2018 4th IEEE International Conference on Information Management

e-Tourism and Culture through Virtual Art Galleries

A pilot study of the usability of an interface

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***Abstract* - Virtual tours of museums and galleries are becoming an increasingly common aspect of e-Tourism marketing. This paper reports on a usability pilot study that analyses the design of icons in a German 3-D virtual art gallery interface. It evaluates the extent to which a sample of typical computer users can interpret the meaning of icons from the interface taken 'out of context'. This was done by assessing a sample of twenty-one icons representing the 'action', 'information' and 'navigation' functions. An Icon Intuitiveness Test (IIT) was used to measure their Icon Recognition Rate (IRR) and to classify them as 'identifiable', 'mediocre' or 'vague' according to an adapted stereotypy. The IIT results show that the meaning of almost 30% of the icons was misinterpreted or confused, which can seriously compromise the usability of an interface. Based on these findings, recommendations are made for icon redesign and replacement and it is concluded that further research is needed into the 'learnability' of icons and users' understanding of icons in context. It is contended that increased usability leading to an improved user experience can have an economic impact on e-tourism.**

Keywords - e-Tourism; interface usability; virtual tours; icon recognition; icon intuitiveness; icon design.

I. INTRODUCTION

Virtual tours of museums and galleries are becoming an increasingly important feature of the phenomenon of e-Tourism and its marketing. Popular international virtual tours include museums and galleries such as the Smithsonian Natural History Museum in Washington, D.C. [1], the Louvre in Paris [2] and the Oxford University Museum of Natural History [3]. In addition, there are sites that feature exhibitions that are not site-specific but are grouped according to cultural themes, such as the European Virtual Museum [4], which combines items from various museums in Europe into a series of virtual exhibitions as 3-D images [5].

Icons are an important part of such interfaces. The fundamental purpose of an icon is to enhance the user's performance in carrying out interactive tasks on a computer interface [6]. From the user's point of view an interface is a complex graphical sign system [7] which comprises a number of component signs (e.g. buttons, scroll bars, and icons) which the user employs to interact directly with the computer system [8]. In a graphical user interface (GUI), icons may be symbols, images or pictures [9] that communicate meaning [7] without the need for words [10, 11]. Therefore, icons have the potential to overcome universal language barriers [9, 12], which can be crucial to effective e-Tourism marketing.

Barr *et al*. [13] state that icons are used in computer software as shortcuts to functions (e.g. a printing icon in a word processing package) and are aids to improving the user's ability to recall and recognise functions without needing further instruction [14]. Greater familiarity should therefore allow a greater level of abstraction (i.e. a less concrete symbol). Gatsou [14] cites the work of Nadin who uses a calculator icon to demonstrate the principle, as in Fig1.

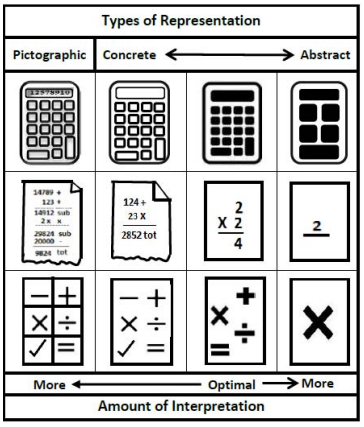

Figure 1. Types of icon representation Adapted from Nadin [18] and Gatsou, *et al*, [14]

This may be overstated, as Scalisi [15] suggests that users may still require an initial period of learning to understand icons through 'visual codification'. Furthermore, icons may be designed to resemble the objects or (functions) that they represent [15] and the closeness of the relationship of an icon to its function is called its 'semantic distance' [16].

Arnheim [17] discusses the relationship between 'concreteness and abstraction', stating that, 'Images can serve as pictures or as symbols; they can also be used as mere signs', implying that increased user familiarity can allow an icon to be simplified yet still preserve the user's understanding.

