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Mobile Application Development to Measure Smartphone Screen Readability

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Abstract

This study aimed to develop an application which can be used to measure the response time needed by subjects to find a set of predetermined "words" in order to determine the level of readability of smartphone screen. The development steps began with concept development, interface design and software testing and verification. The results of this study is a software which can be used for typography experiment in which the subject is asked to find a predetermined word. The software could be used for the experiment of 4 typography factors i.e font style (FS), font size (FZ), contrast (CT), and screen rotation (SR). This software could be used for the 5x3x2x2 factorial experiment with 60 combinations. The response time of subject for each treatment combination has been computed and saved in the smartphone. Finally, the response time could be used to determine the best combination of factor and level factor for readability of smartphone screen.

1. INTRODUCTION

In the last decade, the technology has growth rapidly, changing the way of the people in using the tools they use. In digital technology, the rapid development has caused a shift in information media from printed to electronic media, such as online news sites and social media. The people as the readers have a high tendency to be more interested in materials from the electronic mode rather than the printed media.

The technology is ever evolving, providing users with more and more convenient ways. In this regard, personal computer, notebook and old-fashioned cellphone have been replaced with smartphone. Smartphone, which is portable and more convenient for user to browse information has become a part of life style. Searching information, reading text from internet source, texting friends have become a few daily routine activities for almost majority of people through smartphone. The popular use of smartphone has shifted the urgency of reading from traditional printed documents to reading online information through its screen. This shift has changed the way we read and understand text, as reading text on the screen is different from reading printed document (Erdogan, 2008; Ferrari and Short, 2002).

Taking these facts into account, it is necessary to choose the appropriate typographic factors to enhance the readability of text on the smartphone screen. One of the seldom highlighted issues related to text and font was readability, which refers to the level of easiness in reading, where among the common influencing factors affecting the readability is spaces, font size, and font type (Landa, 2006; Yoshida, 2000). The selection of most appropriate font for a screen display is still debatable among web developers and typography researchers. Many studies have been conducted to determine the best font–serif or sans serif–in terms of readability and reading (Yanto, 2018; Yanto and Lu, 2015; Ling and van-Schaik, 2006; Bernard et al., 2002). However, smartphone has different font style from computer screen. Until this time, there is no research that has examined the readability on smartphone screen, hence there is lack of information regarding factors affecting the readability on smartphone screen.

There are many factors which can be considered for effective smartphone typography such as font type, font size, spacing, color screen, text rotation, and background color. Each text information appears on smartphone screen consists of combination such typography factors. In order to help the researchers to conduct research regarding typography of smartphone screen, a software need to be developed. Therefore, this research aimed to develop the software which can be used to measure

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the response time needed to find a set predetermined words in order to determine the level of readability of smartphone screen.

2. METHODOLOGY

The development steps follow the traditional life cycle model (Bennett et al., 2002) which are the following: *system engineering, requirement analysis, design, construction, testing, installation and maintenance*. The steps in this model were modified so that the development follows three stages, *concept development, design of interface and construction* and *software testing and evaluation.* Similar steps has been used by Lukas et al. (2013) and Bachri et al. (2011) and Yanto and Natasha (2012). In concept development stage, user needs and technical requirements were addressed. In the design of interface, technical requirements were translated into design interface. Finally, the software was tested and verified prior to using for experiment.

2.1 Concept development

In this stage, the researchers identified the users' needs for the software. The needs were obtained by interviewing the lecture as well as studying from literature related to the readability of smartphone. Subsequently, the identified user needs were addressed into the shape of technical requirements. The technical requirements were obtained through discussion between researchers and software developer.

2.2 Design of interface and construction

In design of interface stage, the process was divided into 3 section, the development interface *for input data, typography experimental function*, and *displaying output*. For input data, the user needs to obtain personal data and response time. For *typography experimental function*, the software was targeted for the experiment of 4 typography factors i.e. font style (FS), font size (FZ), contrast (CT), and screen rotation (SR) in which font style has 5 levels, font size with 3 levels, contrast and screen rotation each 2 levels. In general, this is 5x3x2x2 factorial experiment with 60 combinations. Each 60 combination appears randomly for each subject during the experiment. Considering this, 60 pages were design, each consist represented one treatment combination. For each combination, the response time of subject to find a word was measured. Following experiment, the results of 60 response time were obtained through a series of task consisting 60 combination for each subject.

The response time for each subject for each 60 combination were automatically saved into database. To enable the researchers to analyze the results through a series of statistical test, an interface to display output was provided. In this page, the researchers could get personal information and results of response time for each subject as well as response time for all subject. In addition, the software was targeted to have a function to export data into Microsoft Excel format.

