Journal of Mobile Multimedia, Vol. 13, No.1&2 (2017) 075-099

SAHL: A TOUCHSCREEN MOBILE LAUNCHER FOR ARAB ELDERLY

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Mobile phones are becoming a great necessity for elderly people; the features they provide supported by rich functionality made them one of the indispensable gadgets used in their daily life. However, as mobile phones get more advanced and their interfaces become more complicated, new design recommendations and guidelines need to be developed to serve the elderly needs. In this project we distilled guidelines and design recommendations targeting elderly users' needs. Then, we used these guidelines to implement a prototype user interface that takes Arab elderly requirements into considerations. We then evaluated the developed interface on a set of Arab elderly people to determine its appropriateness for the target audience.

Key words: Elderly, Launcher, Arab elderly, user interface, Smartphone, Arabic soft keyboard

1 Introduction

The number of elder people has increased rapidly in recent years [1]. Increasing aging societies has appeared the most among developed countries such as Japan, Europe, and North America. The United Nations have projected that by 2050, elderly above the age of 60 will reach a percentage up to 21% of the world population. This increase in elderly numbers represents a recurring need for establishing suitable market of computing technology devices targeting elderly people [2]. As people get older some of their physical and mental capabilities start to decline. In order to overcome these losses of capabilities for elderly people, recent studies have focused on the development and adaption of technological tools to help the increased number of elderly in society [1]. Among these technologies are Mobile phones.

Mobile phones are becoming one of the more utilized technological items for older people. Some of the reasons why older people possess mobile phones are because they are used as memory aids, let them feel safe and secure, keep them related to social activities and the most important reason is enabling them to perform their daily life activities independently [3].

The percentage of elderly people who is using smart phones is lower than other age groups [4]. This could be because old people do not feel comfortable using new devices or learn new technology [4]. Also older adults have age-related decline ability such as: slower processing speed, memory loss and hand shaking; compared to young people [5].

Today's market has an increase in the number of touch-based smart phones such as (iPhone, and Android) [3]. Touch-screen smart phones offer a suitable screen size for older people with many features that can be adjusted according to their needs. Among these features are bigger buttons, larger text message, and spoken interfaces.

The entry point for any smart phone is through its launcher (a launcher is software that lets users access the phone functions and applications). Various launchers are available in the market for elderly, some of them are designed while taking into account elderly needs, and some are not. These touch-based launchers need sound design recommendations and guidelines for designing mobile interfaces for elderly people especially Arab elderly people. This is because Arab elderly have their own requirements that cannot be found in off-the-shelf launchers.

Arab culture and traditions are rich of values and social practices. It has a strong emphasis on the family as a social institution and a more respect toward older persons. Arab elderly of aged 65 and above has doubled from 5.7 million in 1980 to 10.4 million in 2000. The rate of growth of aging population has increased to 14 million by 2010 and projected to increase to 21.3 million by 2020. Moreover, the average life expectancy is expected to reach 73years by 2025 [6]. The used language among Arab elderly is Arabic.

Arabic language has rich literary heritage; and it is the used language in the Middle East and North Africa. Arabic language is completely different from other language in terms of written and spoken words. It is the official language among Arab communities and the mother tongue and the only language of Arab elderly.

Arabic language is one of the most popular languages and is spoken by about 300 million people around the globe [7].

Remarkably, older Arabs enjoy precious life and work experiences. They possess an active life; and they like to be part of their society in terms of being useful, intellectual and challenged within their family members and ties. Nevertheless, there is not enough research conducted toward the use of technology by Arab elderly. Publication about older Arab people is limited in the region and rare articles are found in scientific international literature [6].

Several factors contribute to scarce research concerning Arab-aging society. These factors include: 'inadequate consideration of older people's issues, lack of funding, and inadequate training in aging research' [6]. Therefore, we carried out our research of smart phone launcher targeting Arab elderly society. Up to our knowledge, we are the first project of its kind that aims to develop Arab elderly launcher. We will use the consolidated guidelines and design recommendations for touch-based mobile phone interfaces appropriate for Arab elderly [8], [9] while designing the interface of our launcher.

The objectives of this research are listed as follows:

1. Develop a touch based mobile launcher that implements the distilled design recommendations, and make it customizable according to Arab elderly needs.

