Assessing the user response to differences in functionality when visualising 3D models of cultural heritage sites using the Technology Readiness Index

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Abstract

Visualisation of cultural heritage using 3D modelling in situ or over the Internet has increased in recent years. This paper examines people's readiness to accept these and their preferred degree of sophistication using a visualisation video of a 3D model of the Fishbourne Roman Palace in West Sussex, England. Participants viewed six visualisations in a controlled environment that sequentially added features such as texture, sound, lighting and ultimately interaction and mobility via game engine technologies. The updated Technology Readiness Index was used to group participants according to their willingness to accept the visualisations. TRI Explorers appreciated the addition of interactivity while enhanced model fidelity satisfied other groups. Linking the profile of the TRI groups with published survey results relating the characteristics of historical museum visitors suggests that TRI Explorers are not the target demographic negating the need for interactivity, although a museum's visitor profile should also be considered.

Key words: visualization; Fishbourne Roman Palace; game engine; 3D modelling

1. Introduction

Visualisation of archaeological remains and antiquities by means of 3D (three dimensional) modelling and delivery of such visualisations using information technology either in situ on installations within visitor facilities or over the Internet have attracted considerable interest in recent years (Sanders, 2008; Bonde and Houston, 2013). These applications may be regarded as a way of 'bringing the past to life' or 'recreating' buildings and artefacts as they used to exist, therefore exploiting cultural heritage for different groups and generations. Generally they seek to achieve this by reproducing to various degrees reconstructed realities as they used to exist. However, researchers have given only limited attention to determining the extent to which past realities should be faithfully reproduced in these visualisations or whether 'less than perfect' representations can offer sufficient reality in virtual formats. One example of interest in this topic is Haugstvedt and Krogstie's (2012) development of a mobile augmented reality application using historical photographs and other information relating to an historical street. In general there seems to be an underlying assumption that both in situ and remote online applications offering greater realism in their representation of the past are more desirable than those with less functionality. This article questions the need for and acceptability of highly realistic interpretations and recreations, and considers whether less sophisticated visualisations might be just as 'satisfactory' to the public. More detailed and sophisticated visualisations invariably imply increased time and resources for their realisation, therefore being aware of users' readiness for such systems has the potential to achieve the desired outcomes without waste of effort. The aim of this paper is to determine how much 'sophistication' is needed in the recreation of past realties and whether this relates to differences between people's attitudes towards information technology.

It has long been recognised that there is the potential for resistance from the intended user community whenever a new or innovative use of technology is proposed (Davis, 1989; Mathieson, 1991). Two strands of research have explored this issue, one focusing on the "the determinants of technology use" turned into the Technology Assessment Model (TAM) and the other on acceptance of technology in relation to "an individual's personality" (Walczuch et al., 2012: 206) formulated as the Technology Readiness Index (TRI). These ideas were originally explored in relation to new or innovative uses of technology in the workplace and were elaborated with regard to the degree to which a person believes that using a particular system would enhance his or her job performance or would not encumber the person with the need to deploy additional effort (i.e. would not require more effort than currently expended).

Davis (1989: 16) suggested that such resistance to technology reflected the interplay between two variables, namely its perceived usefulness and perceived ease of use. He argued that these are '"fundamental determinants of user acceptance" and discussed scales for measuring of these variables to help predict possible resistance. Subsequent research has reviewed the TAM and TRI approaches (Legris et al., 2003) their theoretical basis (Lin et al.,

2007) and their extension to incorporate temporal (Venkatesh and Davis, 1997) and cross-cultural (Meng et al. 2009) components. The TRI focuses on a person's readiness or willingness to use new technology with reference to four personality traits discomfort, innovativeness, insecurity and optimism. The original TRI, published nearly 20 years ago (Parasuraman, 2000) and subsequently updated with a reduced and modified set of items (Parasurman and Colby, 2015), constitutes a widely used way of assessing people's preparedness for new technology. Walczuch et al. (2012: 206) combined these approaches to explore whether a "person's general attitude towards technology [affected] perceived ease of use and perceived usefulness of a given software system."

In recent times there has been enormous growth in the expectation that members of the public are ready to assimilate use of more advanced forms of technology in their day to day lives (such as supermarket self-service scanning, automatic ticket purchase for rail travel and unassisted airport check-in), but apart from a few instances there has been little research pertaining to members of the public's readiness to use such systems (Victorino et al., 2009). We extend consideration of these issues into realm of cultural heritage by examining whether the degree of sophistication in public user facing applications of 3D visualisation of archaeological remains and artefacts can be assessed by means of TRI. The TRI refers to "people's propensity to embrace and employ new technologies for propensity goals in life and at work" (Parasuraman, 2000: 308) and the original version proposed a 36-item scale to measure that propensity. Such categorisation will be used to examine people's response to a series of increasingly more sophisticated 3D models of Fishbourne Roman Palace in West Sussex, England. Davis (1989) acknowledged that these factors are based upon subjective appraisal, but such a scale is essential if we are to determine the possible acceptance of any visualisations of cultural heritage intended for independent, unaided use by members of the general public. The following section provides a brief review of the archaeological excavation and 3D modelling of Fishbourne Roman Palace, next the updated TRI is tested with data obtained through participants viewing the Fishbourne model with differing degree of functionality and sophistication. Finally, the article concludes by noting the wider implications of the findings in respect of 3D modelling of cultural and archaeological heritage.