Once the completed design finished, it was translated into program code by software developer. During this stage, intense communication and discussion between software developer and researchers were needed. A few revisions were done until the final construction was obtained.

2.3 Software testing and evaluation

Prior to testing the software for the subject, the researchers verified all the function whether it met the user needs or not. A set of checklist was prepared for verification purpose. Subsequently, the trial testing was conducted by involving 20 students. This testing aimed to find out whether requirements have been met by using black box testing. During the test, the participants were asked to find out the predetermined "word" for 60 combination and their time for each treatment were calculated and recorded by the software. A test was also conducted to investigate whether the application could be exported the data into Microsoft Excel format.

3. RESULTS

3.1 User needs and technical requirements

Table 1 presents the user needs and technical requirement of the mobile application. The user needs were accommodated by software developers through a set of technical requirements. Technical requirements reveal the relationship of user needs with technical aspects of intended software.

3.2 Results of user interface

Figure 1, Figure 2, Figure 3, Figure 4 and Figure 5 present a few results of user interface for the software. Figure 1 is the welcome page of the software. When the subject opens the application, the first page appears is the menu page (see Figure 1). There are 3 buttons on the menu page, *start, help* and *records*. The start button will direct the user to the information page (Figure 2). In this page, the user need to fill personal data before doing a set of experimental task. When help button is clicked, the users will be directed to the pages about how to use the program (as seen in Figure 4). When the *records* button is clicked, the personal data and results of experiment could be seen (see Figure 5).

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Table 1.

User needs and technical requirements

User needs	Technical requirements
The software could be used for smartphone	The software was designed and developed so that it could be installed on smartphone with screen size 4" or more.
The software has a page to enter demographic data of subject	A dialog box was created containing typical demographic of subject
The software has a page to help the researchers how to operate	A dialog box was created containing step by step how to operate the software
The software could display 60 combinations of treatment and count the response time for each subject to find out a predetermined "word" during the experiment	A set of 60 pages of dialog box representing each treatment combination was created. In each page of a set of 60 dialog boxes, the time for each subject to find out a predetermined word and sequence were displayed. The software could automatically save the response time for each combination for each subject
The software could present individual experimental data (response time) of subject after the experiment	A push button was created on the help page to display the information according to subject The software could present data individually as well as total data of the participants
For the reason of statistical analysis, the format results (response time) could be changed into Microsoft Excel format	An additional function was added so that the experiment results could be exported to Microsoft Excel format.

Tabel 2

Evaluation of user needs and

No	User need verification for software function	Software	Verified ?	Note
1	The software could be installed on the smartphone	yes	✓	
2	Welcome page and Logo could appear on the smartphone screen	yes	✓	Logo need to be added
3	Menu choice on the welcome page could be displayed	yes	✓	
4	Demography data of subjects could be entered	yes	✓	click "start" button first
5	Software could displayed 60 pages for treatment combination of typography experimental test	yes	✓	
6	The 60 pages for treatment combination could be appeared randomly during experiment	yes	✓	See Figure 3
7	The random sequence of 60 pages for treatment combination could be displayed	yes	✓	See Figure 3
8	The software could automatically count the time for each subject to find a predetermined "word" in each 60 pages of treatment combination	yes	✓	
9	The software could automatically save the time for each subject to find a predetermined "word" in each 60 pages of treatment combination	yes	✓	
10	The user could accessed the response time for each subject to find a predetermined "word" in each 60 pages of treatment combination.	yes	✓	
11	The results (response time) for each treatment combination and each subject could be displayed to the users	yes	✓	
12	Experimental data results could be exported into Microsoft Excel format	yes	✓	See Figure 5

Figure 1.
The menu page of mobile application

Figure 2 depicts the page that will appear after the user clicked start at the menu page. This page contained questions about user's information which must be filled by the user to continue to the next page. As can be seen in Figure 2, the user's information consisted of name, NIM (student ID number), age, daily smartphone usage (in hour), gender, whether user wears glasses or not and the powers of lenses (if the user wear glasses). After the user filled out all the questions, the user can click on start button and the page will be directed to the task page as shown in Figure 3. After the start button clicked, all information will be saved automatically in database and can be seen on the record page which was shown in Figure 5.

