Comparison of Mobile Input Methods

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Abstract. This paper presents the results of an experimental study that compared the usability of four different input methods in the context of smart phones with touch screen property. Twenty users were asked to fill in a questionnaire with four different input methods which were radio button, text field, spinner and button. Time required to fill in the questionnaire and the errors occurred were recorded. Overall, radio button was found to be the fastest by causing no error while text field was found to be the slowest input method and more error prone. In addition, participants were asked about their perceived performance before and after filling in the questionnaire. These results were compared with their actual performance. Most of the users could not predict their performance before use and many of the participants still could not make correct predictions about their own performance after use.

Keywords: Mobile input methods · Performance of mobile input methods · Perceived performance

1 Introduction

Interacting with mobile technologies has been widespread since the use of smartphones has increased. Nowadays, these devices are used to perform many of the daily routines conducted with computers such as social networking, gaming or entertainment [1]. People connect web through their smartphones as well. Therefore, they come across form elements on their mobile devices to input information. Users have to fill in forms to buy goods in an e-commerce website, to join a social network or to get their things done with productivity based applications such as online banking. Form elements stand between the goals of users and applications and unusable web forms lead to loss of users [2]. Thus, the research subject of usability and effectiveness of form elements has been carried to mobile context.

Developers of mobile applications should consider usability issues related with form elements to get information timely and accurately from their users with satisfaction. Although there has been substantial research conducted related to usable web form elements [3–5], to the extent of our knowledge, there are not any studies conducted with form elements accessible through mobile devices. In traditional web environment, the mostly studied form elements for performance and satisfaction were

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button, radio button, text field and drop down buttons [4, 6–8]. While text field is advantageous in that it enables inputting free form of data, it is a slower input method. On the other hand, button, radio button and drop-down box are used to gather input from pre-determined options [9]. In the mobile context, since the display area is much smaller than traditional web environment, screen real estate becomes another major concern. In this study, an experiment was conducted to investigate the performance of different mobile input methods which were button, text field, radio button and spinner with a touch-based smart phone since these form elements affect the performance of form usage. The chosen input types and their descriptions are given in Table 1. Specifically, we examined which mobile input method provides faster and more accurate data input and which one is more preferred by the users by conducting a user test in our laboratory. Our work is expected to make the following contributions to HCI research field:

- Determine which input method produces faster data entry with less error and more user satisfaction.
- Present the first detailed investigation of performance of mobile input methods in the context of smart phones with touch screen property.

Table 1. Mobile input methods [10]

Control Type	Description
Radio button	Similar to checkboxes, except that only one option can be selected in the group
Text field	An editable text field
Spinner	A drop-down list that allows users to select one value from a set
Button	A push-button that can be pressed, or clicked, by the user to perform an action

2 Related Work

Many of the web based applications use online forms for registration or communication purposes. Users generally do not want to fill in the forms or they leave the forms without filling all questions because the forms designed are unusable requiring long time or causing difficulties to its users. As it was stated above there were some usability evaluation studies conducted in traditional web environment, in this study we are mainly focusing on input types of form elements such as text field, button, radio button and, spinner (which is used instead of drop down box in mobile context) which weren't studied in mobile context. In this section, we will summarize the most important results of the studies about usability of online forms. Although many of these studies were conducted in traditional desktop environment, their results will shed light to our findings.

One of the early work of investigation of usability of form controls was conducted by Gould et al. [11]. They evaluated seven different methods for calendar input by both experienced and inexperienced computer user groups in traditional web environment.

They reported that text entry method was faster and more accurate than selection methods in both groups.

Tullis and Kodimer [6] conducted a study that investigated the usability of seven input methods in a database application in a Windows® environment. They tried to determine which input techniques were easier to learn and use as well as the most preferred. According to their results, radio button and one entry text field input methods were found to be better based on all three dimensions of practice, time and subjective satisfaction. Miller and Jarret [5] emphasized the use of drop-down to save the screen real estate and the use of radio button since it provided visibility of all options together. Heerwegh and Loosveldt [8] discussed the effect of two response formats which were radio buttons or drop-down boxes that were used in web surveys regarding data quality. They reported drop-down boxes were more difficult to use and required more time than radio buttons but they also concluded that the choice among two different response format was not self-evident. Healey [4] conducted an empirical study to investigate the effect of radio button or drop down to the responses of participants of web surveys and could not find out any significant effect on survey completions, number of non-substantial answers or time to completion but found evidence that at individual question level drop downs took longer response times. Actually, this was not a surprising result based on the Keystroke-Level Model [12] because drop downs require more clicks, first to open the drop down and then select the option, than radio buttons.

