Research on the Impact of Menu Structure of Smart Phones on Dual Task Performance

Huining Xing[✉], Hua Qin, and Dingding Wang

Department of Industrial Engineering, School of Mechanical-Electronic
and Automobile Engineering, Beijing University of Civil Engineering
and Architecture, Beijing 100044, China
1259183822@qq.com

Abstract. The purpose of this paper is to study the influence of smartphone application arrangement on user performance of completing a sub-task and satisfaction in the course of telephoning. Base on simulated smartphone interface, three kinds of application arrangement are designed for the experiment. Participants begin to conduct another application in a kind of application arrangement while telephoning. The results show that the user's operation time is the shortest and satisfaction is the best while frequent applications arranged on the telephoning interface. And the followed is the applied application arranged on the telephoning interface.

Keywords: Smart phone · Menu structure · Application arrangement

1 Introduction

With the emergence of smart phones, applications which with varieties of functions have been appearing, these applications can be used in playing games, navigation, taking photos, learning and so on, in 2015, there are about 1,400,000 kinds of applications for apple smart phone and about 1,830,000 kinds of applications for android mobile phone [1], in which the apple mobile users' download has reached 1 billion times. But due to the limited screen size and too many applications have been downloading, the users' needs to organize them on the mobile phone interface according to the certain way.

The early mobile phone menu organization form is mostly static form, mainly including scrolling menu and hierarchy menu etc., studies have shown that scrolling menu will lower the efficiency of operation [2, 3], but the deeper of hierarchy menu level, the more time users need to spend to learn, and the more wrong choice made on possible paths [3, 4], compared the operation performance of hierarchy menu with the scrolling menu on the small screen, it is found that the operation performance of hierarchy menu is superior to scrolling menu [5].

For smartphone users who need to install new applications and delete old applications constantly, if these applications presented by static way, obviously that can cause trouble to the user. Method applied at present is mainly hierarchical management which is classifying the application or paging in sequence [6, 7], the study also considered that using adaptive user interface can also solve this problem [8, 9], an adaptive

user interface can change its layout, function, structure elements according to user's behavior [10–12], Mitchell and Shneiderman order the arrangement of menu items from high to low according to the usage frequency of menu item. Results showed that this method did not improve the operation performance, users prefer traditional static menus. Due to this method has changed the original structure of the interface, thus undermining the user's mental model [13]. While someone improved the operation performance with this method [14]. At present, for the adaptive menu interface of mobile phone, there are some research started to study in the aspects of situation awareness, shortcuts, etc. [15, 16].

With the continuous expansion of the functions of programs, there is a growing need for the use of other functions while people using a certain function of one application in mobile phone, which namely is that don't turn off one function which is used, at the same time using another or several functions, for example, someone finds the map while telephoning. For such a large screen of computer and it can present multiple applications on the same interface, whereas it's usually difficult to present two or more application interfaces on the same interface, and small size screen will make it hard for users to form mental model on the menu structure, and beyond the capacity of short-term memory [17]. If the user needs to open another one at the same time, which way that the organization of these applications will be presented and makes higher operation performance and better satisfaction is particularly important.

Due to the different navigation effect of different application arrangements on users, therefore, the purpose of this study is to explore the effect of smartphone application arrangement on the operation performance and users' subjective satisfaction of completing sub-task under the conditions of the implementation of the main tasks.

2 Experimental Design

In order to study the influence of the application arrangement of the adaptive menu structure on the operation performance and the subjective satisfaction of users who complete the sub-tasks, the Flash software was used to simulate the mobile phone interface so that participants are able to test by it. Firstly, three kinds of application arrangement are designed, and the participants can complete the main task of the calling under a menu structure in an application arrangement, at the same time they need to complete a sub-task of another application.

2.1 The Application Arrangement of the Menu and Simulation Interface

There are three kinds of application arrangement in the experiment:

Common menu, according to the using frequency of the menu items, the six most frequent items will be presented on the main task interface. If you need other items, you should click on the "home" button and then return to the main interface to find necessary menu items.

History menu, according to the time sequence, which means the used items nearer to the current time then the items presented more ahead. The used items will be

presented on the main task interface. If you need the unused ones, you should click on the "home" button and then return to the main interface to find necessary menu items.