2. Modelling Fishbourne Roman Palace

The modern settlement of Fishbourne is a village located approximately 3 km west of Chichester, West Sussex, England on the generally low lying coastal plain (see Figure 1). The presence of Roman buildings in the area had been suspected since at least early in the nineteenth century when excavations for a new house revealed a pavement and column base. Confirmation that the various finds unearthed over the intervening years were Roman remains of a single structure came in 1960 (Cunliffe, 1998). At that time the laying of a water main brought up a quantity of debris revealing the location of what came to be known as Fishbourne Roman Palace on the basis of its size and presumed importance, and proximity to the modern village. Significant

discoveries during a full systematic excavation of the site in 1961, including amongst several mosaics the notable 'Dolphin mosaic' (Figure 2) helped to assure the site's preservation with the land being purchased by the Sussex Archaeological Trust.
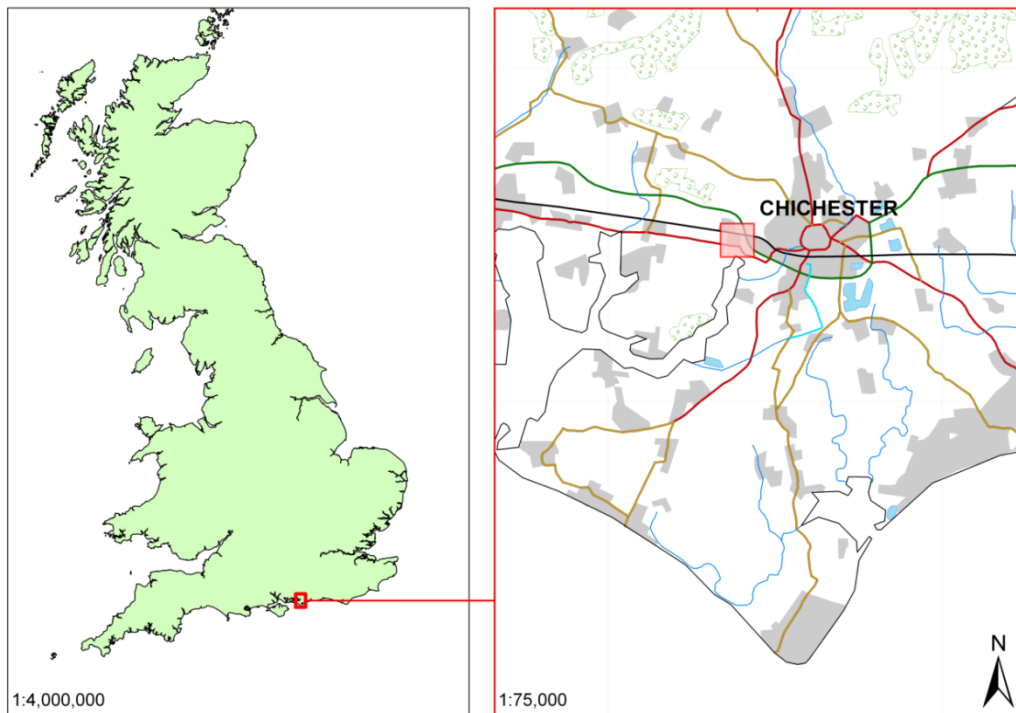

Figure 1: Location of Fishbourne Roman Palace.

Source: EDINA Digimap Ordnance Survey Service.

Figure 2: Dolphin mosaic on display at the museum

Source: authors.

Excavations continued throughout the 1960s, with the discovery of the south wing in 1966, and gardens further to the south in 1969 (Cunliffe, 1998). In parallel to the late 1960s excavations, the Sussex Archaeological Trust constructed buildings to house, preserve, and display the site and its finds. The primary building was erected directly over the north wing footings, the wing with the best preserved flooring according to Cunliffe (1998). Managed by the Sussex Archaeological Trust (later the Sussex Archaeological Society), the museum site was opened to the public in 1968. In common with other such facilities it was recognised at an early stage in planning the museum's displays that a physical model of the Palace would be an important adjunct to the archaeology itself and help visitors to appreciate the hypothecated full extent of the structure as it existed in Roman times. This model, created in 1968, became a centrepiece of the museum display and was based on the results of Cunliffe's excavations up to that point (Figure 3). Various alterations have been made over the years to reflect changes in thinking regarding the geography of the Palace, for example in relation to its proximity to the nearby coastline.

Figure 3: 1968 physical model of the palace on display at the museum

Source: authors.

There was a lull in excavations in the 1970s, but they resumed in the 1980s over portions of the West Wing and detailed study of some of the mosaics

beneath those already visible was made possible when those mosaics had to be lifted and reset to help consolidate them. Excavations were undertaken to the east of the main site which when the A27 was being upgraded and widened to a dual carriageway, which revealed a masonry building. This together with the surrounding area was the subject of further excavations in the 1990s (Cunliffe, 1998) and 2002. These excavations focused on activity in the immediate vicinity of the Palace prior to the Roman invasion and presented clear evidence of a significant Roman presence in the area, although the discovery of flint tools also indicated that the areas surrounding Fishbourne had seen occupation from the Mesolithic period at the latest, these excavations (Manley and Rudkin, 2003). Discoveries were made "of sealed and well-dated imported and local pottery, accompanied by food refuse and a copper-alloy scabbard fitting" (Manley and Rudkin, 2005: 55).

The site at Fishbourne is generally divided into three periods: A.D. 43-75 covers the Roman activity before the building of the Palace; 75-100 the construction and initial occupation; and 100-280/290 was a period of renovation until destruction of the Palace by fire (Cunliffe, 1977). This pre-palace Roman activity consists of what has been interpreted as military store buildings, a granary in particular. Once the Romans landed they would have needed such military buildings, with close proximity to the harbours, to help in their campaigns to subdue the hostile locals (Cunliffe, 1998). Frere (1991) suggests that these buildings in particular were used in the preparations for attacks on the Isle of Wight. Once the Roman frontier moved northwards, the military buildings would have been of no further use, with civilian development taking over.

