EXPLORING THE ADOPTION OF UBIQUITOUS INFORMATION SYSTEMS WITHIN THE MUSEUM CONTEXT

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Abstract

Wireless and mobile technologies are gradually enabling the provision of innovative information services within almost all environments. This study explores the adoption of ubiquitous museum information systems that can significantly enhance and enrich the museum visit. We draw on traditional IS adoption theories and theories from Museum Studies to develop our theoretical model which is empirically tested through a survey addressed to museum visitors (n=118). Model hypotheses are tested through Partial Least Squares modelling. The results show that Performance Expectancy and Personal Innovativeness still represent the core predictors toward the adoption of museum information systems. However, we also report on the predictive strength of two context-related factors, Invisibility and Interaction, which appear to play a particular role toward the formulation of favourable user perceptions. The paper concludes with implications on the design of museum information systems and specific suggestions for future research.

Keywords: Ubiquitous Information Systems, technology adoption, museum information systems, Mobile Information Systems.
1 INTRODUCTION

The majority of technology adoption studies seems to be mainly focused on the workplace, where the use of information systems is regular, continuous and often mandatory (Abowd & Mynatt, 2005). However, Ubiquitous Information Systems (UIS) have today penetrated our everyday life, promising to assist with day-to-day routine, to entertain and inform. Typically, such systems operate by having their IT artefacts “embedded in the physical space, working together to sense and communicate user related and environmental information, and supporting user tasks and activities unobtrusively” (D. Karaiskos, Kourouthanassis, & Giaglis, 2007). As a result, they manage to operate “in the periphery of human lifeworld” (D. Karaiskos, et al., 2007), claim their presence in almost all contexts, transforming them into ‘smart’ environments. Their ubiquitous nature calls for new methods toward the examination of user adoption, specifically for non-work contexts (Hong & Tam, 2006).

Our research is focused on the museum context. Museums today seek access to more social groups and to improve their services (Galloway & Stanley, 2004). At the same time, potential audiences are significantly attracted by innovative devices and applications that offer high levels of interaction and entertainment (Economou, 2008) and the literature highlights a notable interest on behalf of the museums for such systems since they can create conditions for communication and learning through interaction and entertainment (Heath & von Lehn, 2008). As a result, UIS, by being attractive technological artefacts, seamlessly incorporated in the exhibition space and able to offer both entertainment and information, can support museums towards achieving their aforementioned goals.

Within this framework, the present study examines the adoption of UIS by museum visitors. It is doing so by acknowledging the voluntariness and the occasional basis of the museum visit, that the museum is a place of entertainment and informal education and, finally, the technology’s distinct characteristics. The purpose of the study is two-fold; to identify the characteristics that lead to the system’s acceptance by the user-visitor and to propose a validated method for evaluating ubiquitous museum IS.

2 BACKGROUND

2.1 Research on Ubiquitous Information Systems

Ubiquitous Information Systems differ from that of traditional mobile and desktop-based systems, largely because of the novel features these systems introduce. In more detail, UIS are usually used outside the work environment, enabling users to move away from the desktop and interact with the system in the environment where they actually live and where demands change dynamically (Scholtz & Consolvo, 2004). They developed and function using networked devices, wireless communication technologies and smart sensor networks, which allow the system to perceive changes in the surroundings, utilizing movement and speech as input and accordingly reconfigure continuously its function without the user’s explicit prompt.

Until recently, research on UIS has been focused on their engineering perspective by identifying primarily technological and design challenges (Kourouthanassis & Giaglis, 2008). Today there are few studies that investigate user adoption of UIS. However, most of these studies replicate existing technology adoption models, such as TAM or UTAUT (e.g. D. Karaiskos, et al., 2007). We argue that the new interaction modalities that UIS introduce might call for the development of a more holistic approach of user acceptance. We believe the framework developed by Scholtz & Consolvo (Scholtz & Consolvo, 2004) can be a helpful tool. They propose nine evaluation areas: attention, adoption, trust, conceptual models, interaction, invisibility, impact and side effects, appeal and application robustness. We use these areas mostly as a starting point for our research and not as an exact guide. We agree with Connelly’s view (2007), that the framework can’t address “the need for a model (...) to predict user acceptance”, largely because most of the areas are too vague to be applicable, as for example those of
conceptual models and appeal, while that of application robustness is mainly tackled by effort and performance expectancy under the scope of an adoption study. We also feel that these areas alone are not enough to predict effectively and accurately the level of adoption and usage of an information system, ubiquitous or not, in the museum context because they don’t account for the properties of a museum visit.

The following section discusses some of the challenges of museum information systems through the review of previously deployed systems.

2.2 Museum Information Systems

Designing information systems for museums has become an attractive area for researchers interested in Ubiquitous Computing. Audio-guides, introduced in the late 50’s, represent the first form of IS deployed in the museum context. Since then however, as Table 1 illustrates, innovative technologies have been deployed to augment the visitor experience within the exhibition space by supporting new forms of information provision regarding the exhibits.