Hierarchy menu, the first level of the items will be presented on the main task interface, and the following sub menu items will be presented after clicking the first level menu item.

According to the three kinds of application arrangement, the experiment has five simulation interfaces. The interface 1 is the main interface, rendering all the application icons, establishing the link relations to the "home" button on interface 2–4. The main interface has two pages, with a total of 34 application icons. The icons are divided into two types– the task icons and the common icons. The first page has 20 application icons, including 4 task icons and the 16 common icons. There are 14 application icons on the second page, including 2 task icons and 12 common icons. The task icons are the ones which are chosen by the participants in the process of the experiment tasks.

Fig. 1. The interface of common menu

The interface 2 simulates the common menu; the interface function elements include the telephone icon and six commonly used function icons, and a "home" button (Fig. 1).

The interface 3 simulates the history menu; the interface function elements include the phone icon and used application icons. The used application icons can be viewed by sliding around the button, and the icons will be presented at the bottom of the interface (Fig. 2).
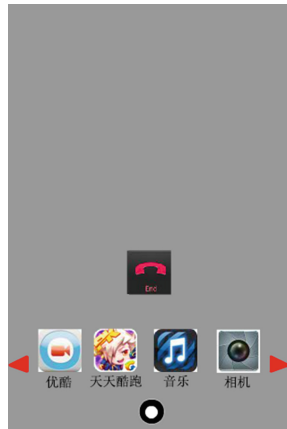
Fig. 2. The interface of history menu

The interface 4 simulates the Hierarchy menu; all the applications are presented by two levels. The four classifications in the first level are presented by four icons and the applications in the second level are categorized into the four types. Clicking on the icons in the first level all the applications contained will appear; and these four categories are "life", "entertainment", "social", "system", respectively (Fig. 3).

The interface 5 is the ending interface.

The experiment simulates the mode of touch interaction interface of mobile phones; the size of the simulation interface is 7.9 * 5.8 cm, and the icon size is 1.3 * 1.3 cm with the menu name placed right under the icon; the font is song typeface and the font size is 9 pt.

Fig. 3. The interface of hierarchy menu

2.2   Experiment Tasks and Processes

There are 18 people tested in the experiment; the age range is about 20 to 30 years old, with an average age of 24. Their using time of mobile phone is more than 3 years. The participants are grouped into three groups by random. The participants in each group only use one kind of menu organization in the experiment. Each participant will complete four different tasks:

> Task 1: when you are chatting with your friend on the phone, he/she sends you an email, and this email is very important, which need you to find this email right now.
> Task 2: now you are chatting with your friend on the phone, at this moment your WeChat ringing; you receive a WeChat message, and you want to view the contents of this message right now.
> Task 3: now you are chatting with your friend on the phone, at this moment you find the roadside scenery is very beautiful; you want to take photo by the cell phones.
> Task 4: now you are on the phone with your friends, and your friend is telling you how to reach the destination, but you can't find the right direction, so you need to use a compass application in the cell phone to determine the azimuth.

Before the start of the experiment, the participants should understand the research purpose of the experiment by the introduction of the experiment, sign the "informed consent", and fill in the tables of personal basic information and mobile phone usage information. Then they need to be introduced the experimental simulation interface, and practice until the participants believe that they have already been familiar with the interface.

In official experiment, the simulation interface of mobile phone will be displayed on the screen of computer; participants start the tasks as soon as they heard "start" and timing begins, after the participants found the target icon, the interface prompts into work and end time. In the process of implementing the task, the TobiiStudio eye tracker will record the participant's line of sight and recording its operation behavior. After completing all tasks, the participants need to fill the satisfaction questionnaire.

3   The Results and Analysis of the Experiment

Table 1 shows the mean and variance of the completion time of the task under the condition of different application arrangement. The data shows that the average time to complete task 3 is 2.31(s), which is the shortest one for common menu. In this menu, the average time to complete task 4 is 8.44(s), which is the longest one. The average time to complete all task is 4.48(s). About history menu, the average time to completing task 2 and task 4 are shorter than others. They are 1.57(s) and 1.90(s). The average time to complete task 3 is 25.62(s), which is the longest one. In this menu, the average time to complete all task is 8.41(s). For hierarchy menu, the average time to complete task 2 is 3.93(s) which is the shortest one. The longest time is the average time to complete task 1 which is 12.10(s). In this menu the average time to complete all task is 10.43(s).