These buildings began as timber, but were subsequently replaced by masonry. Known as the proto-palace, this building was certainly one of some importance as indicated by inclusion of an elaborate bath-suite. This proto-palace was incorporated into the design of the Palace proper once it began construction in A.D. 75. This Palace complex occupied an area of over 150 square metres and consisted of a formal garden surrounded on all sides by many rooms. Another, less formal garden was located to the south. Nearly all rooms were adorned with painted walls and mosaics, some were inlaid with marble, while others had friezes of moulded stucco (Cunliffe, 1971). Later periods saw the construction of bath suites and new mosaics. Such alterations were continuing until the occupied part of the building was destroyed by fire. Post Roman activity includes a few graves dug into the ruins before the area developed into farmland (Cunliffe, 1971).

The second model of Fishbourne Roman Palace was created for the purpose of this research (Smith, 2015), but this time a 3D virtual model was built again going back to the original plans of the Palace (Cunliffe, 1971; Manley and Rudkin, 2003) (see Figure 4). Autodesk Maya, 3D modelling software, was used to transform existing 2D drawings of the Palace into a 3D representation for use within game engines. Apart from being industry standard (used in the television, film and gaming sectors) one of the advantages of using Autodesk Maya was that it allowed the import of images, such as the Palace floor plans, to use a reference when creating structures and adding realistic textures. The starting point for the creation of the 3D model was Cunliffe's (1971) floor plan

(Figure 4a), which was imported into Autodesk Maya. The modelled three dimensional structure of the Palace was built using section views of various buildings (Cunliffe, 1971): with this completed it was possible to progress to creating the internal structures. The next stage involved texturing the surfaces of the model, for example changing the grey default roof to give it the appearance of being covered with Roman tiles. In addition to creating typical textures of the period, such as tiles and plasterwork respectively for the roofs and walls, textures representing the mosaics were created from photographic images to place in the modelled rooms that corresponded with their physical location. Some of the in situ mosaics have degraded over time and the modelling process enabled gaps to be filled or whole mosaics to be created using the original as a reference source. The next stage in the process involved importing the 3D model and its transfer into the Unreal game engine in order to provide the opportunity for user interaction in the 'virtual Palace'.
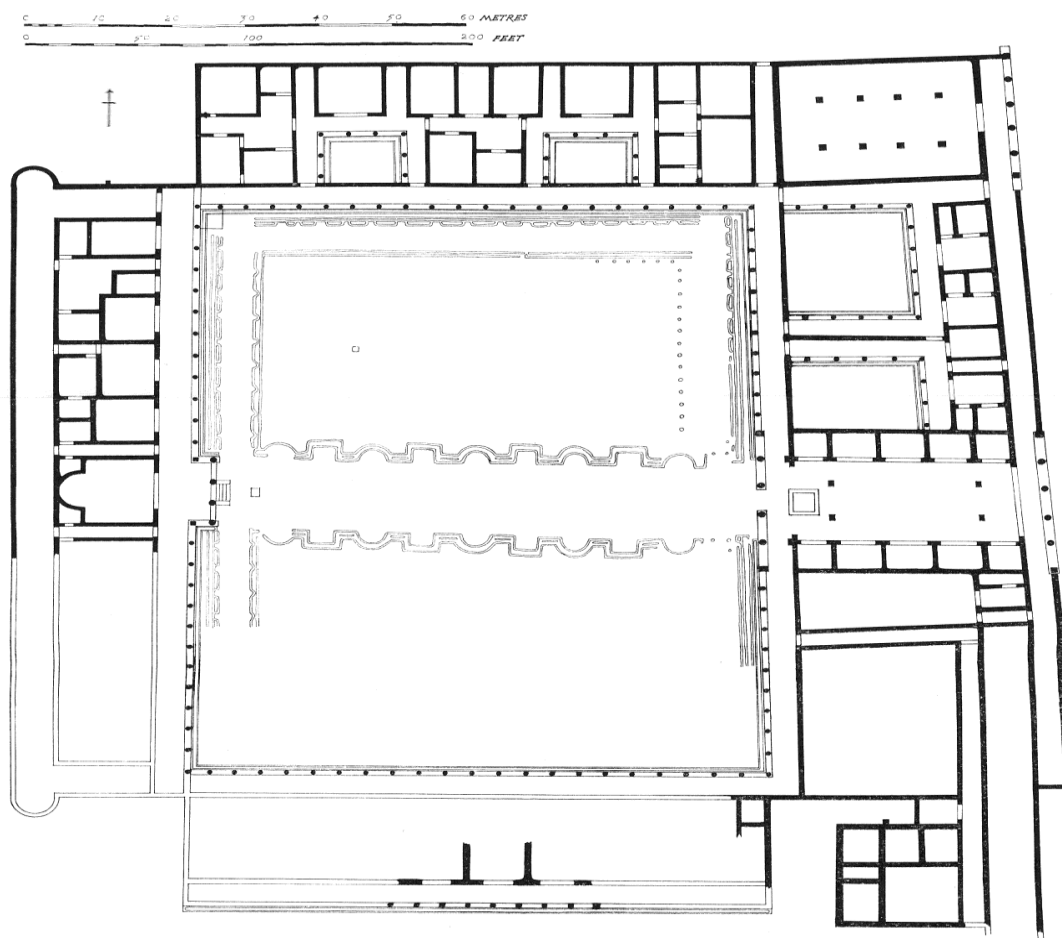
(a) Cunliffe's 1971 plan
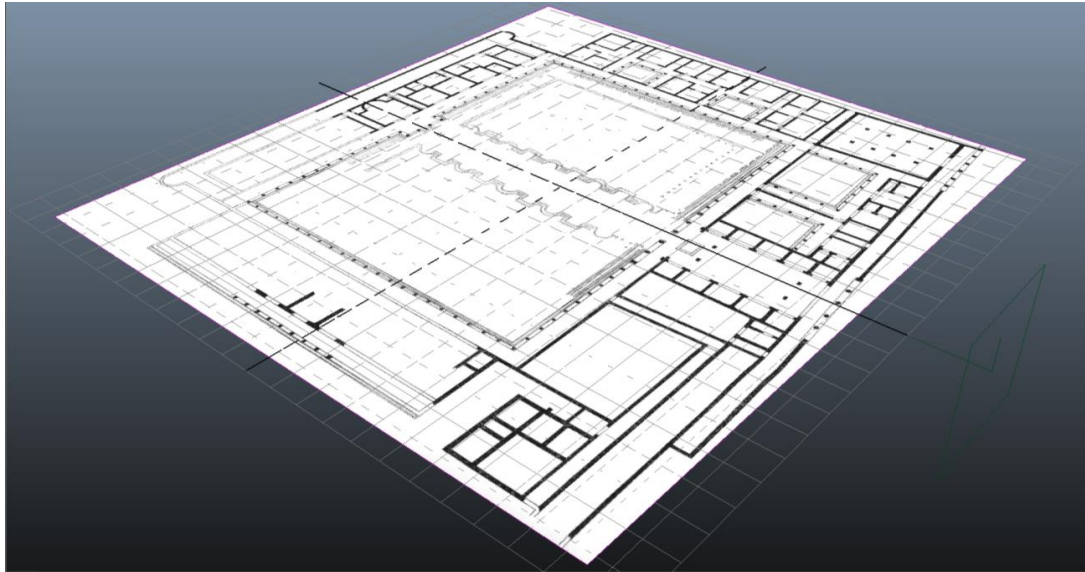
(b) Floor plan imported into Autodesk Maya