<table>
<thead>
<tr>
<th>Museum IS</th>
<th>Location</th>
<th>Technology</th>
<th>Disadvantages</th>
<th>Advantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Museum Wearable</td>
<td>Robots &amp; Beyond ongoing exhibition at the MIT Museum</td>
<td>Private-eye display Bayesian networks Localization sensors Small CPU</td>
<td>Adoption Interaction (companions)</td>
<td>Attention Interaction (system) Trust^3</td>
</tr>
<tr>
<td>(Sparacino, 2002, 2004)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PEACH project</td>
<td>Castello del Buonconsiglio(Trento, Italy)</td>
<td>PDA Infrared emitters Accelerometers Cinematic techniques Avatars (life-like characters)</td>
<td>Attention</td>
<td>Trust^3 Interaction</td>
</tr>
<tr>
<td>(Alfaro, Nardon, Pianesi, Stock, &amp; Zancanaro, 2005)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PhoneGuide</td>
<td>Weimar City Museum (Weimar, Germany)</td>
<td>Bluetooth-enabled mobile phone with a camera Bluetooth emitters Software installation through a memory card Two-layer neural networks</td>
<td>Attention Adoption Trust</td>
<td>Interaction</td>
</tr>
<tr>
<td>(Bruns, Brombach, Zeidler, &amp; Bimber, 2007)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Live!Labels project</td>
<td>New Walk Museum &amp; Art Gallery (Leicester, UK)</td>
<td>LCD labels (with wireless capability) Web-based content administration system Internet connectivity</td>
<td>Interaction (systems)</td>
<td>Attention Adoption Trust^2 Interaction (companions)</td>
</tr>
<tr>
<td>(Parry, 2007)</td>
<td>National Space Centre (Leicester, UK)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1, 2 Advantages and Disadvantages follow as much as possible Scholtz & Consolvo’ framework (§2.1).
3 These systems don’t collect private data neither use visitors’ personal devices, therefore this dimension doesn’t constitute an important dimension toward their assessment.

Table 1 Examples of Museum Information Systems

Museum Wearable is a system that offers augmented (or mixed) reality for the purposes of enhancing and personalising the museum visit by modelling the user behaviour within the exhibition space through Bayesian Networks (Sparacino, 2002). What may be considered as a disadvantage is that interaction with one’s companions is difficult as the visitor gets immersed within the narrative of the museum guide. In addition, its deployment for “La Scena di Puccini” exhibition showed that visitors were keen to adopt it only after having seen others using it (Sparacino, 2004). The information system, developed during the PEACH project, uses a PDA device for the purposes of a personalised visit and the experience is enhanced with the projection of multimedia material combined with cinematic techniques and a life-like character that takes up the role of a museum guide. This system allows the user to interact unobtrusively with her/his companions; yet, having a PDA as the delivery medium is one of its main disadvantages as its screen is relatively small, steering the user’s attention away from the exhibit and showing only a limited amount of information at any given screenshot (Acton, Golden,
Gudea, & Scott, 2004). Also, initial evaluation of the system has shown that the system’s operation was not easily perceived by the users, resulting in various modifications of the first prototype (Stock & Zancanaro, 2007).

PhoneGuide uses the mobile phone of the visitor while demanding the use of a light weight software. The visitor takes photographs with her/his mobile phone of group displays and the device, using object-recognition techniques, identifies the various objects and prompts the user to choose among them so as to return the relevant information. The specific system offers particular benefits for the museum, as it reduces significantly the cost of equipment (Bruns, et al., 2007). However, as in the case of PEACH, this system, too, captures the visitor’s attention away from the exhibits and, contrary to the developers’ argument, trust-related issues can have an important negative impact on the user adoption as illustrated by the related literature [e.g. (Sheng, Nah, & Siau, 2008)]; as visitors are obliged to use their own devices and install, even for a short period of time, an external software privacy concerns may rise.

Finally, the Live!Labels project departs completely from all other systems toward enhancing the museum experience. Slim LCD screens with wireless connectivity are placed next to the exhibits that the curators can remotely update and edit their content in real-time multiple times throughout the day depending on specific ‘triggers’. For example, the curator can adjust the content according to a scheduled visit, new developments on the subject matter of the exhibition, whether (s)he has thought of or read something in relation with the exhibit, or even visitors’ comments (Parry, 2007). This system, following on the footsteps of the traditional labelling system, doesn’t affect the visitors’ attention, however the offered interaction is kept to a minimal degree and its evaluation showed that around half of 763 visitors did not even notice the labels and only 4% described them as ‘live’. The system, having been deployed in two very different settings, in a science-related context and an art-related context also functions for drawing interesting results; in the first one, visitors were much more expectant of interactivity, while in the second they were more likely to describe them as ‘digital’ or ‘different’ (Parry, 2007).

The examples above illustrate that the effectiveness and the success of museum information systems depend upon a number of factors, ranging from the level of interaction and the amount of information to the degree of the visitor’s attention. We therefore argue that this field requires a closer examination through an analytic investigation lens that will allow for the development of an integrated theoretical model explaining visitor behaviour with regards to the adoption of information systems. An initial attempt is presented in the next section.