Thus, the operating time for common menu is the shortest. Figure 1 present the average time to complete tasks in different application arrangement intuitively.

Table 2 shows the mean and variance of the focuses in the process of the task under the condition of different application arrangement. For common menu, the data shows that the average focuses in the process of task 3 are 30.50, which is the least quantity; the focuses in the process of task 4 are 52.17, which is the most quantity. The average focuses in the process of all tasks are 36.96. About history menu, the average focuses in the process of task 2 and task 4 are less than others'. They are 19.67 and 28.50. The average focuses in the process of task 3 are 92.67, which is the most quantity. In this menu, the average focuses in the process of all task are 46.75. For hierarchy menu, the average focuses in the process of task 2 are 26.67, which is the least quantity. The most focuses are the average focuses in the process of task 1 which are 76.67. In this menu the average focuses in the process of all task are 43.96. Thus, the quantity of focuses for common menu is the least. Figure 2 present the average focuses in the process of tasks in different menu organization form intuitively.
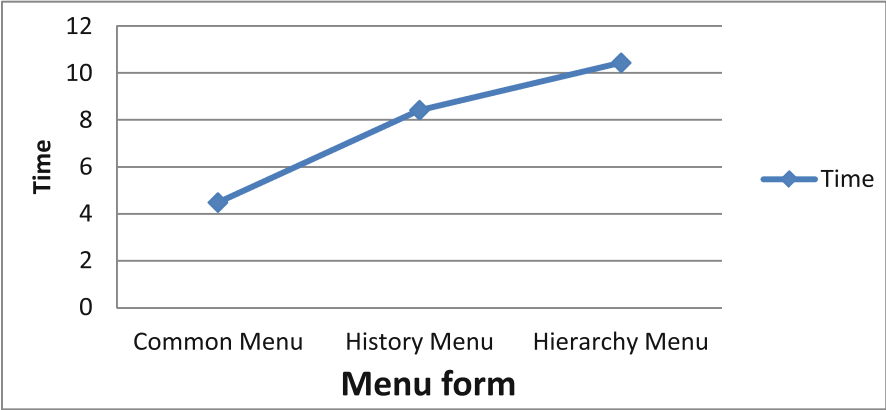
Table 1. Descriptive statistics of time.

Variables	Common menu		History menu		Hierarchy menu	
	Average value(s)	Standard deviation	Average value(s)	Standard deviation	Average value(s)	Standard deviation
Task 1	3.54	1.70	4.55	1.99	22.97	12.10
Task 2	3.64	1.48	1.57	0.36	3.93	1.46
Task 3	2.31	0.60	25.62	12.27	5.60	3.50
Task 4	8.44	8.24	1.90	0.90	9.22	4.25
Total	4.48	4.66	8.41	11.75	10.43	9.87

Table 2. Descriptive statistics of number of fixation

Variables	Common		History		Hierarchy	
	Average value	Standard deviation	Average value	Standard deviation	Average value	Atandard deviation
Task 1	31.33	11.00	46.17	20.89	76.67	22.33
Task 2	33.83	11.22	28.50	4.14	26.67	13.08
Task 3	30.50	9.73	92.67	32.23	33.83	22.12
Task 4	52.17	22.87	19.67	8.24	38.67	23.98
Total	36.96	16.43	46.75	34.17	43.96	27.72

Table 3 shows the mean and variance of the participants' satisfaction under the condition of different application arrangement. The average participants' satisfaction about common menu is 6.35, 5.35 for history menu and 4.90 for hierarchy menu. So the most popular menu is the common menu. The history menu is worst (Figs. 4 and 5).

Fig. 4. Mean time on different menu construction

Table 3. Descriptive statistics of Satisfaction

Variables	Average value	Standard deviation
Common menu	6.35	0.73
History menu	5.85	0.90
Hierarchy menu	4.90	1.29
Total	5.70	1.16

Fig. 5. Mean number of fixation on different menu construction

4   Conclusions

The purpose of this study is to explore the impact of the organization form of mobile phone applications on the operation performance of completing sub-task and subjective satisfaction of users under the implementation of the main task. Experimental results show that the operation time and subjective satisfaction of the users under the common menu are significantly better than the history menu and hierarchy menu, following by history menu.

