Study on Size Design of Touch-Sensitive Button

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Abstract. To examine the effects of button size with different shape on the usability of touch screen devices. Considering the forefinger operation, the subjective and objective evaluation were combined to assess the ergonomics of the touch-sensitive button size, so as to obtain the recommended range of button size. With the size of touch-sensitive buttons specified setting from 3 mm to 25 mm respectively, where the step size was 2 mm, thirsty subjects participated in the test. One-way ANOVA was used to analyze the operational performance (reaction time and error rate) at different key sizes, and then the S-N-K-hoc multiple pairwise comparison test was used for pairwise comparison. The results demonstrated that the recommended range for rounded corner touch button is from 11 mm to 19 mm, round touch button in the recommended range is from 13 to 19 mm. It is also confirmed that the rounded corner touch buttons are superior to round touch buttons in the same size. This research can provide a basis for the design of button size of enterprise electronic products, and has important guiding significance.

Keywords: Touch-sensitive button · Size · Human-computer interaction

1 Introduction

With the development of science and technology and economy, people's standard of living has been improved continuously, and the requirement of comfort has also been raised. At present, all kinds of electronic products sold in the market, such as home appliances, mobile phones and so on, are gradually using touch screen technology to replace the traditional mechanical button technology. The so-called touch screen is a transparent panel that forms input instructions directly by touching [1]. Compared with traditional input tools such as mechanical buttons, it has a more direct human-computer interaction experience, easy to manipulate and use. There are now 16 kinds of touch screen technologies on the market, 8 of which have become common technologies [2]. It has been widely used in actual products, such as Apple's iPad and other products, most of which are multi-touch technology. So far, the new touch screen technology, which has the function of "dynamics feedback", has also been marketed [1]. With the rapid development of technology, people pay more attention to the fluency of human-computer interaction on touch screen. Having good usability and ease of use to meet

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the needs and satisfaction of consumers is the development trend of touch screen in the future. However, the common problem is that the touch screen displays a lot of information, but the interaction space is relatively limited. If the relationship between the two is not handled properly, it is likely to lead to poor user experience. Therefore, it is necessary to study the layout of touch screen buttons in order to realize the clear display of many kinds of information and the effective operation of interactive control in a limited plane.

In recent years, there have been a lot of button characteristics at home and abroad on the impact of operational performance, such as button size, button spacing and input situation, and achieved a series of results. In their study, Park and Han [3] discussed the influence of the three button sizes of 4 mm, 7 mm, 10 mm on the performance of the operation. The results showed that the button size of 7 mm, 10 mm could provide the best performance. By studying the button size of smart phone interface, Jung and Im [4] pointed out that the hit ratio of the button mainly depended on the touchable area of the button, that was, the size of the button. The results of Colle and Hiszem [5] showed that the 20 mm buttons could provide the optimal operation performance, but the different button spacing (1 and 3 mm) has little effect on the user's performance. In addition, some scholars had studied the effect of these button feature factors on the performance of the operation in different situations and groups. Conradi et al. [6] had shown that the 8 mm button size was suitable for static standing. But this size increased input errors, and the 14 mm button size caused a lower error rate when used while walking. Hwangbo et al. [7] studied the operation of the touch screen of the old people. The results showed that the greater the size and spacing of the buttons, the better the operation performance, the higher the subjective evaluation, and when the size of the button was large, the button spacing did not have a significant effect on the performance of the click operation. The results of Jin [8] et al. showed that the elderly can get the highest correct operation rate at the button size of 19.05 mm and the button spacing of 6.35 mm, but the larger button spacing increased the response time for the elderly. At present, most of the related research on touch screen buttons are from western countries. Due to the large differences in human morphological parameters between China and the West, their research results are not suitable for Chinese, only for reference. Some scholars had made some researches on the touch-screen button-related problem interiorly. The experimental results of Zhang Wenlin [9] showed that the button size had a significant effect on the landing point, offset and error rate of the click-through operation, while the effect of button spacing on the operation performance was affected by the button size. When the single button is less than 6 cm in width, it is recommended that the smaller the spacing design of the button, the better the operation accuracy; If the width of the button is more than 6 cm, the distance can be widened, but it is recommended to keep the width of the single button above 6 cm to avoid reducing the accuracy of the operation. At present, the factors such as the relevant size and layout of the touch screen at home and abroad have not yet formed a unified standard. The ANSI/HFES 100-2007 standard [10] recommends that the button size be at least 9.5 mm, and the button spacing be 3.2 mm. The ISO 9241-9 standard suggests that the button size should be the same as the width of the distal knuckles of the 95th percentile male (about 22–23 mm). Other standards [11] suggested that the button size should be 19.05 mm, and the button spacing should be matched with 6 mm.

