Usability of Adaptable and Adaptive Menus

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Abstract. This study investigates the usability of different adaptable and adaptive menu interfaces in a desktop environment. A controlled experiment was conducted to compare two different adaptive menus and one adaptable menu with a traditional menu. The two adaptive menus include an adaptive split menu that moves frequently used menu items to the top, and an adaptive highlight menu that automatically boldfaces frequently used menu items. Target selection times and the number of errors were recorded while the participants were performing menu selection tasks. Subjective satisfaction including perceived recognizability, perceived efficiency, and overall preference were also measured. The results showed that the adaptable menu outperformed the other menus in terms of both the performance and the satisfaction. The adaptive split menu was not as efficient as its theoretical prototype, especially when the selection frequency changed. The adaptive highlight menu, newly proposed in this study, was not significantly better than the traditional menu in terms of the selection time. However, it was preferred by the users since it helped them select frequently used items and was much less sensitive to the variations of selection frequency.

1 Introduction

Menu is one of the most important interface elements in a desktop environment. It becomes longer and longer as the number of functions in the software application increases. This stresses the importance of menu organization. Also, there is an increasing need for customization of menus, since computer systems today are designed to be used by millions of users with various purposes. There are two approaches to the customization/personalization of a menu. One is adaptable menu that can be modified by its users, and the other is adaptive menu that automatically adapts itself to the environment.

Some researchers found that making frequently selected menu items easy to select could reduce the selection time and increase the user satisfaction. Different adaptive menus have been proposed. Sears and Shneiderman [5] proposed 'split menu' in which three or four most frequently selected items are shown at the top of the menu. They compared it with an alphabetic menu and a frequency-ordered menu, and found that the split menu was better than the others in terms of performance and satisfaction when the frequently selected items were located in the middle or bottom of the menu.

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Lee and Yoon [4] investigated the effects of various selection supports for menu selection tasks. They proposed a temporal selection support menu, which shows frequently selected items shortly before presenting the entire list of items. They compared it with the traditional, split and folded menus. The result showed that the split menu only provided spatial support by reducing the distance to high-priority items, whereas the folded menu provided both temporal and spatial supports. They showed that the split menu reduced the selection time in the early stage of use, and also was preferred by the users. However, the performance of the split and folded menus degraded as frequently selected items varied. The temporal menu was relatively insensitive to changes in selection frequency and location of the high frequency items, but there was no significant difference between the temporal and traditional menu in both the selection time and the user preference.

Findlater and McGrenere [3] compared three different types of split menus: (1) Static menu, in which four most frequently selected items always stay at the top of the menu; (2) Adaptive menu, in which two most frequently selected items and two recently selected items are presented at the top of the menu; (3) Adaptable menu, in which items could be moved to the top or bottom section of the menu by the user. The results showed that the static menu was faster than the adaptive menu, and the selection time of the adaptable menu was similar to the static menu in general, except when the adaptable was the first condition of the experiment, where it was as slow as the adaptive menu. The users preferred the adaptable menu to the static menu, but not to the adaptive menu.

The studies described above dealt with the quantitative comparison between various menu adaptation techniques. However, most of them are either incomplete or not systematic enough. Some of the studies are based on an unrealistic assumption about the system's knowledge of selection frequency. Some others that asserted the superiority of the split menu overlooked the adaptive menus' performance degradation under varying selection frequency. In addition, little effort has been made to examine the usability of adaptable menus, although it is generally accepted that many users want to adapt their system by themselves rather than fit themselves to the system.

This study examines the effectiveness of adaptable and adaptive approaches to menus in desktop applications. An adaptable menu and two different adaptive menus were implemented and evaluated. The two adaptive menus consist of an adaptive split menu that moves frequently used menu items to the top, and an adaptive highlight menu that automatically boldfaces frequently used menu items.

2 Methods

A controlled experiment was conducted to compare the usability of the menus. A total of 32 graduate or undergraduate students (25 males and 7 females) participated in the experiment. Their ages ranged from 17 to 25 (mean = 21.1) years. The participants were randomly assigned to one of two groups (Group A or Group B), each of which comprised 16 participants. The participants in a different group conducted experimental conditions in a different order of selection frequency distributions.

