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Exploring digital means to engage visitors with Roman culture: Virtual Reality vs. Tangible Interaction.

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To effectively communicate the archaeological remains of the distant past is a challenge: little may be left to see, and the culture may be very different to comprehend. This paper compares two technological approaches to communicating Roman archaeology in museums: virtual reality and tangible interaction. Although very different in rationale, design, and implementation, the two explorative studies have the same aim of engaging visitors with important exhibits. The challenge is to effectively communicate the exhibit's original and cultural context. In 'Views of the Past' virtual reality was used to support an environmental narrative experience where fragments of history are found scattered in the 3D reconstructed forum of Augustus in Rome. In 'My Roman Pantheon', a tangible interactive installation, visitors act as Romans living along Hadrian's Wall making offering to the deities of the Roman pantheon in order to secure their protection. In both explorative studies the combination of the features (virtual reality + narratives, tangible + acting) make visitors feel 'cultural presence' where the perception of a place is combined with the awareness of the culture and an understanding of the past. Although they work on very different sensorial reaction (sight for virtual reality, touch for tangible interaction), both are promising mechanisms to design effective visitor's experiences for challenging cultural heritage settings.

Keywords: Human-computer interaction, virtual reality, ubiquitous computing, tangible interaction, visitor's engagement, immersion, design research, qualitative research.

1 Introduction

Heritage institutions in general and museums in particular hold objects that have been considered of cultural value, worth of being preserved and passed to the next generation. Besides the duty of looking after and cataloguing their collection, museums strive to communicate the meaning and value of what they display. Archaeological museums face the challenge of engage a contemporary audience with a culture from a distant past that may have very little resemblance to contemporary life. They may display only fragments of statues or architectural features in a context, a museum, that is very different from where those objects were intended to be and where they once held profound meaning, e.g., important public buildings. Moreover, some archaeological artefacts may have very little aesthetic appeal today or else no obvious heuristic central to social practice and yet are crucial potential loci of profound engagement by a contemporary audience with a historical society. Engaging visitors with such a detached and opaque heritage may require triggering imagination to establish a dialogue between the visitors and the collection.

Museums have attempted different strategies to engage visitors with opaque heritage. For example, special events bring visitors close to the action, such as collection handling, when small groups attend a curator looking after and explaining an exhibit [17], or historical re-enactment, when actors perform the past [34]. A different strategy calls the visitors themselves to action by asking them to take part in participative exhibitions [49], e.g., by leaving one's thoughts or memories for other visitors to find.

Even though these approaches achieve the same goal of making the visiting experience memorable, they do so in quite opposite and distinct ways: collection handling and re-enacting shows something special, visitors' participation asks to do something special. A similar dichotomy is explored in the case studies reported in this paper: comparing virtual reality (to show) against an embodied engagement with the exhibits (to do). While the technological means are different, the purpose is the same: to enable visitors to understand and appreciate an archaeological exhibition by recontextualising them within the culture in which those objects were created, and in which they had a profound meaning.
Specifically, this paper explores how the gap between contemporary Western culture and that of ancient Rome could be bridged for museum visitors by two different applications of digital technology:

- *virtual reality* (VR in the following) reconstructs and contextualises some fragments from the Forum of Augustus in Rome (on display at Trajan's Market) as part of an interactive storytelling intervention;
- *tangible interaction* embeds digital technology into objects that react to visitors' actions creating a sense of participation in Roman religious practice at Hadrian's Wall in the north of England.

The two studies have been carried out as part of two different projects. Both studies are exploratory in nature, focused on a naturalistic assessment by a small number of either professionals or visitors. Therefore, the aim of this paper is not to directly compare the two experiences to determine which technology is the most effective or preferred (as instead is done in [36] and [39]). While the two studies are different for the technology used and the evaluation setup, they are both successful in recontextualizing the exhibits in their original culture to support visitors in understanding and appreciating the collection on display in the museums.
This paper sits in the well-established area of interaction design and human computer interaction for museums and heritage [22]. Our work offers multiple contributions: (a) to propose a new understanding on how different approaches could engage visitors and communicate to them opaque aspects of lost and unknown culture; (b) to offer a deeper understanding of the impact of ubiquitous computing within heritage and to open new ways to tangible interaction; (c) to show how interactive storytelling set within 3D reconstructions can make the visual more meaningful to appreciate a different culture; and (d) to inspire other researchers to use creative practices when designing for novel visiting experiences.
The paper is organized as follows: the next section discusses relevant literature on visitor engagement; the research methodologies are described next before the two interventions and the respective case studies are presented in detail in section 4 and 5; a thorough discussion of the visiting experiences in the two museum settings follows in section 6 that closes the paper.

2 Visitor's Engagement via Material and Digital Means

Digital technology and cultural heritage have gone hand-in-hand since the early 90s [48]: cultural heritage has been seen as a suitable place to experiment with the emerging technology of the day, and the sector has been keen to experiment with new digital devices to entice more visitors. From multimedia computers [48] to interactive tables [19], from mobile devices (e.g. PDA [28] and phones [11]) to smart glasses [52], digital technology has been used in cultural heritage with various degrees of success. The literature is vast and diverse. Here we focus on the two types of visitors' engagement relevant to contextualise the two studies reported in this paper, namely visual reconstruction and physical engagement. In reviewing the literature, we focus on how a technology has been used and the visitors' reaction to it.