3 MODEL DEVELOPMENT

This study aims at formulating a research framework capable of predicting individual behavioural intention towards the adoption of UIS in museums. Behavioural Intention is defined as the “measure of strength of one’s intention to perform a specified behaviour” (Davis, Bagozzi, & Warshaw, 1989). Within our research’s context, this is interpreted as one’s intention to use a UIS during a museum visit in the future. Our model draws upon extant theories of technology adoption and is informed by the museum studies discipline. We examined six adoption drivers of innovative ICT in the museum context grouped in three categories, namely IT-related expectancies, Context-related expectancies and Personal Characteristics. In the following sections we discuss these categories in more detail.

3.1 IT-related Perceptions (Expectancies)

IT-related perceptions are individual beliefs regarding the contact with and the use of technology. According to several studies, perceptions on ease of use and usefulness are fundamental to all technology adoption studies [e.g. (Yousafzai, Foxall, & Pallister, 2007)]. The two concepts have been re-coined as effort expectancy and performance expectancy respectively (Venkatesh, Morris, Davis, & Davis, 2003). We chose to use these terms because, as it will be explained later, our study concerns
expectations rather than perceptions developed through experience. Effort expectancy measures the effort one perceives as necessary so as to successfully use an information system. Similarly, performance expectancy captures individual perceptions that the system will help visitors attain their goals in the museum context (e.g. provide entertainment and informational services about the exhibits, navigate them within the museum). Following the established findings in the IS literature we formulate the following hypotheses:

**H1: Effort Expectancy will have a positive impact on Behavioural Intention**

**H2: Performance Expectancy will have a positive impact on Behavioural Intention**

We also examine the predicting effect of perceived behavioural control since interaction with UIS most often occurs through a variety of mobile and multi-purpose information devices whose interaction modality does not follow the desktop paradigm. This construct “reflects perceptions of internal and external constraints on behaviour and encompasses self-efficacy, resource facilitating conditions, and technology facilitating conditions” and is in fact a sub-construct of UTAUT’s Facilitating Conditions construct (Venkatesh, et al., 2003). It should be noted that museum visitors might be occasional users of the system. Hence, they might lack the necessary skills or IT experience to use the system, while at the same time training on the system’s use most often will not be available. Even though Venkatesh et al. (Venkatesh, et al., 2003) exhibited that it has no predictive strength over user intentions, we believe that examining it may offer valuable insight as noted in other studies as well (Taylor & Todd, 1995), we thus formulate the following hypothesis:

**H3: Perceived behavioural control will have a positive impact on Behavioural Intention**

### 3.2 Context-related Perceptions

Context-related perceptions reflect the characteristics of the museum visit in relation with the particularities of a ubiquitous information system. As Falk & Dierking argue, the museum experience is subject to three discreet, interacting contexts: the personal context, i.e. the visitor’s attitude, prior knowledge, motivation and interests, the physical context as prescribed by the objects, the artefacts, the ambience and even the architecture of the space, and the social context, i.e. one’s company during the visit, other people encountered within the same space and so forth (Falk & Dierking, 1992).

Museum UIS requires the physical integration of technological infrastructure in order to ubiquitously support the museum's visitors. Nevertheless, as computing devices become diffused in the museum environment, interaction with the system may become distractive, while at the same time, according to Falk & Dierking (Falk & Dierking, 1992), museum visitors will be performing physical and social activities during their interaction with computing devices. As a result, the degree of the system’s integration will affect the physical context of the museum experience and in turn the museum visit itself. For this reason, computational resources of UIS for museums should be integrated in the physical surrounding in a manner so as to promote Invisibility, as defined by Weiser (Weiser, 1991). We thus adopt the concept of Invisibility in our study and we claim that it will have an influential role on both effort and performance expectancy. Also, we hypothesize that Invisibility will have an effect on Behavioural Intention as Invisibility in use will enhance one’s intentions to use the system under examination:

**H4: Invisibility will have a positive impact on Effort Expectancy**

**H5: Invisibility will have a positive impact on Performance Expectancy**

**H6: Invisibility will have a positive impact on Behavioural Intention**

Drawing again from Falk & Dierking’s theorization –specifically both the personal and social contexts- and the constructivist learning theory, Interaction is a feature that strongly enables and enhances informal education, one of the museum’s goals (Eilean Hooper-Greenhill, 1999). According to this theory, new knowledge is constructed through one’s experiences, where learning can be regarded as a social activity (Hein, 1999). This suggests that learning occurs also through one’s
interaction with the surroundings, the exhibits, her/his companions visiting together the museum, the mobile guide and so forth. In addition, Interaction is a central component of many contemporary types of entertainment that are being adopted by the younger population, as for example the numerous gaming consoles. Moreover, ubiquitous technologies can provide alternative means of interactivity between the system, the exhibits and the visitors. However, the degree of Invisibility may hinder or act in favour of Interaction between the visitor and the system, the exhibits or other members of a larger group and we hypothesise that as the system and its IT artefacts become more and more invisible, it will promote a greater level of interaction:

**H7: Invisibility will have a positive impact on Interaction Expectancy**

In addition, the ease of use of a given system, ubiquitous or not, is important toward the successful interaction with the system, even more so when it occurs on an occasional basis without prior training. A mobile guide that it is difficult to operate can easily draw the visitor’s attention on the operation of the system itself and away from the exhibits, hindering thus the interaction with other members of the group (if that is the context of the visit), affecting in turn the museum experience as a whole. We thus hypothesise that the level of difficulty a prospective visitor is faced with while operating the system, will also have an impact on the Interaction.

