A Comparative Study between Younger and Older Users on Mobile Interface Navigation

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Abstract— **Mobile interface navigation is an important aspect when directly manipulating the mobile technologies, yet the navigation behavior is not well understood at the level of visual presentation of navigation elements and task complexity for users among different age groups. This comparative study utilized an experiment to compare the mobile interface navigation between younger and older user groups, by examining three types of visual presentations and three levels of task complexity. The results showed that there were significant differences between age groups in navigation efficiency, effectiveness and subjective evaluation. In addition, the navigation performance was significantly lower when the task required more information sources to be remembered and integrated, especially for older users. However, no significant effect of visual presentation was reported on the navigation performance and subjective evaluation. Understanding the mobile interface navigation behavior among different age groups will assist in designing appropriate visual presentation of navigation elements and keeping task complexity to an accepted level for targeted user groups.**

Keywords- age; mobile interface; navigation; task complexity; visual presentation.

I. INTRODUCTION

With the prevalence of mobile technologies, navigation through mobile interfaces is becoming an important aspect to search for the contents and utilize relevant functions provided by the mobile websites or applications [1]. Instead of interacting with the mouse and keyboard, mobile technologies generate their specific mobile navigation patterns due to the different interactive mode, limited interface space, and complex information architectures. Thus, it poses a considerable challenge of how to improve the user experience of mobile interface navigation for diversified user groups.

In particular, the direct user interface allows users to navigate through the applications by directly pointing or clicking the navigation elements on the interfaces, such as touch-screens [2]. The well-designed navigation elements can help users accomplishing tasks efficiently and effectively [3]. For instance, the menu navigation is a typical and popular way of representing the mobile application structures and functions [4]. Users can navigate their way to the desired target by selecting navigation elements (i.e., icons, hyperlinks, and buttons). In this way, the visual presentation of navigation elements is recognized as an important design consideration that helps users to better use navigation elements to find relevant information and complete tasks [5].

To fulfill the functional goals of the application or website, the designers may start from collecting specific navigation elements, to further grouping or arranging them into different hierarchies or categories. Also, designers could use these visual presentations to guide users' navigation patterns [6]. In fact, there is a long history examining the visual presentation in terms of icon characteristics on computer tasks [7][8]. They mainly emphasized the importance of icon characteristics on visual searching, such as concreteness, semantic distance, color quality, size, shape and location arrangement. However, most of the previous studies were mainly considered within the context of visual recognition and function matching tasks. It is still unknown how the visual presentation of navigation elements matters in the mobile navigation tasks.

Currently, an increasing number of older users are using mobile technologies for health management and social interactions, which involves information searching, decision-making, and problem-solving tasks [9]. Thus, the mobile interface navigation should also be concerned with the task complexity [10]. Task complexity, as defined by Campbell [11], lies in the nature of multiplicity, and deals with the collections of paths needed to reach the directions and even conflicts between the paths and expected results. Specifically, navigation task is concerned with how to organize the sequences of actions to search for desired information in order to achieve the task goals [12].

Previous studies normally defined the task complexity based on the page complexity and path complexity [13] [14], which concerned the number of navigation elements on the pages, the difficulty of judging the relevance of these elements and task goals, as well as the total steps and depth to gain the target information. Yet, we think it is also important to consider the task complexity based on the cognitive load and mental work needed. If the more complex a task is, the more information resources users need to remember and integrate, thus acquiring for more working memory and information processing. Therefore, this study examined the task complexity with the number of information sources needed to be remembered or integrated during the whole task.

Although strides have been made in studying web navigation, little investigation existed about the user experience of mobile interface navigation. This study was

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conducted as the first phase of a larger study to investigate the possible effects of visual presentation of navigation elements and task complexity on the mobile interface navigation. In order to include a diverse group of users, this study examined the differences of mobile interface navigation between age groups. The user experience of navigation was highlighted by aspects of task performance and subjective evaluation [15].

