fun, curiosity for you? And fear, anxiety, distrust...?), their physical reactions (physiological dimension: e.g. Has VR given you an adrenaline rush and satisfaction? And dizziness, vertigo?), and their overall evaluation of the experience (motivational dimension: e.g. Do you think the technological experience is worth the visit? Would you recommend it to others? Do you think it adds value to the heritage site? And to the destination?). PO helped corroborate these findings, providing additional insights into the cognitive dimension (specifically, visitors' ability to comprehend the technology), as well as the physiological and affective dimensions.

Subsequently, the data collected from both interviews and PO were triangulated to determine if what was reported by the users coincided with what was observed, and if what was observed was reported by tourists and in what way. Such a mixed-method approach led to the formulation of our fifth hypothesis:



**Fig. 4** AR experience at the Abrics de la Ermita.  
Source: Photo by Irene Pinto

(H5): There is a discrepancy between the cognitive, physiological and affective dimensions experienced by VR/AR users (as captured through PO) and what they are able to verbally express through interviews.

The table below, created by the authors, outlines which method we used to analyse each dimension. As previously indicated, for our research purposes, we considered the expressive dimension as a method, corresponding to the interviews (Table 1).

Following this, existing literature on the varying degree of immersivity of VR and AR applications (Voit et al. 2019; Verhulst et al. 2021) prompted us to further investigate the consequent different impacts of the two technologies on visitors' emotional sphere. From this exploration, we developed our sixth hypothesis, which we addressed through a comparative analysis of the findings of the two experiences.

(H6): VR, compared to AR, due to its higher degree of immersivity, produces a higher positive emotional impact on visitors across all dimensions considered.

### 3.2.1 Analysis with physical tools

Before participating in the collective visit of the day, the researcher openly informed the visitors of her role, explaining that the study purpose was to fully understand the cognitive, emotional and sensorial/physical impacts that these experiences would arouse in them. All participants (seven for AR and seven for VR) accepted to take part in the study. They were informed that the visit would be partially videorecorded but were encouraged to behave naturally and express themselves freely. In order to maintain spontaneity in the visitors' behaviours, the researcher, supported by the guide, participated in the visit as a standard visitor, interacting with participants and recording videos with a smartphone. Participants were also asked to stay on the site after the visit to take part in an interview. Initially, some socio-demographic details were asked of them (age, place of origin, profession), to which they all consented.

To ensure the validity and transferability of this real-world study, observer influence was assessed through the adoption of rigorous protocols to reduce the risk of bias or

misleading interpretations. It is important to note that the subjects selected were visitors present on those specific days during the visits, completely unknown to the researcher and without any prior knowledge of the study. The lack of previous preparation, in line with the features of a real-world study, offers the advantage of obtaining more objective answers or results, as no one had been contacted beforehand to participate in the study. However, this approach also has limitations, as it only captures the responses of the actual visitors on that day, and the number of visitors was low, partly due to the peripheral location of Ulldecona. Nevertheless, being this a qualitative and real-world study, the number of visitors is only relatively significant, as it does not aim to be representative of a specific population or typology of visitors. Instead, it delves deeper into the different reactions of random visitors to the two technological experiences. Yet, the two participants' groups were quite heterogeneous in terms of age, gender, origin, profession/socio-economic background. Moreover, despite the small sample, the study proposes an analytical model that can be applied to other heritage contexts.

The following table, elaborated by the authors, shows the profiles of the visitors observed and then interviewed for each experience. Specifically, it shows their gender, age range (<45 or >45), and the profession. These characteristics are not intended to generalise the results but rather to better characterise each interviewee's profile based on key socio-demographic features. Age range was specifically considered, as we expected notable differences in reactions across generations (specifically between younger visitors and middle-aged/senior ones), and we aimed to highlight this distinction (Table 2).