In previous studies, there has been no mention of the effect of button shape on touch button operation. At the same time, the objective evaluation method is used in the study to analyze the influence of various factors on the operation performance, and the subjective feelings of the users are not considered. Based on the above factors, this paper mainly aimed at the ergonomics evaluation of touch button size with different shapes by combining subjective evaluation with objective evaluation under the condition of standing touch screen in order to obtain the recommended range of button size under different touch button shape, providing data support and scientific basis for ergonomic design of touch screen button on enterprise, so as to improve the layout of touch screen and enhance user satisfaction.

2 Method

2.1 Subjects

The subjects were required to meet the following conditions: normal vision or correction above 1.0, no cognitive impairment, between 22 and 50 years old, having experience in the use of touch-screen electronics. In order to ensure the reliability and effectiveness of the results, the subjects were evenly distributed in different age groups. The total number of samples was 30, among which, 15 males and 15 females. The subjects volunteered to participate in the experiment, and filled out a written consent form. After the completion of the experiment, they were paid a certain amount of money. Before the experiment, none of the subjects had been exposed to the task.

2.2 Experiment Design and Variables

2×12 within-group design was used in the study, in which variables were: button shape (round and rounded corner) and button size (3 mm, 5 mm, 7 mm, 9 mm, 11 mm, 13 mm, 15 mm, 17 mm, 19 mm, 21 mm, 23 mm, 25 mm). Through the actual investigation of the touch button spacing of the related electronic products in the market, combining with the existing literature theories, the reasonable horizontal and vertical spacing were selected, which were set as 8 mm and 12 mm respectively. It had been verified through pre-experiment that the selected button spacings were within reasonable ranges, which would not affect the final results of the experiment. On the basis of this, the experiment task of touch button operation was designed to explore the effect of button size on operation performance and user satisfaction under the shape of two kinds of buttons. Among them, the operation performance was evaluated by two indictors, reaction time and error rate. The user satisfaction was measured by a subjective evaluation scale with five levels as shown in Fig. 1.

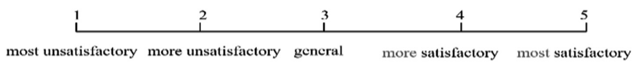


Fig. 1. Subjective evaluation scale

2.3 Experimental Software

The touch button operation task software was programmed in C# on NET Framework platform. The shape of the button and the size of the button could be set according to the experimental design. Button styles including font type, size, font color and background color could also be set according to the actual situation. Figure 2 showed the main interface of the task. It mainly included the task displaying area and the button operation area. The displaying area would generate N numbers randomly, and the operation area was consisted of 9 numeric buttons from 1 to 9. The sizes of buttons were fixed according to the parameters that had been set, and they would not change along with the size of the touch screen. When the stimulus displayed in the displaying area, subjects were required to enter the corresponding digitals as quickly and accurately as possible by using the digital buttons in the operation area, and then began the next trial until the end of the task. After the experiment, the software records the results of this operation automatically.