Overall, this study aims to contribute to a better comprehension of the user experience with mobile interface navigation among different age groups. It will assist designers in choosing the appropriate visual presentation of navigation elements and keeping the number of information sources to an accepted level of task complexity for targeted user groups. The organization of this article is as follows. Section II describes the details of participants recruitment and experiment design. Section III outlines the results of participants' navigation performance and subjective evaluation, with relevant correlations analyzed. Then, the section IV detailed discusses and interprets the results with some previous literatures. Finally, the section V presents the main conclusions, discusses the major limitations, and points out the possible directions to be explored in the future.

II. METHODS

The method of experiment was employed in present study to investigate participants' navigation performance and subjective evaluation.

A. Participants

A total of 15 participants were involved in this study. The majority of the participants were recruited from local universities and elderly centers. All the participants were in good physical and cognitive conditions, and had the ability to read Chinese characters. The participants were divided into two age groups: the younger group with an average age of 28.63 years old (SD= 4.60; age range: 24-38); and the older group with an average age of 69.57 years old (SD=11.62; age range: 52-81).

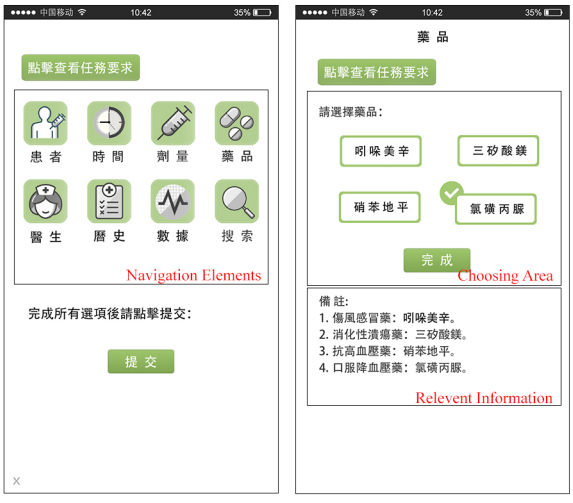

Figure 1. Interface design for menu navigation page (left) and sub-page: medication (right).

B. Experimental Design

In order to test the effects of visual presentation of navigation elements and task complexity on navigation performance and subjective evaluation, 9 tasks were planned with a 3 (visual presentation of icon-text, icon-only, and text-only) × 3 (level 1, level 2 and level 3) factorial design.

As shown in Figure 1, a simulated iOS mobile application that used to remind users to take medicine was implemented by Unity: users could browse the four sub-pages through a menu navigation page. A total of 8 real size navigation elements were presented in the menu navigation page, in which, 4 of them can be clicked to direct users to the 4 sub-pages: patient, medication, dose and time. In each of the four sub-pages, participants needed to choose the answers according to different task instructions. There was also some relevant information provided in the sub-pages.

1) Visual presentation manipulation: Three kinds of visual presentations were used for the menu navigation page: icon-text, icon-only, and text-only. The visual presentation followed the principles of applying concrete, semantic-closed, simple colored, and uncomplicated shapes for icons and text with dynamic hit provided [8]. The sizes of icon and text were controlled to be exactly the same. The positions of navigation elements were randomly presented for each task.

2) Task complexity manipulation: Three levels of task complexity were manipulated in this study. At the complexity of level 1, participants were asked to choose the answers directly following the task instructions, which didn't require any memory load or information integrating (e.g., please remind Awen to take one piece of aspen after lunch). At the level 2, the task instruction was as similar as level 1; whereas, the task instruction disappeared after the task began. Thereby, it required a memory load to remember the task instructions. At the level 3, participants were asked to choose the answers based on both of task instruction and the relevant information provided by each sub-page. The process required users to remember task instructions and integrate relevant information across all the sub-pages (e.g., please help Awen who got cold to make the medication plan).

C. Measurement

Navigation performance was measured using data that automatically recorded by the background system. It was assessed based on the efficiency, effectiveness, and the number of return steps and incorrect clicks. Specifically, efficiency was measured by the completion time, which was the seconds the participants required to finish each task. Effectiveness was measured by the correctness of answers, which was the percentage of correct answers chosen for each task. The number of returns was defined as the number of returning to previous sub-pages. The number of click was defined as the number of incorrect click of the navigation elements on the main menu page.