**H8: Effort Expectancy will have a positive impact on Interaction Expectancy**

Finally, building upon the concept that museum visitors will seek out ways to interact with their companions and friends and with the provided ubiquitous information system more constructively, rather than use it solely as a guide, we propose that:

**H9: Interaction Expectancy will have a positive impact on Behavioural Intention**

### 3.3 Personal Characteristics

The function of personal characteristics as moderators and predictors toward the formulation of behavioural intentions is well recognized by the majority of adoption models. In the present study they also reflect the importance of the personal context of the museum visit, as discussed by the Falk & Dierking (Falk & Dierking, 1992).

In this set of factors we include the notion of Personal Innovativeness as a significant predictor of user behaviour. Personal innovativeness is defined “as the willingness of an individual to try out any new information technology” (Agarwal & Prasad, 1998) and has its roots in the theory of the diffusion of innovations (Rogers, 1983). According to Rogers, individuals tend to differ to their degree of personal innovativeness; as ubiquitous systems in the museum context are still considered as an innovative set of services, at least in the Greek setting where this study took place, Personal Innovativeness is expected to serve as a determinant for the adoption decision.

As Lu, Yao & Yu note, “results concerning [Personal Innovativeness] have not been consistent” (J. Lu, Yao, & Yu, 2005). For example, Agarwal & Karahanna (Agarwal & Karahanna, 2000) have examined its impact on Cognitive Absorption, Perceived Usefulness and Ease of Use and got encouraging results only for a relationship with the first construct. Next, Lu et al (J. Lu, et al., 2005) investigated the direct effect of Personal Innovativeness on Behavioural Intention, together with that on Ease of Use and Perceived Usefulness, while Lewis, Agarwal & Sambamurthy (W. Lewis, Agarwal, & Sambamurthy, 2003) have examined its impact only on the latter two. Both studies illustrated the importance of Personal Innovativeness for usefulness and ease of use. Nevertheless, the second study did not assess Behavioural Intention at all, but rather examined user beliefs on IT use as the dependent variables. Finally, other studies showed that Personal Innovativeness may be an antecedent of Perceived Usefulness and Behavioural Intention (Lopez-Nicolás, Molina-Castillo, & Bouwman, 2008), of Perceived Behavioural Control, Subjective Norm, Result Demonstrability, Perceived Ease of Use and Image (Yi, Jackson, Park, & Probst, 2006) and of Perceived Ease of Use and Intention to Accept (Behavioural Intention) (June Lu, Liu, Yu, & Wang, 2008).
In light of these studies, and the inconsistency of their results, within the framework of our study we decided to focus on the primary definition of Personal Innovativeness and examine solely its direct relationship with a user’s intention to try out any new type of IT, i.e. with Behavioural Intention.

Consequently, we hypothesize that:

\[ H_0: \text{Personal innovativeness will positively affect Behavioural Intention} \]

The proposed research model is illustrated in Figure 1.

![Research Model](image)

**Figure 1. Research Model**

### 4 RESEARCH METHOD

For the purposes of hypotheses testing, we conducted a questionnaire-based survey. We also designed a mock-up of a ubiquitous information system, adapted for the museum context and incorporating the following functionalities: dynamic information retrieval regarding the exhibits delivered through multimedia (e.g. video, audio, animation etc), navigational information within the museum space, personalized recommendations based on the visitor’s profile that could be accessible during a future visit as well, provision of information regarding other related exhibitions in other museums, bookmarking and e-mailing capabilities of one’s favourite exhibits and so forth. We also developed a presentation-based walkthrough scenario that described to the participants the use of the mock-up during a typical museum visit. The scenario informed participants that the system’s functionalities were available through the use of sensors and other IT artefacts that could read the visitors’ walking pace within the museum and their position in front of the exhibits, making possible the its continuous and automatic reconfiguration, without the user’s explicit prompt or specialized knowledge on their behalf. Therefore, the aforementioned presentation had as its main objective to help participants feel more accustomed with the features of the proposed system and the scenario was carefully designed so as to ensure that the system’s functionality and distinct characteristics would be adequately understood and appreciated.

#### 4.1 Data Collection

Participants of the study were invited using electronic means. Similarly, all the related material was distributed using electronic means, i.e. through e-mail. The participants were exposed to the mock-up
system and the detailed use scenario through the developed presentation. Overall, the sample consisted of 118 participants. Table 2 summarizes the demographics of the participants.

