Device Impact on User Mobile Infotainment Access

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Abstract. User considerations are paramount when it comes to take up of technologies, and even more so in the case of mobile devices, in which the success of a particular device often depends on its novelty appeal. However, relatively little work has been undertaken exploring how day-to-day tasks are affected when mediated by such access devices. This paper reports the results of an empirical study placed in a 'real-world' setting, in which participants undertook typical infotainment - combined information and entertainment - access tasks on three different wireless-enabled mobile devices. These were a laptop, a Personal Digital Assistant (PDA) and a Head Mounted Display (HMD) device. Our results show that, with the exception of participants' level of self-consciousness when using such devices in public environments, the user wireless information access experience is generally unaffected by device type. Location was shown, though, to be a significant factor when users engage in tasks such as listening to online music or navigation.

1 Introduction

All Portability, convenience and affordability are all factors behind the increase in take-up of wireless devices. Improvements in technology, especially in respect of computational processing capabilities, together with the homologation of the IEEE 802.11 family of wireless networking standards have pushed the barriers of anywhere / anytime information access.

While the allure of ubiquitous information access still has novelty appeal, it is unlikely that appeal per se will still be enough in the future to sway customers to adopt such technologies if the expected infotainment (i.e. combined information and entertainment) return is not going to justify the initial outlay. However, whilst research in the area has focused on themes such as usability, multimodal interaction and haptics [1]-[4], the field of context aware computing has primarily concentrated on application-centred issues [5], and adaptation based on location and device [6]-[8]. Nonetheless, comparatively little work has been done examining the user mobile information access experience when this is mediated by different devices – which is the precise issue we address in this paper.

Accordingly, the structure of this paper is as follows: Section 2 presents an overview of mobile information access devices and reviews work done with respect to user experiences of mobile computing. Such work provides the foundation for our project, whose experimental method is described in detail in Section 3. Whilst Section 4 presents the results and implications of our study, Section 5 draws conclusions.

2 Mobile Information Access Devices and the User Experience

2.1 Laptops

Laptop technology emerged in the late 1980s and hit mainstream computing in the 1990s. Initially, similar to the case of other mobile devices, laptops were beset by issues of bulk and weight, and had comparatively less resources – from memory and processing power viewpoints– than their standalone counterparts. It is only recently, however, with the advent of 3G and WiFi technology that laptops have been able to harness the full potential of the Web wirelessly.

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It is only relatively recently, however, with the advent of 3G and WiFi technology that laptops have been able to harness the full potential of the Web wirelessly. Thus, a study on evaluation of clinical response to wireless technology by Seckman, Romano and Marden [9] focuses on measuring perceived usefulness, easy of use and impact of wireless technologies. Their results show that the nurses were the most frequent users of the wireless laptops, with 86.9 percent, and staff feedback show that the new technology is easy to use with no interference with medical devices. From another viewpoint, Rodriguez et al [10] compared PDA and laptop based versions of a nursing documentation application. In the study, both of the devices were wirelessly connected to the hospital mainframe system to enable collecting and entering patient's data at the point of care. 18 staff nurses participated in this study, selected from local teaching hospitals. They had no prior PDA experience, and their computer literacy ranged between 0.1 and 20 years. The results of the experiment show that it took nurses less time to look for vital signs measurement and acknowledge a pending medical order on a PDA. However it took them less time to read text and enter the vital sings measurements on a laptop.

On the other hand, from an applied computing aspect, Chu and Ganz [11] examined portable teletrauma system that assists health-care centres in pre-hospital trauma care. In this study, simultaneous transmission of patient's video, medical images and electrocardiogram signals, which is required though the pre-hospital procedure, is demonstrated by coupling a laptop computer with a commercially available 3G wireless cellular data service. The evaluation of the system revealed that the tool has the potential in reducing patient mortality when it is used by emergency services personnel to provide immediate care to the patient. However, the quality of the images and video transferred is reduced significantly due to the jitter and the delays caused by 3G wireless network (CDMA) limitations.

2.2 Personal Digital Assistant

Personal digital assistants (PDAs) probably exhibit one of the most popular and easily recognisable showcases of portable computing, manifesting a 28% market growth in Western Europe in the second quarter of 2004 [12]. Nonetheless, they do inherit issues typical of mobile devices, such as small screen size, slow input facilities, low bandwidth, small storage capacity, limited battery lifetime and relatively slow CPU speed [1], [2], [13].

The apparent contradiction between the increasing popularity of PDAs and the above enumeration of problems have made PDAs a popular area of research. For instance, the Power Browser (Buyukkokten, et al., 2000) was created to provide easy navigation in complex web sites using small screen mobile devices. Here, a proof-of-concept application implemented on a Palm operating system PDA uses an HTTP proxy that receives the requests from the mobile user and, based on the request fetches of the user, dynamically generates a summary view to be transmitted back to the client. Top Gun Wingman [13] is another transcoder targeted for the Palm operating system PDAs. Although similar to the Power Browser, this application not only provides ease of navigation but instead also converts the pages, images, and files (Zip / PalmDoc) to a browser-specific suitable format.