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Subjective evaluation was measured by the 5-point Likert scales based on five aspects of ease-of-use, disorientation, effort needed, helpfulness, and satisfaction [16] [17]. For the first three questions of ease-of-use, disorientation and effort needed, it scored 1-5 from a rating of very agreed to very disagreed. Specifically, the ease-of-use was evaluated by whether the application is hard to learn; the disorientation was asked by whether it is easy to get lost and disorientated; the effort needed was assessed by whether a lot of efforts were needed to fulfill these tasks. In addition, the last two questions of helpfulness and satisfaction were used to examine users' overall feelings from the rating of very dissatisfied to very satisfied (1-5).

D. Procedure

The experiment was conducted in a separated and quiet room, with one participant and two experimenters there at one time. Before the experiment, the experimental instruction and consent form were given to the participants. Each participant was allowed to free explore the experimental application for 5 minutes. At the same time, the experimenters provided the task description document with the participants and instructed them how to use this application. Following that, participants completed three trials to familiarize himself or herself with the experiment without the task description document. After a 2-min rest, the experiment began. Each participant was given 9 tasks to complete. Following each task, the subjective evaluation was collected respectively. The whole interactions between users and application will be recorded by the background system and the whole process for each participant was controlled in one hour.

E. Data analysis

Normality test was first performed to assess the normality of the data. Since the data were collected from only 15 participants, it is unsurprised that they were not normally distributed. The non-parametric testing was then utilized to analyze the results in SPSS. Specifically, the Mann-Whitney test was employed to compare the differences of navigation performance and subjective evaluation between the younger and older user groups. The Friedman test was utilized to test for differences in navigation performance and subjective evaluation when participants were measured at different visual presentations and task complexities. Based on the results from the Friedman test, the Wilcoxon signed-rank test was further used to compare the differences between each of the two measurements from the same participants.

III. RESULTS

The experiment compared the navigation performance and subjective evaluation between age groups. The possible effects of visual presentation and task complexity were also investigated.

A. Navigation performance

The descriptive data of navigation performance between younger and older user are shown in graphical forms in Figure 2 and Figure 3, including the completion time, correctness of answers, and the number of return steps and incorrect clicks.

1) Comparison between age groups: Analysis of Mann-Whitney test was used to compare the difference of navigation performance between age groups. In terms of the completion time, the results revealed that younger users completed the tasks significantly faster than older users with all the visual presentations of icon-text, icon-only and text-only when the task complexity was level 1 (U = 4.00, p =

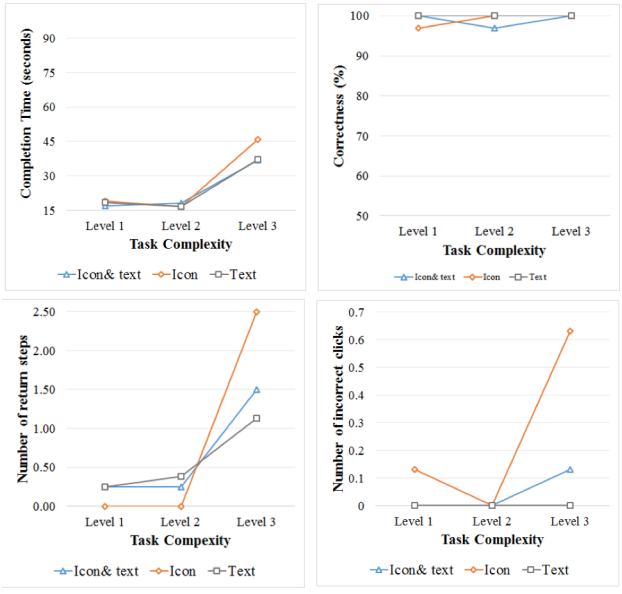

Figure 2. Navigation performance of younger users with different visual presentation and task complexity.