2.1 Virtual Reconstructions

Visual reconstruction is a unique way of engaging visitors with archaeological sites where very little is left to see and experience. Panels with artists' impressions and scale models of how a certain place

could have looked have been used for decades in museums. Computer graphics progressively substituted analogue representations with digital and interactive means resulting in a plethora of augmented, mixed and virtual reality applications [24]. These new forms of documentation and representation have been instrumental to open new ways for scholars to test hypotheses about a site or a building [12][16]. Academic visual reconstructions have been also used for dissemination and visitors' engagement. Early experiments used large installations, such as CAVE display, to give groups of visitors an experience of the past [15][53]; more recently, headsets have offered visitors individual immersive experiences [21][23][47]; and mobiles have put 3D reconstructions of places in visitors' pockets [27]. The shift of visual reconstructions from research tool to visitors' attraction was, initially, very successful. However, now that sophisticated computer graphic is much more common, audiences "are no longer impressed with basic walk-throughs" [53] pushing developers to provide more interaction, participation, and content [53]. To give more meaning to the experience of 3D reconstructions, the scenes have been (re)used as background for 'gamified' heritage experiences [25] [5]. Research, however, has mostly focussed on tools and processes for making serious games rather than understanding the players' own experience. Instead, the intersection between entertainment and historical sources has been exploited with much success by the games industry: popular titles such as 'Assassin's Creed' [9] and 'Rome: Total War' [30] show that, even if those games do not pretend to be accurate, players value scholarly authenticity [56]. Therefore, there are opportunities in combining highly accurate 3D reconstructions with some aspects of interactive and immersive entertainment for the purpose of making heritage more engaging.

A further substantial change has been the use of virtual reality. When seen through a virtual reality headset, 3D reconstructions become immersive: visitors have the unique experience of being 'in the past' [7]. Now VR is used in museums to complement exhibitions [54] [47] or as part of educational programs [44].
For the immersive experience to emerge, the real world around must disappear: a high sense of presence in VR requires a simultaneous low level of presence in the real world [33][50]. For the sense of immersion it gives, VR engenders presence even when the virtual environment is unpopulated and no interaction is expected [50]. Presence in virtual worlds is: *environmental*, how the world around is represented; *social*, how the individual affects others in the virtual world; *cultural*, a distinct "sense of inhabitation, of social values and behaviours preserved and transmitted through rituals, artefacts and inscriptions." ([5], pg.148). Social presence does not require others to be there, neither does cultural presence require one to purposely act in the virtual world. What is needed is richness and depth of interpretation that is instrumental to understand the virtual world and its inhabitants through artifacts and cultural remains [5]. Following this line of thoughts, virtual world created to communicate heritage to a general audience needs an accurate reconstruction not only of the buildings but of the lives lived within them and rich stories to interpret what is encountered while exploring the virtual world.

It is this line of enquiry that has been followed in the first study of this research. The 3D reconstruction of the Forum of Augustus in Rome [13] has been transformed into a living place with chairs, tables, scrolls abandoned cloths and lost coins [41], and made interactive with snippets of stories [41]. In our study, VR is experienced as part of the visit, it immerses visitors in the past to see the exhibits on display in their original context[1]. Our contribution is then to better understand how VR could be used as part of a visit to create a sense of presence in the past that encompasses the environment, the social and the cultural.

[1] Although this work reuses some content from a videogame [41], the intent is very different. Away from the museum exhibition, [41] expects players to be at home and engage with the game for a long time (60 to 90 minutes). Instead, we explore the use of the 3D reconstruction and some interactive storytelling as part of the visit for brief immersions in the past when in front of an archaeological exhibit, as described in section 4.

2.2 Physical Engagement

The engaging power of being in physical contact with exhibits [10] and to attend or take part in historical performances [34] is well-known in museum studies. Such events offer visitors a unique experience, although substantially different from VR. Here the real world is dominant, and the physicality is part of a rich multisensory experience [29].

Technology has entered the physical world of heritage sites and museums via embedded sensors and computational units that make objects and spaces 'smart' to create experiences that seamlessly cross the boundaries between the material and the digital. Objects with strong material properties conceal digital technology and become reactive to other smart objects or spaces and people [20] [37]. This new form of tangible and embodied interaction has been used in several installations receiving a very positive response from visitors. Tangible interaction brings the visitor closer to the heritage itself; it centres the visiting experience around materiality and physical engagement as opposed to the information-centric approach that has been prevalent for many years [55]. Simple examples of tangible interaction offer visitors scaled replicas of exhibits to use as an input: for example, the manipulation of the replica could control the display of multimedia content in a nearby screen [2] [42]. A more integrated approach is the materialisation of the digital content in the museums space to show visitors what is available and invite them to make a choice. For example, replicas of historical cups, placed in an interactive soundscape, told different stories when handled by visitors [45]; in an exhibition on life in the city of The Hague (The Netherlands) in WWII, visitors used multiple replicas of exhibits to delivery audio visual content revealing a plurality of voices of those affected by the German occupation [32]. In both these examples visitors are invited to choose what they want to listen to, they participate and become active.

A further push for visitors to become actors and to participate in a comprehensive interpretation of the place is a set of five interactive tableaux representing five fictional characters that inhabited a house museum since Tudor times, a character for each century [6]. The visitors present objects to the characters that respond with their own stories but could also send visitors to meet another character or talk to the museum volunteers or simply to come back later: the logs show visitors followed those instructions allowing themselves to be part of a playful exploration of the house museum [6].

