EFFECT OF SIZING AND SPACING OF TOUCH SCREEN BUTTONS ON PERFORMANCE OF NUMBER INPUT TASK: COMPARISON BETWEEN YOUNGER AND OLDER ADULTS

Jeong Min KIM*, Keita ISHIBASHI*, Koichi Iwanaga*

*Chiba University Yayoi-cho 1-33, Inage-ku, Chiba 263-8522, Japan

Abstract: Since the introduction of full touch screen smartphones in 2007, touch screen based user interface became a major type of user interface for interacting with computers. This research focus on usability test of touch button which is the most commonly used element for touch screen based graphical user interfaces. An experiment was executed to investigate how different button size and different spacing between the buttons influence the operation time and input accuracy of number input tasks. Two different age groups of subjects were recruited to investigate the influence of age. The result showed that 9mm button and 11.2mm button showed equally good performance in terms of operation time and input accuracy. In case of designing user interfaces for devices with limited display area such as for smartphones, 9mm button size should be recommended. Different spacing did not affect the operation time but significantly affected input accuracy. Age group difference was significant with time performance but not with input accuracy.

Keywords: Button Size and Spacing, Older Adults, Touch Screen, Number Input Task

1. Introduction

The style of our everyday computer usage has completely changed since mobile computing devices such as smartphones and mobile tablet PCs equipped with full touch screen were introduced. We see people sending emails, accessing internet at cafes and even inside buses using these new-generation mobile touch devices. These devices are equipped with specially designed touch screen user interfaces optimized for fingertip interactions. Since natural fingertip interaction is much more direct [1] and intuitive [2] compared to conventional mouse and keyboard interaction, users are showing great interest towards this advanced type of user interface.

For touch screen user interface (UI), touch button is the single most important and frequently used UI element. Therefore a number of previous studies have provided recommendations for target button size (BSIZE) and spacing between the buttons (SPACING) used for mobile touch screen devices and also for fixed-location touch screen devices.

Lewis [3] mentioned in his report that BSIZE for touch screen device can even be as small as 1.7 x 2.2 mm. Parhi et al. [4] investigated the effects of different BSIZEs on time performance and input accuracy with mobile PDA (personal digital assistant) and concluded that the BSIZE for handheld device should be 9.2 to 9.6 mm. Park and Han [5] evaluated three touch key sizes (4, 7 and 10 mm) with mobile PDA concluding that the 10 mm key size provided the best usability. Colle and Hiszem [6] conducted number input experiment with four different BSIZEs (10, 15, 20 and 25 mm square) and two different SPACINGs (1, 3 mm). Entry times were longer and error rates were higher with the smaller BSIZEs (10, 15 mm) but different SPACING did not affect the performance. However, their research focus was on kiosks and other fixed-location touch devices so the smallest BSIZE tested was 10 x 10 mm. Lee et al. [7] identified that BSIZE (18 mm) smaller than the average finger width of male (22 mm) was even acceptable. They also mentioned BSIZE affected performance, specifically with the BSIZE smaller than 10 mm in width.
Above mentioned researches can be useful as reference material for setting BSIZE and SPACING for general users. However situations have greatly changed with the recent huge market success of full touch screen smartphones. Touch UI is rapidly replacing conventional UIs for not only mobile phones but also mobile tablet PCs and even desktop PCs. Consequently new generation of mobile touch devices are targeting for a much broader age range of customers. Therefore investigating older adults’ performance with touch UI is becoming more and more important. Unfortunately not so many reference researches are available yet.

Jin et al. [8] investigated time performance and input accuracy for different BSIZE and SPACING of touch screen UI with older adults. They concluded that BSIZE of 16.51 mm and SPACING of 3.17 to 6.35 mm should be appropriate for older adults. Chaparro et al. [9] identified that the older participants were slower than younger participants with mouse and trackball manipulation tasks.

With above mentioned researches that focus on older adults, we can understand to a certain degree, the age-related differences and the physiological explanation underlying behind the differences. However, a direct age group comparison regarding touch button usability was not found.

This study aims to make a direct comparison between younger and older adults regarding usability of touch buttons. Two different age groups of subjects were recruited to investigate the effect of age on performance, more specifically, how different BSIZE and SPACING influence the operation time and the input accuracy of the number input task. Different BSIZEs were selected based on the dimensions which were experimented with above mentioned researches.