II. Icon Usability Testing

Icon usability testing is a useful evaluation tool for assessing how an icon accurately portrays its intended meaning. Ferreira *et al*. [19] cite the work of Barr, *et al*. [13] and define an icon as successful, "…if the *interpretant* of the user matches the *object* that the designer had intended with that sign, and [it is] unsuccessful otherwise" [19, p 2]. In other words, a recognisable icon (i.e. 'identifiable') should be easy to interpret and be unambiguous in order for it to succeed.

There are many different icon usability test methods such as Icon Understandability Testing [20, 11], Test with Comparison [12], Matching Method [21], Icon Intuitiveness Testing [22] and Standard Usability Icon Testing [22]. An Icon Intuitiveness Test (IIT) is designed to find out how well users interpret and recognise icons using insight and experience. Nielsen and Sano [22] first mention an IIT as one of the methods used by Sun Microsystems for testing paper-based black and white icons without descriptive labels. Ferreira *et al.* [19] performed a paper-based IIT to assess the participants' ability to identify correctly the meaning and functionality of a particular set of icons. Foster [23] suggests that the test can be administered on a computer or on paper while Bhutar *et al*. [12] conducted a similar 'test without context' using a MS PowerPoint® presentation and paper-based questionnaires.

Bhutar *et al.* [12] state that an icon test should adhere to the following guidelines:

- Icons should not have a text label included in them [22, 24].
- Icons should not be displayed within either the actual or proposed interface (i.e. out of context).
- Only one icon should be visible at a time.

The IIT of twenty individual icons conducted by Ferreira *et al.* [19] used the benchmark of the Organization for International Standardization's ISO 9186 [25] of 66% for successfully recognising icons. However, Gatsou *et al*. [14] cite the work of Piamonte *et al*. and also adopt the more stringent standard ISO 3864 [26] which has a slightly higher benchmark of 66.7%.

This standard is also used in Gatsou's evaluation of 54 mobile phone icons. Gatsou *et al.* [14] subsequently developed a new grading system for correctly identifying icons (i.e. above 66.7 % was considered as 'good' and below 66.7% as 'low') based on earlier work by Howell & Fuchs [27]. An adapted version of this scale is used in the following pilot study.

III. Pilot Study

The research requires an advanced e-Tourism interface as a subject with icons that are capable of a number of different interpretations, and which carry out many functions (e.g. action, information and navigation) and that include sophisticated features. The first of these factors suggests art as a suitable application, while the second and third factors suggest a gallery tour. A search of virtual art galleries on the World Wide Web identified more than 100 possible candidates. A German 3-D virtual art gallery interface (hereafter referred to as Artweb.com) was selected for the test, as it is felt to include a representative range of icons, some of which would not be familiar to users of common software packages. This test examines the users' understanding of icons 'out of context' (i.e. without reference to their use in the interface).

A. Icon Intuitiveness Test

Twenty-one icons were selected for the IIT. This number is close to the recommended number of twenty used in a previous study [22]. A paper-based IIT [19, 24] was adopted as the method of evaluating the icons. The icons were taken at random from the toolbars of the Artweb.com interface and were intended for the functions of initiating action, providing information and carrying out navigation, as in Table I.

TABLE I. Twenty-one Icons Evaluated

Images of twenty-one evaluation icons							
1		2		3		4	
	Action		Action		Information		Navigation
5		6		7		8	
	Information		Action		Action		Navigation
9		10		11		12	
	Navigation		Action		Action		Action
13		14		15		16	
	Action		Navigation		Navigation		Information
17		18		19		20	
	Information		Action		Navigation		Navigation
21							
	Navigation						

The IIT results for all twenty-one icons taken out of context were separated into classes adapted from a study by Howell and Fuchs [27]. According to the Howell and Fuchs

stereotypy, icons achieving 60% Icon Recognition Rate (IRR) or above are classed as 'identifiable', whereas icons scoring less than 60% IRR are 'unsuccessful' in conveying their meaning. Our adaptation further divided these 'unsuccessful' icons into 'mediocre' (30% - 59% IRR), 'vague' (0% - 29% IRR), as in Table II.