Bargas-Avila et al. [3] proposed 20 guidelines for usable web forms and they included items related with input types. Seckler et al. [13] conducted an empirical evaluation of these guidelines. In that study, users mostly mentioned about the requirement of easy and fast filling in of the forms during interviews which were conducted to determine their negative experiences with the forms. In another study [14], input methods of button, combo box, radio button and text field were compared according to their performance on web form filling and it was found out that button input type was the fastest and text field was the slowest contrary to Tullis and Kodimer's [6] study. In addition, Bargas-Avila et al. [3], compared six input methods of date entry used in an interactive form on the web and found out that using a drop-down is the best when format errors were to be avoided but text field input was faster and had higher user satisfaction.

Apart from these studies, Welch and Kim [15] conducted an empirical study to investigate the effect of menu element size on mobile applications regarding the effectiveness and efficiency issues. Although the main objective of this study was actually different from our study's scope it is worth to mention about it. Their study didn't not focus on different input elements but they used different sizes for menu elements. They reported the element size had a direct correlation to increased user preference and usability.

3 Method

In this study we performed a user test to examine which input method provides faster and more accurate input in a touch based smartphone environment. Four different input methods which were button, text field, spinner and radio button were evaluated.

3.1 Participants

Twenty participants (8 female, 12 male) took part in the study. Their age ranged from 20 to 59. Average age of participants was 34. Participants were grouped as adults and elderly, according to their age. The first group was between the ages of 20 to 30 and the other group was between the ages of 50 to 60. They were grouped in two age groups based on the median age. First group who were between 20 and 26 years old was determined as young participants and the second group who were between 27 to 59 years old was determined as elderly participants. We grouped participants who had been using smartphone for equal or less than two years as novice and participants who had been using smartphone for equal or more than three years as expert. Participants' smartphone's operating system information was also gathered but two of the participants did not reported (NR) about this information. Only one of the participants had owned the smartphone that was used in this experiment. The details can be seen in Table 2 below.

Table 2. Demographic and smartphone related information of the participants

Gender		Age		Smartphone usage experience		Mobile phone operating system		
Male	Female	Young (20–30)	Elderly (50–60)	Novice (<=2 years)	Expert (>=3 years)	Android	iOS	Others
12	8	15	5	10	10	10	7	3

3.2 Data Gathering Tools

We applied two questionnaires to our participants. One of the questionnaires was to gather their demographic information including gender, age as well as participants' previous experience with any smartphone or the smartphone that we have used in our study. We also included a question regarding their perceived performance of input methods before and after use in this questionnaire. The second questionnaire was used as a "test questionnaire" on the smartphone and included questions related to the personal preferences of participants on general subjects.

A mobile application was developed in Java programming language. Samsung Galaxy S4 smartphone which had an Android OS was used in the experiment. In this mobile application, four versions of the test questionnaire, with different input methods, were used as can be seen in Figs. 1, 2, 3 and 4. The questions and their answers were shuffled for each user and for each trial in order to minimize the learning effect. Application has its own chronometer. It started to track the time at the background of the application when the participant started to fill in any version of the test questionnaire until s/he pressed the complete button. Error correction was disabled in the mobile application to determine which of the input method provided more accurate data input. In the "Text Field" method, the backspace button was disabled and in the other three methods after any of the choices was selected, the others became invisible.

Fig. 1. Button input method

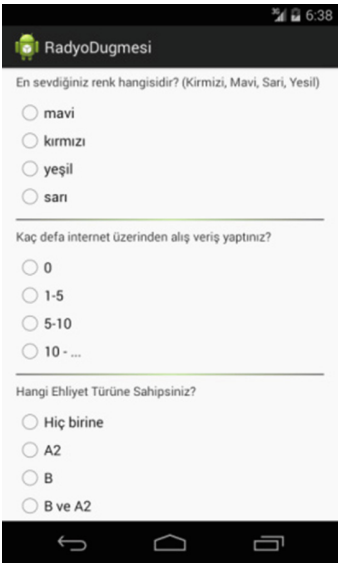

Fig. 2. Radio button input method

Fig. 3. Text field input method

Fig. 4. Spinner input method

3.3 Procedure

At the beginning of the user test, we informed the participants about the procedure and got their consent. First, we wanted them to fill in the demographic information questionnaire and the paper-based version of the test questionnaire to gather their correct responses of their personal preferences. Then we asked them to use the mobile application and fill in the four versions of the questionnaire using different input method for each. We observed the participants while filling in the questionnaire through the mobile application and afterwards asked them which input method they perceived the fastest and noted their answers.

4 Results

The results of the user test was analyzed regarding the required time to fill in the different versions of questionnaires, errors occurred and participants' perceived performance before and after use and actual performance among the four different input methods in a mobile context. We summarized these in the following sub-sections.