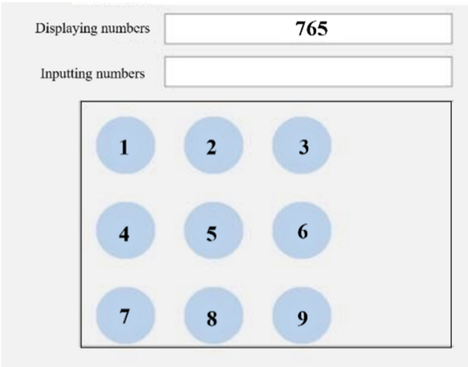


Fig. 2. The main interface of task presentation

2.4 Experimental Process

Based on the above software, the ergonomics recommendation range of the size of the touch buttons was determined by conducting button-press operation tasks, combined with the users' experience and evaluation. During the test, each subject was required to perform 2 × 12 tasks. Each task was consisted of 20 trials, and each trial randomly displayed 3 numbers. The subjects were asked to enter the corresponding numbers as quickly and accurately as possible using the touch buttons in the operation. After each task, the subject needed to rate the satisfactory scores of the button sizes combining with their own feeling. Meanwhile they were required to rest for 5 min after each test task avoiding the fatigue effect on result which was caused by long-time experiment, and then began the next task until all the experimental tasks were completed. The experiment was arranged in a relatively quiet environment. The touch-screen notebook with touch button operation task software was put on a lifting table before the experiment. The subjects adjusted the height of the table according to their comfort. Then formal experiment was conducted.

2.5 Statistical Analysis

The behavioral performance data and the satisfaction rating data during the experiment was collected, and SPSS 19.0 was used to analyze the data. One-way ANOVA was used to analyze the performance data (reaction time and error rate) of touch-sensitive buttons with different shapes under different button sizes [12]. Then S-N-K post hoc test was used to carry on the pairwise comparison [13]. At the same time, the subjective satisfaction rating was used to demined the optimal recommendation range of button size. All significant levels were $\alpha = 0.05$.

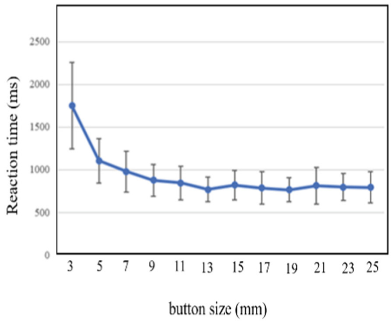
3 Result and Discussion

3.1 Analysis of the Results of Rounded Corner Touch Button

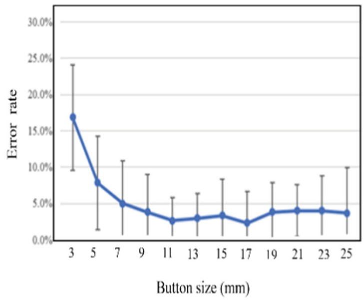
Figure 3 showed the changing trend of task performance with button size for a rounded corner touch button. It could be seen that the average reaction time and error rate decreased gradually along with the increase of button size. One-way ANOVA was used to analyze the reaction time of the rounded corner button with different sizes, as shown in Table 1. Combined with Fig. 3(a) and Table 1, the result was obtained that the reaction time was significantly reduced ($F = 11.560$, $P < 0.05$) as the button size increased. Further pairwise comparison by S-N-K-hoc test found there was no significant difference in the reaction times of buttons with sizes ≥ 7 mm, that was, the button size needed to be ≥ 7 mm to ensure the high efficiency of operation. Similarly, One-way ANOVA was used to analyze the error rate of the rounded corner button in different sizes. The results were shown in Table 2. Combined with Fig. 3(b) and Table 2, the result was obtained that the error rate was reduced significantly ($F = 18.269$, $P < 0.05$) with the increase of button size. Further pairwise comparison by S-N-K-hoc test found that the error rates of button sizes ≥ 7 mm had no significant difference, that was, the button size needed to be ≥ 7 mm, in order to ensure the high accuracy of touch button operation.

Table 3 showed the statistical results of subjective satisfaction scores with different sizes of rounded touch buttons (mean + standard deviation). Figure 4 showed the curve of the subjective satisfaction scores varying with the button sizes of the rounded corner buttons. It could be seen from the diagram that the subjective satisfaction increased firstly and then decreased with the button size.

In summary, the operation task performance of the rounded corner touch button was analyzed and the results showed that the size of the rounded corner square button should be at least >=7 mm in order to satisfy the efficiency and accuracy of the operation. At the same time, considering the subjective satisfaction evaluation, satisfaction score >=4 was chose, then the recommended range of the final rounded corner button was obtained: $11 \sim 19$ mm.