In our study we continue this line of inquiry looking at what happen when visitors are invited to act to make sense of what is around them, in this case make meaning from rows and rows of Roman carved stones in a museum of archaeological finds (Fig. 4). Our intervention was an archaeologically informed, yet playful physical experience that required visitors to look carefully at the exhibits and understand the Roman religious culture. In 'My Roman Pantheon' (discussed in section 5), we invited visitors to take up a role in Roman society to make meaningful choices that impacted on their future. In this way the visit becomes performative and explorative. The study reported here aims at understanding what is the impact on the visitors and their visit and their understanding of the Roman culture.

In summary, virtual reality recreates a virtual past for the visitor to look at, and tangible interaction that physically engages the visitors with the exhibition, are two opposed technologies that have been used in museums. The experiences they offer are radically different, yet they could be equally effective in communicating a difficult and opaque past.

3 Research Methodologies

The two museum interventions, although very different in nature, use the same research methodologies: *design research* to produce knowledge by generating concepts and testing prototypes [26] [31] *qualitative research* to evaluate the effect of the interventions using an ethnographic approach [8]. The theoretical framework of reference is constructionism, the view that meaning is not in the object of study 'per se', but in the way in which the human interacts with it within a specific environment [26] [8]. When applied to cultural heritage, the meaning is not in the device taken in isolation, but in the way in which the visitors interact with it within their social context (e.g., with visiting companions) and the specific environment of the museum. We outline design research and qualitative research before moving to the design rationale and the qualitative evaluation of each study.

3.1 Design Research

Design research explores the effect of new interventions created for the specific[2] [26][31]. Design research is practice-led: it is an iterative process centred around the making of multiple and different prototypes evaluated under different conditions and for different purposes [26]. The two interventions (discussed in section 4 and 5) are the outcome of an iterative process that started from different premises.

'Views of the Past' brings the 3D reconstruction of the Forum of Augustus inside the museum, where the archaeological remains are displayed. As part of the design research, we developed and tested two different devices to deliver the 3D: a VR visor and a tablet (Fig. 1, image 2 shows both). A comparative study of the two prototypes [36] showed that the tablet did not convey the sense of immersion VR did; the tablet was suitable for a heritage setting where the visitors could compare today and the past[3]. The remains of the Forum of Augustus are on display in a museum, not in the Forum itself as very little of it is left: the VR visor contextualises the exhibit the visitor sees in the museum in its original place.

The design of 'My Roman Pantheon' followed a similar path, yet the aim was different. Our goal was to gently push the visitors to pay more attention to the collection and understand the value the exhibits had for the Romans as a physical representation of their culture [38]. Three concepts implemented as early prototypes were tested in situ resulting in a new understanding of the space (the Victorian museum Fig. 4) and how the visitors use it [38]. Informed by our new knowledge the collaborative team generated new concepts finally focusing on the experience that became 'My Roman Pantheon'.

Both 'Views of the Past' and 'My Roman Pantheon' are the outcome of a design research iterative process to create the most effective visitor's experience for that specific place. The aim is to communicate key aspects of the Roman culture that are not evident from the exhibits on display.

Figure 1. A fragment of the statue of Mars and Venus (1) and the illustration panel (2) as displayed in the Trajan's Market Museum. A visitor using VR (3) and what they see: the reconstruction of the statue in the temple of Mars the Avenger (4).

3.2 Qualitative Research

Design can be evaluated in different ways depending on the stage of the design process and what the researcher wants to understand [26]. Early prototypes are assessed informally, controlled evaluations find an answer to a specific question, and 'in the wild' focuses on what happen in place. An evaluation 'in the wild' is qualitative and inductive, open to what emerges from naturalistic conditions. Researchers do not test hypothesis or set goals but observe what happen and critically assesses how their intended design is used, they look for misconception or new forms of engagement. The focus is on the individual,

[2] While natural phenomena do exist besides human intervention and can, therefore, be 'discovered' and explained, what is created by humans is just one of the many possibilities, it is "the ultimate particular" [35, pg. 31]. For its focus on the specific, design research does not seek a generic solution that can be used elsewhere as is; rather it generates knowledge and understanding that is transferable to other contexts [26] [31].

[3] The comparative study in [36] tested the visor and the tablet in two different heritage sites, the Trajan's Market and the house museum of Dr Jenner. The rooms in the house museum now display the work of Dr Jenner on vaccination and the dispel of smallpox; the reconstruction showed the house as it was in 1823 at Dr Jenner's death, with furniture and objects that functioned as anchor for Dr Jenner's story. With the tablet the visitors were able to quickly compare today and the past and see how the house had changed.

how the participant (the visitor) interacts with others (their visiting companions) and the world around them (the digital intervention and the museum) [8].

Both 'Views of the Past' and 'My Roman Pantheon' have been assessed using qualitative research. The source data is the visitors' behaviour and the narrative they use to express their feelings. The role of the researcher is to interpret behaviours and conversations to understand how the digital interventions change the visit. In our research, we also question participants to dig deeper into the visiting experience that has been observed. The dialogues captured during the observations and the opinion offered as part of the interviews are evidence of the impact of the interventions on the visit.
Through the lens of qualitative research, the differences between the two studies become irrelevant as the focus is on the visitors' experience and how they talk about it. By focusing on what they do and what they say we learn how our intervention changes the way visitors understand and appreciate the Roman culture.