4.1 Task Completion Times

Task completion time of four different input methods were recorded during the test. Task completion times for each participants' each method can be seen in Fig. 5.

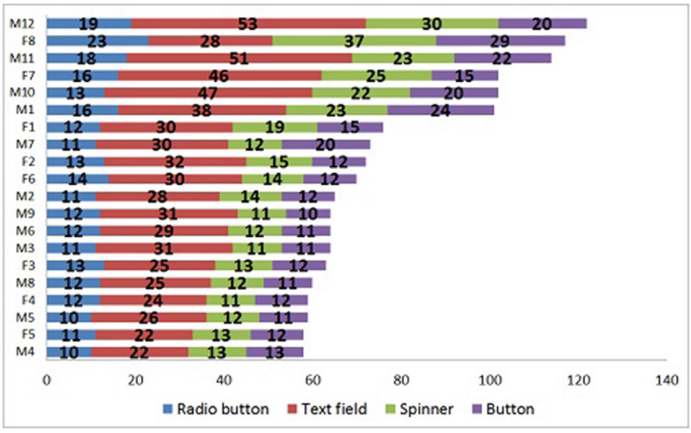

Fig. 5. Task completion times for all participants with four input methods (Color figure online)

There was a statistically significant difference in task completion times depending on the four different input methods, $\chi^2(3) = 39.963$, $p = 0.000$. Post hoc analysis with Wilcoxon signed-rank tests was conducted with a Bonferroni correction applied, resulting in a significance level set at $p < 0.008$. Mean values of task completion times for radio button, button, spinner and text box running trial were can be seen in Fig. 6. Radio button was significantly faster than text box ($Z = -3.924$, $p = 0.000$) and

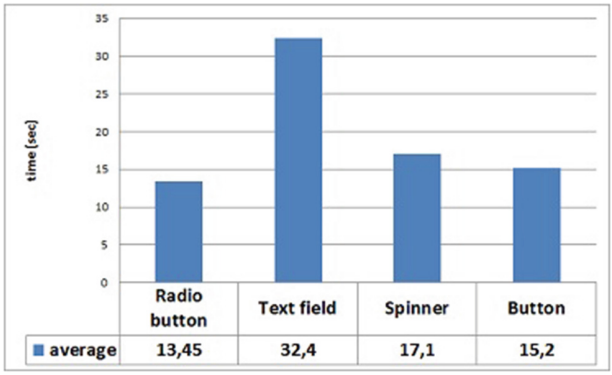

Fig. 6. Average task completion times of four input methods

spinner ($Z = -3.188$, $p = 0.001$) whereas there was no significant differences in task completion times between radio button and button running trials ($Z = -1.746$, $p = 0.081$). Text-box is significantly faster than spinner ($Z = -3.848$, $p = 0.000$) and button ($Z = -3.848$, $p = 0.000$). There was no significant differences in task completion time between spinner and button ($Z = -2.653$, $p = 0.008$). This result was mainly related with the number of keystroke required to fill in the questionnaire with the used input method. Text field and spinner data entries required more time since they required more keystrokes as can be predicted with the Keystroke-Level Model (Card et al. [12]). Spinner method required two steps to input data while radio button and button methods required one step.

Figure 7 shows comparison of average task completion times by age. The fastest input method is radio button among all age groups and text field is the slowest. Young participants performed significantly better than elderly. Performance differences were statistically significant at $p < .05$ among age groups with all input methods.

We also analyzed the task completion times according to participants' gender as can be seen in Fig. 8. Males performed better than females with three of the input