(a) Reaction time



(b) Error rate

Fig. 3. Behavior performance with different button sizes

Table 1. One-way ANOVA results of reaction time with different button sizes

	Sum of squares	df	Mean square	F	Sig.
Between group	5058214.067	11	459837.642	11.560	.000
Within group	13842577.533	348	39777.522		
Total	18900791.600	359			

Table 2. One-way ANOVA results of error rate with different button sizes

	Sum of squares	df	Mean square	F	Sig.
Between group	.522	11	.047	18.269	.000
Within group	.903	348	.003		
Total	1.425	359			

Table 3. Subjective satisfaction score under different sizes of rounded touch buttons

Button size	Mean	S.D.
3	1.50	0.82
5	2.57	0.90
7	3.07	0.94
9	3.57	0.77
11	4.13	0.82
13	4.27	0.69
15	4.33	0.66
17	4.33	0.80
19	4.20	0.92
21	3.87	1.04
23	3.50	1.14
25	3.33	1.27

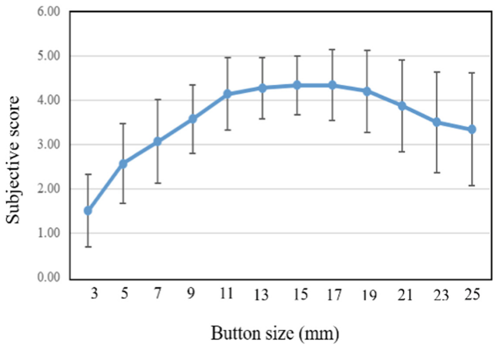
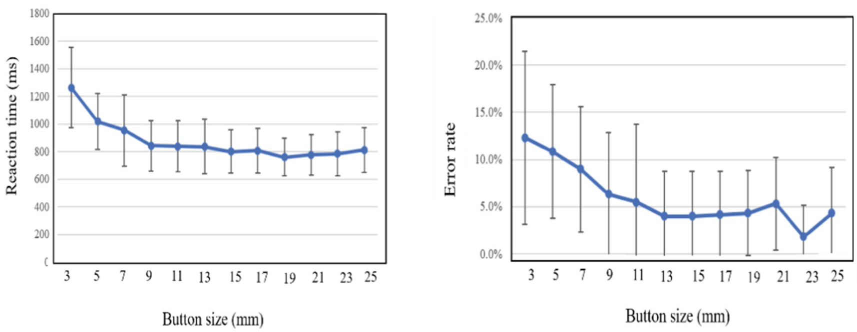


Fig. 4. Subjective satisfaction scores with different button sizes

3.2 Analysis of the Results of Round Touch Button

Figure 5 showed the changing trend of task performance with button size for round touch buttons. It could be seen that reaction time and error rate decreased with the increase of button size. The reaction times of round touch buttons at different sizes were analyzed using One-way ANOVA. The results were shown in Table 4. Combined with Fig. 5(a) and Table 4, the result was obtained: the reaction time decreased significantly with the increase of button size (F = 16.715, P < 0.05). Further pairwise comparison by S-N-K-hoc test found there was no significant difference in the reaction times of buttons with sizes >=9 mm (P > 0.05). Therefore, the button size should be >9 mm to ensure the high efficiency of touch button operation. Similarly, the error rate of round touch buttons at different sizes was analyzed using One-way ANOVA. The results were shown in Table 5. Combined with Fig. 5(b) and Table 5, the result was obtained: the error rate decreased significantly with the increase of button size (F = 8.093, P < 0.05). Further pairwise comparison by S-N-K-hoc test found there was no significant difference in the error rates of buttons with sizes >=9 mm (P > 0.05). Therefore, the button size should be >9 mm to ensure the high efficiency of touch button operation.



(a) Reaction time (b) Error rate

Fig. 5. Behavior performance with different button sizes

Table 4. One-way ANOVA results of reaction time with different button sizes

	Sum of squares	df	Mean square	F	Sig.
Between group	6777732.322	11	616157.484	16.715	.000
Within group	1.283E^7	348	36862.747		
Total	1.961E^7	359			

Table 5. One-way ANOVA results of error rate with different button sizes

	Sum of squares	df	Mean square	F	Sig.
Between group	.323	11	.029	8.093	.000
Within group	1.261	348	.004		
Total	1.584	359			

Table 6 showed the statistical results of subjective satisfaction scores with different sizes of rounded touch buttons (mean + standard deviation). Figure 6 showed the curve of the subjective satisfaction score varying with the size of the round touch button. It could be seen from the diagram that the subjective satisfaction score increased firstly and then decreased with the increase of button size.

