Reading with Mobile Phone & Large Display

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Abstract

In this paper we compare performance and usability between three different device combinations: a) mobile phone b) touch screen c) mobile phone & screen. We show that mobile phone & screen has a better performance than phone only. We also discuss some interaction issues when using a mobile phone with a large screen.

Keywords
User Study, Mobile Phones, Public Displays

ACM Classification Keywords
H5.m. Information interfaces and presentation

Introduction

Interaction with information-rich content is difficult on mobile devices due to the small screen size. One approach to solve this problem is to spontaneously connect to public displays [1] and frameworks have been proposed to support a screen-on-demand [2, 3]. For example a painting program uses a large screen as canvas and a small device as a toolbox, similar to a paint palette creating one interface across two devices [5]. Many studies have looked at small personal devices interacting with shared public displays, in terms of collaboration and privacy [4, 6]. However, little is known about how interaction with two devices (mobile phone

& screen) compares to a single device (touch screen or mobile phone) in terms of performance and usability. To address this, we conducted a user study comparing performance and usability of a mobile phone & screen against the two individual devices (touch screen, mobile phone only).

This paper presents firstly the design of the experiment, followed by the results and their discussion. We finish with a conclusion and look at future work.

Experiment

The aim of the experiment was to compare people's reading performance in three different conditions: a) mobile phone b) touch screen c) mobile phone & screen. The large screen allows users to scan the text faster while the high familiarity with mobile phones speeds up text entry. We proposed the following hypotheses:

H1: Users' completion time is faster for mobile phone with public screen than for mobile phone only.

H2: Users' completion time is faster for mobile phone with public screen than for touch screen only.

H3: Ranking the device conditions for ease of use and perceived speed, the mobile phone with public screen condition will be ranked as easiest and fastest.

Design

The experiment design is a within-subjects design with one independent variable, device combinations. This has three levels: mobile phone, public display, mobile phone & screen. The order of presentation is randomized using a Latin square.

For the reading and comprehension task, we compiled three different task blocks. Each block consisted of four random texts from Wikipedia[8], each about 270 words long. From the text, one sentence was chosen and displayed separately with a word missing. Participants had to scan for the sentence, identify the missing word and enter it in the text entry field on the bottom of the screen. Within one block, participants read four different texts and enter four words. For each device combination, participants complete one block. The blocks are randomized over the device combinations using a Latin square.

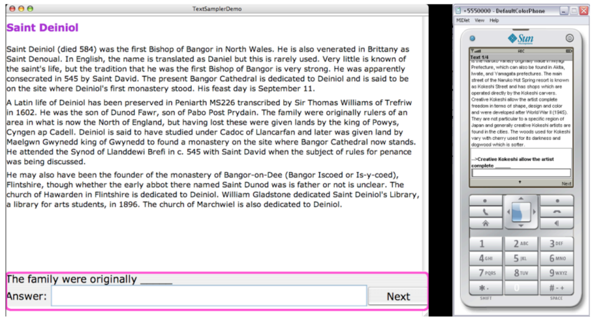

figure 1 Screenshots of the independent applications: On the left the touch screen with text entry, on the right side the mobile phone with part of text and text entry widget.

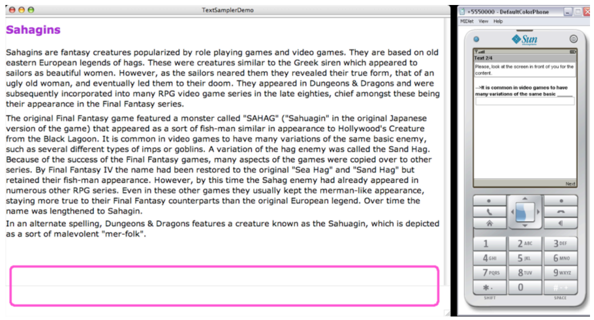

figure 2 Screenshots of mobile phone & screen.

Apparatus
Three applications were implemented.
Touch Screen: A Java application ran on a Powerbook G4, displaying the text and entry field, see fig.1 (screenshot) and fig. 4 (setup). A SmartBoard SB580 was attached to the Powerbook G4 and served as a touch screen. A NEC MT1065 projected the application on the board producing a screen size of 113x72 cm, with a resolution of 1024x768px.
Mobile Phone: A J2ME application ran on a Nokia 3110 mobile phone, with a 128x160px resolution and 2.8x3.5cm screen dimension, displaying the text and entry fields, see fig.1 (screenshot). The phone was not in the predictive text mode.
Mobile Phone & Screen: A Java server-client application ran on the Powerbook G4 and mobile phone. The devices communicated via Bluetooth with each other. The interface was distributed across the two devices; the text widget was displayed on the large screen while the entry box with the missing word was on the mobile phone, see fig. 2 (screenshot) and fig. 3 (setup).