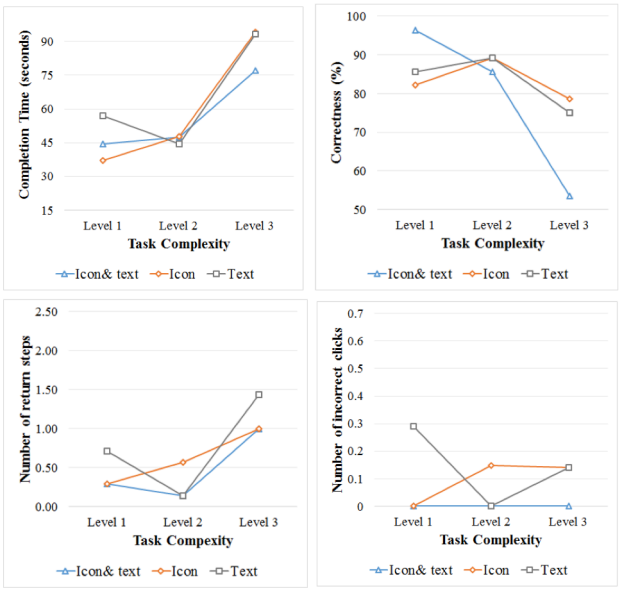

Figure 3. Navigation performance of older users with different visual presentation and task complexity.

0.004; $U = 1.50$, $p = 0.001$; $U = 1.00$, $p = 0.001$), and level 2 ($U = 0.00$, $p = 0.000$; $U = 0.00$, $p = 0.000$; $U = 0.00$, $p = 0.000$). The same results were found for the visual presentations of icon-text and text-only when the task complexity was level 3 ($U = 6.00$, $p = 0.009$; $U = 0.00$, $p = 0.000$).

The correctness was found no significant difference between age groups, except for the visual presentation of icon-text at the task complexity of level 3 ($U = 4.00$, $p = 0.004$), in which younger users had a significant higher correctness of answers. Similarly, no significant difference was found for the number of return steps and incorrect clicks between age groups.

2) Effects of visual presentation on navigation performance:

a) The younger group of users: Analysis of Friedman test was firstly employed to examine the statistical differences between navigation performances of 9 tasks. The results reported significant differences in completion time (χ^2 (2) = 44.228, $p = 0.000$) and the number of return steps (χ^2 (2) = 27.591, $p = 0.001$). Then, the Wilcoxon signed-rank test was used to test where the differences actually occurred. However, the results did not reveal significant differences of completion time and the number of return steps between different visual presentations for all of three levels of task complexity.

b) The older group of users: Friedman test also reported significant differences in older users' completion time (χ^2 (2) = 20.086, $p = 0.010$), the correctness of answers (χ^2 (2) = 16.597, $p = 0.035$), and the number of return steps (χ^2 (2) = 15.504, $p = 0.050$). Nevertheless, in the further analysis of Wilcoxon signed-rank test, no significant difference was found in terms of navigation performance between different visual presentations across all the levels of task complexity.

3) Effects of task complexity on navigation performance:

a) The younger group of users: Followed the previous Friedman test, a Wilcoxon signed-rank test was also used to examine the effects of task complexity on navigation performance among younger users. The results reported statistically significant differences in navigation performance between different levels of task complexity. Specifically, it indicated there were significant differences of completion time between the task complexity of level 1 and 3 (icon-text: Z = -2.524, $p = 0.012$; icon-only: Z = -2.524, $p = 0.012$; text-only: Z = -2.521, $p = 0.012$), as well as level 2 and 3 (icon-text: Z = -2.533, $p = 0.011$; icon-only: Z = -2.521, $p = 0.012$; text-only: Z = -2.521, $p = 0.012$), in which the task complexity of level 3 induced longer completion time. The same results were also found in the number of return steps between the task complexity of level 1 and 3 (Z = -2.207, $p = 0.027$), level 2 and level 3 (Z = -2.207, $p = 0.027$), in which the task complexity of level 3 elicited more return steps, but only for the visual presentation of icon-only.

b) The older group of users: Based on the previous Friedman test's results of older users, the Wilcoxon signed-rank test was conducted. Significant longer completion time was reported at the task complexity of level 3 when comparing with level 1 (Z = -2.371, $p = 0.018$; Z = -2.028, $p = 0.043$) for the visual presentation of icon-text and icon-only, and level 2 for the visual presentation of text-only (Z = -2.028, $p = 0.043$). The same results were found in the correctness of answers between the task complexity of level 1 and 3 (Z = -2.220, $p = 0.026$), level 2 and 3 (Z = -2.041, $p = 0.041$) for the visual presentation of icon-text.