2. Methods
2.1. Subjects

A total of 60 Korean people participated in the experiment. Among the participants, 31 people (21 females and 10 males) were younger adults mainly in their ages of 20s and 30s (mean 32.5, S.D. 5.08), and the other 29 people (17 females and 12 males) were older adults mainly in their ages of 50s and 60s (mean 52.8, S.D. 4.95). All of the participants had different demographic backgrounds and were selected after going through a short interview regarding their visual abilities and dominant hand. All participants had normal or corrected to normal vision and were right handed.

2.2. Experimental design

The computing device used for the experiment was a 10.1 inch full touch screen mobile tablet PC (ASUS eee touch PC). The resolution of the touch screen display of this device was 1024 x 600 pixels (WVGA). A computer software for the number input task experiment was programmed with Microsoft Visual C++. As shown in figure 1, number input task instructions were given on the top left side of the screen, and the subjects had to input numbers by touching the number buttons which were shown on the right side of the screen. Participants had to press ‘next’ button to proceed to the next task. They were only allowed to use their fingers to press the buttons during the experiment. If the number entered and the number given as task did not match, they received 'wrong number error' message on top of the number display box. The numbers participant had pressed were immediately shown on the number display box located right above the number buttons. Participants could touch ‘clr’ button to erase all the numbers they had input on the number display box. A function of erasing one number at a time was not offered.

Figure 1. Schematic layout of the number input task shown on the display (original task instructions and button markings were offered in Korean)
Button configuration type A had buttons with the size of 11.2 x 11.2 mm, configuration type B and B' had 9 x 9 mm buttons and configuration type C and C' had 7.1 x 7.1 mm buttons. Button configuration type A, B and C had same vertical and horizontal pitch (62 pixels) between the center points of the twelve buttons, while BSIZE, vertical and horizontal SPACING of configuration type A, B' and C' were proportionally identical (vertical and horizontal SPACINGs were 8, 5 and 4 pixels for configuration type A, B' and C').

Participants had to input a total of 12 randomly generated numbers (4 times each for 4, 6 and 8 digit numbers) for each button configurations making it 60 random number inputs for the entire experiment. The button configuration type offered to the participants was in random orders. All of the button touch the participants made was recorded in to log files, together with the time information of when it was pressed. In order to investigate the input accuracy, 'miss hits' (invalid touches made inside the number pad area that failed to hit the number buttons) were also recorded.

2.3. Procedures

After a short instruction about the experiment was given, participants were asked to perform the test undisturbed. Before the main test, they were given six trials of number input practice chance with an odd size button (11.3 x 5 mm) set. This button set was intended to have the least similarity with the other three type of buttons used for the main test. The button touching experience was the most difficult with this button type since the height of the button dimension was lowest compared to the other buttons used in the main experiment. The main purpose of offering the practice session was to let the participants familiarize with the touch experience and the touch sensitivity in order to stabilize their touch performance. Before they started the experiment they were informed about the non-invasiveness of the experiment. In addition they were told that the collected experiment data and the provided personal information would not be used elsewhere except for the analysis purpose of the research. The main experiment of 60 random number input started after the practice session was finished.

2.4. Analysis

Two-way repeated measures analysis of variance (ANOVA) was used to analyze the main effects of age group and configuration type on operation time and input accuracy. Button configuration type was assigned as within subject factor and age group as between subject factor.

All data were expressed as mean with S.D. and the level of significance was set at $p < 0.05$.

3. Results

3.1. Operation Time

Figure 3 illustrates the mean value of Operation Time (OT) each participants marked to complete the given tasks for each button configurations. The graph clearly shows that the younger adults recorded shorter OTs with all five button configurations.

Two-way repeated measures ANOVA revealed the main effect of age group to be significant ($F(1,58)=31.544$, $p<0.001$) implying that the two age groups showed different performance levels.
significant difference in time performance. Specifically, younger adults required significantly less amount of time to complete the given number input tasks. Main effect of the button configuration type was also significant ($F(4,232)=17.577, \ p<0.001$) implying that the OTs participants recorded to complete given tasks of each button configuration type was also significantly different. The interaction between age group and button configuration was not significant ($F(4,232)=0.196, \ p=0.902$).

Bonferroni corrected pairwise comparison revealed significant differences between the OTs of the five button configuration types. Age group difference was not considered with this comparison. The connection lines above the bar graph (figure 3) represent each pair of configurations that showed significant difference between their OTs.

The result showed that configuration type A, B and B’ was significantly faster than configuration type C and C’. But no significant differences were found between configuration type A and B nor between A and B’. This result suggests that although 11.2mm buttons were considerably bigger than 9mm buttons, they showed no significant difference regarding time performance.

Significant differences in OT were not found between configuration type B and B’ and between C and C’ meaning that time performance difference did not exist between the configuration types with same pitch (larger SPACING) and the configuration types that were proportionally identical (smaller SPACING).

