Mobile Application Menu Design for Elderly in Indonesia with Cognitive Consideration

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Abstract. Higher life expectancy resulted in the growing number of elderlies in Indonesia. Unlike elderly in the develop country, many elderlies in Indonesia are digital immigrants with no prior experience using technology such as computer, telephone, and other information technology. Nowadays, technology has become pervasive and penetrate all aspect of modern life. However, elderly in Indonesia may not fully taking advantage of technology because they are not technological savvy. To encourage elder people making use of technology, can be done by designing a user-friendly interface. This study is part of several studies conducted in investigating various elements of user interface, more specifically this study looked at various menu layout (namely horizontal, list, and grid). Using task to measure user performance (completion time and number of steps), it was found that grid menu was the most efficient layout for elderly. This study also investigates the influence of cognitive ability in the successfulness of interacting with different menu layouts.

1. Introduction

The world's elderly population continues to grow both in absolute numbers and in percentages [1]. This advanced age growth is most rapid in developing countries, including Indonesia [2]. Based on population census data from 1970 to 2000, Statistic Indonesia Bureau concluded that Indonesia experienced a change in population structure from a young structured country to a state with an old structure where the percentage of the population aged 60 years and over continued to rise above 7%. With a significant increase in population, the elderly group plays an important role as a technology user. Research in the field of Human and Computer Interaction (HCI) for elderly people has increased in recent years, especially to find methods that can be used to design usable interactive systems [3].

Elderly in Indonesia experiencing technology leap. As a developing country, few decades ago, not many people have access to technology [4]. For example, according to World Bank Group, in 1990, only 0.588 per 100 people have fixed telephone subscription compared to 2017 where 4.32 per 100 people are subscribing to fixed telephone line and 173.84 per 100 people have mobile cellular subscription [5][6]. Technology has become affordable and accessible to many people. However, many elderlies miss out the advantage of technology because being a digital immigrant and non-e-literate person they have difficulties using it. E-literate means one would be able to read and write by using new electronic medium like internet and mobile technology [7]. On recent study to elderly in Yogyakarta, Restyandito and Kurniawan found that the most influencing factor for elderly in adopting technology is their perception of their own ability [8]. Many elderlies felt that their skills and knowledge were inadequate and they are reluctant to try learning new skills in using technology. This finding is in

accordance with study conducted by Hernández-Encuentra, Pousada, and Gómez-Zúñiga, based on the result of group discussion and questionnaire they found that elderly's adoption of Information Technology (IT) needs to be treated as more than merely a question of usability because they need more confidence in using IT [9].

To encourage elderly embrace technology, it needs to be designed in a way that is not intimidating for them. It can be done by designing technology suitable to their conditions and abilities. Characteristics of the elderly that should be considered in designing technology consist of sensation, perception, cognition and movement control. This paper looks at one of these characteristics which is cognition, a process by which the brain takes sensory information from the ears, eyes, etc. and transforms, reduces, stores, recovers, and uses that information [10]. More specifically, this paper investigated the effectiveness of menu layout design by considering elderly's cognitive ability namely spatial perception, visual abstract processing and problem solving.

This study is part of several studies conducted by the author in investigating various elements of user interface such as icon design (representation, size, and type), menu layout (horizontal, list and gird), and menu representation (text based, icon based, picture based, icon and picture based).

2. Related Work

Gerontechnology is an interdisciplinary field of scientific research in which technology is directed towards the aspirations and opportunities for the older persons. Gerontological design focuses on providing effective solutions to improve the way of life for aging people, through gerontological knowledge and design research methods to obtain a better understanding of individuals' preferences and requirements [11]. Some implementation of gerontechnology is the use of mobile phone which are widely available today. Specific mobile applications were designed to help elderly such as mobile application to improve therapy-adherence rates in elderly patients [12], mobile application to assist elderly in public transport [13], and mobile health monitoring system for the elderly [14]. However, there are still many works to be done, like: designing the interface to be friendlier and more predictable depending on the characteristics of the elderly [14], other study also suggests that in order for the elderly to be able to use the application effectively, they need offline training [12].

Many researches has been conducted on effective interface design for the elderly. There are some barriers that hinder elderly people to use mobile device effectively, namely cognitive complexity, motivational issues and physical impairments. Attitude towards new technology in general is a strong contributor to the willingness to adopt technology [15]. Whilst physical degenerative may contribute to the difficulty in using technology. Basically, there are five distinct human factors which show measurable disparities between older and younger people: learning time, speed of performance, error rate, retention over time and subjective satisfaction [16]. Therefore, even though many researchers have developed various applications to increase the quality life of older people, not all of them were successfully accepted by elderly. More over, elderly who are non-e-literate.

Cognitive requirements often overlooked in display design because cognitive effects of an interface on behavior do not appear as measurable as perceptual effects [17]. Furthermore, when a display is poorly designed for cognition, users tend to blame themselves rather than the interface. One of the major reasons influencing the adoption of technology by elderly in Yogyakarta is their perception that technology is difficult and they do not have sufficient ability [8]. Many elderlies think they are not smart and savvy enough to use technology when they encounter difficulties, while it may actually be an interface design issue.