Figure 4: Simplified general floor plan of the Palace and imported version in Autodesk Maya.

Source: floor plan adapted from Cunliffe (1971).

3. Materials and Methods

The updated and simplified TRI index (Parasuraman and Colby, 2015) constituted an efficient way of evaluating the effectiveness and acceptability of different versions of the 3D model by members of the public. The accompanying videos and the still images in Figure 5 illustrate the series of different visualisations progressing in functionality from the relatively simple to the more sophisticated involving interactivity. These were as follows:

- Visualisation A (Figure 5a): the 3D model without textures
- Visualisation B (Figure 5b): the 3D model with textures
- Visualisation C (Figure 5c): the 3D model with textures and realistic lighting
- Visualisation D (Figure 5c): the 3D model with textures, realistic lighting and sound
- Visualisation E (Figure 5d): the 3D model with textures, realistic lighting and sound in Unreal game engine allowing interactivity and free navigation
- Visualisation F (Figure 5e): the 3D model with textures, realistic lighting and sound in Unreal game engine allowing interactivity, free navigation and shadow effects.

Visualisations A to D were presented as a film exported from Autodesk Maya with a fixed navigation path through the model using 3D projection, while Visualisations E and F were viewed on a PC allowing participants to interact with the 3D model enabling external and internal navigation in the virtual
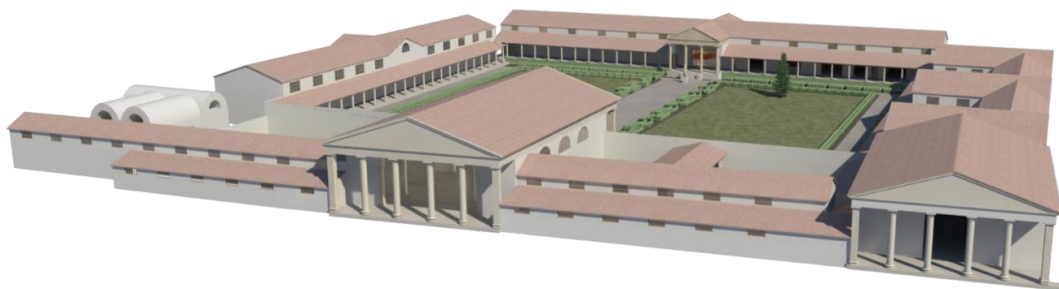
model. Interactivity with the visualisation was achieved by means of a standard Microsoft Xbox 360 control pad.
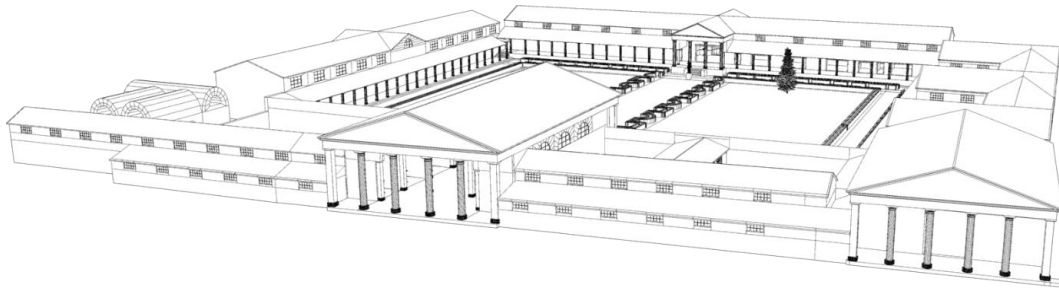
(a) Visualisation A

(b) Visualisation B

(c) Visualisations C and D

(d) Visualisation E

(e) Visualisation F

Figure 5: Different visualisations of the 3D Fishbourne Roman Palace model used in Technology Readiness Index evaluation.