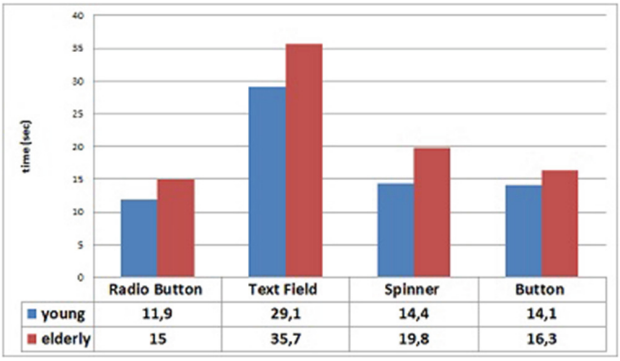

Fig. 7. Average task completion times by age groups

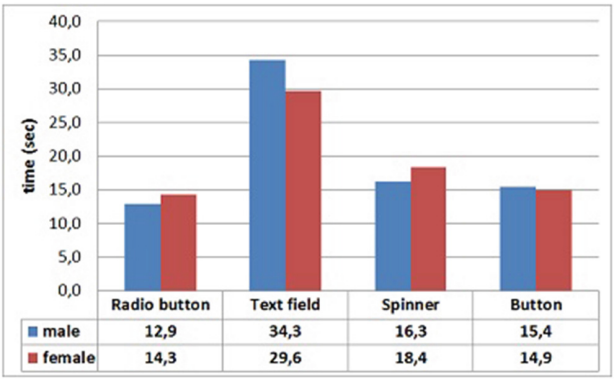

Fig. 8. Average task completion times by gender

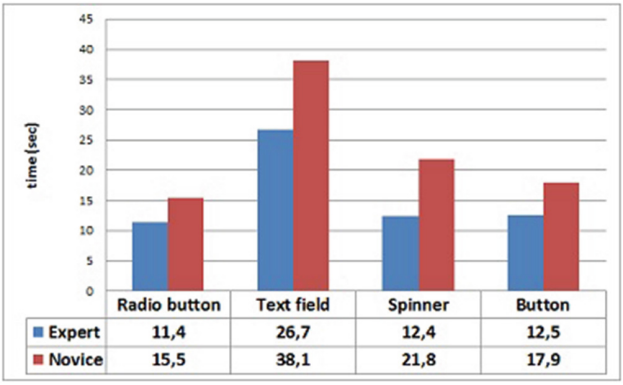

Fig. 9. Average task completion times by experience levels

methods; however, females performed better than males with text field input. However, the difference among the gender groups was not found statistically significant at $p < .05$.

Figure 9 shows the average task completion times of the participants by their experience level. Among the novice and expert groups, expert group performed better than novices and all the differences were found to be statistically significant at $p < .05$.

4.2 Errors

Errors made by the participants while filling in the questionnaires were recorded. Most of the participants made mistakes when filling in questionnaires with "text field" input method except one. Interestingly, he was in the inexperienced elderly group. All of the experienced users made some mistakes when filling in with the "text field" input method. All participants completed questionnaires without any mistakes in the other three input methods.

4.3 Perceived and Actual Performance

We asked participants about their perceived performances before and after the experiment. Participants' perceived performances differed after the experiment; however, their actual performance was also different. Before the experiment only 30 % of the participants stated they would perform better with radio button. After the experiment this percentage increased to 35, however 65 % of the participants performed better with radio button. 25 % of the participants perceived they performed better with spinner after the experiment; however, none of them performed better with this input method. The details can be seen in Fig. 10.

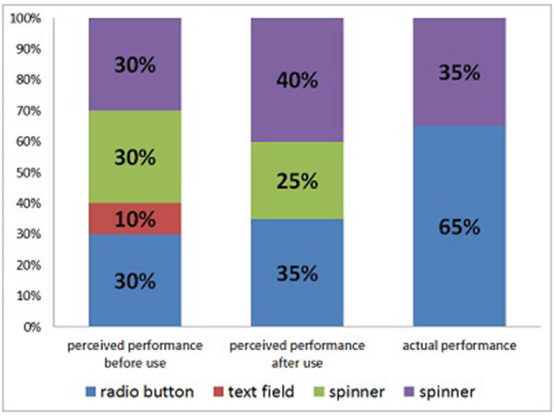

Fig. 10. Participants perceived and actual performances (Color figure online)

5 Discussion

The analyses we have performed on the task completion times of participants with four different input methods indicate that "radio button" is the best of the four approaches studied for this form filling task in the context of smart phones with touch screen property. This result is similar to the previous study's findings [6] although it was in a different context. Form filling with a text field required more time since it required more typing as it was defined in Keystroke level model [12]. Moreover, participants performed more errors with text field. Even we required from the participants to type very short answers by the use of a virtual keyboard of the smartphone, they made errors. There are findings of studies that show people often make errors with virtual keyboards [16].

Another finding of this experiment was related with the people's perceived and actual performances. Our participants weren't able to predict their performance before experiment which is a consistent finding of Dillon's [17] studies. Moreover, they could not predict their performance after the experiment.

The results of this study shows that use of radio button will provide faster form filling in mobile context. Since there is not any statistically significant difference among

radio button and spinner input methods, mobile interface designer can prefer spinner while considering screen real estate. In addition, they should avoid text field input as much as possible since it takes longer and causes more errors.

There are some limitations regarding with this study. First of all, this study was conducted in a laboratory setting which could be considered as an artificial environment for mobile context. Because mobile users use these input methods while they are moving and that requires more cognitive overload. Another limitation is that the sampling of the study included few number of participants. They also cannot be considered as well-representative or the population since convenience sampling was used. Therefore, similar studies should be conducted in a more natural setting with more representative users.

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