2.3 Head Mounted Devices

Head mounted displays (HMDs) are a sub-set of wearable computer technology, which aim to allow hands free access to computer functionality. They consist of two canonical displays, and usually comprise either two liquid crystal display (LCD) or cathode-ray tube (CRT) screens that are either mounted on a helmet or on a glasses-frame structure.

It should also be noted that ergonomic and usability factors vary considerably between different types of HMD devices, with issues such as display size, weight and adjustability of physical and visual settings all affecting the usability of a particular head-mounted display for any specific task [14]. Additionally, the large and encumbering size of CRT-based HMDs is also an identified obstacle towards their adoption [15], as is the current high cost of HMDs that display both high resolution and a wide field of view.

However, despite the computational costs and usability drawbacks of the head-mounted displays, they are widely used in current research, ranging from virtual environments to wearable Internet applications. Thus, the Smart Spaces [16] project promises to implement anywhere / anytime automatic customisable, dynamically adaptable collaboration tools with the use of augmented reality and ubiquitous information access devices. The main driving force of this research is information access anytime / anywhere, whilst the user is engaged in other tasks.

Whilst such application-oriented research is attractive, the emphasis of our study, though, is on the user experience of mobile information access, when it is being mediated by different access devices. Accordingly, in the next section we provide an overview of work in the area.

2.4 User Experiences of Mobile Information Access

Anderson et al. [17] studied experiences with a tablet PC-based lecture system in computer science courses. The proposed wireless system enables collaboration between the projected slide and students' tablet PC, so that either lecturer or students can make notes using digital ink. Evaluation of the developed system in an educational context showed that the new approach increased student attention during lectures by 55 percent.

From a different perspective, Freire et al. [18] developed WebViews, an application which performs transcoding of traditional web content so that it could be accessed via mobile devices. Here, the user creates views of any web content that would like to access on-the-move and saves them into his/her profile. The WebViews server then reformats the profile contents and sends the data to the requesting mobile device (PDA, WAP-enabled phone or mobile phone) accordingly.

Although in their work Gulliver et al. [19] have explored how user perceptions of variable multimedia quality are affected by access devices of different mobility, however, to the best of our knowledge no work has been done exploring how a user's experience of mobile information access is affected by the different access devices that (s)he is utilising. This forms the focus of our current investigation, whose methodological approach we now detail.

3 Experimental Method

3.1 Participants

Participants in our experimental study were aged between 18 – 32 years old and were drawn from various professional backgrounds (students, academics, psychologists, nutritionists, bankers, blue-collar workers). A total of 36 people participated in the study.

3.2 Experimental Variables

Experimental variables in our study included: device type, computer expertise, user location, and task group type. Accordingly, our study incorporated three different types of mobile access devices – a laptop, a PDA, and a head mounted device – all of which boasted varying information display capabilities, as shall be described in section 4.3 and varying degrees of portability (these range from a relatively bulky laptop, to a handheld PDA, to a wearable HMD The experiment took place in two different settings – one was an 'on-the-street' setting, in which participants accessed information whilst physically being on a busy high street bench; the other was a 'coffee shop' setting in which participants accessed the Web from a café. Lastly, as part of the experiments, users were asked to perform two groups of tasks, each of which reflected one of the main reasons behind users' wishes to access Web material–

accordingly, one group of tasks was mainly informational in nature, whilst the other was entertainment-related.

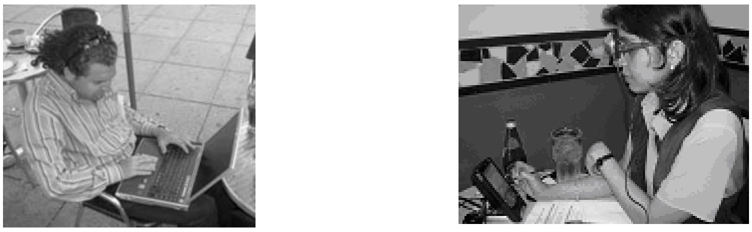
Data was analysed with the Statistical Package for the Social Sciences (SPSS) for Windows version (release 11.5.0). An ANalysis Of VAriance (ANOVA), suitable to test the significant differences of three or more categories, and the t-test, suitable to identify the differences between two categories, were applied to analyse participants' responses. A significance level of $p < .05$ was adopted for the study.