Source: authors.

Staff and students in a British university (different from the institution in which the research was carried out) were invited to participate in the study with a target of 25 people drawn from a range of backgrounds and with different experience of information and communication technology. There were 25 participants whose ages at the time of the study ranged from 18 to 65 years. Although care was taken to ensure that participants were drawn from as broad a demographic as possible, conducting a similar study with an expanded target audience covering a broader range of occupational groups and age cohorts would help to determine if interactivity could be tailored to different user communities. The addition of storytelling could also be included to improve user perception. The participants viewed the series of six visualisations including the two interactive ones (E and F) in sequence one after the other accompanied by the researcher in a quiet room. The overall average time required to participate in the study was approximately 30 minutes and consent forms were completed notifying participants of their right to withdraw if they wished.

All participants completed a pre-viewing questionnaire and one post-viewing questionnaire after each visualisation. The TRI pre-viewing questionnaire comprised a series 21 statements separated into four dimensions or domains representing the multifaceted concept of technology readiness. These are:
   Optimism – a positive view of technology and a belief that it offers people increased control, flexibility, and efficiency in their lives.

Innovativeness – a tendency to be a technology pioneer and thought leader.

Discomfort – a perceived lack of control over technology and a feeling of being overwhelmed by it.

Insecurity – distrust of technology, stemming from scepticism about its ability to work properly and concerns about its potential harmful consequences. (Parusuraman and Colby, 2015: 60)

Participants responded to each of these statements on a seven-point Likert scale ranging from Strongly Agree to Strongly Disagree (see Appendix). Statements in the optimism and innovativeness dimensions are regarded as 'motivators' reflecting people's readiness to embrace technology, whereas those classed under discomfort and insecurity are considered as 'inhibitors' militating against their readiness. Parasurman and Colby (2015: 70) maintain that "the relatively low pairwise correlations ... among the combinations of dimensions" supports the case for using the TRI as a segmentation scheme. Following their approach responses under the four dimensions were separated into two groups optimism with innovativeness to denote motivation and discomfort with insecurity to signify inhibition. The median values of participants' scores for the two groups of statements were classified as Low (0.0-3.0), Moderate (3.5-4.5) and High (4.5-7.0). This application of the TRI enabled the participants to be segmented into five groups in respect of their readiness to use technology as shown in Table 1.

	Motivation	Inhibition	Group characteristics
Sceptics	Low	Low	Need concrete reasons to adopt new technologies, tend to have a detached view of technology, with less extreme positive and negative beliefs.
Explorers	High	Low	Interested in new technologies and needing minimal help to master them, tend to have a high degree of motivation and low degree of inhibition.
Avoiders	Moderate	High	Satisfied with basic functionality but need support and reassurance, tend to have a high degree of inhibition and low degree of motivation.
Pioneers	High	High	Needing little convincing to adopt technology but require more support to be satisfied, tend to hold both strong positive and negative views about technology.
Laggards	Low	High	Satisfied with basic functionality but need support and reassurance, they stand out due to their low degree of innovativeness.

Adapted from Parasuraman and Colby (2015)

Table 1: Application of updated Technology Readiness Index to segment study participants.

The post viewing questionnaires took the form of a core set of six questions that were tailored to suit the visualisation just viewed by the participant. These questions, adapted from Davis (1989), also used a seven-point Likert scale had the following generic format:

1. The visualisation enables me to understand the environment of Fishbourne Roman Palace.
2. Viewing the visualisation improves my ability to understand the environment of Fishbourne Roman Palace.
3. Viewing the visualisation increases my effectiveness in understanding the environment of Fishbourne Roman Palace.
4. Viewing the visualisation makes it easier to understand the environment of Fishbourne Roman Palace.
5. Overall, I find the visualisation useful in understanding the environment of Fishbourne Roman Palace.
6. Overall, I find the visualisation easy to use.

Following the approach favoured by Kostoulas (2013) the medians of the participants' Likert scale responses to the six visualisations have been used in this analysis. The following section presents the results obtained from analysing participants' reactions to the six visualisations using the TRI groups as a segmentation framework.