### 3.2.2 Participant observation during the visit

PO allows developing a holistic understanding of the phenomena analysed and also to capture users' physical and sensorial reactions to the experience that may not be reported by them (Musante and DeWalt 2010), defining the physiological dimension of emotions. PO was carried out for the whole duration of the visits (approximately 2 h for each heritage site) to allow for a comprehensive analysis of participants' experiences. Visitors were encouraged to express themselves freely and naturally during the visit to ensure that they did not feel uncomfortable due to the presence of a person observing and recording them (Fig. 5).

Throughout the PO work, the researcher focused on studying, observing and discovering the interaction and perceptions of the visitors towards the object of study. Specifically, in both visits, attention was given to:

- Their facial expressions,

**Table 1** Methods used for each dimension (authors' elaboration)

Dimension	PO	Interviews / Expressive dimension
Cognitive (device understanding)	x	x
Cognitive (knowledge raising)		x
Physiological	x	x
Affective	x	x
Motivational		x

**Table 2** Participants' profile (authors' elaboration)

Interviewees	Gender	Age range	Origin	Profession
AR 1	Woman	<45	Italy (living in Tarragona)	Student
2	Man	<45	UK (living in Tarragona)	Student
3	Man	>45	Almeria (living near Tortosa)	Retired
4	Woman	>45	Tarragona	University Professor
5	Man	>45	Valls (living in Tarragona)	Computer scientist
6	Woman	<45	Tarragona (living in Barcelona)	Student
7	Man	<45	Tarragona	Economist
VR 1	Woman	>45	Vinaròs	Administrative personnel
2	Woman	>45	Ulldecona	Graphic designer
3	Woman	>45	Ulldecona	Housekeeper
4	Man	>45	Ulldecona	Factory worker
5	Man	>45	Ulldecona	Ambulance driver (retired)
6	Man	>45	Vinaròs	Welder
7	Woman	<45	Italy (living in Tarragona)	Student

**Fig. 5** Physiological reactions of visitors (e.g., leaning against a wall or sitting) while wearing VR glasses.

Source: Photo by Irene Pinto

- Comments made by participants,
- Their conscious and unconscious physical movements.

Additionally, in the VR experience, the researcher focused on capturing:

- The difficulty encountered by participants in wearing the VR glasses,
- Their balance while wearing them and walking.

The visitors' reactions were videorecorded with the smartphone in order to complement the researcher's on-site observation with subsequent post-observations analyses. The behaviours exhibited by tourists encompassed the cognitive dimension (considered as the ease of understanding the functioning of the devices), the physiological and the affective dimensions. The actions observed among visitors served to validate whether their reported experiences aligned with their actual experiences during the visits.

### 3.2.3 In-depth interviews post-visit

In-depth interviews (considered here as the expressive dimension) allow extending the findings of the observation, maximising understanding and meaning while capturing the subjective knowledge, sensations and emotions reported by the participants. This method also allowed us to explore the cognitive and the motivational dimensions, making it suitable for our research purpose due to its flexibility and ability to generate rich information (Olabuénaga and Ispizua 1989).

The interview with the person responsible for Ulldecona's heritage served as a major source of information and for creating a storyline of the development of the two projects over time. The interviews with visitors aimed to explore the cognitive, emotional and sensorial impact that the two technological attractions had on them, as well as their overall evaluation. Before the observation, all visitors present were asked if they would mind participating in an interview after the visit. The purpose of using in-depth interviews is in fact to emphasise the quality of insight gained rather than focusing on numerical data, delving deeply into subjective reactions rather than drawing statistical conclusions.

During the interviews, participants were asked about their:

- Sociodemographic data and profession;
- Cognitive aspects: in-depth questions were posed to investigate the ease of comprehending the functioning of the technologies and whether they increased visitors' knowledge about Ulldecona's history;
- Affective and physiological aspects: participants were asked to describe their emotional and physical/sensorial reactions to the two experiences;
- Motivational aspects: participants provided an overall evaluation of the experience, including whether the technological experiences constituted an added value to the physical visit, whether they would repeat such an experience and/or recommend it to others.

