Usability of Hybridmedia Services – PC and Mobile Applications Compared

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Abstract. The aim is to present results of a usability test of a prototype of a context-based personalized hybridmedia service for delivering product-specific information to consumers. We recorded participants' eye movements when they used the service either with a camera phone or with the web browser of a PC. The participants' task was to search for product-specific information from the food product database and test calculators by using both a PC and mobile user interface. Eye movements were measured by a head-mounted eye tracking system. Even though the completion of the tasks took longer when the participants used the mobile phone than when they used the PC, they could complete the tasks successfully with both interfaces. Provided that the barcode tag was not very small, taking pictures from the barcodes with a mobile phone was quite easy. Overall, the use of the service via the mobile phone provides a quite good alternative for the PC.

Keywords: Hybridmedia, usability, eye tracking, barcode reading.

1 Introduction

Two trends in computer technology can be identified: On the one hand, devices become smaller and more mobile; on the other hand, their interfaces become more complex. For example, mobile phones are more than just telephones: they have developed into multifunctional tools of everyday life. From the end user's point of view this means that the use of computers is more and more demanding.

Even though mobile devices may provide wireless access to the Internet with its potentially useful information and services it is quite clear that mobile phones do not suit very well for the presentation of web-based information. Most of these problems are caused by the small screen size.

Several approaches have been developed to transform web pages to small screens. For example, it has developed methods to summarize parts of web pages on small-screen devices [1]. Several ways to improve reading and information search have also been suggested and designed [2].

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1.1 Reading of Barcodes by a Camera Phone

Mobile cameras can be exploited in barcode reading. Barcode tags of packages are first read with a camera phone, and after that product-related information is delivered to the mobile phone. Barcode reading by mobile cameras provide, in principal, immediate access to relevant information - search phase can be totally skipped. Since there are good reasons to assume that making pictures of barcodes is quite easy after a short period of practice, the mobile application generally provides a good alternative for the PC version of a hybridmedia service.

1.2 Eye Tracking in the Usability Evaluation

There are a growing number of studies on the usability of human-computer interfaces in which eye tracking is used. Eye tracking can supplement behavioural studies by providing more specific information, e.g., about the specific areas of the stimuli that cause problems and cognitive processes that are involved in a particular task [3].

Our previous results suggest that eye tracking is a useful method, but it is only applicable for solving certain kinds of usability problems [3]. We still need more studies on which kinds of problems can be successfully solved by eye-tracking methodology.

1.3 Present Study

The present study is a part of the Finnish project called "A context-based personalized information system for delivering product information to the consumer (TIVIK)". In this project, a hybridmedia service was developed to deliver product-specific information to consumers about foods. The system can be accessed both with a PC web browser or a camera phone, which was used to read barcode tags of food packages.

Our first aim here was to compare the usability of mobile phone and PC-versions of the TIVIK service. The second aim was to study barcode reading by means of a camera mobile phone, and the third aim was to assess the usefulness of eye tracking in the study of usability of mobile phones. An experiment was carried out to test the pilot version of the system in the laboratory while users' eye movements were recorded.

2 Method

2.1 Participants

Eight volunteers participated in the experiment (four men, four women). The mean age of the participants was 31. They were all unaware of the purpose of the experiment. None of them had used the service earlier. Participants were paid for their participation. All of them had experience using PCs and were regular Internet users. One participant did not own a mobile phone, and she had only little practice on its use.

2.2 Apparatus and Stimuli

The PC-version was displayed on a normal PC computer monitor. Display resolution was 1024 x 768 pixels. The mobile device was a mobile phone with a camera (model Nokia 3660). Viewing distance was 70 cm when using the PC service and 50 cm when using the mobile phone.

A pilot service was developed to deliver health-related information to consumers about the nutritional quality of food products. In the prototype the user could obtain product-specific information by reading barcodes of food packages with the camera phone. After reading the barcode, product information is shown on the XHTML browser. The same information could also be accessed with a web browser on a PC. The mobile phone provided basic information about the product. On PC a larger amount of nutrition related information could be examined, and products could be compared.

2.3 Procedure

Eight information search tasks were carried out with the PC and five tasks with the mobile phone. Five of the tasks were common for the two applications. When using PC participants had to search for a particular product, and after that they had to find product-specific information and/or put the product into different calculators that calculated, e.g., the energy content of the consumed food. When using the mobile service the product was displayed on the screen immediately after barcode reading, and the participant's task was to search for product-specific information or put the product into the calculators. Half of the participants carried out the tasks first with the PC application and half with the mobile device.

There were two products for each task. One of the products was used when using the PC, the other one when using the mobile phone.

Participants did not practice the search tasks beforehand. They were provided basic information about the content of the application, and they were asked to read the introductory text that was presented on the portal page of the service. They also read the instructions of the mobile service. After the product search task, reading of barcodes of the packages was examined. Reading of barcodes was practised for about five minutes. The time to accomplish the task was measured and the search performance was measured and video-recorded.