B. Subjective evaluation

1) Subjective evaluation between age groups: Analysis using Mann-Whitney test revealed that older users evaluated significantly higher in the aspect of helpfulness compared with younger users when the task complexity was level 1 (icon-text: $U = 10.00$, $p = 0.040$; text-ony: $U = 6.00$, $p = 0.009$), level 2 (icon-only: $U = 10.50$, $p = 0.040$), and level 3 (icon-text: $U = 6.50$, $p = 0.009$; icon-only: $U = 4.00$, $p = 0.004$; text-only: $U = 10.00$, $p = 0.040$). The same result was also found in the evaluation for the satisfaction when the task complexity was level 1 (icon-text: $U = 10.00$, $p = 0.040$; icon-only: $U = 10.00$, $p = 0.040$; text-ony: $U = 5.00$, $p = 0.006$), level 2 (icon-only: $U = 9.50$, $p = 0.029$), and level 3 (icon-text: $U = 10.00$, $p = 0.040$; icon-only: $U = 5.00$, $p =$

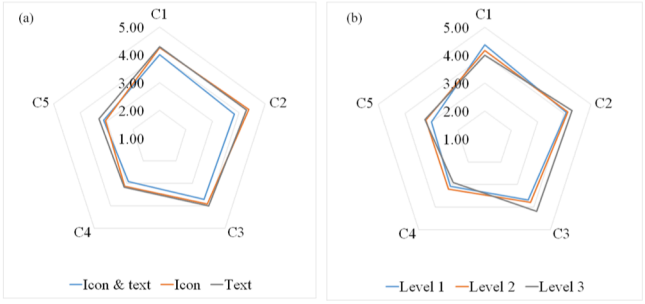

Figure 4. Subjective evaluation of younger users with different (a) visual presentation and (b) task complexity (C1: ease-of-use; C2: disorientation; C3: efforts; C4: helpfulness; C5: satisfaction).

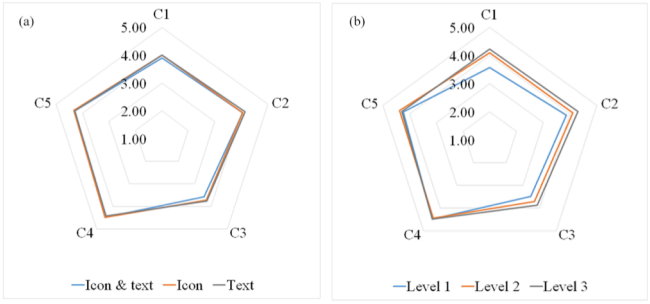

Figure 5. Subjective evaluation of older users with different (a) visual presentation and (b) task complexity (C1: ease-of-use; C2: disorientation; C3: efforts; C4: helpfulness; C5: satisfaction).

0.006).

2) Subjective evaluation on visual presentation and task complexity: To further analyze the differences between subjective evaluations of 9 tasks, Friedman test was used. Nevertheless, there were no significant differences in subjective evaluation between different visual presentations and task complexities. The descriptive data of subjective evaluation from younger and older users were shown in Figure 4 and Figure 5. Generally, for younger users, the visual presentation of text-only and icon-only resulted in the feelings of less disorientation and efforts needed. Nevertheless, the other aspects of subjective evaluation between different visual presentations and task complexities followed quite a similar pattern.