Table 6. Subjective satisfaction score under different sizes of rounded touch buttons

Button size	Mean	S.D.
3	1.33	0.48
5	1.83	0.75
7	2.47	0.68
9	2.97	0.72
11	3.50	0.86
13	4.00	0.64
15	4.17	0.70
17	4.17	0.87
19	4.07	0.94
21	3.83	1.09
23	3.57	1.19
25	3.13	1.28

In summary, the operation task performance of the round touch button was analyzed and the results showed that the size of the round button should be at least >=9 mm in order to satisfy the efficiency and accuracy of the operation. At the same time, considering the subjective satisfaction evaluation, satisfaction score >=4 was chose, then the recommended range of the final round button was obtained: 13～19 mm.

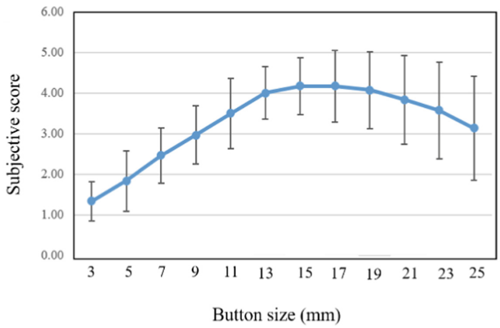
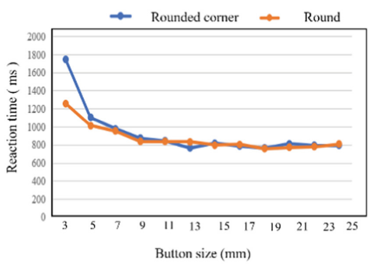


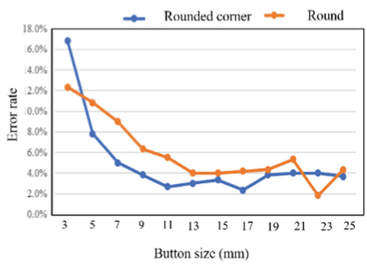
Fig. 6. Subjective satisfaction scores with different button sizes

3.3 Comparison of Operation Results Between Rounded Corner and Round Buttons

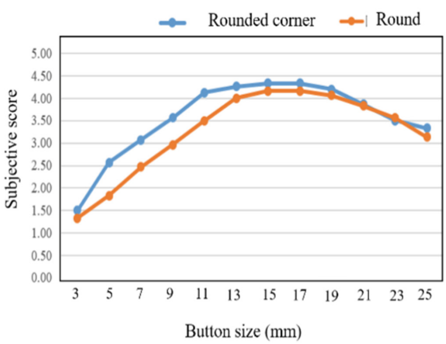
The behavior performance and subjective satisfaction results between the operations with rounded corner and round touch buttons were compared. Figure 7 showed their comparative curves. It can be seen from the figure that the reaction time of using round square touch button and round touch button operation is basically the same, but the error rate of round square touch button operation is obviously lower than that of round touch button. At the same time, the user's subjective satisfaction of the round square



(a) Reaction time



(b) Error rate



(c) subjective score

Fig. 7. Comparison of operation results between round corner and round buttons

touch button is higher than that of the round touch button. Therefore, it can be inferred that, at the same size, round square touch buttons are superior to round touch buttons.