3.3 Experimental Material

Three different types of devices were used in our experiments. The first device was a Hewlett Packard laptop equipped with a 54Mbps Netgear PCMCIA wireless network card. The laptop ran the Microsoft Windows XP operating system, and was equipped with 128MB RAM, a 15-inch screen transflective thin film translator (TFT) screen and a 910 MHz Mobile AMD Athlon XP 2000+ processor (Figure 1a). In our experiments, the laptop represented mature technology.

The second device was an HP iPAQ 5450 PDA with a 16-bit touch-sensitive TFT LCD that supports 65,536 colour. The display pixel pitch of the PDA device employed is 0.24 mm and its viewable image size is 2.26 inch wide and 3.02 inch tall. The device incorporates WiFi 802.11b connectivity as standard and runs the Microsoft Windows for Pocket PC 2003 operating system on an Intel 400Mhz XSCALE processor.

The third and last device employed in our study was an Olympus Eye-Trek FMD 200 head-mounted display. Accordingly, the HMD employed in our study used two LCD displays, each one of which contains 180.000 pixels with a viewing angle of 30.0° horizontal and 27.0° vertical (Figure 1b). Although the HMD by itself is not wireless enabled, it was interfaced via a Lifeview Fly Jacket with the PDA employed in our study, and thus connectivity was ensured



a) b)

Fig. 1. a) On-the-street scenario using a laptop; b) Coffee-shop scenario using an HMD

3.4 Experimental Set-up

Our study involved real participants engaged in real-life tasks in realistic scenarios. These tasks involved users searching for their nearest shopping centre on the Web, and then locating sports stores in the centre, also via the Web. Once this was done, participants had to physically go to the identified sports stores (there were two) and had to obtain price information on a specific good (a sports shoe, in our case), Once this was done, participants had to find the corresponding price for the good over the Web and e-mail the cheapest price found to a friend via e-mail.

The second task was mainly entertainment-related. This comprised users listening to a mainstream online radio station, noting down the details of the track currently being played and then searching for the album cover of the respective track on the Web. Once this was done, users were asked to download the cover on their device for future reference in a music store.

These two tasks were undertaken in two different real world environments. The first involved users accessing the required information needed to fulfill their tasks on a busy high street bench, whilst the second involved users undertaking the same set of tasks in a comparatively secluded café. Both locations were covered by WiFi blankets.

The 36 participants involved in our study were evenly assigned to one of the two environments and, moreover, participants were also evenly distributed as far as the use of the three experimental devices is concerned, with 12 participants being allocated for the laptop, PDA and HMD, respectively.

3.5 Experimental Process

Before undertaking the experiment, all participants were verbally explained that the experiment consisted of two main groups of tasks, which they should accomplish at their own pace. Once this was done, they were given the respective experimental devices they were to use towards the accomplishment of the tasks. Although users did not need to log on to any of the devices, they were given the user name and password needed to log on to the wireless internet service provider employed in the study.

For each of the tasks involved, participants were asked to indicate their opinions on a 5-point Likert scale (strongly agree, agree, neutral, disagree, strongly disagree) to a series of seven statements concerning the tasks (Table 1). Once this was accomplished, users could indicate in writing any further comments that they had about their experience. Lastly, participants were thanked for their time and effort.

Table 1. Infotainment Questionnaire

Information	**Entertainment**
Q1: It is easy to logon to the Internet.	**Q1:**It is easy to navigate through the *Virgin Radio* website.
Q2: It easy to navigate through search results on the device.	**Q2:**It is easy to listen to online radio.
Q3: It is easy to find sports shops in the malls near to you.	**Q3:**It is easy to identify the track that is playing.
Q4: It is easy to read maps on my device.	**Q4:**It is easy to interact with the device.
Q5: It easy to find online prices of the product and make a comparison.	**Q5:**It is easy to do searches on the Web.
Q6: It is easy to send e-mails.	**Q6:**It is easy to access information and save it on my device.
Q7:I am comfortable using the device in a public place	**Q7:**I am comfortable using the device in a public place

4 Results

4.1 Device Impact

A one way Analysis of Variance (ANOVA), with type of device as independent variable revealed that, with the exception of four tasks, across the two scenarios of our study, the particular device type does not have a significant impact on the user information access experience. This observation holds true, even though, as Figures 2 and 3 show participant mean opinions scores for the HMD were (with only one exception) consistently lower than that of the other two devices considered in our investigation. The one exception to this trend is users' ability to identify the currently playing track on the visited online radio station – in the case of the HMD this was facilitated by three factors: the first is that the online radio site had a mobile version tailored for PDA browsers (the HMD accessed the web through the PDA, as previously mentioned); moreover, in this version the details of the current track being played were placed on top of the page, in an instantly viewable location.