3. Results

The fivefold classification of participants forms the basis for assessing their engagement with and appreciation of the different types of visualisation, although it should be noted that segmentation of the 25 participants did not assign anyone to the Sceptics group. The majority of participants fall into the 'Explorer' and 'Avoider' categories (32% and 44% respectively), which is not unexpected from university staff and students, and there were only small numbers of Pioneers and Laggards (4% and 8% respectively). Recalling that the visualisations were sequenced in order of increasing complexity and sophistication, Figure 6a shows an increasingly positive response for visualisations A to D, followed by a less favourable reaction once basic interactivity was introduced and then a resumed upward trend when shadow effects were included. This may indicate that interactivity is less appreciated than increased visual and audio fidelity, although several participants had trouble with the controls (a standard Microsoft Xbox 360 control pad), and there was at least one instance of motion sickness caused by the movement on the screen. The dispersion of participants' scores around the median also suggests that an appreciation of fidelity over interactivity prevailed as visualisation D records the highest level of agreement among participants, with a high median. In comparison the participants had a much wider range of
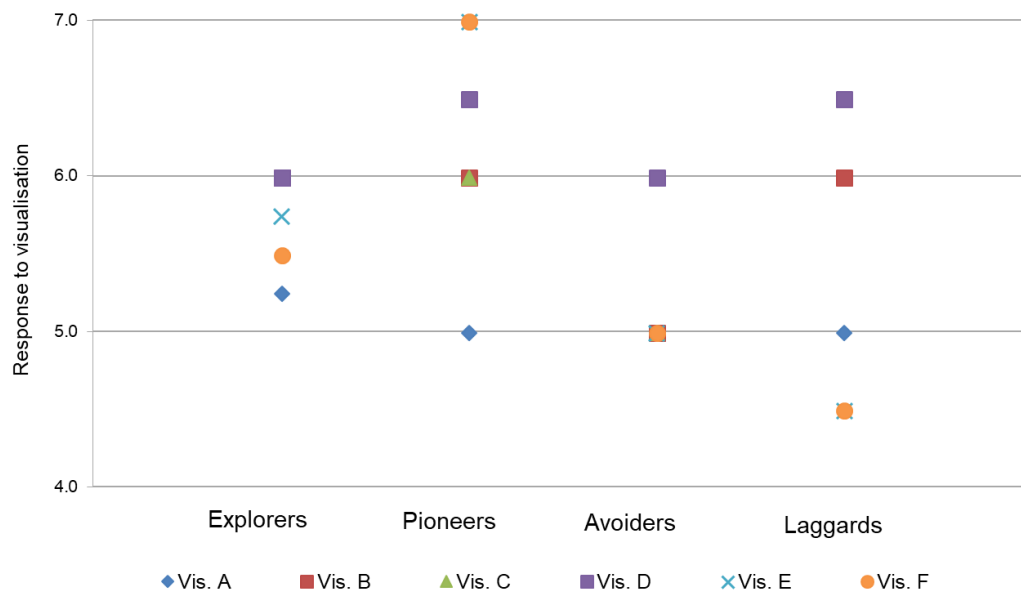
opinion for visualisations E and F, indicating that interactivity may be contentious.
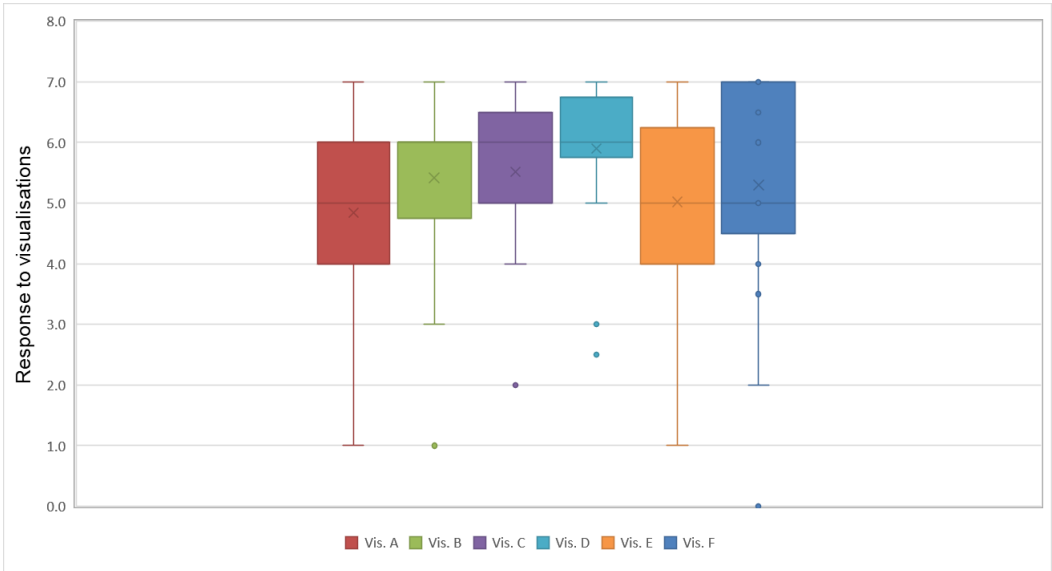
(a) Overall response of all participants to visualisations
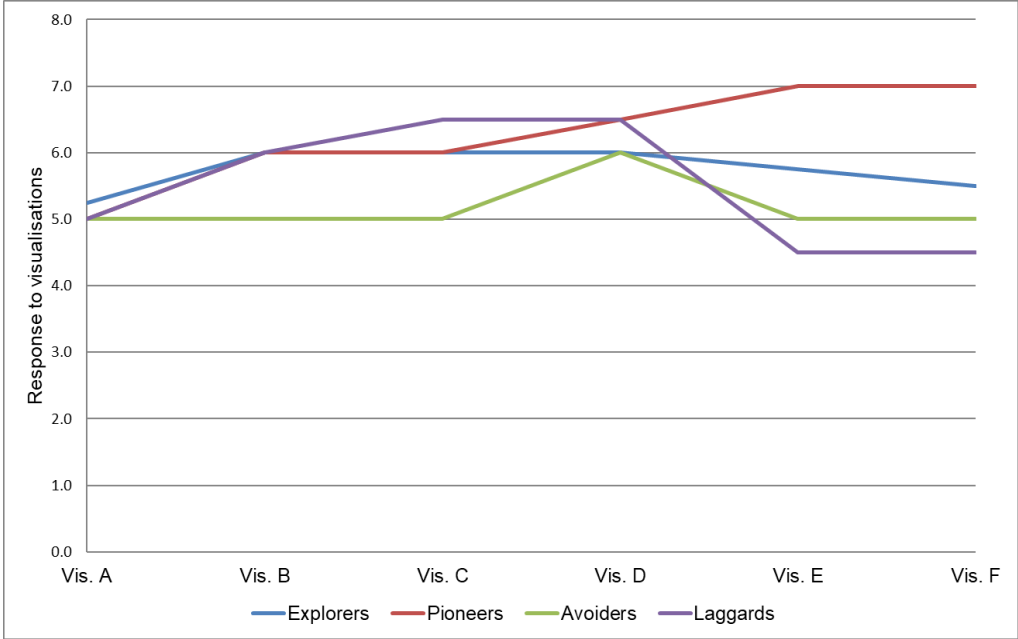
(b)   Disaggregated response to visualisations

