AN ERGONOMICS STUDY OF MENU-OPERATION ON MOBILE PHONE INTERFACE

XUE-MIN ZHANG, WEN SHAN, QIN XU, BIN YANG, YUN-FENG ZHANG

Beijing Normal University, School of Psychology, Beijing Key Lab of Applied Experiment Psychology, Beijing, PRC, 100875, E-MAIL: xmzhang@bnu.edu.cn

Abstract:
The studies on user and mobile phone interaction have been an important problem in small screen interface design. The present study was intend to investigate the impact of three common mobile phone menu displays: matrix, tree, and page-to-page – and differential organizations of their sub-menus and functions by reaction time experiment. We also used rating scale to investigate users’ preference of different mobile phone menu displays. Reaction time for accurately completing these operations was fastest when participants were presented with the matrix menu and fastest when participants were presented organizations emphasizing logical categorization rather than non-logical categorization. The result also showed consistency between users’ operating efficiency and mobile phone users’ interface preference. Finally, the implications of these findings for mobile phone design are discussed.

1. Introduction

Human computer interface or user interface is the visual medium through which users could input or output information or finish some special functions, such as edit document, sent messages, find the calling number et al. It consists of hardware and software for information exchange or communication (Aaltonen A., Hyrskykari A., & Raiha K., 1998)[1]. User interface has passed a long way from those just with words or characters to those with various pictures, icons, audio input or output and multiple-model functions. In any kinds of user interface, the user played an very important role in the interaction between users and interface. Therefore, in order to improve efficiency of information exchange and communication between user and interface, it is necessary to study the users’ cognitive and behavioral performance when they user the computer or mobile screen devices. In the present study, the most important question we focused was the user and mobile phones’ interaction. As the popularization of the computer and communication technology, mobile phone has become an most important communication device in our daily life, and both the designers and users have been paying more on the combination of mobile phones and computer technology, and make the mobile phone work well in individualization, convenience, and efficiency of operation.

According to the perspective of ergonomics, the user interface designer should design the interface in the following principles, that is easy operation, less memory load and more efficiency (Chen et al, 2000) [2,3]. These principles are also very important for the designing of mobile phone interface, such as menu display pattern and submenu logical categorization (in depth and breadth) et al. The mobile phone interface should be designed with convenient or well operating menu structure, convenient navigation system, high operating efficiency and better visual effect.

In resent years, with the popularization of the mobile phone, more and more mobile phone producers designed mobile phone with different style interface, and the users also chose different interface mobile phone according to their favorite or preference. As an very important communicating device, the most important things is the efficiency of operation with better visual or multiple-model interface, and their favorite or personal preference. The mobile phone also should be operated with less users’ memory load, harmonious word or icon-recognition system and high efficient navigation system. These functions can not only satisfy users’ needs of communication, and entertainment, but also satisfy the users’ favorite and preference.

Menu system as one of the most commonly used function of mobile phone, it can help users to communicate with others in different ways. The menu displaying pattern should be identical with human cognition and keep the information communication in natural and effective ways (Chen J., 2000) [4]. So, the well-operated menu will make the communication work in high efficient ways. Some kinds of menu design are obviously lack of convenience and, less of efficiency in operating. For instance, some mobile phones require users to view the menus in a page-to-page pattern to
check the functions which are without logics and need long time to finish the communication especially in send message or find some commonly used functions. Some mobile phone menu make the communication more efficiently, so that menu with naturally, high efficient, convenient and well-operated navigation interface will be the better choice for most users.

In the mobile phone menu interface design, structure and conceptual design are very important in the process of menu designing. Structure design refers to the design of the overall structure of interface after researches of user’s cognitive process and analysis of the operating tasks. Structure design includes depth and breadth design of interface and hierarchy of menu. The conceptual design and refers to the number of operating tasks in the same hierarchy menu. Some researches suggested that the more complex of the hierarchy menu, the less effective of the operation, and the effect of depth design was well-operated than that of the breadth design (Allen, 1983; Laarni J., 2002 Laarni J., Simola J., Kojo I., & Risto N, 2004) [5,6,7]. These studies and its suggestions were adopted in the designing of computer menu, for example, in order to reduce the depth, the designer should make the breadth of menu work efficiently. In the structure designing, a well-operated logic of the menu content was very helpful for the users to operate the menu conveniently and easily (Shieh K., Hsu S. H., & Liu Y., 2005) [8].

The well-designed menu will make the cognitive process of operation easily and also make the information communicating fluently. A well-designed menu interface should follow the principle that “the operation should be identical to human behavior habits and cognition” (Liu Y., & Shen M., 2000, Melchior M., 2001) [9,10]. For instance, the process of visual search was an important part of menu selection, which includes two possibilities: parallel or serial selection (Aaltonen, Hyrskykari, & Raiha, 1998) [11]. Some researchers suggested that menu font size, font and background color and icon size had significant effect on message sending of mobile phone (Zhang X. M. et al., 2006; Zhang X., He L., & Lan X., et al., 2004) [11,12].