4 Virtual Reality to Immerse Oneself in the Past

4.1 'Views of the Past': rationale and interaction
The first study uses VR and environmental narrative principles, the strategic placement of stories within a virtual environment, to contextualise exhibits from the Forum of Augustus, now on display at the Trajan's Market in Rome. The exhibits bear evidence of the statues, the architectural details, the marble decoration that enabled archaeologists to reconstruct, to a very detailed level, how the Forum of Augustus may have looked [13]. Figure 1 illustrates the challenge to engage visitors' interest with the fragment of a statue that is difficult to interpret and easy to overlook: VR takes the visitor into the temple of Mars the Avenger in front of the statue. Visitors carry a VR device (Fig. 2), a curious, steampunk stereoscope that invites to look inside the binoculars. The device senses the visitor's position and automatically displays a virtual reconstruction when they reach a relevant exhibit. The visitor looks into the stereoscope and explores the surrounding scene visually. The scene is dark, it is night, only few elements have a spot of light shining on them (Fig. 2), those hotspots anchor the audio that plays when that hotspot is in focus. The stories complement the VR reconstruction in a seamless interaction: the act of arriving at an exhibit activates the scene and looking around triggers the audio files attached to the hotspots.

Figure 2. The VR device (left) used at the model of the Forum of Augustus (centre) and the audio attached to the highlighted statue: "I've seen often Augustus walking here, thoughtful. I think he felt the burden of being the successor of Cesar, his adoptive father, assassinated in the senate. He contemplated these statues as if he were seeking advice from them, the symbols of his descendants" (stereoscope design © Nick Dulake)

4.2 Implementation
'Views from the Past' is a VR app on Android developed in Unity 3D for headsets such as Google Cardboard; the smartphone is Bluetooth-enabled to detect if, in its surroundings, there is a Beacon, a small battery-powered hardware device that continuously transmits a Bluetooth Low Energy (BLE) unique signal. Unity 3D offers two mechanisms to implement the smooth and easy interaction:

- The automatic change of the VR scene: Beacons are placed next to relevant exhibits; when the visitor approaches the exhibit, the Beacon's signal is detected by the smartphone; an event is triggered to automatically display the scene corresponding to that specific BLE (exhibit).
- The focal point of vision activates the story: the '.' at the centre of the scene is a pointer within

the VR world; when it enters a hotspot, an event is triggered to automatically play the audio content associated to the hotspot (Fig. 3).

Key to the experience is the 3D model of the Forum of Augustus: the plan, the architectural elements, the statues, and other objects are a hypothesis based on current archaeological knowledge [13]. This model was used for the environmental narrative videogame 'A Night at the Forum' where snippets of stories were scattered around the scene for players to find [41]. Android was chosen because of its compatibility with Unity 3D. Unity supports selection within the scene allowing to trigger audio content 'by looking'. To complete the interaction, an event in Unity is triggered when a specific Beacon ID is detected. In this way, the selection of a 3D scene is done via the Beacon: when the visitor enters a room the app senses the Beacon ID and automatically changes the scene to the correct place. 'A Night at the Forum' was developed for Sony PSVR that has significantly more processing power than the average mobile phone. To support the transition from PSVR and Android tests were carried out to find the optimal balance between device performance and visual quality for the intended experience. Only the five scenes relevant for the visit were imported in Unity and three interactive hotspots were created in each scene. The digital assets created for PSVR was imported into Unity with mixed success as the models resulted with no textures; textures were then applied to each model to create new prefabs that would work in Unity. An early test of the phone performance with the exported assets from Unity showed the quality was not good enough for a smooth experience.

Figure 3. The interaction in front of the fragment of the Colossus of Augustus. Bottom: the cube-map (four sides and the ceiling). The top two inserts show the visitor's view: on the left the '.' shows the visitor is exploring the scene; on the right the 'o' shows an audio narrative has been triggered.

The solution adopted takes advantage of the visitor's interaction as envisaged within the museum: the visitor stays still and turns on the spot to explore their surroundings in VR. For this purpose, a pre

rendered cube-map projection of the room or space would yield an almost identical result as no objects are so close to the viewers as to require a change in depth perspective during the rotation. A reflection node was then used to make a cube-map to pre-render the virtual environment for the app. A limitation of this solution is that, if the visitor moves to get closer to an object seen in VR, the display does not resynchronise with the new position.

Interactivity in Unity is set up with a box collider and event triggers as a target area overlaps an object. The visitor looks around to find the object to which a story is attached: the small '.' in the centre works as a pointer to 'scan' the scene and find the content, when the '.' becomes an 'O' (Fig. 3 top) the hotspot is in focus and the audio 'attached' to it plays automatically. To make a hotspot easier to find and the interaction smoother a spot of light is shed on each hotspot. In Fig. 3 (top), the Colossus of Augustus has two hotspots marked by two lighter areas that attract the visitors' attention in a seamless way as the visitors is naturally inclined to look at the highlighted points thus playing the story attached. The narratives were nondidactic, e.g., personal accounts as retold by the emperor Augustus himself or by people who knew him (Fig 2), descriptions of how parties were summoned to court[4], and aspects of everyday life.

4.3 Evaluation

Eleven participants took part in the evaluation[5], all were cultural heritage professionals familiar with the museum: museum guides, historians, archaeologists, and heritage communicators. They visited in small groups of 2 or 3, a kind of 'walking focus group' in which participants discussed ideas, pitfalls, and opportunities. The researcher discreetly followed the groups taking notes on their behaviours and conversations, sometimes asking to clarify their comments.

The involvement of professionals was due the very small number of visitors on the days of the planned evaluation. However, professionals brought to the fore aspects that visitors would not have been able to suggest, for example the type of story told in front of Mars and Venus discussed below.

The findings (relevant for this paper[6]) can be summarized as: sense of presence, sense of proportion, and storytelling.