It is important to note that all questions covered both positive and negative aspects. The interviews were recorded and later transcribed. Following this, we applied the five dimensions of emotions, identified through the theoretical framework, to the results obtained from both interviews and PO. This enabled us to build a table illustrating both positive and negative emotions for each dimension and for each technological experience (VR and AR), while also distinguishing between emotional reactions of young visitors and those of middle-aged or senior ones.

The outcomes of the interviews primarily included the cognitive dimension (in terms of knowledge acquired) and the motivational dimension. Additionally, they revealed visitors' awareness or lack of awareness of their reactions, further explored through PO, related to the cognitive dimension (intended as ease of understanding the technology), to the physiological and affective dimensions.

The motivational dimension allowed us to verify H1, H2, H3 and H4. The findings emerged through the interviews (expressive dimension) were then corroborated through PO, where the real comments and actions of the visitors during the visit were observed and later analysed. This process helped to verify H5. The combination of PO with in-depth interviews sets this study apart from other previous ones, the majority of which are based solely on self-report methods (questionnaires or interviews).

Moreover, this mixed-method approach was applied to two different technological experiences at the same peripheral destination, enabling a comparative analysis between the two cases. This outlined the different perceptions and degrees of involvement associated with VR and AR, thus helping to corroborate H6.

## 4 Results

The mixed-method approach used, consisting of PO and in-depth interviews, allowed us to identify the five dimensions of emotions applied to our cases and to verify the six hypotheses. The table below, created by the authors, presents the findings for the cognitive, affective, physiological and motivational dimension for both virtual experiences, following the triangulation of results. Explanations for the results obtained for each dimension will be provided subsequently, along with a paragraph dedicated to the triangulation of results (Table 3).

### 4.1 Cognitive dimension (device understanding)

- In VR, most participants reported finding the device easy to understand and use thanks to the guide's accurate

explanation and support. PO confirmed this result for young visitors. However, observation also revealed that most middle-aged participants, despite the practical support of the guide throughout the experience, encountered difficulty in understanding the device, as shown by their struggle to correctly wear and utilise the glasses.

- In AR, most participants reported finding the device easy to understand, thanks to the guide's explanation. In this case, participants' assertions were confirmed by PO.

Therefore, in VR, the cognitive dimension (intended as ease of understanding the device's functioning) was very positive for young visitors and negative for middle-aged visitors. Differently, in AR, was very positive for both visitor groups.

### 4.2 Cognitive dimension (knowledge enhancement)

- In the VR experience, participants reported that the technology enhanced their knowledge of the castle and the history of Ulldedeona.
- Both VR and AR visitors reported that the technologies effectively facilitated visualisations of the heritage sites, providing them with a realistic depiction of the sites. In the case of the castle, VR enabled visitors to explore it from various physical and historical perspectives, while for rupestrian art, AR showed visitors the enhanced details in the drawings.

Given all this, it appears that the cognitive dimension, when referred to the ability of technologies to transfer and enrich knowledge about the heritage site to visitors, is very positive for VR users. This is attributed to VR's capability to offer visitors deeper insights into history through enhanced visualisation from various physical perspective and historical epochs. On the other hand, for AR users, this dimension is "only" positive. In fact, despite offering plausibility and improved visualisation of the drawings, AR did not significantly contribute to convey additional knowledge to visitors.

### 4.3 Affective dimension

- In the VR visit, during interviews, participants mainly reported feelings of amusement, wonder, adrenaline and a sensation of being transported to the past. These positive feelings were validated through PO. Additionally, PO revealed a negative feeling of fear and distrust among middle-aged visitors, although these negative feelings were only minimally reported by visitors during the interviews.