<table>
<thead>
<tr>
<th>Demographics</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>46</td>
<td>39.0</td>
</tr>
<tr>
<td>Female</td>
<td>72</td>
<td>61.0</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18-25</td>
<td>22</td>
<td>18.6</td>
</tr>
<tr>
<td>26-35</td>
<td>82</td>
<td>69.5</td>
</tr>
<tr>
<td>36-50</td>
<td>13</td>
<td>11.0</td>
</tr>
<tr>
<td>51-65</td>
<td>1</td>
<td>0.8</td>
</tr>
<tr>
<td>Visit Context</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personal visit</td>
<td>59</td>
<td>50.0</td>
</tr>
<tr>
<td>Group visit</td>
<td>59</td>
<td>50.0</td>
</tr>
<tr>
<td>Prior use</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>76</td>
<td>64.4</td>
</tr>
<tr>
<td>No</td>
<td>42</td>
<td>35.6</td>
</tr>
</tbody>
</table>

*Table 2  Descriptive statistics*

The collected data reveal that the majority of the respondents have used in the past similar information systems while visiting a museum (64.40%). A prior experience with such a system ensures a higher level of accuracy of the given answers.

### 4.2 Instrument Development

Most of the instrument’s items were derived from relevant studies. However, since the implementation environment is clearly determined and very different from those examined by previous researchers, many items have been adjusted to better fit the museum context. They were also translated into the participants’ native language, i.e. Greek. The list of items used in this study can be found in the Table 3. All answers were given using a seven-point Likert scale, with 1 representing ‘completely disagree’ and 7 representing ‘completely agree’.

<table>
<thead>
<tr>
<th>Item ID</th>
<th>Factor loading</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE15</td>
<td>0.89</td>
<td>The system would make the visit more interesting</td>
<td>(Venkatesh, et al., 2003)</td>
</tr>
<tr>
<td>PE29</td>
<td>0.83</td>
<td>Using the system would increase my understanding of the exhibits</td>
<td></td>
</tr>
<tr>
<td>PE9</td>
<td>0.79</td>
<td>Working with the system would be fun</td>
<td></td>
</tr>
<tr>
<td>EE5</td>
<td>0.88</td>
<td>I would find the system easy to use</td>
<td>(Venkatesh, et al., 2003)</td>
</tr>
<tr>
<td>EE25</td>
<td>0.87</td>
<td>Learning to operate the system would be easy for me</td>
<td></td>
</tr>
<tr>
<td>EE14</td>
<td>0.75</td>
<td>I would find it easy to get the system to do what I want</td>
<td></td>
</tr>
<tr>
<td>IA24</td>
<td>0.88</td>
<td>Interaction is an important feature for a museum IS</td>
<td>Newly developed**</td>
</tr>
<tr>
<td>IA27</td>
<td>0.86</td>
<td>I believe a museum IS should empower interaction</td>
<td></td>
</tr>
<tr>
<td>IA8</td>
<td>0.83</td>
<td>I believe interaction with my companions is a way of enjoyment</td>
<td></td>
</tr>
<tr>
<td>I22</td>
<td>0.88</td>
<td>I wouldn’t have to concentrate fully on the IS when using it</td>
<td>(D. C. Karaiskos, Kourouthanassis, &amp; Giaglis, 2009)</td>
</tr>
<tr>
<td>I10</td>
<td>0.87</td>
<td>My attention wouldn’t need to be focused on the IS the whole time</td>
<td></td>
</tr>
<tr>
<td>I28</td>
<td>0.84</td>
<td>I don’t need to be intensely absorbed when using the IS</td>
<td></td>
</tr>
<tr>
<td>I26</td>
<td>0.79</td>
<td>The usage of the IS would not disrupt me from other activities</td>
<td></td>
</tr>
</tbody>
</table>
Perceived Behavioural Control

<table>
<thead>
<tr>
<th>Item</th>
<th>Cronbach’s Alpha</th>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>PBC20*</td>
<td>1.00</td>
<td>I have the knowledge necessary to use the system</td>
<td>(Venkatesh, et al., 2003)</td>
</tr>
<tr>
<td>PBC17*</td>
<td>0.80</td>
<td>I would have the resources necessary to use the system</td>
<td></td>
</tr>
</tbody>
</table>

Personal Innovativeness

<table>
<thead>
<tr>
<th>Item</th>
<th>Cronbach’s Alpha</th>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>PI18</td>
<td>0.93</td>
<td>I find it easy to follow advances in the technological field</td>
<td></td>
</tr>
<tr>
<td>PI7</td>
<td>0.91</td>
<td>I am keen on using up-to-date technologies</td>
<td>(J. Lu, et al., 2005)</td>
</tr>
<tr>
<td>PI31</td>
<td>0.81</td>
<td>I usually use the latest gadgets/devices</td>
<td></td>
</tr>
</tbody>
</table>

Behavioural Intention

<table>
<thead>
<tr>
<th>Item</th>
<th>Cronbach’s Alpha</th>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>BI23</td>
<td>0.97</td>
<td>I intend to use the system if it is available during my next visit</td>
<td>(Venkatesh, et al., 2003)</td>
</tr>
<tr>
<td>BI16</td>
<td>0.96</td>
<td>I predict I would use the system during my next visit</td>
<td></td>
</tr>
</tbody>
</table>

* These items were used by (Venkatesh, et al., 2003) to test the respective sub-construct (among others).
** Two experts (first and second authors), after studying the relevant literature, created a larger pool of items for the specific construct. The table contains only those that loaded well on the construct and allowed the later to exceed the threshold for Cronbach’s Alpha index (Table 4).