TABLE II. ICON RECOGNITION RATE

Icon recognition rate (IRR) classification	
IRR (%)	***Classification***
60 – 100	Identifiable
30 – 59	Mediocre
0 – 29	Vague

B. Test Sample

A total of five regular computer users participated in the test, all native English speakers. A consent form was shown to the participants containing ethical statements explaining the nature of the research, the role of the participants and guaranteeing anonymity and confidentiality. The participants were also informed that they could withdraw from the test at any time.

The choice of a small sample size in this type of qualitative research is based on similar studies of icon usability [22]. The 'richness' of the data required by this type of study means that a sample size of five is deemed to be adequate for a pilot study [22]. There was one female subject and four males - a ratio that is proportionate to the gender balance of the organisation in which the tests were conducted and therefore this is a representative sample.

All the participants were within the age range 20 – 29 years, again representative of the subject population. The participants had not used the Artweb.com virtual interface before, which allowed individuals of different levels of competence to be tested on an equal footing. Eighty percent had experience of using a virtual tour interface and of other 3-D 'virtual worlds. All had more than ten years' experience of using computers, as shown in Table III.

TABLE III. COMPUTER EXPERIENCE IN YEARS

Years' experience of using a personal computer	
Range of experience	***No. of users.***
0 – 4 years	0
5 – 9 years	0
10 -14 years	4
15 -19 years	1
20 -25 years	0

The majority of the subjects fell into the range of 30 – 44 hours of weekly computer usage, with one subject exceeding 65 hours as shown in Table IV.

TABLE IV. COMPUTER USAGE PER WEEK (HOURS)

Hours of computer usage per week	
Range of No. of hours.	***No. of users.***
0 - 14	0
15 - 29	0
30 - 44	4
45 - 59	0
60 +	1

C. Test Procedure

The icon intuitiveness test (IIT) procedure used a variation of the common 'card sorting' technique [28]. The participants were provided with brief details of the test scenario as in previous studies of this type [29]. The test administrator then conducted the IIT with participants individually, each session lasting approximately 45 minutes. The test administrator greeted the participants and introduced them to the test environment and a general description of the IIT procedure was read out from the briefing instruction sheet. The participants were then asked to complete the background information questionnaire and to sign the consent section before proceeding with the test. The icon recognition test booklet was placed face down until the test was ready to begin. The test administrator then shuffled the twenty-one small icon cards (measuring 28mm by 28mm), before placing them face down on the table in a pile. This was to ensure that no bias occurred and that the icons were not grouped in any way (e.g. by spatial association) as they are in the actual interface.

The test administrator then picked up one card at a time from the pile and this card was revealed to each participant at the same viewing angle and distance as in the interface. The participant was then prompted verbally to attempt a reasonable interpretation of the meaning of each icon and was allowed to provide more than one interpretation of a single icon. If a participant was not able to interpret the icon within one minute, he or she was encouraged to move on to the next icon card. The responses were noted in the appropriate column of the icon recognition booklet. When a response was recorded, the test administrator discarded the icon card onto a separate pile and the participant was not allowed to revisit any of the icons. This procedure was repeated until all twenty-one cards had been displayed. An overall results table was produced by calculating the IRR expressed as a percentage for each of the twenty-one icons using the formula:

(No. of correct responses / No. of participants) * 100 = Icon Recognition Rate %.

IV. RESULTS FOR ICONS 'OUT OF CONTEXT'

The IIT results for all twenty-one icons tested 'out of context' were placed into classes (i.e. 'identifiable', 'mediocre' and 'vague') based on the participants correctly interpreting their meanings. In the test fifteen icons (i.e. 71.4%) were classed as 'identifiable', one was classed as 'mediocre' (i.e. 4.8%) and five were classed as 'vague' (i.e.

23.8%). This high proportion of 'identifiable' icons could suggest that the designs were generally successful in this interface. However, the meaning of 28.6% if the icons (i.e. the 'mediocre' and 'vague' classes) was misinterpreted or confused, which could seriously compromise the usability of the interface.