**Table 3** Dimensions identified for VR and AR visitors after results' triangulation (authors' elaboration)

Dimension	VR		AR	
	<45	>45	<45	>45
<b>Cognitive (device understanding)</b>	Very positive	Negative	Very positive	Very positive
	Device easy to use	Device not very easy to use	Device easy to understand	
<b>Cognitive (knowledge enhancement)</b>	Very positive	Very positive	Positive	Positive
	Increased knowledge; improved visualisation; plausibility.		Improved visualisation; plausibility	
<b>Affective</b>	Very positive	Positive	Positive	Very positive
	-	Fear, distrust	Moderate wonder and amusement	Wonder and amusement
	High degree of wonder and amusement, adrenaline and evocation of the past			
<b>Physiological</b>	Very positive	Negative	Very positive	Very positive
	-	Vertigo, dizziness, and physical instability (hand movements, visitors sitting down or leaning against the wall for balance)	-	-
	Rapidly changing facial expression showing wonder		Rapidly changing facial expression showing wonder	
<b>Motivational</b>	Very positive	Very positive	Very positive	Positive
	High added value to the physical visit; willingness to repeat the experience and to recommend it to others		High added value to the physical visit	Moderate added value to the physical visit
			Willingness to repeat the experience and to recommend it to others	

- In the AR visit, interviews brought to light a high level of wonder and amusement among middle-aged and senior visitors, and a lower level of the same emotions among young visitors. In this case, PO validated all these findings.

Therefore, concerning VR, the affective dimension is very positive for young visitors, for whom the experience provoked all positive emotions, and "only" positive for middle-aged participants, who, in addition to the positive emotions, also experienced some negative feelings. As for AR, the affective dimension is very positive for middle-aged and senior visitors, who encountered the technology with heightened wonder and amusement, while it is "only" positive for young visitors, who expressed slightly less surprise and amusement with the technological experience. We considered that this difference was probably due to young visitors' greater familiarity with such technologies.

#### 4.4 Physiological dimension

- In both experiences, participants expressed wonder, a feeling that was also validated through PO. We indeed observed rapidly changing facial expressions showing continuous wonder in participants of all ages, in both VR and AR.
- In VR, during interviews, middle-aged participants either did not report or only minimally mentioned any negative physical reactions. However, PO observed various physical responses such as sitting down, leaning against the wall for balance, and multiple hand movements, identifying sensations of vertigo, dizziness, and physical instability, that were only minimally reported by participants. Young visitors did not express any particular physiological reaction during interviews, nor were any observed through PO.
- AR visitors did not report significant physical reactions through interviews, a finding confirmed by PO.

In VR, the physiological dimension appears negative for middle-aged visitors, who, despite their expressions of wonder (as confirmed by interviews), experienced multiple negative physiological reactions (vertigo, dizziness and physical instability). Conversely, for young visitors in VR, this dimension is very positive, as they did not experience any negative physiological reactions. In AR, the physiological dimension can be considered very positive for both young and middle-aged visitors, who only expressed wonder and did not report or exhibit any negative physical reactions.

#### 4.5 Motivational dimension

- In both visits, visitors expressed their desire to repeat such an experience and affirmed that they would recommend it to others.
- VR offered a heightened level of enhancement of the visit, particularly due to the empty nature of the castle, which constituted an ideal setting for such immersive virtual experiences, creating a complete detachment from reality and fostering imagination.
- Differently, AR served as a valuable addition to enhance the physical visit, making it more appealing. However, some middle-aged and senior visitors reported that the rupestrian art paintings were enjoyable even on their own (without the need for AR). Thus, for young visitors, the technological experience added significant value to the visit, while other visitors reported that they would have enjoyed the visit even without the AR, considering it merely as a plus.

Overall, the motivational dimension is very positive for both young and middle-aged VR visitors, who perceived the experience as significantly enhancing the overall visit; they also affirmed that they would repeat such an experience and recommend it to others. For AR, this dimension is very positive for young visitors, who perceived the technology as a substantial added value, and less positive for middle-aged ones, who enjoyed it but considered it as less essential to their visit. However, they all said they would repeat such an experience and recommend it to others.