3. Methodology

3.1. Participants

A total of 60 elderlies (17 males, 43 females) participated in this study. They were 60-85 years of age (Average = 68.08, STD = 6.24), mostly are retired (96%). Respondents came from various education background (33% primary school, 40% secondary school, 25% undergraduate, 2% post graduate).

3.2. Apparatus and Instruments

Research was carried out using ASUS Zenfone MaxPro mobile phone, Qualcomm Snapdragon 636, 3GB RAM, 32GB ROM with 5.99 screen 1080x2160 resolution. Test application was made using: Java SDK 1.8; Android SDK; IDE Visual Studio 2017; Xamarin Cross Platform Mobile Development Framework; Grial UI Kit and Syncfusion for Xamarin. Cognitive test was conducted using Block Design of Wechsler Adult Intelligence Scale (WAIS) tool and Mini-Mental State Exam (MMSE).

3.3. Procedure

The study consists of two experiments. The first experiment was to measure respondents' cognitive ability using WAIS block design and MMSE. The block design test is a subtest on many IQ test batteries used as part of assessment of human intelligence. It is thought to tap spatial visualization ability and motor skill [18]. The test-taker uses hand movements to rearrange blocks that have various color patterns on different sides to match a pattern. The items in a block design test can be scored both by accuracy in matching the pattern and by speed in completing each item.

The second experiment was performance test based on different menu layout. Three different menu layout were presented to the participants (horizontal, grid and list). Horizontal menu, enable participant to see big and clear picture of the menu category and items, because each item was presented one at a time. However, participant may find it difficult to remember the previous menu or item selection. Grid menu, display all the menu category and items in one screen, however the picture for each menu category and item are not as big as the horizontal menu. Lastly, the list menu, combined the advantage of bigger picture and more menu categories and items in a single screen. The design of these menu can be seen in Figure 1. Each menu category contains two levels of sub menu: items in a category and detail (Figure 2). Respondents were given task to find an item by navigating through these menus. To reduce the bias of not knowing the task, two sets of test case were created. One test case was to find the price of food and the other was to find the address and location of a place. For each case, there are 101 items (food or place). The task was given in random order to minimize the learning effect from doing the previous task because respondent can become more familiar with the menu option and item as they answer more questions. To familiarized device used in the experiment, respondents were given practice tasks. Some respondents may accustom to certain screen resolution and mobile phone size or they may not have any experience using a touch screen device.

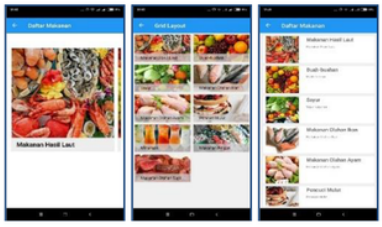

Figure 1. Different menu layout : Horizontal display, Grid display and List display layout (problem domain: food price).

Figure 2. Main menu showing all categories, places in a category and item detail (problem domain: location and address).

The experiment procedure has pass ethical clearance from the ethical committee of Medical Department, Duta Wacana Christian University to make sure the procedure will not endanger the respondents. Therefore, the time given for each respondent is limited to 30 minutes for each experiment. If respondent can not complete the task in the given time, his or her data is disregarded.

4. Results and Discussion

After cleaning the data, there were 50 valid respondents' data that will be analyzed. The other respondents were excluded from the analysis because of various reasons, such as very poor eyesight,

cannot finish all the tasks in the given time or not available during the second experiment. The two experiments were conducted on different days to avoid respondents became too tired in doing the cognitive test and Menu Layout performance test. A total of 900 data were collected (50 respondent x 3 menu layout x 2 problem domain x 3 task).

Participants MMSE score were 24-30, this result is similar to a study conducted to 18,927 healthy individuals in Medan, North Sumatera. Result showed, those who are 60 years of age and older have MMSE score around 21-29 [19]. Based on Alzheimer's association, people with normal mental skill has MMSE score of 25-30. MMSE score of 20-24 suggest mild dementia. It can be concluded that respondents have cognitive ability necessary to operate mobile phone.

Single factor ANOVA was conducted to see the effect of menu layout on the time needed to complete the tasks. Shapiro-Wilk test was conducted to make sure the observations were from normally distributed data. Levene's test was conducted to test whether the groups have equal variance. There was a significant effect of menu layout on completion time at the $p<.05$ for the three layout [$F(2,897)=60.44$, $p=0.00$]. Single factor ANOVA was also conducted to see the effect of menu layout on the number of steps needed to complete the tasks. More steps suggest respondent was lost in finding the items. Data were tested for normality and homogeneity of variance. An analysis of variance showed that the effect of menu layout on number of steps needed to complete task was significant, $F(2,897)=18.61$, $p=0.00$.

Result showed that menu layout affects the effectiveness of completing the task, both in completion time and number of steps. The fastest completion time were Grid menu, List menu and Horizontal menu. Grid menu was 45% faster than Horizontal menu, and List menu was 38% faster than Horizontal menu. Like wise, the least number of steps to complete tasks were Grid menu, List menu and Horizontal menu. Grid menu was 19% less steps than Horizontal menu, and List menu was 14% less steps than Horizontal menu (Table 1).