Procedure
Participants were first introduced to the task: The investigator showed the participant a short text on paper, explaining the missing word task. Then, participants tried the paper example on the mobile phone and on the touch screen. This ensured that they were familiar with the text entry method of all combinations.

When they had performed the training task, the investigator started the experiment. For example, one participant completed the task block on the mobile phone, followed by a questionnaire about the usability. This was then repeated for the two other device combinations, touch screen and mobile phone & screen.

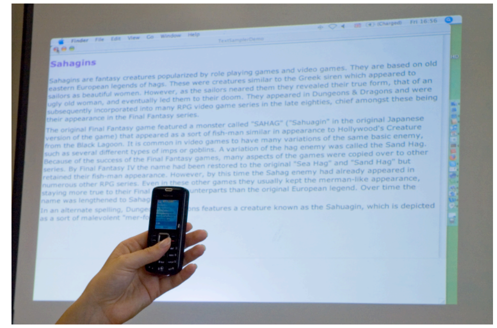

figure 3 mobile phone & touch screen setup.

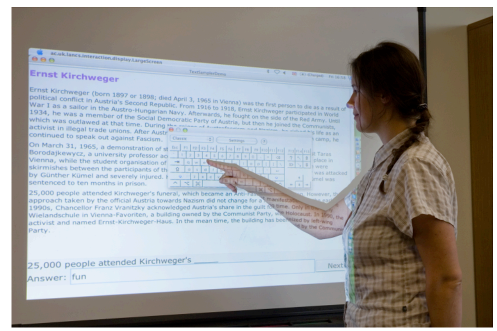

figure 4 touch screen setup.

Finally, the investigator conducted a semi-structured interview: participants ranked the device combinations according to the ease of use and to the perceived speed by explaining their choice. They were also asked whether they would use mobile phone & screen in reality.

Participants
15 participants took part in the study, 4 female (26.7%) and 11 male (73.3%). The average age was 29.9 (SD=4.8), 66.7% were postgraduates while 33.3% were University employees. Only one participant did not have a mobile phone, and 80% of the sample used the mobile phone on a regular basis. Features such as phone calls (93.3%) and text messaging (73.3%) were most often used on a regular basis. The built-in camera and address book was used by 46.7% while only a few people used features such as email, MMS, Calendar, Games or Video.

Results

We first present the task completion time, followed by the ranking results and conclude with the qualitative results of the device configurations.

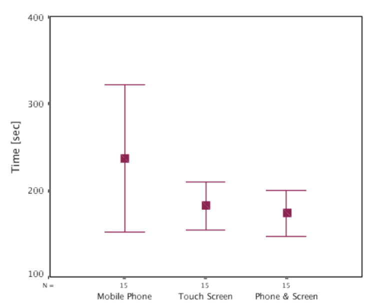

figure 5 Completion time of the three device combinations

Fig. 5 plots the error bars of the task completion time. It is clearly visible that the average of completion time is lower for the touch screen (M=182.9, SD=50.0) and mobile phone & screen (M=173.6, SD=47.6) than for the mobile phone, (M=236.8, SD=153.6). In fact, times for the mobile phone ranged from 127 to 705 seconds. The task completion times in the mobile phone condition D(15)=0.26, $p<0.05$ were significantly non-normal.

For transformation, the function $f(x)=100/(x+1)$ was used to make the set distributions normal. On average, participants completed the task significantly faster on the mobile phone & screen (M=0.52, SE=0.05) than on the mobile phone only (M=0.61, SE=0.05, $t(14)=2.21$, $p<0.05$, r=0.51). In this respect, the data supports our first hypothesis (H1). In contrast, participants did not complete the task significantly faster with mobile phone & screen (M=0.61, SE=0.18) than with the touch screen only (M=0.57, SE=0.04, $t(14)=-0.89$, $p>0.05$), and therefore the data rejects the second hypothesis (H2).

There was a significant association between the device combination and whether it would be ranked as the easiest to use $\chi^2(4)=18.8, p<0.05$. This seems to represent the fact, that two third (66.5%) chose the mobile phone & screen as the easiest to use while 66.5% chose the phone only condition as the most difficult (see tab. 1).