Table 3  Questionnaire items and factor loadings

5 DATA ANALYSIS

The data were analysed using Partial Least Squares (PLS), a structural equation modelling technique that has become increasingly popular for the purposes of early stage exploratory research (Hein, 1999). Moreover, it was specifically chosen for the purposes of this study as this technique poses fewer restrictions with regards to the sample size and the distribution of the data (Henseler, Ringle, & Sinkovics, 2009). The software used was SmartPLS 2.0.

5.1 Instrument Validity and Internal Consistency

Table 4 presents the results regarding the instrument’s validity and internal consistency. As shown, Cronbach’s Alpha index for all constructs exceeds the 0.70 threshold, ensuring that the items examining the aforementioned variables are consistent. Composite reliability, a measure that examines also internal consistency and which should not be lower than 0.60 (Henseler, et al., 2009), also exhibits satisfying results since all our constructs fit very well above this value. Average variance extracted (AVE) was proposed by Fornell & Larcker (Fornell & Larcker, 1981) as an adequate measure for assessing the amount of variance captured by a latent variable in relation to that due to measurement error and literature suggests that convergent validity can be considered as acceptable if AVE exceeds 0.50 (Hair, Black, Babin, Anderson, & Tatham, 2006), which is the case for all our constructs.

Table 4  Reliabilities, Convergent validity and Discriminant validity

Table 3 presents the items’ loadings on the respective factors. As shown, they all fit well above 0.70, with the lowest loading 0.75 on its factor, thus none was dropped (Hulland, 1999). Discriminant validity is considered acceptable when the square root of AVE of all constructs is greater than all other cross correlations, AVE exceeds 0.50, item loadings exceed 0.60 on their respective constructs and
items cross-loadings are not high (Fornell & Larcker, 1981). Having ensured that items’ cross-loadings are not high and after checking the results in Table 4, our findings suggests that discriminant validity is satisfying for the purposes of an exploratory study.

### 5.2 Hypotheses Testing

Table 5 presents a summary of the results for our inner (structural) model and Figure 2 its graphical representation. In order to test the statistical significance of the direct and total effects, our approach required that we also examined the t-values and p-values via the bootstrapping method for which we computed 5,000 bootstrap samples.

<table>
<thead>
<tr>
<th>Hypotheses</th>
<th>Direct Effects (β)</th>
<th>t-value</th>
<th>p-value</th>
<th>Total Effects</th>
<th>t-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1: EE → BI</td>
<td>0.01</td>
<td>0.10</td>
<td>0.923 (NS)</td>
<td>0.12</td>
<td>1.22</td>
<td>0.223 (NS)</td>
</tr>
<tr>
<td>H2: PE → BI</td>
<td>0.54</td>
<td>4.57</td>
<td>0.000</td>
<td>0.54</td>
<td>4.57</td>
<td>0.00</td>
</tr>
<tr>
<td>H3: PBC → BI</td>
<td>0.00</td>
<td>0.04</td>
<td>0.968 (NS)</td>
<td>0.00</td>
<td>0.04</td>
<td>0.968 (NS)</td>
</tr>
<tr>
<td>H4: IG → EE</td>
<td>0.46</td>
<td>3.58</td>
<td>0.000</td>
<td>0.46</td>
<td>3.58</td>
<td>0.000</td>
</tr>
<tr>
<td>H5: IG → PE</td>
<td>0.58</td>
<td>4.84</td>
<td>0.000</td>
<td>0.58</td>
<td>4.84</td>
<td>0.000</td>
</tr>
<tr>
<td>H6: IG → BI</td>
<td>-0.18</td>
<td>2.91</td>
<td>0.004</td>
<td>0.22</td>
<td>1.61</td>
<td>0.109 (NS)</td>
</tr>
<tr>
<td>H7: IG → IA</td>
<td>0.14</td>
<td>1.21</td>
<td>0.226 (NS)</td>
<td>0.39</td>
<td>2.79</td>
<td>0.005</td>
</tr>
<tr>
<td>H8: EE → IA</td>
<td>0.54</td>
<td>4.82</td>
<td>0.000</td>
<td>0.54</td>
<td>4.82</td>
<td>0.000</td>
</tr>
<tr>
<td>H9: IA → BI</td>
<td>0.21</td>
<td>2.12</td>
<td>0.034</td>
<td>0.21</td>
<td>2.12</td>
<td>0.034</td>
</tr>
<tr>
<td>H10: PI → BI</td>
<td>0.29</td>
<td>3.10</td>
<td>0.002</td>
<td>0.29</td>
<td>3.10</td>
<td>0.002</td>
</tr>
</tbody>
</table>

Notes: EE: Effort Expectancy, PE: Performance Expectancy, PBC: Perceived Behavioural Control, IG: Integration, IA: Interaction, PI: Personal Innovativeness, BI, Behavioural Intention, NS: hypothesis not supported

Table 5 Model Summary

Our results show that the proposed theoretical model manages to predict 64% of the observed variance in the values of behavioural intention. With regards to the developed hypotheses, most of them are supported by our findings. In more detail, Performance Expectancy is found to have the strongest positive impact on Behavioural Intention, while Personal Innovativeness and Interaction have an impact of a similar magnitude.