3.2. Input Accuracy

In order to investigate input accuracy, the count of miss hits participants made were analyzed. Figure 4 illustrates the mean value of the Count of Miss Hits (CMH) each participants made while completing given tasks for each button configurations.

Two-way repeated measures ANOVA revealed the main effect of Age Group to be not significant ($F(1,58)=0.330, \ p=0.857$) implying that the older adults and the younger adults did not show significant difference regarding input accuracy.

Main effect of the button configuration type was significant ($F(4,232)=26.117, \ p<0.001$) implying that the amount of input error participants made while completing given tasks of each button configuration type was significantly different. The interaction between age group and button configuration was not significant ($F(4,232)=0.215, \ p=0.737$).

Participants recorded highest CMH under configuration C which was greatly exceeding the CMHs of the other configurations and they recorded lowest CMH under configuration A and B’. To investigate whether these perceivable differences were actually significant, Bonferroni corrected pairwise comparison was executed.

The comparison result is shown with connection lines above the bar graph (figure 4) which represent each pair of configurations that showed significant CMH differences. CMH of configuration C actually was significantly higher than all the other configuration types. Interestingly CMH of configuration B was significantly higher than configuration B’ and configuration C was significantly higher than configuration C’ meaning there was significant input accuracy difference between the two configurations having same BSIZE but different SPACING. This novel finding was against the conclusions made from the previous studies [6, 8].

4. Discussions

4.1. Effect of Age

Using a mobile touch tablet PC, we have studied the effects of different touch BSIZE and SPACING on number
input task performance. In addition, we have made a 'direct age group comparison' between younger and older adults regarding the performance, which establishes the originality and differentiation from previous researches.

Regarding time performance, older adults did show lower performance as expected. Compared to older adults, younger adults required approximately 25.2% less time in average to complete the entire experiment. In detail, 26.9, 23.7, 23.9, 25.9 and 24.2% less time were required for completing the assigned tasks for each button configuration type A, B, C, B' and C'. It was assumed that older adults would suffer more from small size buttons and smaller SPACING, but in fact it was interesting to see the individual percentage differences mentioned above showed rather similar values. Bigger margin of superiority expected with smallest BSIZE or SPACING was not shown. In addition, interaction between the age group and the configuration type regarding the time performance (OT) did not exist. In fact, F-ratio of the interaction was <1.0; therefore the error variation was much larger than the interaction effect. These results imply that any perceivable characteristic difference with time performance between the two age groups did not exist. In other words, we can conclude that there was not any specific BSIZE or SPACING younger or older adults were especially stronger or weaker with, therefore extra large BSIZE or SPACING is not necessary when designing UIs for older adults of their ages around mid 50s. Considering even older adults of ages over 60, the results can be different. This can be investigated with future studies.

Regarding input accuracy, with surprise, age group difference was not found. Chaparro et al. [9] explained that the increase in the noise-to-force ratio in neural muscular control is one of the main reason why older adults move slower in order to achieve equivalent accuracy of the younger adults. In line with their explanation, our results showed that the older adults indeed moved slower but it did not mean they were inaccurate.

4.2. Effect of Button Size

9mm buttons and 11.2mm buttons showed significantly lower OTs compared to 7.1mm buttons. OTs of the three configuration types (A, B and B') showed similar values and also CMH of the two configuration types (A, B') showed similar values. However when designing User Interfaces for mobile devices with limited display area such as for smartphones, 9mm buttons would be a better choice, this is consistent with [4]. Main icon size used for most of the smartphones is around 9 x 9mm and this can be explained with the conclusions made from the previous researches [4, 5, 7, 8] and with the conclusions made from this research.

4.3. Effect of Spacing between the Buttons

SPACING difference did not affect time performance (OT) which is consistent with [8, 10], but it did significantly affect input accuracy (CMH). The more inactive untouchable area between touch sensitive area, the more count of miss hits the user made. Therefore reducing the inactive area will lead us to less count of miss hits while performing tasks. In other words if we can change the inactive untouchable area into active touch sensitive area, then it would naturally lead us to improved input accuracy. In fact, software developers and UI designers have already been practicing this kind of technique from some time ago. They have been putting invisible touch sensitive area around the edges of the touch buttons to collect the miss hits in order to enhance performance. Moscovich [11] has briefly mentioned about this technique in his paper. With the explosive market growth of mobile touch screen devices and touch screen UIs, investigating the observable effects and characteristics of this kind of 'invisible touch sensitive area' technique can be a good research issue for future studies.

5. References