Rank	Mobile Phone	Touch Screen	Phone& Screen	Total
1st	0	5	10	15
2nd	5	6	4	15
3rd	10	4	1	15
Total	15	15	15	45

table 1 Device Configuration Ranking for "easy to use"

There was also a significant association between the device combination and how participants perceived their task completion speed, $\chi^2(4)=18.8, p<0.001$. This seems to represent the fact that 80% perceived mobile phone & screen as the fastest to complete the task. Both rankings therefore support our third hypothesis. The majority of participants ranked the mobile phone & screen as best.

Rank	Mobile Phone	Touch Screen	Phone& Screen	Total
1st	2	1	12	15
2nd	8	4	3	15
3rd	5	10	0	15
Total	15	15	15	45

table 2 Device Configuration Ranking for "perceived speed"

Errors

During the task, we also logged the text input. Only one participant produced one logged error in the mobile phone & screen condition. The participant wanted to correct the misspelling but chose the wrong button on the mobile phone. A few other participants noted the buttons of the mobile phone were a problem. "I was really scared of pressing the wrong button when scrolling. I did not want accidentally finish the trial", explained another participant in the study. The "Next" button to receive the next text was the large middle button of the phone. To scroll the text, participants used the same button but the edges of it.

Qualitative Data

In each questionnaire, participants were asked to write about aspects they liked or disliked about the device combination they had just used.

Mobile Phone: 11 participants disliked the scrolling of the mobile phone, followed by the small screen of the device (7) and the cognitive load of remembering the question (1). On the other hand, 4 participants found the phone easy to use. Other positive aspects mentioned by participants were: their focus is on a single device (4), there were no fixed location constraints, so were able to sit down during the task (2), responsiveness was high (1) and they found it fast (1).

Touch Screen: All participants mentioned projector occlusion and distortion of the projection as a dislike. We explained this as an artifact of the "simple" touch screen construction and asked them to focus on other issues. 7 participants disliked the on-screen keyboard because it either occluded the text or question. Other negative aspects were: forwards and backwards movement for interaction (3) and difficulties keeping their hands raised for a long time (1). On the other hand, 10 participants liked the large screen. Other aspects such as familiarity with keyboard (1), easy to use (1) and fun (1) were mentioned too.

Mobile Phone & Screen: Using the phone for text entry without prediction was mentioned most often as a negative aspect (6). Another negative issue was the switching between devices (5). Also mentioned was the amount of scrolling required for longer sentences (2) and the "Next" button of the phone (1). On the other hand, 9 participants liked the additional large screen for the task. Other positive aspects were entering the text by phone (5), less location constraints (2), clarity of display (1) and enjoyable to use (1). One person in particular liked the division of the widgets for the task.

Discussion

Looking at the first hypothesis, participant's completion time was indeed faster when they had an additional screen with the mobile phone. However, there was no real increase in performance when mobile phone & screen was compared to the touch screen. This was surprising because we thought that typing text with phone would be more efficient than with an on-screen keyboard. And indeed, looking at the perceived speed (table 2), only one person thought that touch screen was the fastest and only 5 people the second fastest.

When ranking the devices, our hypothesis was again confirmed, however we were still surprised that the mobile phone (as a single device) received more second places than the touch screen which we had originally expected.

From the qualitative results we found it surprising that participants mentioned that working between two devices was confusing. We thought that the separation of concerns was similar to the one of having two screens on a computer that was described in Tan et al. [7]. However, there is a larger distance between the two screens. Depending on the position participants chose for interaction they had to move their heads up and down. We think that the mobile phone & screen was perceived as two entities rather than one (as would be the case with two screens attached to a PC).

As reported in the results, 3 people reported that they didn't like the moving forwards for typing and backwards to adjust the distance for reading. Also, the "Next" button was not in an optimal position for all participants. One participant in particular complained about the physical effort for the interaction. Keeping hands raised for typing can be very exhausting and needs to be taken into consideration for wall mounted touch screens.

In the final interview, all participants could imagine using a large screen-on-demand, especially when mentioning scenarios such as navigation, timetables or sharing videos. This contrasts with issue of focus that was mentioned when having to divide attention between two devices. We believe that there is a trade-off between added benefit and problems with division of attention.

Conclusion

We compared mobile phone & screen performance with touch screen and mobile phone only, for a reading and text entry task. We found that mobile phone & screen increased performance compared to the mobile phone only. We learned that all participants liked the idea of screen-on-demand, however some reported that the division of focus between devices was an issue. Further investigation is needed for clarification.

Acknowledgements

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Citations

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