Figure 3 showed 1 of 60 tasks that must be done by each subject. Each page contained 1 task which was a combination of level factors, there were 60 task pages in total. At the top of the page, few information about the task were showed, which were the current time, task sequence, and sample number. In figure 3.11, the information at the top of the page showed that the current time spent on that page was 5,34 sec, the current task was the 1st task out of 60 tasks, and the subject was the 75th subjects in the experiment. Below the information was the command to find certain word in the box. In Figure 3, the command was to find the word "shiver". And below the command was a box that contained a group of words that have the same initial letters and similar word structure. When the subject found the word "shiver" in the box, the subject had to click that word. If the subject clicked on the right word, the text "Correct, your time is …" and "Next" button will appear. But if the subject clicked on the wrong word, the text "False" will appear and the subject had to find the right word to make the "Next" button appear to be able to proceed to the next task.

Figure 2.
Users' information page of mobile application

Figure 3.
Task page of mobile application

Figure 4 showed the page that will appear if Help button on the main page was clicked. There were several pages that will show the directions on how to use the application. Before the subjects start the experiment, the subjects will be asked to click the help button first, so the subjects will get the picture of application appearance and how to do the tasks. The intention of this step was to reduce the bias caused by task sequence.

The output page will appear when the Record button on the menu page was clicked. The appearance of output page was shown in Figure 5. Figure 5 showed the page that will appear if Record button on the main page was clicked. Record page will contain user's information that was asked on users' information page and the response time needed to finish each task. The task column showed the treatment from the 1st to 60th. The time column showed the time needed to finish each task. The sequence column showed the order of task appearance to prove the random function on task sequence. The row and column showed the position of the word that must be found to prove the random function on word position. In the bottom, there was a button to export all data to Ms. Excel.

Figure 4.
Help Page of Application

3.3 Verification and Testing

Table 2 shows the results of verification by the researchers. For each 12 checklist criteria, the researchers checked the function of the software. Based on verification, the researchers inferred that the software was verified for all functions which were required, and hence it was ready for the typography experiment.

In this study, the software was tested according to what is known as black box testing. Using this approach, test data is put into software using experimental test by participants and the output are seen through record page. The response data could also be exported into Microsoft Excel format. Figure 6 presents results of the response time of the 20 participants for 60 treatment combination which were exported into Microsoft Excel format.

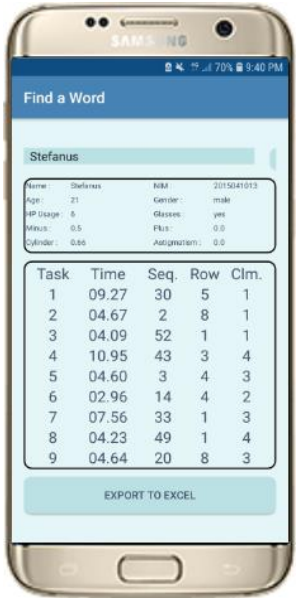

Figure 5.
Record Page of Application

4. DISCUSSION

In this study, a software aimed to be used to measure the response time of subject to find a set of predetermined "words" has been developed. It has pages to enter demography and experimental data of participants. For the response time, a set of 60 combinations of smartphone readability test could be measured. The 60 combinations were obtained from 4 typography factors i.e font style (FS), font size (FZ), contrast (CT), and screen rotation (SR).

In testing any component of the system, the aim is to find out if its requirements have been met (Bennett et al., 2002). In this study, the software was tested according to what is known as black box testing. Using this approach, test data is put into software and it produces some output, but the testing does not investigate how the processing is carried out (Bennett et al., 2002). During the test, the participants were asked to find out the predetermined "word" for 60 combination and their time for each treatment were calculated by software. The results showed that the software could produce the output i.e. the responses time for each 60 combination (as presented in Figure 5). Hence, the software passed the testing and ready to be used for the experiment of smartphone readability.

Future study suggested that the testing could also investigate the ease of operation and users' perception of the software. For instance, prior study by Lukas et al. (2013) tested the software by combining usability test and preference test. The results showed high and positive correlation between the ease of operation and users' perception. Similarly tests have also been done by Yanto and Natasha (2012) and Bachri et al. (2011).

5. CONCLUSION

This study aimed to develop a software to be used to measure the response time needed by subjects to find a set of predetermined "words" in order to determine the level of readability of smartphone screen. The development steps began with user needs identification, technical requirement, user interface design and testing and verification. The results of this study is a software which can be used for the experiment of 4 typography factors i.e font style (FS), font size (FZ), contrast (CT), and screen rotation (SR). This software could be used for the 5x3x2x2 factorial experiment with 60 combinations. The response time of subject for each treatment combination could be computed and saved in the smartphone. Finally, the response time could be used to determine the best combination of factor and level factor for readability of smartphone screen.

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