Despite the fact that the screen of smartphone only presents a single interface of the application when the current users in the operation of an application, but with the increasing of functions of smartphone applications, there are more and more demands to operate two or more applications at the same time, for the small screen, how to improve its operation performance and satisfaction while users in the operation of a function of an application and easy to find other applications at the same time, which are closely related with the application arrangement.

References

1. Wikipedia. http://is.gd/pzjWb6
2. Dillon, A., Richardson, J., McKnight, C.: The effects of display size and text splitting on reading lengthy text from screen. Behav. Inf. Technol. **9**(3), 215–227 (1990)
3. Jones, M., Marsden, G., Mohd-Nasir, N., Boone, K., Buchanan, G.: Improving web interaction on small displays. Comput. Netw. **31**, 1129–1137 (1999)
4. Tang, K.: Menu design with visual momentum for compact smart products. J. Hum. Factors Ergon. Soc. **43**(2), 267–277 (2001)
5. Wang, A.H., Lai, Y.Y., Sun, C.T.: Effect of PDA scrolling- and hierarchy-menu design on users' operating performance. Displays **25**, 109–114 (2004)
6. Bohmer, M., Bauer, G.: Exploiting the icon arrangement on mobile devices as information source for context-awareness. In: Proceeding of Mobile HCI (2010)
7. Huhtala, J., Mäntyjärvi, J., Ahtinen, A., Ventä, L., Isomursu, M.: Animated transitions for adaptive small size mobile menus. In: Gross, T., Gulliksen, J., Kotzé, P., Oestreicher, L., Palanque, P., Prates, R.O., Winckler, M. (eds.) INTERACT 2009. LNCS, vol. 5726, pp. 772–781. Springer, Heidelberg (2009)
8. Benyon, D.: Adaptive systems: a solution to usability problems. User Model. User-Adap. Inter. **3**(1), 65–87 (1993)
9. Weld, D.S., Anderson, C., Domingos, P., Etzioni, O., Gajos, K., Lau, T., Wolfman, S.: Automatically personalizing user interfaces. In: Proceedings of the 18th International Joint Conference on Artificial Intelligence (2003)

10. Van Velsen, L., Van der Geest, T., Klaassen, R., Steehouder, M.: User-centered evaluation of adaptive and adaptable systems: a literature review. Knowl. Eng. Rev. **23**(03), 261–281 (2008)
11. Verkasalo, H.: Contextual patterns in mobile service usage. Pers. Ubiquit. Comput. **13**(5), 331–342 (2009)
12. Do, T.M.T., Perez, D.G.: By their apps you shall understand them: mining large-scale patterns of mobile phone usage. In: Proceeding of the 9th International Conference on Mobile and Ubiquitous Multimedia (2010)
13. Mitchell, J., Shneiderman, B.: Dynamic versus static menus: an exploratory comparison. SIGCHI Bull. **20**(4), 33–37 (1989)
14. Park, J., Han, S.H., Park, Y.S., Cho, Y.A.: Adaptable versus adaptive menus on the desktop: performance and user satisfaction. Int. J. Ind. Ergon. **37**(8), 675–684 (2007)
15. Bridle, R., McCreath, E.: Inducing shortcuts on a mobile phone interface. In: Proceeding of the 11th International Conference on Intelligent User Interface, pp. 327–329 (2006)
16. Vetek, A., Flanagan, J.A., Colley, A., Keränen, T.: SmartActions: context-aware mobile phone shortcuts. In: Gross, T., Gulliksen, J., Kotzé, P., Oestreicher, L., Palanque, P., Prates, R.O., Winckler, M. (eds.) INTERACT 2009. LNCS, vol. 5726, pp. 796–799. Springer, Heidelberg (2009)
17. Albers, M., Kim, L.: Information design for the small-screen interface: an overview of web design issues for personal digital assistants. Tech. Commun. **49**(1), 45–60 (2002)