2.4 Eye Movement Recordings

Participants' eye movements were recorded using a head-mounted gaze tracking system (SMI iView^{TM}). A participant's right eye was monitored with a miniature infra-red camera while one infra-red LED illuminated the eye. The scene camera video-recorded the scene the reader was viewing. The eye tracking system was controlled by a PC computer. It computes the centres of the pupil and corneal reflection, from which it can compute the point of regard.

Video images of the pupil and corneal reflections were captured at 50 Hz by the eye tracker. The resolution of the system is better than one degree. The eye movement system was calibrated using a set of 5 screen locations. The participant had to stay immobile during the calibration process. After calibration the participant was asked not to move. However, since the tracker is head-mounted, small movements of a participant's head do not spoil the measurement (SensoriMotoric Instruments, 1999). iView software was used to detect fixations and calculate their durations. Fixation points were identified using a dispersion-based algorithm [4]. To be considered a fixation, a gaze point had to fall within a spatial area between about 30pt x 30pt deg, and had to have a minimum duration of 100 msec. Gaze position in iView is related to the calibration area settings. This area was in the present study 692pt x 278pt.

The eye movement data included the x and y coordinates of eye position and the processed fixations. The data collected were saved for subsequent analysis. The recorded video displayed the current field of view and the superimposed gaze cursor.

We also used an observational method to analyze the eye-movement data. Observer Video-Pro™ application was used in the analysis. The analyses were based on the location of the cursor which was superimposed over the scene. Here we were interested in by which way the user's gaze moves around the device.

3 Results and Discussion

3.1 Basic Findings

Except for the first task, the search for the target product seems to last for 20-40 sec. Because of occasional problems with connection speed, the length of time the product page took to upload was subtracted from the search times.

The completion of the first search task took over six times longer than the second one. One reason for the difficulties is that the titles of the product categories did not provide enough information of where a particular product can be found.

A two-dimensional ANOVA with service type and task as factors was carried out for the study of the completion of a task after the subtraction of search time. The effect of service type (PC application vs. mobile phone application) was significant, $F(1,61) = 12.69$, $p < 0.001$. The completion of a task lasted significantly longer when using the mobile phone. Also, the effect of task was significant, $F(4,61) = 3.06$, $p < 0.05$, and the interaction between service type and task was marginally significant, $F(4,61) = 2.39$, $0.05 < p < 0.1$. For example, the fifth task was the easiest one for the PC application, but it was the second slowest for the mobile application. The comparison of execution times for all tasks when using the PC showed that all tasks requiring the searching for products from product category lists were time-consuming.

We compared search with the PC application to that of the mobile phone for three products. With the mobile application, in order to estimate the total time required, we added the mean barcode reading time to the duration of time required for the completion of the task. According to a two-way ANOVA, the effect of service type and task were not statistically significant, $p > 0.1$, whereas the interaction between service type and task was, $F(2,40) = 5.8$, $p < 0.01$. For the first task, the mobile application performed better than the PC version, that is, the search was faster when using the mobile phone. For the second and third tasks, the search with PC was somewhat faster than search with a mobile phone.

3.2 Evaluation of the Hybridmedia Service

All the participants thought that the information was comprehensible and satisfactory. Product-specific information was quite easily found, even though many of the product names were not familiar to them. Many of the participants also thought that both services were quite easy to use. Many of them, however, blamed the slowness of both applications. There were many reasons for this slowness, for example, the uploading of the service lasted in some cases a long time. For many participants the terms and the product names were quite unfamiliar, and the mobile-phone interface was somewhat confusing.

Four of the eight participants thought that the product information could be better visualized, for example by using images and graphics. Moreover, two participants thought that the width of the PC screen should be better utilized. Since the names of the product categories are not very familiar to people, it might be useful if the same product could be found under several categories. Another possibility is to provide more information of the products. Illustrative pictures of the products could also be used.

Overall, the service was considered to be quite useful. Especially, the exercise counter was considered to be an interesting and useful feature. Most of the participants thought that they might use the service at least on some occasions.

The mean usability score for the mobile service was 6.5, the scores ranging from the minimum of 4 to the maximum of 7; the mean score of the PC service was 7.8, the scores ranging from the minimum of 6 to the maximum of 9. It must be specially emphasized that the participants used the service for the first time, and their evaluations were based on one usage occasion.

3.3 Eye Movement Recordings

According to a two-way ANOVA, the service type had a marginally significant effect on fixation duration, $F(1,61) = 3.3$, $0.05 < p < 0.1$. However, the effect of task was not significant, $p > 0.1$, neither was the interaction between task and service type, $p > 0.1$.

Since the fourth and the fifth task were identical for the PC- and mobile-phone application, we could compare them in respect of the number of fixations they required. A two-way ANOVA showed that the task had a significant effect on fixation number, $F(4,24) = 9.4$, $p < 0.001$, and the service type also had a marginally significant effect, $F(1,24) = 3.94$, $0.05 < p < 0.1$. The number of fixations was somewhat higher when using the mobile phone, partly because the participants had problems in closing the mobile application.