Consistently with previous research, all participants commented on feeling a strong sense of presence, "the subjective sensation of 'being there' experienced and reported during immersion in a [virtual environment]" [43]. This sense of 'being in the past', was triggered by both a careful reconstruction of the building [13] as well as objects that made it seem a place that was in daily use [41]. Chairs, tables, and scrolls as well as abandoned clothes and lost coins were evocative of a place with plenty of people and activity during the day but deserted when closed for the night: "*it [the Forum] feels as lived in*" and "*it is like the Romans just left leaving a bit of a mess*".

The participants commented on sensing the building's proportion, the feeling of one's body with respect of the reconstructed space. A physical model of a building can show architectural details (Fig. 2), a panel can give the measurements, but neither can give a sense of what it feels to be in it. Knowing that the Colossus was 12m high is not the same as feeling how small we are in relation to it (Fig. 3). VR made the participants appreciate the grandiosity of the Forum in a way no other form of communication could: in front of the Colossus "*you feel small that is what he [Augustus] wanted you to feel*"; in front of the polychrome marbles that decorated the walls "*the hall is amazing!*". Much discussion occurred around the 3D reconstruction, on what is known (e.g., the hall of the colossus), what is a reasoned guesswork (e.g., the function of the apses), and what is still unknown (the side of the forum under one of Rome's main roads is represented as a building site [13]) reflecting the tension between a strict academic remit vs. a complete and aesthetically pleasing reconstruction for public consumption [12]. Although caution in visually representing a lost space was a major concern, all the professionals agreed that to give a sense of the place should be the driving force for VR.

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[4] Roman justice was administered in the forum where legal proceedings were held.

[5] Following Italian privacy law, the volunteers signed a consent form before starting; they also filled in a questionnaire at the end.

[6] This study is part of a larger research reported in full in [36].

The professionals acknowledged the tone and the length of the storytelling was right: an audio-guide style, they said, is dated, and often the narratives are too lengthy and boring. The personal accounts were commented as more engaging than factual descriptions. Critiques concerned the content of the fragments imported from the game: "*it is not really connected with what you see, is it?*" and "*it is not the most relevant piece of information you would give in front of Mars and Venus*" (see Fig. 1). They suggested creating engaging, short stories better connected with the exhibit, since they would be more emotional, curious and easy to relate to. As an example, in front of the fragment of the statue in Fig. 1 an historian commented that the belligerent Mars, the god of war, can only be controlled by Venus who is represented as a calming presence in this sculpted pair with Venus resting her hand on Mars' torso. He said this was the only way in which Mars could stay (and be represented) within the city walls, always with Venus at his side, and put forward ideas on how to transform this fact into a humorous dialogue with Venus as a caring wife telling Mars to relax.

5 Experience design for active engagement

5.1 Acting as a means to appreciation and understanding

'My Roman Pantheon' engages visitors with Roman culture by inviting them to take part in rituals analogous with Roman religious rites through the mediation of tangible interaction. Tangible interaction in the heritage domain can overcome the gap between the material, tangible qualities of heritage, e.g., the collection on display, and the related multimedia digital content [34][3]. In tangible interaction digital technology (sensors, computational units, and actuators) is embedded into real objects to create experiences that seamlessly cross the boundaries between the material and the digital. Indeed, visitors respond very positively to these type of experience [2][6][32][45] as it brings visitors closer to the heritage via a direct physical engagement as opposed to an information-centric approach that puts information between the visitors and the archaeological collection or site [56].

Figure 4 The Clayton Museum at Chesters Roman Fort.

'My Roman Pantheon' is a bespoke tangible interactive installation designed for a small archaeological museum along Hadrian's Wall in the north of England. The museum is dominated by a sequence of statues, relief sculptures and religious altars displayed on multiple rows (Fig. 4). Many are fragmentary or hold Latin inscriptions that are often illegible or partially missing and therefore seemingly esoteric to visitors. As such, the display is challenging and visitors often spend only a few minutes looking around and leave, missing the opportunity to appreciate the richness and relevance of the pieces on display. A multidisciplinary team with designers, computer scientists, and curators co-designed and co-created the tangible interactive installation [38] to encourage the visitors to engaged more deeply with the stones as objects of great significance for the Romans - as objects that were once interacted with, rather than passively viewed as museum artefacts.

5.2 'My Roman Pantheon': take part in a ritual

When entering the museum, in the vestibule visitors first encounter the shrine of the Roman goddess

Juno (Fig. 5 top left). The instructions tell the visitor to pick up a votive lamp and place it in the bowl in the shrine. Juno appears welcoming the visitor and "charging" their votive lamp with three lights; she then invites the visitors to use the lamp to gift those gods that would help them the most with their life on Hadrian's Wall. She also instructs the visitors to come back later "to receive your reward". At the start of the process, the lamp in the shelf was blank, but as Juno finishes three flickering lights appear (Fig. 5, top right), symbolising the three offerings each visitor can make to the Roman gods.