An application program was developed using Microsoft Visual Basic 6.0. Four menu types implemented in the program were traditional, adaptable, adaptive split, and adaptive highlight menus. The traditional menu is a typical static menu. In the adaptable menu, the user could move the menu items by dragging-and-dropping. The adaptive split menu is divided by a horizontal line into two sections. The top section keeps three most frequently selected items while the bottom section contains the others. It counts how many times each item has been used in recent 50 selections and updates the list after a selection is made. As in Sears and Shneiderman [5], both sections are organized in a traditional order that the entire list would have been presented in. In the adaptive highlight menu, the most frequently selected items are boldfaced instead of being moved. This menu selects the high frequency items in the same way as the adaptive split menu does. Fig. 1 presents the adaptable, adaptive split, and adaptive highlight menus.

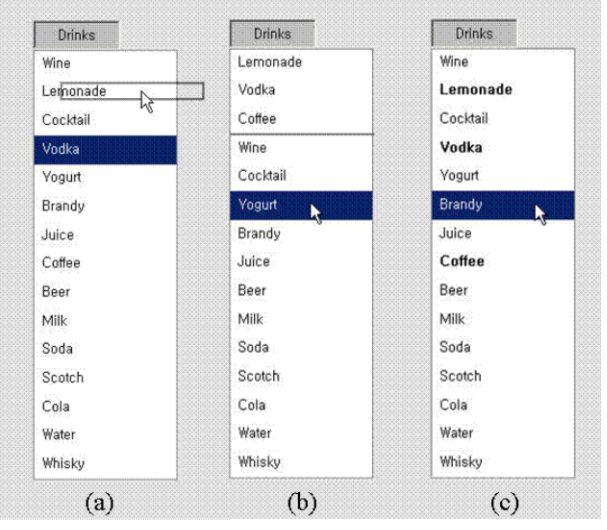

Fig. 1. Menu types: (a) adaptable menu (changing positions); (b) adaptive split menu; (c) adaptive highlight menu

Sixty different nouns from four label categories (fifteen nouns for each category) were used as labels of the menu items. The categories were body parts, countries, drinks, and sports. Nouns shorter than 4 characters or longer than 10 characters were excluded, and no more than four nouns in a category had the same initial letter. The category name was shown in the title bar at the top of the menu. Each menu contained 15 different items under a category.

The presentation order was counterbalanced using two Latin squares (one for the menu type and another for the menu label), which resulted in sixteen treatment conditions.

Two selection frequency distributions adapted from the literature with slight modification [4] [5] were employed to investigate the performance of these menus

under varying selection frequency. High frequency items are located in the top half in Distribution 1, while they are found in the bottom half in Distribution 2.

In the main experiment, the participants performed the four conditions (menu types) in the pre-determined order given by the experimenter. A condition was comprised of four task blocks, each of which contains 50 selections. The traditional menu was used in every first block of the conditions (Block 1) so that the participants could be acquainted with the label and occurring frequency of the items. Block 1 was excluded from the analysis. In the second, third, and fourth blocks (Block 2, 3, and 4), the participants were provided with one of the four menu types depending on the condition. The selection frequency started to vary at the beginning of Block 4. The participants in Group A, who had experienced Distribution 1 in the first three blocks, were presented with Distribution 2 in Block 4. Meanwhile, the participants in Group B, who had gone through Distribution 2 first, experienced Distribution 1 in the last block.

When a target item was presented on the screen, the participants were asked to open the menu by clicking the menu title, and then select the same item from the pull-down menu as quickly and accurately as possible. They were instructed to repeat the selections until they correctly selected the target item. When a participant selected the correct item, the menu was disabled for 1 second before the presentation of the next item. Target selection times and the number of errors (incorrect selections) were measured while the participants were performing the menu selection tasks. A short break (about two minutes) was given between the blocks. In the adaptable menu condition, the participants were given an opportunity to change the position of the menu items twice, once after Block 1 and once after Block 2. They could change the positions of the items if they wanted to do so. In a debriefing session, the participants were asked to rank the menu types on the basis of perceived recognizability of the items, perceived efficiency of selection, and overall preference.