According to the previous studies, the present study considered three most commonly used mobile phone menus (matrix, tree and page-to-page) used the mobile phone simulator with Chinese interface (see Figure 1). The participants were Chinese college students. We expected that users’ performance would be most efficient when they were given the matrix pattern menu display and an organization type that capitalized on linking related sub-menus together (see Figure 2, left panel). We also predicted that participants’ performance would be compromised when presented with the organizational type emphasizing breadth as opposed to that emphasizing depth. The participants’ performance would be middle (see Figure 2, right panel). Finally, we hypothesized that performance would be least efficient when users were provided with the page-to-page pattern and the organization type emphasizing breadth (see Figure 2, bottom panel). Additionally, the participants’ rated their preference of the three menus.

2. Research Method

2.1. Participants

Sixty undergraduate students (20 males and 40 females) from Beijing Normal University, aged 18 to 26, participated in exchange for token payment. All reported as mobile phone users with normal or corrected-to-normal acuity and color vision. Prior to the study, participants were asked to indicate their familiarity with basic mobile phone operation and to report which of the three menu displays to be used in the experiment, with which they had the greatest experience. Based on their reports, experience with each of the menu designs was, for the most part, equally represented.

2.2. Apparatus

The trials were administered using a phone-simulator as presented on a 17 inch computer screen. The simulator represented a standard mobile phone keyboard, display, and operation interface (see Fig. 3). The simulator screen was 200 (Width) by 215 (Height) pixels. Normal working illuminance (130 Lux) was kept constant throughout all trials.

2.3. Materials

The study used a mixed design with menu display

![Figure.1 mobile phone simulator](https://example.com/figure1.png)
![Figure.2 Three menu patterns](https://example.com/figure2.png)
pattern as a between-subjects factor and organization type as a within-subjects factor. Participants were assigned to one of three menu design groups: matrix, tree, or page-to-page. Assignments were made such that individuals familiar with each type of menu design were equally represented in each condition. Within each condition, half the trials reflected an organization emphasizing breadth and half emphasizing depth. After the experiment, participants were required to complete a 7-point Likert rating scale about their preference to the mobile phone interface.

2.4. Procedures

All participants were run individually and seated 50 cm from the screen. Participants were given first presented with practice trials to familiarize themselves with operation of the simulator.

During the experiment proper, participants were asked to send an image labeled “Birthday Cake,” that had been saved in the mobile phone, as quickly and accurately as possible. This response entailed making a series of key presses and then pressing “yes” on the simulator. However, if any of the key presses were inappropriate, a pop-up warning was displayed that indicated that the participant should re-try the key-press. A trial was complete when all the key presses were correct. The time to complete a trial was recorded for each participant.

Participants completed 36 randomly presented trials and could take short rests between trials if so desired. Instructions about what to do during the course of the experiment were given orally by the experimenter. Further instructions during the course of a trial were presented on the computer screen.

The total time for testing was 20 minutes.

Note of figure 3: the left panel illustrates an organization that emphasizes depth; the right panel illustrates one that emphasizes breadth. In both panels, the functions in the far left are those intrinsic to the phone such as short text messages, radio, or camera. Functions in the middle of the panel (see dotted line of the arrow) are sub-menu levels for each of these functions such as a radio tuner for the radio function. The far right of each panel (see arrow head) refers to the outcome of the selection resulting in connection to a desired radio station.

3. Results

According to the results, there was no such speed-accuracy trade-off. The mean and SD of the RT and error rate (ER) was shown in Table 1. Table 2 and Table 3 showed preference results of three levels of menu displaying patterns and 2 levels of logical categorization of options.

<table>
<thead>
<tr>
<th>menu-display pattern</th>
<th>categorization of options</th>
<th>The mean of the RT(s) (the mean of false times)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>matrix pattern</td>
<td>Totally logical</td>
<td>15.85 (0.097)</td>
<td>2.021</td>
</tr>
<tr>
<td></td>
<td>non-totally logical</td>
<td>15.406 (0.195)</td>
<td>2.068</td>
</tr>
<tr>
<td>tree pattern</td>
<td>Totally logical</td>
<td>14.078 (0.075)</td>
<td>1.891</td>
</tr>
<tr>
<td></td>
<td>non-totally logical</td>
<td>16.158 (0.182)</td>
<td>2.326</td>
</tr>
<tr>
<td>page-to-page pattern</td>
<td>Totally logical</td>
<td>15.528 (0.053)</td>
<td>1.868</td>
</tr>
<tr>
<td></td>
<td>non-totally logical</td>
<td>16.901 (0.251)</td>
<td>2.202</td>
</tr>
</tbody>
</table>
The reaction time results (see Table 1) indicated that in each condition of logical categorization, the sequence of the RT from fastest to slowest was matrix<tree<page-to-page, and both the RT and ER in the totally logical categorization condition were smaller than non-totally logical categorization. Table 2 and Table 3 showed that participants had more preference to matrix, and less preference to page-to-page.

3.1 Effects of the menu pattern on the efficiency

The repeated measures ANOVA of reaction time in three menu display patterns yielded a significant main effect, F(2, 60)=3.221, p=0.047, that was the menu display patterns had effect on efficiency of operating, the post hoc test indicated that the matrix was fastest (M=15.663sec), then was the tree pattern (M=15.108sec), page-to-page pattern was the slowest (M=16.241sec). No significant main effect of error rate in three menu level was found.