(c)   Variation within disaggregated response to visualisations

Figure 6: Participants' response to the different visualisations of the 3D Fishbourne Roman Palace model.

Disaggregation of the results according to the participants' TRI group offers further insight into their preferences for the different styles of visualisation. Following on from the earlier description of each group's preparedness to engage with information and communication technology and its application obtained during the pre-viewing questionnaire prior to the visualisations, Figure 6b shows that only members of the Pioneer group did not experience a deflation of their appreciation when basic interactivity was introduced. This reaction accords with the segments definitional conviction towards adopting new technology and their strong positive and negative opinions about it. However, there were some architects amongst the whole set of participants

and they indicated a preference for the cleaner line drawing of visualisation A over the textured model of B. The Explorers, not surprisingly given their interest in and lack of inhibition towards new technology, stand out for professing increased appreciation across the series of visualisations. The Explorers' appreciation of visualisations E and F, in comparison with the other TRI groups, suggests that use of the Microsoft Xbox controls was the issue rather than the visual and audio fidelity; Explorers tended to be more motivated and accepting of new control methods over the other categories and displayed least variation across the range. Avoiders, being willing to accept basic functionality in new technology, showed the expected pattern with increasing appreciation through the range with a muted appreciation of the interactivity offered in visualisations E and. Laggards were even less well disposed towards the visualisations involving interactivity than the Avoiders. Figure 6c shows that the Avoiders and Explorers recorded the least difference of opinion between the visualisations, indicating that the former saw minimal improvement and displayed some resistance to the viewing the 3D model by any means, and the latter some preference for interactivity. Pioneers and Laggards expressed greater variation in their opinions: the two Pioneers showed enthusiasm for interactivity, whereas the Laggards recorded the least interest in the interactive version with shadow effects and preferred visualisation D with increased visual and audio fidelity. The number of participants included in this study militates against extensive statistical analysis of their response to the series of visualisations. Nevertheless, applying Kruskal-Wallis test with respect the difference in medians between the four TRI groups on their scores in respect of the six visualisations resulted in non-significant results in each case (see Table 2).

	Vis. 1	Vis. 2	Vis. 3	Vis. 4	Vis. 5	Vis. 6	N
Explorer	15.00	14.81	14.81	12.06	15.13	13.07	8
Pioneer	13.25	15.50	15.00	17.00	23.00	20.50	2
Avoider	11.41	9.77	9.91	11.50	10.86	11.91	11
Laggard	13.25	17.00	16.88	17.00	9.63	9.13	4
Test statistic	1.163	4.432	3.935	2.564	6.342	3.837	
P	0.762	0.218	0.269	0.464	0.096	0.280	

Note: Kruskal-Wallis tests were all non-significant.

Table 2: Mean rank score of TRI groups in respect of six visualisations of the Fishbourne Roman Palace.

4. Discussion and Conclusion

The results of the study should be tempered by recognition that, while the participants came from a balanced male/female demographic with a range of ages, a more diverse set of occupational groups and larger number of participants would allow the responses of different age cohorts to be explored in order to consider the potential customising interactivity to fit with the

different TRI groups. Nevertheless, the results suggest that the addition of interactivity to the visualisation is only appreciated by the TRI Explorers and Pioneers groups. In many respects this is unsurprising, since these groups comprises people who are highly motivated by new technologies and need minimal help to master them. It may be worth noting however that the biggest issue non-Explorer participants had with visualisations E and F were with using the controls, an issue that would be resolved with experience, or revision to a different control scheme. These findings help to answer the questions: 'who are the intended audience for a heritage visualisation?' and 'how much, if any, interactivity should be incorporated?'. If Explorers are the target group, more interactivity would be recommended, but these formed only a minority of participants, even among a set drawn from different staff grades in a university and its students. The majority of potential users from the general public are likely to come from the other TRI groups and an expanded study would help to elucidate this.

The more challenging question is deciding whether and what proportion of visitors to the Fishbourne Roman Palace museum would appreciate having the opportunity to use an interactive or non-interactive visualisation of the 3D model. Parasuraman and Colby's (2015) analysis not only defined the technology readiness of their five groups but also summarised their dominant demographic and socio-economic characteristics, which are summarised in Table 3. These characterisations are reasonably consistent with expectations: in comparison with other groups these authors found the Explorers were mainly male, aged under 50 years, having a degree and working in technology-related employment. The Avoiders were mainly female, overwhelmingly aged over 50 years, possessing a university degree but not engaged in technology-related employment. Parasuraman and Colby (2015) found Pioneers to be similar to Explorers except there was a slightly higher percentage of females than males and they were marginally less likely to possess a degree and/or work in technology-related industry. The distinguishing characteristic of Laggards is that very few were engaged in technology-related employment.