#### 4.6 Triangulation of results

In VR, both young and middle-aged visitors confirmed, during the interviews, all positive emotions detected through PO. However, when it came to negative emotions observed among middle-aged visitors, encompassing some cognitive, affective and physiological aspects, they either denied or

minimised their negative feelings, not fully recognising the extent of their experience as noted through PO.

In AR, all visitors' reports, both the very positive and the less positive ones, were confirmed by PO. Through observation, the researcher did not highlight any peculiar reaction that had not been previously reported by visitors during interviews.

#### 4.7 Hypotheses validation

Considering the findings from all dimensions and the triangulation of results, the validation of hypotheses can now be undertaken.

- (H1) aimed to examine whether the cognitive dimension influenced the motivational dimension. For VR, the hypothesis was fully validated for young visitors, as their very positive cognitive dimension (in both its meanings) significantly influenced their (very positive) motivation. However, for middle-aged visitors, the hypothesis could not be completely validated, as their difficulty in understanding the device did not negatively affect their motivation, which remained very positive. Conversely, H1 was completely validated for all categories of AR visitors, where both the cognitive and the motivational dimensions were either positive or very positive.
- (H2) aimed to explore the influence of the affective dimension on the motivational one. This hypothesis was validated for both VR and AR, as a positive or very positive affective dimension corresponded to a positive or very positive motivational dimension.
- (H3) examined whether the physiological dimension affected the motivational one. For VR, this hypothesis was validated for young visitors, whose very positive physiological reactions influenced their motivation (which was also very positive). However, for middle-aged/senior visitors, the hypothesis could not be validated, as their negative physiological reactions did not affect their overall evaluation of the experience, nor their willingness to repeat such an experience and to recommend it to others (all this corresponding to a very positive motivational dimension). For AR, the hypothesis was fully validated for both young and middle-aged visitors, as their very positive physiological reactions corresponded to their very positive motivational dimension.
- (H4) investigated the influence of the expressive dimension on the motivational one. This hypothesis was almost fully confirmed, as visitors, in both VR and AR primarily reported very positive aspects during interviews, which positively influenced their motivation (which was always positive or very positive). However, the minimal negative aspects (related to the physiological

dimension) mentioned by visitors during interviews did not affect their motivation, resulting in H4 not being fully validated.

These findings also suggest that the negative emotional effects experienced by participants, encompassing the physiological and affective dimensions, do not significantly influence visitors' decisions or willingness to engage in such activities, nor do they affect their inclination to recommend them to others or to repeat such an experience. We may assume that the positive aspects that emerged among visitors are the primary drivers influencing participants' decisions.

- (H5) investigated the misalignment between the actual users' emotional experiences (captures through PO) and their verbal report in interviews (the expressive dimension). This hypothesis was confirmed by empirical findings. Specifically, the cognitive, physiological, and affective dimensions captured through PO do not always correspond to what participants expressed verbally (expressive dimension), especially for the negative aspects. This underscores the importance of employing a mixed-method approach to gain more comprehensive outcomes.

When comparing the findings from both experiences, it results that positive emotions were predominant among both VR and AR visitors. However, emotions tended to be more moderate in AR, while VR elicited stronger emotional responses, including adrenaline, evocative power, higher amusement, and wonder, due to its heightened level of immersion and detachment from reality. Notably, negative emotions such as physical instability, dizziness, vertigo, distrust, and fear were exclusively associated with VR, whereas AR did not evoke any negative emotions.

- (H6) posits that VR, with its greater immersivity, produces a stronger positive emotional impact compared to AR. However, this hypothesis was only partially confirmed, as the heightened immersivity of VR not only amplified positive emotional responses but also negative ones. This finding suggests that all emotions, both positive and negative, are more pronounced in VR than in AR.