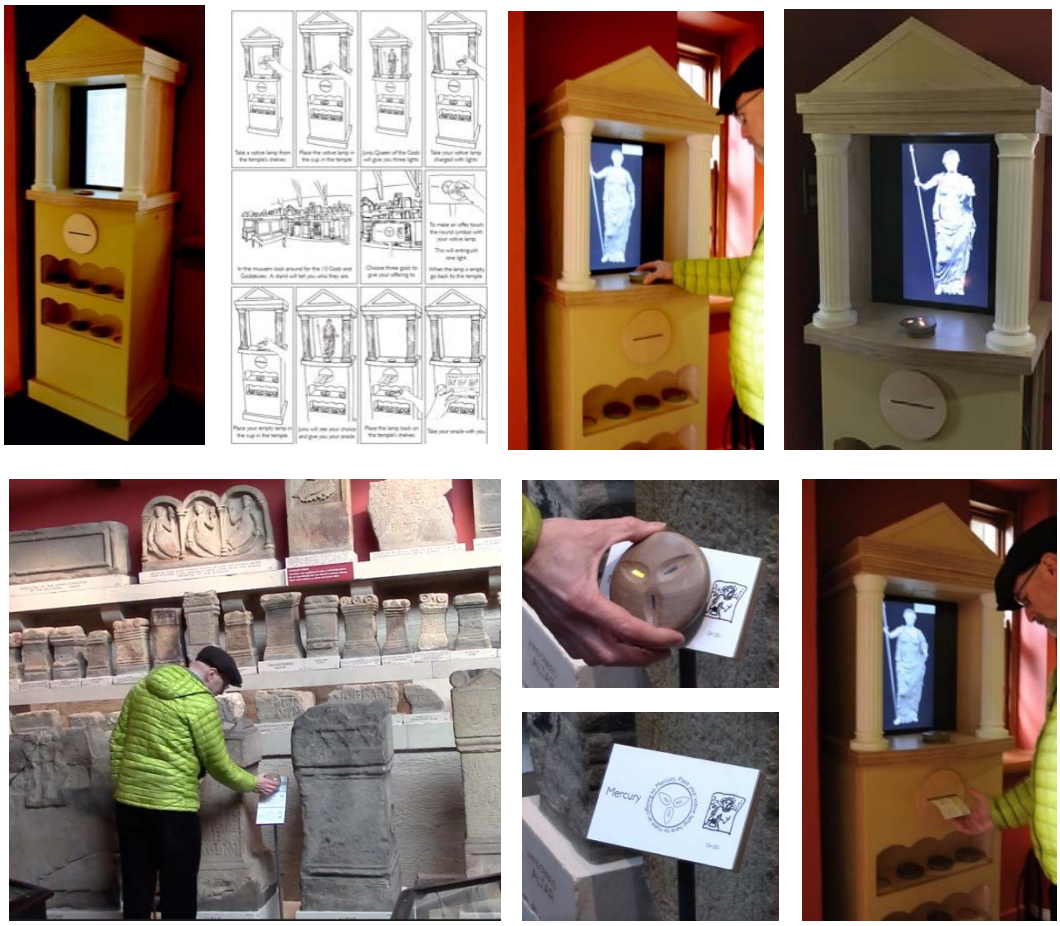

Figure 5. My Roman Pantheon interaction steps: the shrine and the instruction panel; the lamp lit by Juno; the offering in the museum and the collection of the postcard.

Inside the museum (Fig. 5, bottom left), the visitors seek to find 13 stands, one for each of the deities to whom they can offer their lights (as illustrated in the instructions). Gods and goddesses have been carefully chosen by the museum curators to represent the peculiarity of the Roman Empire, one that absorbed the religion of the conquered lands as part of their ever-expanding system of beliefs. Therefore, the deities to choose from included Mercury and Minerva, gods from Rome, but also Cautes from the Middle East, Mars Thinscus from Germany, and Coventina from a sacred well along Hadrian's Wall. As Roman religion was transactional, meaning an offering implied a return of favour from the deity, the gods and goddesses chosen in the museum represented different goals and needs people could desire, from health (Aesculapius) to wealth (Mercury), victory in gambling (Fortuna) or the battlefield (Victoria). Romans believed that the divine inhabited people, places and objects; this is represented in the museum by Genius Loci (the spirit of the place) and the cult of the emperor (Emperor Genius). Such a variety of deities intended to stimulate curiosity, questioning and, ultimately, to impact on the visitors' choice: would they seek protection? Or success in business or war? Or be intrigued by unknown gods from far lands in the empire?

To offer a light to a god the visitor places the lamp closer to the stand: a flash sparks from the votive

lamp ad a light is then extinguished. When the offerings are given, it is time to return to Juno. When the votive lamp, now empty, is placed back in the shrine, Juno reads the offering and gives an 'oracle', a postcard with the deities chosen and how this will affect the visitors' lives on the Wall. As there are 13 deities, choosing only 3 generates 289 different combinations giving the impression of a unique experience. The date on the postcard (Fig. 6) adds to the personalized souvenir.

Figure 6 A few of the 289 different oracles (postcards).

5.3 Implementation

The curators provided six characteristics to represent a deity's role in the Roman pantheon: local – gods connected with Hadrian's Wall; tradition – the cornerstone of the Roman pantheon; acculturation – gods that Rome embraced from various origins; success – in various form, life, afterlife, health, war and trade; victory – literally and very important for the military; comradeship – gods that show concern or will help with a military career. For example, the Emperor, Genius Loci, and Cautes were all tagged as 'comradeship', but the Emperor was also tagged as 'tradition', Genius Loci as 'local' and Cautes as 'acculturation'. When chosen by the visitors the three deities would compose a group of tags; the dominating tag-type would determine which oracle would be printed on the postcard (see examples in Fig. 6).

The technological infrastructure is an implementation of a simple Internet of Things with digital components embedded into the shrine, the lamp, the stands:

- the lamps are an assembly of an NFC[7] reader, a wirelessly-enabled Arduino Fio, a lithium-ion battery, an inductive charger, and 3 programmable RGB LEDs (Fig. 7, left);
- the shrine frames a screen, a PC, and a printer to: (i) respond to the communications from the Arduinos in the lamps (via a host USB wireless receiver), (ii) play the videos, (iii) generate text and graphics for the postcards and (iiii) control the commercial ticket printer that produces the

[7] NFC, Near Field Communication, is a communication protocol by which small microchips (attached to stickers) store minimal information that can be read by in-range (4 cm) mobile devices.

postcards;
- each stand in the museum conceals an NFC tag; a further NFC tag is in the offering bowl in the shrine.