3.4 Qualitative Analysis of Eye Movements

PC-based service. When using PC the participants' gaze moved from the top of the page to the bottom along the product lists. The gaze typically moved from one product name highlighted with a bold typeface to another one and passed by product information that was marked by a normal typeface. Yet, the participants typically did not pass by a target product if its name was visible on the screen. Many participants, however, selected first the wrong item from the product category list. A central problem seemed, thus, to be how to find the right product category.

When searching for a product name from a list, the participants moved their gaze from the top to the bottom and back again. Quite often the wrong category was selected, and the users had to return to the previous page and select another product category. The participants easily failed to notice that the list continued from one page to another. One participant searched for a particular product over six minutes. After that the experimenter interrupted the execution of the task.

When the right page was in view, the product was quite easily found. However, when the list included many products that have a quite similar name, the user typically had to read the list from the beginning until the target was found.

In general, after the product has been found, the participants had no problems to find the searched-for information. In the beginning, the participants had some problems to find the buttons linking to relevant calculators. When using the exercise calculator the gaze easily wandered around the screen before the right button was found. Five of the eight participants did not notice the Compare products -button and thus, they were not able to compare the products by having the text side-by side on two columns.

Mobile service. When using the mobile application the participants typically had no problems to find the buttons of the calculators. However, it was somewhat confusing to them that they first had to select the favourites or food calculator from the list, and after the upload of the product information they had to press a specific button. The participants, thus, had to make two choices in order to add the product to the calculators and favourites.

One participant accidentally logged out from the service, and another one searched for the asked for information over four minutes. Participants did not immediately notice that the information was located under a specific link. Most of the participants had some problems to find the right link from the list of product information. Additionally, some participants had a lot of problems in leaving the service.

3.5 Reading of Barcodes by a Mobile Phone

The duration of time that was needed for barcode reading somewhat differ between food packages. According to a one-way ANOVA the effect of package type was significant, $F(1,7) = 4.5$, $p < 0.001$. The slowest reading time was over 20 seconds longer than the fastest one. The size of the barcode tag can in part explain the differences in reading time. For example, the barcode which was read at the slowest speed was much smaller than the barcode which was read at the fastest speed. The correlation between the size of the barcode and the reading time was not linear, however. The reading of a small barcode was difficult, but when the size of the barcode was above a threshold value its size had no effect on reading time.

The curvedness or the evenness of the surface did not seem to have any effect: the reading of a barcode was quite successful even when the surface was curved or crumbled. However, the level of lightness seems to play some role: If the surface does not receive enough light, the reading of the barcode was quite difficult. During the session, the participants learned to turn the package in such way that its surface was sufficiently lit.

The participants were sitting at the table. Four of the eight participants supported the product against the table or against the knee, rest of them held the package in the air during barcode reading.

The participants tried to keep the package immobile during the barcode reading and move instead the mobile phone as was needed. Seven of the eight participants kept the package in an upright position during the barcode reading, and they turn the package in a horizontal position when the barcode was in an upright position. One participant, however, held the package in a horizontal position during the barcode reading.

4 Conclusions

The main problem with the usability of the PC application was the slowness of the product search. Some products were extremely difficult to find. After the searched-for product had been found, the participants could typically complete the task quite fast.

Reading of barcodes was quite fast and easy. When using the mobile service and when the product is selected by reading the barcode from the package, the product search is nearly an instant process. Therefore, the use of the mobile service is nearly as efficient as the use of the PC-based service.

Despite of this, the mobile service was evaluated much worse than the PC-based service. The problems with the mobile service are more related to the properties of the device than to the properties of the mobile-phone version of the service. Because of small screen size, the product information has to be more densely packed, e.g., the fonts have to be smaller, and the spacing between lines has to be narrower. Input methods are also more cumbersome when using the mobile phone keyboard than using the mouse.

Difficulties with product search were the most serious problem with the PC-based service. The search could be made more efficient by different ways. For example, the product could be found from different product categories; there could be additional information with the category names; and the content of the categories could be illustrated by pictures. If the number of products in a category is large, the search based on product names is the easiest and most convenient way to find the searched-for product. It is important that the search based on product names often led to a successful result even when the participant did not know the exact name of the product.

Since most of the information is presented on PC as vertical lists, the user has to scroll the content. Since the list often continues from one page to another, the reading of this kind of list is often cumbersome. The user may also fail to notice that the list continues from one page to another. One possibility is to better utilize the width of the page when using the PC-based service.

In sum, our findings suggest that even though the PC-based service was thought to be more usable than the mobile service, the completion of the tasks was comparable to that of the phone camera-based service. Overall, mobile service is thus a considerable alternative, and reading of barcodes is not a serious problem. Additionally, our results suggest that eye tracking and eye movement analysis can support traditional usability evaluation methods. For example, eye movement data could provide quite specific information of the users' behavior during task execution.

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