For the purposes of the pilot study a 'traffic light' system was used to indicate the classification, from best to worst, (i.e. green applies to 'identifiable' icons, amber to 'mediocre' icons and red to 'vague' icons) as in Table V.

TABLE V. CLASSIFICATION OF ICONS BY IRR SCORE

Classification of icons as identifiable, mediocre or vague					
No.	*Image*	*Meaning*	*Score*	*%*	*Class*
1		Start Virtual Tour	5/5	100.0	Ident.
2		Previous tour position, pause tour, next position.	5/5	100.0	Ident.
3		Exhibition information	5/5	100.0	Ident.
8		Previous artwork to the left	5/5	100.0	Ident.
10		Play animation button to circle artwork	5/5	100.0	Ident.
11		Pause animation button to circle artwork.	5/5	100.0	Ident.
13		Pan and zoom image.	5/5	100.0	Ident.
16		Information on artwork.	5/5	100.0	Ident.
17		Contact the exhibitor (by email).	5/5	100.0	Ident.
19		Navigation arrow buttons	5/5	100.0	Ident.
5		Help information for navigation.	4/5	80.0	Ident.
14		Next artwork to the right	4/5	80.0	Ident.
6		Full screen of virtual exhibition.	3/5	60.0	Ident.
7		Return to screen to window size.	3/5	60.0	Ident.
18		Close window button.	3/5	60.0	Ident.
12		Slider to zoom in & out of image.	2/5	40.0	Med.
9		Rotate left (anti-clockwise)	1/5	20.0	Vague
15		Rotate right (clockwise).	1/5	20.0	Vague
20		Fast jump to location.	1/5	20.0	Vague
21		Jump to next room.	1/5	20.0	Vague
4		Back to start point of virtual art exhibition.	0/5	0.0	Vague

V. FINDINGS FROM THE PILOT STUDY

Some universal icons from applications with which participants were already familiar (i.e. by prior knowledge and experience) were easily recognised. Icons that were similar to those used in other packages, but which had different functions, were confusing to the respondents and did not match their expectations. The icons that meet the 'identifiable' standard can be maintained, but where icons were only marginally identifiable with a score of 60% (i.e. icons 6, 7 and 18) a small modification may be considered to increase their clarity. The single icon that was classed as 'mediocre' (icon 12) is serving its purpose but requires more fundamental redesign to increase its recognition rate. However, icons that were classed as 'vague' (i.e. icons 9, 15, 20, 21 and 4) all of which are used for navigation should be replaced, perhaps with another navigation method more suitable to a virtual environment, as in Table VI. Some icons may be replaced economically by adopting icons from software that has undergone ISO benchmark tests (e.g. MS Word®).

TABLE VI. DESIGN DECISIONS BY ICON CLASSIFICATION

Icon classifications and design decisions			
Icon Classification	*Icons in class/Total*	*Class %*	*Decision*
Identifiable	15/21	71.4	Maintain
Mediocre	1/21	4.8	Redesign
Vague	5/21	23.8	Replace

It can be concluded from the pilot study that icons that resemble more closely their intended function and do not require prior learning or experience achieve a higher IRR. This reinforces the conclusions of Barr *et al.* [19] that icons are best for representing system qualities or objects rather than navigation. Icons when taken out of context or having more than one meaning and/or function or which may have been encountered previously in another application or context can be confusing or ambiguous according to the user's experience, knowledge and familiarity with that type of interface. In such cases, further contextual information may be needed for these non-standard icons and this should form the basis of further research.

Some icons in the interface appeared to be generic (e.g. the 'question mark') but were used for a more specific purpose, contrary to user expectations. Therefore adding more visual detail to the icons in order to make them more concrete may help users by reducing ambiguity but may initially take them longer to process mentally. In fact, individual designers' adaptation of the same icon for different uses appears to be creating misinterpretations. However, there are other factors which may influence icon recognition. These include the icons' grouping in tool bars, their location on the screen, their navigational function, distinctiveness, colour and boldness.