The code in the lamps controls the overall experience (Fig. 5): when the lamp is placed in the bowl in the shrine the first time, it communicates to the PC to play the welcome video and then lights the three LEDs that represent the flames. When the lamp is swiped over the NFC of a stand one of the LEDs brightens suddenly before being turned off to show the offering is consumed. When the lamp is returned to the bowl in the shrine, the Arduino in the lamp communicates to the PC the three codes of the offerings to generate the postcard (on the bases of the tags associated to each deity); the PC prints the personalised card and plays the closing animation with Juno handing out the oracle.
The shelves for the lamps conceal a system of inductive charging that warms the lamp, a contemporary interpretation of a 'lucerna' (Fig. 7 right): when lit up, the flickering light on the dark wood feels precious, warm, and real. The stands name the deity and help the visitors to identify the exhibit among the many. The printer and the roll of tickets to print the postcards sit within the body of the shrine.

Figure 7 The votive lamp (design © Nick Dulake).

5.4 Evaluation

The interactive installation is a permanent feature at the Clayton Museum. In the evaluation visitors were observed in their use of My Roman Pantheon and later approached to see if they were willing to fill in a short questionnaire about their experience[8]. The observations capture how they moved, what they looked at, how they behaved and if they talked to their companions. The questionnaires recorded what they choose and why, how they found the experience, what they liked and disliked. Sixteen groups of visitors that used 'My Roman Pantheon' were observed and 11 filled in the questionnaire. The vast majority of participants were families with children under 10 years of age (10 groups) and teenagers (3 groups), a couple (in their 30s) and two lone visitors (in their 20s and 30s). A further 14 groups who did not use the installation were observed too. These non-participating groups were families with young children (6 groups with children under 10) and teenagers (4 groups), couples (4 groups aged 50+). The two groups of visitors, participants vs. non-participants, are demographically similar, yet there was a marked difference in behaviour between the two groups. Those who did not use the lamp moved slowly and in packs; they spoke only occasionally and in whispers, they were very quiet and 'shhing' for silence. On the contrary, the visitors with the lamp were more explorative of the space with dynamic movements and louder in their conversation, most of the time between a parent and a child: dad reading the labels and son saying - "*I made my choice*"; and another pair "*which one is the best, daddy?*" and "*is up to you son*". The lamp substantially increased the lingering time: children who entered the museum without the lamp looked bored and did nothing until they saw someone with the lamp, went

[8] Following UK privacy law, a sign outside the museum informed visitors of the study taking place and invited who did not want to be observed to approach the researchers. Visitors who consented to respond to the questionnaire signed a consent form and parents gave consent for the entire family.

back in the vestibule to collect one for themselves and suddenly became excited about their visit and engaged with the exhibition. As a questionnaire had: "*Brilliant! If we had come to this museum without the digital exhibition my 6 and 8 years old would have got bored quickly. This exhibition has helped them (and me!) understand the sculptures and Roman religion*.". Many families picked more than one lamp, one for child was the norm, but often one of the parents decided to have their own. A mother was observed to go back and take her own lamp while father and son were discussing which god to pick; she was then heard saying "*I'll have this Genius Loci – the spirit of the place*" and in the questionnaire motivated her choice "*I chose Celtic ones because I like prehistory*". In another case father and son where comparing their choices and the father said: "*I've got wings, I've got money and I've got war*." These comments seem to indicate that My Roman Pantheon gave license to adults to indulge in a little performance of their own, a little game, a bit of fun in the context of a historically-accurate cultural visit.

The lamp seemed to sustain the visitors' interest for the museum. Adults often would studiously read the labels, then select only those they found interesting or even read all the labels first and come back to the three they really wanted. Indeed the 4 visitors who indicated in the questionnaire their choice was determined by reading the labels where all aged 33-40. Sometimes reading the label in the context of using the lamp gave to the exhibit an extra value: "*oooh you want victory, she is the best*". Of the other participants, 4 indicated their choice was random and 3 were driven by how much they liked the statue or the altar. However, even those visitors that stated their selection was random reported they read the labels more than they would have done without it ("*fun and engaging to myself an adult. It made me want to read more*.") and only 3 out of 11 respondents said they were not induced to read more. In the questionnaire the postcard was rated high as a souvenir: only a few were found abandoned around the site showing visitors appreciated it as a memento of the day. Some children were observed going around with the lamp several times in what seemed to be an attempt to collect all the gods. A few participants mentioned the postcard as their favourite "*that's really cool!*" and "*I like the postcard best*". The experience was considered very easy and usable, although a few visitors were observed ignoring the instructions at the shrine and then misusing it in the museum, e.g., placing the lamp on an altar, until they saw others and corrected themselves. The experience was rated as surprising, unexpected, immersive. It was commented upon as out of the ordinary: "*never seen anything quite like it in a museum*", "*an immersive and interesting experience*", and "*love it! Brilliant way to make a dry (for kids) museum into something exciting*". A surprising comment was made by a mother and her child on taking part in a pagan ritual: "*It was fun but slightly weird to make offerings to gods who I believe don't exist*" (child) and "*Using the physical thing [the lamp] was great, but I felt very uncomfortable about it being presented as 'making offerings to the gods' - it felt like this was asking my child to make a pagan offering in order to enjoy the museum (from a perspective of a Christian). The physical interaction was excellent though*" (mother). We could speculate that this reaction was somehow triggered by the analogy of lighting a candle in the church or by the 'mise en scène' (discussed below). What seem certain is that 'My Roman Pantheon' touched these two visitors in a deep and emotional way that was against their religious beliefs, and this pushed them to express their discomfort. The many positive comments, even from these two critical visitors, and the strong engagement observed suggest that such emotional engagement was felt by other visitors but channelled in a positive way.