The reaction time repeated measures ANOVA analysis of the effect of logical categorization yielded that main effect was significant, F(1, 60)=133.859, P<0.001, that was, the time in totally logical categorization condition (M=14.488sec) was faster than that in non-totally logical categorization condition (M=16.241sec). No significant main effect of error rate in three menu level was found.

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The the reaction time repeated measures ANOVA analysis of the effect of logical categorization yielded that main effect was significant, F(1, 60)=133.859, P<0.001, that was, the time in totally logical categorization condition (M=14.488sec) was faster than that in non-totally logical categorization condition (M=16.241sec). These results were consistent with the hypothesis. The analysis on the error rate suggested that the main effect of the logical categorization was significant, F(1, 60)=19.183, P<0.001, that was, the error rate in the non-totally logical categorization was significantly higher than that in the totally logical categorization, which was consistent with the hypothesis.

No interaction was found between menu display patterns and logical categorization both in reaction time and error rate.

3.2 Users’ preference of menu display

The mean and SD results were shown in Table 2 and Table 3. The repeated measures AVONA analysis of users’ preference on the menu display yielded a significant main effect, F(2, 60)=33.429, P<0.001, that the post hoc test indicated that the paired comparison of the three menu display level were all significant, which the matrix pattern was rating highest preference (M=5.007), the second was tree pattern (M=4.447), and the page-to-page pattern was the lowest (M=3.816).

Furthermore, the repeated measures ANOVA analysis of users’ preference to the logical categorization yielded a significant effect, F(1, 60)=26.00, P<0.001, which indicated the participants prefer to the totally logical categorization (M=5.144) than the non-totally logical categorization (M=3.817).

No interaction was found between preference of menu display patterns and logical categorization.

4. Discussions

4.1 Effects of the menu display pattern on the efficiency of operation

According to the previous analysis, the result of the operating efficiency between different patterns was significant, the matrix pattern yielded the highest efficiency, then the tree pattern, and the page-to-page pattern yielded the worst, which was consistent with the hypothesis.

The reason of why the matrix pattern yielded the highest efficiency was that the distance between operations was shorter than that of tree and page-to-page menu, and the users could switch from one operations to another more easily. And the operation of matrix pattern depended on navigation by cognition process, not by memory process, so the users would not get lost. The reversibility in operation was one of the reasons, too. Furthermore, the matrix pattern had bigger capacity for information so that the users could get more information without scrolling pages.

4.2 Effects of the logical categorization on the efficiency of operation

The results showed that the operating efficiency was better in totally logical categorization than non-totally logical categorization. The reason was probably that the totally logical categorization could cost less users cognitive load in their operation process than non-totally logical categorization.

Moreover, the operating efficiency of deeper and narrower menus was better than that of shallower and broader ones. Therefore, the designers should pay more attention on the depth and breadth when designing mobile phone menus.

Table 2: menu display patterns preference (n=60)

<table>
<thead>
<tr>
<th>Menu display pattern</th>
<th>MEAN</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Matrix pattern</td>
<td>5.007</td>
<td>1.350</td>
</tr>
<tr>
<td>Tree pattern</td>
<td>4.477</td>
<td>1.154</td>
</tr>
<tr>
<td>Page-to-page pattern</td>
<td>3.816</td>
<td>1.508</td>
</tr>
</tbody>
</table>

Table 3: categorization preference (n=60)

<table>
<thead>
<tr>
<th>Logical categorization of options</th>
<th>MEAN</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Totally logical categorization</td>
<td>5.144</td>
<td>1.162</td>
</tr>
<tr>
<td>Non-totally logical categorization</td>
<td>3.817</td>
<td>1.112</td>
</tr>
</tbody>
</table>
4.3 Relationship between patterns and users’ preference

Generally, users preferred menu display patterns and totally logical categorization in which the reaction time was faster, and the reaction time to those less preference menu and non-totally logical categorization was slower.

The results also showed the further evidence that the matrix pattern and totally logical categorization could help users to operate the mobile phones more efficiently, which provided suggestions to the mobile phone interface designers on how to design small screen interface with high naturally efficiency, individuation and powerful functions.

5. Conclusions

According to the present study, we could draw the following conclusions and implications:

5.1. Menu display patterns had significant effects on operating efficiency: the matrix pattern yielded the shortest operating time, then the second was the tree, and the page-to-page yielded the longest.

5.2. The operating time in totally logical categorization condition was significantly shorter than non-totally logical categorization, and users made fewer errors in totally logical categorization condition.

5.3. No significant interaction between the menu display patterns and logical categorization condition both the reaction time and the error rate were found.

5.4. No significant interaction between the operating time and the preference in all levels of the menu display patterns was found; and no the interaction between the operating time and the preference in all levels of the logical categorization were found.

5.5. The present study had important implications on designing of mobile phone menu display interfaces, and related small screen interfaces of such as PDA. The matrix or tree menu and totally logical categorization could help users to improve small screen operating efficiency and their preference.

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References