VI. IMPLICATIONS OF THE PILOT STUDY

The purpose of a pilot study is to provide pointers and guidelines so that further research can be carried out more effectively. Reflection on the pilot study offers the following insights:

A. Icon Evaluation

The IIT in this research concentrated solely on evaluating different icon types with different functions taken from one interface. The study by Ferreira *et al.* [8] using a similar test compared iconic and symbolic signs from different interfaces with the same functionality. In both Ferreira's and our research the IITs were limited to identifying the icons' functionality and meaning in the form of paper-based tests. A more sophisticated and comprehensive IIT could be carried out using technology that would record more information about the users' responses (e.g. interactive MS PowerPoint® slides with key logging). The tests used in the research could also be extended so that the participants could explore the virtual art exhibition interface in context.

B. Sampling and Demographics

The small sample size means that some values were so marginal that one correct or incorrect interpretation of the icon could increase or decrease the success rate by as much as 20%. A larger sample would improve the statistical validity of the tests, but would make it more difficult to capture the same 'richness' of data. Nielsen and Sano [22], who devised these tests, justify the use of a sample of five for this reason. The age range of the participants in the study could be expanded. In the present study all of the users were in the 20-29 year range. A study by Gatsou *et al*. [14] that included participants in the 20-29 to 70-79 age ranges demonstrates that icon recognition declines consistently as the age of the participants increases. It would be interesting to find the reasons for this. Similarly, the participants in our study were all expert computer users with experience of virtual environments. Future research 'in context' could include novice users, which would provide an interesting comparison of the way in which experts and novices interpret icon types.

C. Contextual Considerations

Our study focuses on icons from a single virtual interface taken 'out of context'. Further tests could be carried out to assess the users' understanding of the meaning and purpose of the icons in context – a more realistic evaluation of their functioning in an interface. It would be interesting to experiment with icons in different contexts (e.g. different rooms within the gallery) by carrying out standard usability tests of the same icons with and without textual help. It is therefore planned to carry out further tests of icons in context, which will be the subject of future published research.

D. User Profiling

A user's personal factors such as; prior knowledge and experience, interests and preferences, cognition and learning style can affect the usability of the interface as well as his or her 'immersion' in the virtual interface.

VII. Conclusion

This pilot study with five expert computer users of a typical virtual gallery interface finds that, although the majority of the icons tested (15/21 or 71.4%) are 'identifiable', a significant proportion are not functioning effectively. Of the icons tested 'out of context' 28.6% (6/21) failed to meet the adopted level of identifiability, which is actually lower than the ISO standard for signs. Of these 'unsuccessful' icons, one was classed as 'mediocre' (scoring 40% IRR) and 23.8% of the total (5/21) were in the lowest 'vague' class, having an IRR of 20% or lower. The meaning of one icon was not recognised by any of the participants (scoring 0% IRR). As a result, recommendations are made for improving the usability of e-Tourism interfaces by redesigning or replacing the 'unsuccessful' icons to enhance the user experience. It is suggested that the research needs to be extended to include the same set of icons 'in context'. The next stage could therefore be to use non-functional screenshots of the interface to show the position of the icons and tool bars and other visual clues. A further stage could be to carry out a longitudinal study to evaluate the 'learnability' and recall of the icons over time, as it was suggested by the pilot study that familiarity with an interface can have an important influence on its usability.

Generally, this pilot study has prompted the suggestion that customised icons or buttons are possibly not the best way to carry out the navigation function in a virtual interface. This function is perhaps best suited to newer 'built in' technologies such as 360° VR. However, icons may still be the preferred way for the user to interact with the action and information functions and should therefore be of an optimum design and be used sparingly.

Acknowledgements

We thank all the participants in this research who evaluated the icons and provided detailed interpretations of their understanding of their meaning. We also acknowledge the skill and expertise of the designers and operators of the German virtual art gallery website for providing a rich and useful source of enjoyment to art lovers and material for researchers and students of semiotics and human-computer interaction.

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