6 Discussion and Conclusion

'Views of the Past' and 'My Roman Pantheon' intend to engage visitors with challenging Roman archaeological findings. However, the way in which this is pursued by the two interventions is very different. 'Views of the Past' uses VR to trick the visual perception and to transport the visitor into the past. The accuracy in the reproduction and the high level of details to represent not only the building but the lives lived within that place is the driving force. This strategy is borrowed from the design of environmental narrative videogames that use the space to tell a story: "the story is told through the world itself" [46]. Fragments of the story are scattered around an unpopulated space: no people, no dialogues, but evidence of what happened in that space before we arrived there [46]. It is the player, or in the case of this paper the visitors, who will reconstruct the story while encountering fragments of it, pieces of evidence that have been placed in the environment by the designer [14].

Taking inspiration from environmental narrative, in 'Views of the Past' the visitor finds fragments of the history of the Forum of Augustus in the VR world and interprets them to reconstruct the life at the forum, how the place was used, how people were summoned to court, how they behaved. When visitors use 'Views of the Past' and find scrolls and chairs in the apsis where the court was hold and the laws administered, they can start to answer the crucial questions "What is this place? How was it used?". When they find abandoned clothes or a rag doll, they are pushed to wonder "Who has been in this place before me?" and discover the story of defendants trying to move the judge to pity by pretending to be poor or by taking their children with them to court. Through these fragments of lived history the visitor is taken well beyond admiring the reconstructed architecture of the place: they step into the imperial Roman culture that built and used that place. It is this synergy between the storytelling and the carefully designed VR environment with evidence of human presence, even if no-one is there, that transforms a 3D reconstruction into a cultural experience and makes visitors feel 'cultural presence'. "Cultural presence corresponds to the feeling that people from a specific culture occupy or have occupied a virtual environment and transformed it into a culturally meaningful place" ([4] in [43], pg. 88). The evaluation of 'Views of the Past' seems to show that it is the fidelity of the representation (e.g., the size of the colossus, the richness of the decoration, the lost and displaced everyday objects) that sustains the storytelling and makes visitors to experience cultural presence. It is the interaction structured around fragments of dispersed narrative that reveals the meaning of the place to those visitors seeking it: the sense of presence, triggered by VR, becomes a "being – not only physically but also socially, culturally – there and then" ([43], pg. 89).

The experience of cultural presence seems to be achieved also in 'My Roman Pantheon' albeit through the opposite means of tangible interaction rather than via virtual reality. 'My Roman Pantheon' invites visitors to act within a *mise en scène* set-up via the tangible components, the shrine and the lamp, the presence of the goddess Juno. This triggers the 'suspension of disbelief'[9]: those visitors that choose to take part will set aside the reality of entering a museum, and instead step into an experience of the Roman's religious landscape. This permission is physically embodied by the lamp which visitors carry. The design of the lamp invites and engage visitors: it fits snuggly within the hand, the slits invite tactual interaction [51] and may evoke intentionality because it has its own behaviour [40], e.g. lighting up at the command of Juno, each light automatically extinguished when offered to a god. Holding the lamp for an extended period, not just a few minutes, contributes to engaging the visitors in a deep and personal way. Neuropsychology tells us objects we hold become an extension of the self and we can sense the world through them [1]. Perhaps the strong engagement is because touch is the only sense that is interactive, we touch and we are touched in return [51], it is considered the sense that makes us sentient and self-aware [18]. As such, touch is much more intimate than sight or hearing and can be used to create a personal connection with Roman Chesters, in that place, at that time. The lamp is a call to action and a permission to perform. The call to action of offering to the gods is strengthened by being forced to choose among the 13 deities the only three that are important for the individual visitor. The lights representing one's votive capital disappear upon each tap making one conscious of losing something and hopefully provoking you to think carefully about the consequences of your choice. Each act of making an offering is a motion of personal ritual, analogous with the rituals of those that once lived here and interacted with the stones now on display. Forcing the visitor to choose immerses them in the broad parameters the Roman community faced and prompts them to feel that the choice matters as it did to the Romans. Those who took part in the ritual seemed to experience the same cultural presence where one is engaged physically, socially and culturally with the past.

A limitation of this research is the small samples of participants involved in the evaluation and the different types of participants, professionals for 'Views from the Past' and visitors for 'My Roman Pantheon'. However, the responses of both groups are encouraging as they consistently point toward an appreciation of Roman culture via non-traditional technological means. In both case studies the combination of different features (VR + narratives, tangible + acting) make visitors feel 'cultural

[9] The suspension of disbelief is the intentional avoidance of critical thinking in examining something surreal to believe it for the sake of enjoyment. The effect is a sense of immersion in what's happening for the time the experience lasts such as a theatre performance.

presence' where the perception of a place is combined with the awareness of the culture and an understanding of the past. Both, therefore, could be valid mechanisms to design effective visitor's experiences. What is important is the bespoke character of the interventions: they are designed to fit a specific museum, and a specific challenge of visitor engagement.

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