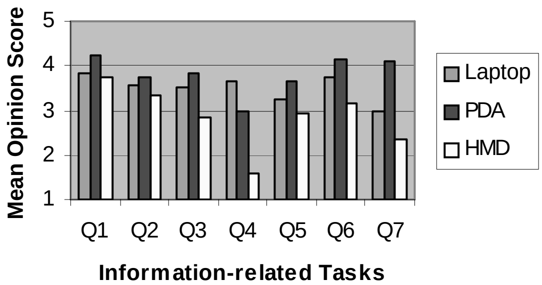


Fig.2. Device Type Impact on Participant Mean Opinion Scores for Information-related Tasks

The particular type of device employed was shown to have a significant impact on the user information access device in the case of reading maps from the screens of the device (F=9.420, p<.01), and users' comfort factor with respect to using a mobile information access device in a public place (F=6.492, p<.01). We believe that reasons for the first finding is that most maps that people found online had virtually unreadable labels – this problem was exacerbated in the case of the small screen PDA, whilst in the case of the HMD, which did provide full immersion, this was done so at the expense of resolution. As far as the second observation goes, the participants who wore HMDs should feel particularly self-conscious in public places, as would those accessing information via relatively bulky laptops – people were most comfortable with using the PDA as an information access device in a public context, which might be one of the main drivers behind their popularity.

In the case of entertainment-related tasks, type of device was found to have a significant effect on users' navigation on the online radio website (F= 4.295, p<.05) and, again, on their comfort factor associated with using a wireless access device in public (F=7.869, p<.01). Whilst we have already elaborated upon what we believe are the reasons behind the latter, we believe that the reason for the former observation lies in the fact that many users found it difficult to navigate through a website using the point-and-tap functionality of the stylus whilst wearing the HMD.

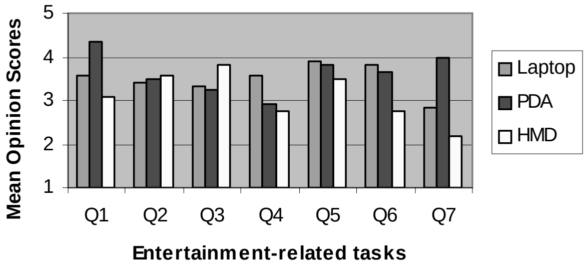


Fig. 3. Device Type Impact on Participant Mean Opinion Scores for Entertainment-related Tasks

4.2 Location Impact

An independent samples t-test revealed that information-related tasks were not affected by the particular location of the user (Figure 4). However, as far as the group of entertainment-related tasks is concerned, navigation ($F=14.331$, $p<.01$) and ease of listening to online radio ($F=11.824$, $p<.01$) was found to be significantly affected by user location (Figure 5).

These results highlight that when a user is engaged in accessing content for informational purposes, (s)he is prepared to disregard possibly detrimental environmental factors such as noise and lighting levels. However, when accessing entertainment related material, levels of lighting (brighter and sunnier in the 'on-the-street' scenario) affect the glare of the device being used, and, as such, negatively impact upon the user experience. In the relative seclusion of a café the experience is perceived to be more enjoyable than when attempted in a busy and noisy outdoors environment.

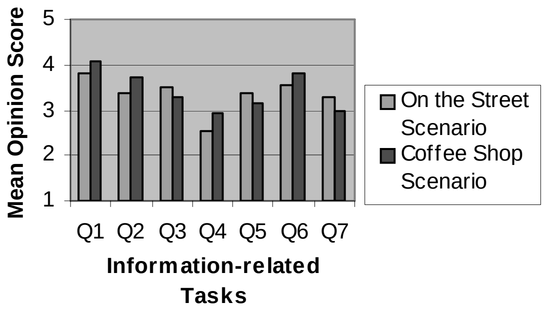


Fig. 4. Impact of Location on Information-related tasks

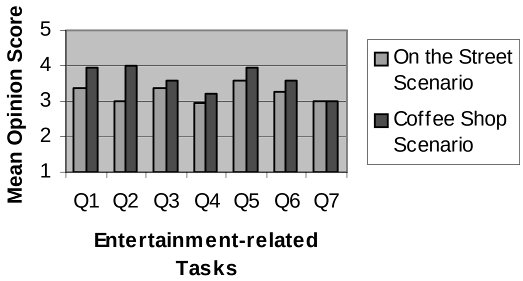


Fig. 5. Impact of Location on Entertainment-related tasks

5 Conclusions

This paper has explored the user wireless information access user experience, when this is mediated by three different access devices. Whilst we recognize that participant sample size could be improved in our study, our results highlight that although mobile device types seem to heighten user levels of self-consciousness in public places – particularly if the device in question is a wearable one – generally the user information experience is unaffected by the type of wireless device responsible for it. Moreover, whilst ambient noise and light do impact on users' efforts to wirelessly access entertainment content; such factors, however, are ignored when informational content is sought, though.

Our work has raised the prospect of interesting future research, the main thrust of which will be covered by context and location-based adaptation, and it is in this direction that our future efforts shall be concentrated on.

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