3 Results

Means of the target selection times are presented in Table 1 and Table 2. Learning occurred in Block 1, and the selection time increased in most cases when the frequency changed in Block 4. For each participant group, the analysis of variance (ANOVA) was used to analyze the selection time for Block 2 and 3 combined (ideal performance), and Block 4 (performance under frequency variation) separately. Data from Block 2 and 3 were merged because the same condition was used in these blocks. The effect of menu types was found to be significant in all the four ANOVAs ($\alpha = 0.05$).

Differences between the menu types were analyzed by using SNK (Student-Newman-Keuls) test at $\alpha = 0.05$. The results showed that Group A participants were significantly faster with the adaptable and adaptive split menus than with the others in Block 2 and 3. However, in Block 4, the adaptable menu was the fastest, while the adaptive split menu was slower than any other menus. For Group B, the adaptable was significantly faster than the traditional and adaptive highlight in Block 2 and 3. There were no differences among the conditions except the adaptable. In Block 4, the

adaptive split was significantly slower than the others. But, there were no differences among the other conditions.

The number of errors per target selection ranged from 0.013 to 0.027 (0.019 on the average). Because the error occurred very rarely, a Chi-square test was used to analyze the number of errors. The result showed that there was no significant difference in the number of errors among the menu types (χ^2=2.509, p = 0.474).

Table 1. Means and standard deviations of selection time for Group A (s)

Block	Traditional		Adaptable		Adaptive split		Adaptive highlight	
	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.
1	1.309	0.189	1.315	0.180	1.275	0.252	1.243	0.183
2	1.005	0.149	0.914	0.113	0.943	0.179	1.011	0.191
3	0.945	0.144	0.861	0.134	0.850	0.198	0.932	0.182
4	1.008	0.141	0.897	0.147	1.148	0.252	1.051	0.199

Table 2. Means and standard deviations of selection time for Group B (s)

Block	Traditional		Adaptable		Adaptive split		Adaptive highlight	
	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.
1	1.390	0.289	1.393	0.237	1.390	0.282	1.367	0.329
2	1.082	0.227	0.964	0.146	1.066	0.214	1.079	0.255
3	0.983	0.178	0.902	0.181	0.908	0.186	1.002	0.230
4	0.925	0.152	0.925	0.208	1.162	0.198	0.968	0.226

The Friedman test revealed that, in terms of all the three subjective criteria, there were significant differences in rankings among the menu types at $\alpha = 0.05$. The differences were further analyzed using Dunn's post-hoc test at $\alpha = 0.05$. The participants considered the adaptable and adaptive highlight menus more recognizable than the others. As for the perceived efficiency, the adaptable was better than the adaptive highlight or traditional, whereas the adaptive split was only better than the traditional. The traditional was found to be perceived as less efficient than any other conditions. In terms of the overall preference, the traditional was the least preferred and there were no significant differences among the others.

4 Discussion

The traditional menu could be easily learned by the user, since it never changes the position or style of an item. If a user memorizes an item's position, he/she can easily find it. But, it usually takes time before he/she memorizes the position of all the items, and until then, he/she has no other choices but searching for the target item by scanning through the list. Even after he/she already knows the position of frequently used items, the menu does not provide any support to make the selection easier. This lack of support for finding and selecting frequent items explains why the traditional

menu was slower than the adaptable or adaptive split menus in Block 2 and 3. For the same reason, it was rated as the worst among the four by the participants. One half of the participants (50%) indicated that frequently used items were relatively difficult to select with this condition, and nine of them (28%) noted it was annoying when frequently selected items were located near the bottom of the list.