The collected data did not support our hypotheses for a relationship between Perceived Behavioural Control or Effort Expectancy and Behavioural Intention. Nevertheless, the second factor, that is, Effort Expectancy, did prove to be quite significant for Interaction. Therefore, and since Interaction has a significant impact on Behavioural Intention, we also examined Effort Expectancy’s total effect on Behavioural Intention in hope for an indirect effect, captured through Interaction; however we were disproved since the total effect although apparent it is not statistically significant.

As far as the factor of Invisibility is concerned, the relevant hypothesis is supported, having nevertheless a reversed effect, exhibiting a negative relationship with Behavioural Intention. However, the examination of the total effect and in light of the results for hypotheses H4 and H5 calls for further investigation. Invisibility appears to be highly significant, as expected, both for Effort Expectancy and Performance Expectancy, explaining 38% and 33% of the variance in their observed values, respectively, while not having any significant total effect on Behavioural Intention. Finally, Integration also proves to have no direct effect on Interaction, yet it does exhibit a total effect, apparently transmitted through Effort Expectancy. In the next section we discuss in more detail our study’s findings and make suggestions with regards to the design and development of Ubiquitous information systems.
DISCUSSION

In our study we have investigated the level of acceptance of UIS in the museum context through the examination of visitors’ perceptions and expectancies. Although there are a number of similar models measuring users’ acceptance of IT, to the authors’ knowledge, the proposed model is unique in its character. It examines specifically ubiquitous IS, applied in a non-work environment, considering the occasional basis of using an IS during a museum visit.

The model was developed using constructs from extant technology acceptance theories and the Museum Studies discipline in order to ensure that it also examines the primary objectives of the museum visit. It manages to explain more than 60% of the variance in user behavioural intention and most of our research hypotheses have been validated by the results. Nevertheless, one of the most interesting observations in our study was that Effort Expectancy was not found to have an impact on Behavioural Intention. Similar findings have been reported in the past. Bouwman & van de Wijngaert (Bouwman & van de Wijngaert, 2009) have illustrated in their study that TAM-based factors, such as ease of use, may no longer be as relevant as traditionally considered and other factors, context-based, may be more important, driving the adoption of individual users. In the framework of our study, and drawing some analogy to Bouwman’s & van de Wijngaert’s work, Effort Expectancy appears to have an impact only on the interaction among one’s companions or the interaction with the IS, thus functioning as an integral antecedent. Therefore, for the museum context, our findings show that ease of use is only important so as to allow the user to effortlessly interact with the system, without being obliged to focus her/his attention on the particularities of directly operating it or solving issues relevant to its function. In other words, expectations regarding the ease of use are central for one’s interaction with the museum’s exhibits or her/his peers, if a group visit is taking place.

Next, and in relation with the other TAM-based factor, that is, Performance Expectancy, it is important to highlight that this has been adjusted so as to depict the context of the museum. ‘Performance’ in this study reflects informal education and entertainment, both being among the objectives of visiting a museum (Table 3). Its strong impact on Behavioural Intention suggests that, a prospective visitor expects that a given UIS will enhance her/his experience within the museum premises, offer increased levels of entertainment and enrich its knowledge on the exhibition’s themes.
in a meaningful manner, hopefully also avoiding what is commonly known as ‘museum fatigue’ \(^1\) (Davey, 2005). Our findings attribute particular importance to Integration, one of the central characteristics of the emerging class of ubiquitous IS. Even though it has a negative direct effect and no total effect on one’s intention to use the system, it proves to be of particular importance for other factors. Specifically, within our research model, it functions as an antecedent of IT-related perceptions and exhibits a strong predictive strength over visitors’ expectations of the system’s ease of use and usefulness. Therefore, one can safely conclude that the smooth integration of the ubiquitous information system within the museum premises, along with its various supporting components, works in favour of augmenting IT-related perceptions, allowing the visitor to fully concentrate on the museum experience itself. As such, the visitor unobtrusively navigates around the exhibition space without shifting her/his attention away from the exhibits and without being intensively absorbed in directly operating the IS while taking full advantage of what the system has to offer.