IV. DISCUSSION

Mobile interface navigation is an important aspect when interacting with mobile technologies to complete different tasks. In contrast to previous studies focusing on menu item searching [18] [19], or specific digital tasks [20] [21], this study obtained a unique perspective of simulating different levels of task complexity for mobile navigation tasks. One question of interest for the present study was whether the age matters for navigation performance as well as subjective evaluation. Also, the effects of visual presentation and task complexity were concerned.

A. Comparison of mobile interface navigation between age groups

Consistent with the previous findings within the context of information finding [19] and menu navigation tasks [22], older users indicated poorer navigation efficiency in our studies. They averagely spent twice the length of younger users' completion time. There are also some differences between their navigation strategies. The younger users tended to make more return steps and incorrect clicks when the task complexity is high. On the other hand, the older users tended to be consistent with their navigation paths. The fatigue issue should also be considered for older users in this experiment. Older users were not consistent with their performance between tasks because they were easier to feel tired.

However, to some extent, older users showed a positive attitude towards digital tasks. Despite of lower navigation efficiency, older users reported a higher rating of helpfulness and satisfaction towards their navigation experience. The reason could be that older adults normally show positive feelings of experience [23]. In this way, we suggest rather than only relying on analyzing user's subjective feelings, tasks and experiments could help to enhance the comprehension of what happened in the real world.

B. Effects of visual presentation of navigation elements

Navigation tasks involve a lot of visual exploration and searching actions; thereby, it emphasizes the design of visual presentation for navigation elements. However, the present study found no statistical and significant differences between three kinds of visual presentations, i.e., icon-text, icon-only and text only. On the one hand, the possible reason is that the duration of searching for specific navigation element in the menu navigation page only accounts for a quite small portion of the whole task completion time. On the other hand, the navigation element used in this study was quite different with each other, which didn't cause many efforts in searching and recognizing processes.

Little evidence in previous studies exists in examining the effects of visual presentation of navigation elements on mobile interface navigation. Although there was no significant result reported in this study, the pattern of different visual presentations could be preliminarily deduced from this study. For younger users, in agreement with the previous study [24], the visual presentation of text-only seemed to have better navigation performance when the task complexity was high; whereas the icon-only design induced a lot of return steps and incorrect clicks.

C. Effects of task complexity

Task complexity is a broad-defined concept in navigation tasks. This study took a specific perspective from the task requirements for remembering and integrating different numbers of information sources. As expected, the higher level of task complexity led to the lowest navigation efficiency both for the younger and older groups. Nevertheless, the younger users still kept high navigation effectiveness when the task complexity was high compared with the older users.

Previous studies stated that user's visual ability of scanning and searching largely influence the number of navigation elements that should be displayed [25]. Nevertheless, to fulfill the specific functional goals, users also need to remember a lot of information that generated from the task itself, as well as integrating information from some other sources. Consistent with the previous study examining mobiles' complexity levels [26], the present study also found that older users performed worse than younger users when the task complexity was higher, however their performance was similar to younger users when the task complexity was lower. Specifically, this study shows that the navigation performance could not be affected when the memory load is low, such as remembering one-sentence task description. However, the navigation performance could be significantly affected when the users are required to integrate a lot of information sources at the same time.

V. CONCLUSION AND FUTURE WORK

This study compared the differences of mobile interface navigation between younger and older groups with three types of visual presentations of navigation elements and three levels of task complexity. Firstly, it can be concluded that navigation performance and subjective evaluation were significantly different between age groups. Secondly, the navigation performance was significantly lower when the task requires users to remember and integrate a lot of information sources. This occurs more often for older users. However, no significant effect of the visual presentation of navigation elements was found in present study. Thus, in

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extending the finding in improving the user experience of mobile interface navigation, we suggest that the task complexity could be important design considerations especially for older users.

This study should also be considered in the light of limitations. For instance, the age of older users varied a lot in present study. Thereby, their navigation performances were quite different with each other. For future research, more participants will be recruited to cover more age groups, and the demographics factors and technology experience will also be investigated. Furthermore, it is better to employ a better evaluation method (e.g., task analysis) to investigate participants' mobile navigation behavior in details. For example, it is interesting to examine how long the user spends on each section of tasks including information searching, decision-making and checking.

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