4 Discussion

The influence of button size with different shapes on touch screen operation was discussed in the paper. Results showed that there was a negative correlation between the button size and both the reaction time and error rate respectively, which was consistent with the previous research [12, 15]. Previous studies had showed that the input performance of buttons with size between 19 mm and 22 mm was optimal. Furthermore, the button size ranges for different button shapes were given in the study respectively. The button sizes were at least 7 mm and 9 mm for round corner touch buttons and round touch buttons respectively, which could ensure the efficiency and effectiveness of the operation. However, the increase of button size on this basis had no significant effect on the improvement of input performance. Clearly, the satisfaction of the users' experience had become a major factor. That was, on the basis of ensuring the input performance, the subjective satisfaction of the user should be considered. The subjective and objective evaluation methods were combined to obtain the final results: the recommended size range of round corner touch button was 11 ~ 19 mm and that of round touch buttons was 13 ~ 19 mm. At the same time, the input performance and user experience satisfaction of round corner touch buttons were higher than round touch buttons. These results could be referred for the design of touch screen button size of electronic products which need to be operated in a standing state, so as to avoid the complicated interface caused by unreasonable button size design, and ensure the simplicity and efficiency of interface design. On the other hand, the research on touch buttons with different shapes was more accurate and comprehensive.

5 Conclusion

By exploring the influence of two button features (shape and size) on the input performance and preference of touch screen, a new opinion for the design of touch screen button is provided. The experiment results showed that the size and shape of the buttons had different effects on the input performance of the touch screen. User preference affected the design of the deeper layer of button operation and directly affected the user's satisfaction with the button design. In the future research, we should consider a variety of button design factors and user subjective perception to explore the optimization of touch screen button design scheme.

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References

1. Park, Y., Han, S.: Touch key design for one-handed thumb interaction with a mobile phone: effects of touch key size and touch key location. Int. J. Ind. Ergon. **40**(1), 68–76 (2010)
2. Jung, E., Im, Y.: Touchable area: an empirical study on design approach considering perception size and touch input behavior. Int. J. Ind. Ergon. **49**(1), 21–30 (2015)
3. Colle, H.A., Hiszem, K.J.: Standing at a kiosk: effects of key size and spacing on touch screen numeric keypad performance and user preference. Ergonomics **47**(13), 1406–1423 (2004)
4. Conradi, J., Busch, O., Alexander, T.: Optimal touch button size for the use of mobile devices while walking. Procedia Manufact. **3**(1), 387–394 (2015)
5. Hwangbo, H., Yoon, S.H., Jin, B.S.: A study of pointing performance of elderly users on smartphones. Int. J. Hum.-Comput. Interact. **29**(9), 604–618 (2013)
6. Jin, Z., Plocher, T., Kiff, L.: Touch screen user interfaces for older adults: button size and spacing. In: Conference on Universal Access in Human-Computer Interaction, pp. 933–941. Springer, Heidelberg (2004)
7. Wenlin, Z.: Effects of button and gap sizes on task accuracy for keyboard of touch sensitive mobile phone. Institute of Design, National Taiwan University of Science and Technology, Taiwan (2011)
8. Greiner, T.: Hand Anthropometry of U.S. Army Personnel. U. S. Army Report NATICK/TR-92 011. U. S. Army Natick, Research, Development and Engineering Center, Natick, Massachusetts (1991)
9. Telecommunications Industry Association. Resource Guide for Accessible Design of Consumer Electronics. Electronic Industries Association and the Electronic Industries Foundation, Washington D.C. (1996)
10. Bing, H.: Touch screen technology and its application. Chem. Ind. **32**(5), 175–176 (2008)
11. S3C2440A Chinese Handbook (Ma Zhijing’s translation) (2007)
12. Chen, K., Savage, A., Chourasia, A.: Touch screen performance by individuals with and without motor control disabilities. Appl. Ergon. **44**(2), 297–302 (2013)
13. Chourasia, A., Wiegmann, D., Chen, K.: Effect of sitting or standing on touch screen performance and touch characteristics. Hum. Factors **55**(4), 789–802 (2013)
14. Jin, Z.X., Plocher, T., Kiff, L.: Touch screen user interfaces for older adults: button size and spacing. In: Stephanidis, C. (ed.) UAHCI 2007. LNCS, vol. 4554, pp. 933–941. Springer, Heidelberg (2007). https://doi.org/10.1007/978-3-540-73279-2_104
15. Kim, H., Kwon, S., Heo, J.: The effect of touch-key size on the usability of in-vehicle information systems and driving safety during simulated driving. Appl. Erogon. **45**(3), 379–388 (2014)