TRI Group

Sceptics: female (52%); aged over 50 (50%); without university degree (58%); not in technology-related employment (92%)
Explorers: male (56%); aged under 50 (66%); without university degree (54%); not in technology-related employment (82%)
Avoiders: female (59%); aged over 50 (79%); without university degree (71%); not in technology-related employment (93%)
Pioneers: female (53%); aged under 50 (59%); without university degree (58%); not in technology-related employment (87%)
Laggards: male (52%); aged over 50 (69%); without university degree (61%); not in technology-related employment (98%)

Table 3: Characterisation of TRI groups using selected demographic and socio-economic characteristics. (Adapted from Parasuraman and Colby (2015).

Note: sceptics group not represented in study participants.

Assessing the profile of visitors to the museum in relation to these characterisations offers an entry point for deciding whether investment in an interactive or non-interactive visualisation of the 3D model might be worthwhile. According to a study by Museum Audience Insight (Reach Advisors, 2010), the majority of visitors to historical museums are aged over 50 (65%) and female (60%). If the visitors to Fishbourne Roman Palace accord with these figures, Avoiders would comprise the base audience for a visualisation of the 3D model. Our findings indicate that this group were somewhat averse to interactivity and preferred visualisation D. However, all museums are not the same and Fishbourne enjoys regular school visits, whose members are likely to possess the characteristics of the Explorer and Pioneer TRI groups and be highly appreciative of interactive displays. The introduction of such displays may also help entice more visitors of an Explorer persuasion through Fishbourne's doors.

It seems reasonable to suggest users of a heritage visualisation in situ (i.e. within a museum) would have limited time to familiarise themselves with the system, given the transitory nature of their visit and the presence of other visitors seeking to use the installation, and therefore a non-interactive facility would be more appropriate. However, it might be feasible and worthwhile including interactivity if developing an online visualisation in parallel with an in situ one. This would allow people less ready to use information technology to access it in a less pressurised situations affording them time to learn how to use the control interface. Remote online access to an interactive visualisation could have additional functionality that helped to plan for or reflect on a personal visit to museum site itself. Further investigation into the demographic and socio-economic characteristics of Fishbourne Roman Place Museum's current visitor base would help to confirm whether an interactive or non-interactive visualisation is appropriate in this instance. Overall the study has indicated that the specifics of an individual museum's visitor profile should be taken into account alongside the overall readiness of the public for the introduction of in situ or online 3D visualisation.

collection, analysis and interpretation of data in writing the article and the decision to submit the article for publication.

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Appendix

Pre-viewing Technology Readiness Questionnaire

Interactive and Immersive Technologies for Community Engagement

Technology Readiness Questionnaire

OPTIMISM

1. Technology gives people more control over their daily lives

strongly disagree   1 2 3 4 5 6 7   strongly agree

2. Products and services that use the newest technologies are much more convenient to use

strongly disagree   1 2 3 4 5 6 7   strongly agree

3. You prefer to use the most advanced technology available

strongly disagree   1 2 3 4 5 6 7   strongly agree

4. You like computer programs that allow you to tailor things to fit your own needs

strongly disagree   1 2 3 4 5 6 7   strongly agree

5. Technology makes you more efficient in your daily life

strongly disagree   1 2 3 4 5 6 7   strongly agree

6. Learning about technology can be as rewarding as the technology itself

strongly disagree   1 2 3 4 5 6 7   strongly agree

7. You feel confident that machines will follow through with what you instructed them to do

strongly disagree   1 2 3 4 5 6 7   strongly agree

INNOVATIVENESS

8. In general, you are among the first in your circle of friends to acquire new technology when it appears

strongly disagree   1 2 3 4 5 6 7   strongly agree

9. You can usually figure out new high-tech products and services without help from others

strongly disagree   1   2   3   4   5   6   7   strongly agree

10. You keep up with the latest technological developments in your areas of interest

strongly disagree   1   2   3   4   5   6   7   strongly agree

11. You find you have fewer problems than other people in making technology work for you

strongly disagree   1   2   3   4   5   6   7   strongly agree

DISCOMFORT

12. Technical support lines are not helpful because they do not explain things in terms you understand

strongly disagree   1   2   3   4   5   6   7   strongly agree

13. Sometimes, you think that technology systems are not designed for use by ordinary people

strongly disagree   1   2   3   4   5   6   7   strongly agree

14. If you buy a high-tech product or service, you prefer to have the basic model over one with a lot of extra features

strongly disagree   1   2   3   4   5   6   7   strongly agree

15. There should be caution in replacing important people-tasks with technology because new technology can breakdown or get disconnected

strongly disagree   1   2   3   4   5   6   7   strongly agree

16. Many new technologies have health or safety risks that are not discovered until after people have used them

strongly disagree   1   2   3   4   5   6   7   strongly agree

17. New technology makes it too easy for governments and companies to spy on people

strongly disagree   1   2   3   4   5   6   7   strongly agree

INSECURITY

18. You do not consider it safe to send any kind of financial or personal information online

strongly disagree   1   2   3   4   5   6   7   strongly agree

19. Whenever something gets automated, you need to check carefully that the machine or computer is not making mistakes

strongly disagree   1   2   3   4   5   6   7   strongly agree

20. When you call an organisation, you prefer to talk to a person rather than a machine

strongly disagree   1   2   3   4   5   6   7   strongly agree

21. If you provide information to a machine or over the Internet, you can never be sure it really gets to right place

     a. strongly disagree 1   2   3   4   5   6   7   strongly agree

Adapted from: Parasuraman, A. (2000).