## 5 Discussion, limitations and conclusion

The study delves into the emotional impacts of two distinct advanced technologies, VR and AR, within two heritage sites, the mediaeval castle and the cave paintings of

the Abrics de la Ermita, both located in the peripheral town of Ulldecona (Catalonia, Spain). The qualitative methods employed, namely PO and interviews, allow us to explore the specific effects of each technology on visitors. The choice of a real-world study, and the adoption of a cross-sectional perspective, enables us to examine a diverse sample of visitors, spanning various ages and backgrounds. This approach minimises potential biases that could arise from a more homogeneous sample or from external factors that might change over time. However, the main limitation of the study is the relatively small sample size, which constrains the generalisability of our findings to broader populations or specific demographic categories. Nonetheless, given the diversity within the group, it still offers valuable insights.

Our study utilises the five dimensions of emotions framework, theorised by Soon et al. (2023), to explore visitors' emotional responses within the two heritage sites. Adapting this framework to heritage sites situated in a peripheral area stands as a primary contribution of our research. Consequently, the theoretical framework employed in this study holds potential applicability to other heritage sites incorporating VR or AR experiences. In such contexts, where the systematic investigation of the emotional impacts and their influence on visitor motivation is pivotal, such framework offers valuable insights into enhancing the appeal and reputation of peripheral destinations.

In our specific cases, we demonstrate how visitors' motivation is only influenced by their positive cognitive, affective, and physiological reactions, as motivation tends to remain high despite any negative emotions experienced. The expressive dimension (corresponding to the interviews), mainly highlighting the positive aspects of the experiences, also reinforces the visitors' motivation and positively contributes to their overall evaluation.

Moreover, the mixed-method approach employed reveals a disparity between what users report in interviews (the expressive dimension) and what is observed in their actions and physical reactions. This underscores the need, in future qualitative research on advanced technological experiences, for PO as a complement to in-depth interviews, as it provides a more comprehensive overview of the real effects of VR and AR on visitors. In addition, integrating the two methods also allow for a more thorough elicitation of visitors' negative reactions. The reliability of results is also bolstered by the real-world approach, with visitors that had not been prepared in advance.

Regarding the comparative objectives of the study, it is evident that there are differences in the experiences generated by the two technologies (AR and VR) due to their varying degrees of immersivity. AR, being less immersive, is more suitable for contexts where a non-digital experience is already present, thereby "extending" it. On the other hand,

VR's higher level of immersivity makes it suitable for contexts with limited physical experiences, such as an empty castle, enhancing places with rich history but few physical remains. In such settings, VR is capable of "transporting" visitors to the ancient place and to provide them with a parallel virtual experience. The study also highlights that positive emotional impacts tend to be higher in VR than in AR. However, VR is also the technology that elicits some negative impacts, especially in the physiological dimension. Despite this, users do not typically report these negative emotions during interviews, possibly due to unawareness or a reluctance to acknowledge them. However, it seems that these negative emotional impacts do not significantly influence the visitors' evaluation of the overall experience.

Overall, the positive emotional responses observed among visitors to advanced technologies in heritage sites suggest their potential to attract tourists to other peripheral and scarcely known areas through their application to heritage sites. Moreover, these technologies have the potential of reinforcing the sense of community and enhancing resilience. Future research should apply the five dimensions of emotions scheme to other peripheral areas and investigate the influence of visitors' physical and emotional reactions on their motivation. Finally, a step further could involve the exploration of the holistic impact of such technological interventions on peripheral communities. Moving in this direction, the insights gained from this study can inform strategic initiatives aimed at enhancing the reputation of peripheral destination, also fostering sustainable development.

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## Declarations

**Conflict of interest** The authors declare no competing interests.

**Research involving human participants** This study involved human participants. Informed consent was obtained from the participants involved in the study.

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