The adaptable menu was always one of the fastest. The participants could easily find target items by reordering the items or putting frequently used items at the top of the list. This leads to high rating scores in the perceived recognizability and efficiency by the participants. However, one shortcoming of this menu is that additional efforts are required for a user to reorganize the frequent menu items. Five participants (16%) indicated the inconvenience of performing adaptation on their own, and one participant (3%) did not adapt the menu at all because he felt it was unnecessary.

The adaptive split menu was significantly faster than the adaptive highlight or traditional menus when frequently used items were located in the upper half of the list and the selection frequency remained stable (Block 2 and 3 of Group A). In other conditions, it was not faster than the traditional one. A major drawback of this menu is that it is very sensitive to the variation of selection frequency. When frequently used items changed in Block 4, the selection time noticeably increased and it became slower than any other menu types regardless of the location of frequent items. It complies with the disadvantage of spatial inconsistency posed by Card [2] and Somberg [6]. According to them, positional consistency of items can increase the efficiency of search.

The adaptive split menu, which dynamically changes the items in the top based on the recent selection history, was found not to be as efficient as its theoretical prototype that has been highly rated in the literature. Although most participants (91%) responded it enabled efficient selection of items in the top, three-fourths of the participants (75%) complained that it was confusing when the selection frequency changed, and seven participants (22%) indicated the inconvenience of selecting infrequent items. For this reason, the adaptive split menu was not preferred to the traditional menu in terms of perceived recognizability, though it was rated high in terms of the perceived efficiency and overall preference. These imply that the utility of the split menu might be limited in practical applications where selection frequency is unstable and difficult to predict.

The adaptive highlight menu had no advantage in terms of the selection time compared with the traditional menu. It means that, in terms of the selection time, no benefit is obtained by highlighting frequently selected items, or the benefit, if any, is cancelled out by a side-effect. As four participants (13%) indicated, highlighted items sometimes interfered with the participants' search for a non-highlighted item. Nevertheless, the adaptive highlight was rated higher than the traditional menu in every aspect, and even higher than the adaptive split in perceived recognizability. Twenty five participants (78%) reported they could easily find an item when it was highlighted. Eleven participants (34%) indicated they were satisfied with this menu because the position of the menu items did not change.

The participants were able to efficiently organize the menu employing various criteria such as selection frequency and alphabetic order. A few participants used their likes and dislikes for the menu items or the word length. When they adapted the menu, they could easily find and select a target item. This advantage was maintained

even when the selection frequency changed. They seemed to recall the position of each menu item better, because they made the change by themselves. However, there remain some issues to resolve for practical applications. First, it is questionable whether the users are able to easily determine when the interface needs to be adapted to produce a benefit. Second, the users may not know what should be adapted to make menu selection more efficient. In this experiment, the participants adapted the menu after performing at least 50 selections for a short period of time. It may be difficult for the users to know the accurate frequency of each menu item or proper criteria for ordering the items, if they are asked to adapt the menu in the middle of long-term use. As Bunt et al. [1] suggested, providing adaptive support might help the users to determine what to adapt.

5 Conclusion

This study systematically compared the effectiveness of different adaptable and adaptive menus. The results have led us to conclude that the adaptable menus are very efficient and preferred by the users compared to the others. However, additional efforts are required for the users to adapt the menu, and it has been a major barrier that inhibits the adaptation. On the other hand, the adaptive split menu was not as efficient as its theoretical prototype, and the performance seriously deteriorated when selection frequency changed. These drawbacks seem to limit the utility of the split menu in practical applications. A new type of adaptive menus, i.e., the adaptive highlight was proposed and examined. This menu was preferred to the traditional one. Spatial consistency of the menu item in this menu type appealed to the users, though it could not reduce the selection time. Implications on the menu design were identified. The system needs to provide an efficient method for the users to easily reorganize the menu items using such criteria as frequency and recency of the items and alphabetic order. A hybrid combination of adaptive and adaptable menus would be interesting future research. The adaptive highlight might be applied to the adaptable menus to provide accurate selection frequency information based on history data and motivate the users to reorganize menu items at the same time.

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