Table 1. Average result comparison between menu layout

Menu Layout	*Time (ms)*	*Steps*
Horizontal	53006.42	3.12
List	33126.67	2.69
Grid	29386.43	2.51

Even though, horizontal menu provides clearer picture and bigger font, participants need to swipe through all of the menu options, while doing so, they may already forget the previous option. Therefore, respondents need more time to decide the correct option. According to Johnson and Finn, designer must take care when relying on scrolling [20], there is a tradeoff between bigger font and picture with how many information can be displayed on a mobile phone. Furthermore, when presented with scrolling menu especially horizontally, it may falsely indicate the bottom of a page, thus it took more time for respondent to realize it as a menu option. One alternative design to show larger font but not using scroll is by split the menu into multiple pages. But this alternative design still has disadvantage because it requires user to remember the options on different pages.

To investigate further the effect of cognitive ability (memory and spatial recognition), a regression analysis was conducted. The purpose of this analysis is to figure out, whether cognitive ability (based on the WAIS score), age, education and experience in using mobile phone affect user performance in finishing the task. Result of the regression analysis can be seen in Table 2. The adjusted R^2 value was 0.78 so 78% of the variation in completion time can be explained by the model. Age had significant positive effect, indicating older respondents needs more time to complete task. Menu layout (coded in the following order: 1=Horizontal, 2=List, 3=Grid) had significant negative effect. MMSE score, education and experience using mobile phone also had significant negative effect, indicating respondents with higher MMSE score and higher education were expected to finish task faster. Lastly, experience using mobile phone had significant positive effect on completion time. In the pre-survey, respondents were asked whether they ever use mobile phone (feature phone / smartphone) and if they do, how long have they use it for. Most of elder respondents has been using feature phone for several years. On the opposite, younger respondents may have only been using mobile phone for short period

of time, however they are using smart phones instead of feature phones. This explain why mobile phone usage had positive effect on time needed to complete task.

WAIS and Mini-Mental State Examination (MMSE) has long been used to measure age-related performance [21]. It was found that MMSE influence the effectiveness of respondents in interacting using different menu layouts. This finding is in accordance with the result of study by Farber et al., which found that MMSE may be a reasonable alternative measure of overall intellectual functioning [22]. Respondent with higher MMSE score means higher intellectual level, it may also correlate with their education background, therefore respondent can finish the task faster. In this study 73% of the respondents have education background of secondary school or lower. In developing country like Indonesia, elderly may not have access to good education as well when they are young.

Table 2. Regression analysis on completion time

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	94080.4384	24803.3345	3.793056066	0.0001588
Age	1013.36263	163.9859255	6.179570744	**9.764E-10***
Menu	-11798.701	1071.548526	-11.0108884	**1.582E-26***
MMSE Score	-3485.8715	822.6171922	-4.23753782	**2.495E-05***
Block Design Score	167.008923	150.0522038	1.113005463	0.2660059
Education	-2947.5315	1368.035736	-2.15457202	**0.0314625***
Smartphone	-3374.8314	1897.120326	-1.77892324	0.0755928
Experience	689.131495	298.2781689	2.310365179	**0.0210953***

The result of the regression analysis on number of steps can be seen on Table 3. The adjusted R^2 is only 0.07 suggesting that the model can only explained 7% of the variation in number of steps. Furthermore, only age and menu layout contribute to the number of steps taken by the respondents. This may be due to the fact that most of the steps are less than 4 steps, as the category menu only has two level sub menu.

Table 3. Regression analysis on number of steps

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-0.0335085	1.179560854	-0.02840762	0.9773434
Age	0.03387286	0.007618531	4.446114003	**9.846E-06***
Menu	-0.2771551	0.049590694	-5.58885213	**3.037E-08***
MMSE Score	0.06179391	0.038541216	1.603320301	0.109218
Block Design Score	-0.0075267	0.007022272	-1.07183221	0.2840853
Education	-0.105416	0.063658496	-1.65596132	0.0980814
Smartphone	-0.158949	0.088218802	-1.80175927	0.0719208
Experience	0.01031687	0.014018426	0.735950846	0.4619541

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5. Conclusion

This study investigates different menu layout usable for elderly in Indonesia. It was found that menu layout affects the effectiveness of user interactivity. User perform faster and made less mistakes when menu layout is presented using grid. It is not advisable to use horizontal menu layout style, because it required higher mental load to memorize the option presented. However, when using grid menu the font and the picture is smaller, which will not benefit user with poor eyesight. Therefore, designer must consider the balance and tradeoff of presenting many information on one screen thus user needs less memory load, or bigger information thus user can seek information easily.

Result of this study showed cognitive play an important role in the successfulness of navigating through menu options. Elderly suffer from degenerative illness which may influence their physical and cognitive ability. It is a challenge to design interface usable for old people, especially older people who have no prior experience in using technology. However, this may not be an excuse not to design a universal interface which is also easy to use for older people.

Acknowledgment

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