Moving on to the findings in relation to Personal Innovative, our study shows that this factor has the second strongest impact on Behavioural Intention. And indeed, theoretical and empirical studies have shown that personal innovativeness is an important driver forming perceptions and, consequently, one’s intentions. Agarwal & Prasad (Agarwal & Prasad, 1998) suggest that innovators and early adopters require much fewer positive perceptions on a system’s functionalities in order to adopt it over late adopters, while Lu et al. (J. Lu et al., 2005) have shown explicitly that innovativeness is in fact an important stimulus, influencing one’s perceptions toward the adoption of mobile services. Similarly, within the context of the museum, innovativeness appears to be still an important driver. Using therefore an innovative information system as a lever, museums can attract a wider audience from across more age and social groups, especially the younger ones (Rogers, 1983), and succeed in keep them more engaged during their visit on the exhibition’s themes.

As far as Perceived Behavioural Control is concerned, the relevant hypothesis was rejected. Venkatesh et al (Venkatesh et al., 2003) have illustrated that, in the presence of Effort Expectancy, Facilitating Conditions, a construct that contains within it Perceived Behavioural Control, doesn’t have any strength over predicting intentions. This is perhaps the case in our study; Perceived Behavioural Control’s impact on Behavioural Intention may have been captured by the incorporation of Effort Expectancy in our research model. It is probable that, even if there is the necessary infrastructure for the user’s support, the visitor will be much keener in either seeking help from her/his companions or try to understand the system’s operation on her/his own, rather than seek help from the museum’s personnel.

Summarizing, our findings illustrate that the museum context calls for a different approach during the development of ubiquitous IS; one that places a greater emphasis on the context-related factors and transforms the IS from a pure mobile guide into an instrument, smoothly integrated in its surroundings, unobtrusive in its operation, allowing all the while visitors to interact with each other. In addition, our research reveals several features that should be incorporated in the design of UIS for museums. On the one hand, ubiquitous systems should minimize the feeling of imposed learning, enhance entertainment and innovativeness, which all in turn lead to a greater level of knowledge and information absorption. On the other hand, as illustrated through the significance of Performance Expectancy, the available content should be interesting and meaningful to the users so that they can appreciate the interaction’s outcomes and in turn disregard any difficulties they may face while operating the information system.

6.1 Limitations

Our study was carried out under specific restrictions; these should be taken into consideration while one is interpreting its results. Firstly, respondents did not actually use a ubiquitous system; they were instead exposed to a mock up demo that presented the system’s functionality. Although attention was

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\(^1\) Museum fatigue denotes a decrease in the visitor’s interest and selectivity during the visit. This decrease is most often the result of a combination of reasons e.g. visitors factors (cognitive processing, tiredness), environmental factors (architecture, setting, exhibits) among others (Davey, 2005).
given to fully present and describe in detail the characteristics of ubiquitous technology to the respondents and descriptive statistics showed that the majority of respondents have used in the past a similar IS, these results cannot ensure in any way absolute understanding. Next, related to the methodology of conducting our study, our instrument, i.e. questionnaire, measured participants’ expectancies rather than the outcomes of their real interaction with the mock-up or any other system. As such, constructs such as Invisibility and Interaction in fact reflect the visitors’ desires for the optimal museum UIS. Finally, even though our results imply the existence of indirect effects, we were unable to examine for full or partial mediation since restrictions posed from our sample size and the distribution of the data prohibited us from conducting the relevant tests.

6.2 Future Research

As Falk & Dierking (Falk & Dierking, 1992) point out, the surroundings and the social context both play an important role in shaping the museum experience. During our study, we did not cover all aspects of these contexts. Yet, they should be examined within the framework of a future study. Introducing an information system in the museum alters the environment and consequently the experience. In our research, a distinction among the several types of museums was not made and there were no clarifications regarding the nature of the space studied. However, research in Museum Studies shows that, depending on the nature of the museum, its ambience changes demanding a different type of approach. Therefore, future research in this area could perhaps be focused in the implementation of ubiquitous IS in different museum environments in order to fully understand their needs, which can in turn result in their better support by a proposed information system.

Moreover, touching upon the social context, visiting the museum individually or as member of a larger group can have a different effect on the visiting experience and everything else that derives from it (Falk & Dierking, 1992). Looking into Visitor Studies, and more specifically on the work of Hooper-Greenhill [e.g. (E. Hooper-Greenhill, 1994)], as a group, one can consider families, school classes, friends, tourist groups and so forth. Each individual has different needs of information, both in terms of quantity and quality, depending on whether (s)he is visiting the museum independently or entering as part of one of the aforementioned groups. Within the framework of a future study it would be therefore interesting to examine how this context may affect the level of interaction one is seeking when entering the museum, whether there is a need for customisation of the provided material and how it affects the overall individual behavioural intention through multigroup comparison analysis. Further to the social context, within our study we did not examine the aspect of Social Influence as it was difficult to incorporate it given the methodology of our research. However, it is a highly influential construct as shown by numerous user adoption studies [e.g. (Kim, Jahng, & Lee, 2007; J. Lu, et al., 2005; Venkatesh, et al., 2003)] and the “Museum Wearable” system illustrated its importance for adoption purposes. We therefore believe that Social Influence is one of the dimensions that need to be examined in a future research within the museum setting.

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