2. Develop a new Arabic keyboard layout for the use by elderly and people with low education.

3. Evaluate the designed launcher to determine its appropriateness for the target audience.

The remainder of this paper is organized as follows. First, in section 2 we summarize related work. Next we describe user research of heuristics extraction and structured interview of Arab elderly. Then in section 4 we present our Sahl launcher. We also evaluate in section 5 the accessibility and usability of our launcher and complement the evaluation via eye tracking devise. Finally, we conclude this work with some recommendations.

2 Related Work

In order to fulfil the requirements of our project, the literature review will address the studies on elderly interaction with mobile phones.

2.1. Elderly interaction with mobile phone

There have been many studies in the use of mobile phones among elderly people. Furthermore, according to our systematic review of 208 publications from 1992 to 2013 in the field of elderly technologies. The adoption of intelligent user interface and personalization for older adults are one of the worth to inspect research fields, which is gaining momentum in recent years [10].

Previous studies have been conducted to evaluate the effectiveness of mobile phones in general e.g. [11], however mobile applications usability evaluation is still new area to research. This led to more research covering this topic as will be discussed next. The authors in [12] investigated the suitability of the available mobile phones for older users in South Africa. Their findings indicated that most mobile phones do not address the limitations of aging, even the phones that were designed for older users. Similarly, the authors in [13] investigated the usage of mobile phones and preferences of mobile functions by older people in Hong Kong. They found that older people had positive attitudes towards mobile phones. Also, the elderly used mobile phones for very limited purposes, such as: calling, checking time and date and searching telephone numbers.

On the other hand, older people reported frustrations in their interactions with mobile devices, which suggest that current mobile phone systems are not well designed to accommodate older adults' capabilities [13]. Thus, a mobile phone designed to address the elderly needs becomes necessary. Moreover, the authors in [14] analyzed the issues and challenges that elderly people may encounter when using smartphones, the main issues experienced by the elderly were accidental taps of buttons adjacent to the target buttons. The authors suggested providing better feedback through both audio and visual when a key is pressed. In addition, the authors in [15] presented an initial exploration of elderly interaction with language-technology-driven interfaces, and how these interactions measure up against traditional physical interaction channels. In this study two focus groups were conducted, they were divided into primary (who defined as persons aged 65 and older and may have some physical limitations and/or restrictions in their vision and hearing), and secondary users (who represented informal (family members) and formal (relatives/friends)). The study used The Wizard of Oz (WOZ) method to convey the idea of future system along with demonstration of existing voice-controlled features in recent smart phones. The authors found that voice can be seen as an efficient and appealing input modality for elderly especially if they suffer from age-related physical restrictions.

From a heuristic point of view, there has been a recent surge in heuristics evaluation of mobile for elderly people. A study by [16] presented a set of broad heuristics for mobile devices. Another more specific study evaluated existing iOS mobile applications for diabetes management and spotted drawbacks to avoid in designing such mobile applications [17].

The usability of mobile applications differs from regular software applications in issues related to context, connectivity, screen size, and resolution, text and data entry methods. In [11] the authors proposed a general framework for conducting usability test for mobile applications. Therefore, there is a need to propose a corresponding set of heuristic that considers the specific needs of elderly people while interacting with touch-based mobile phones.

As the number of elderly people has increased [18] this fact signals the need for designing mobile phones targeting senior adults. This led our research to focus primarily on icon design and the interactions with touch-based mobile phone as will be demonstrated next.

The authors in [19] have proposed and designed icons for mobile phone functions by involving elderly in the design and evaluation phases. The study consisted of five steps; (1) Conduct task analysis by interviewing participants aged between 60 and 79. (2) Conduct a Questionnaire for the elderly about proper icon design. (3) Design an initial icon based on the results of the survey, expert advice, and previously studied design guidelines. (4) Evaluate final icons design by aging adults. (5) Complete the interfaces design by users' preferences. (5) Complete the interfaces design by users' preferences.

Their findings suggested that older adults preferred to use colorful, not animated icons, which are supported textually. Also, their study found that labels are more efficient for older people to initially use icons. Furthermore, the study pointed that the use of icons and text together offers an alternative interface, but this has the disadvantage of requiring more space on the interface, which could be a problem for small screen size phones. These interesting findings were a result of having the involvement of elderly during the design phase.

A recent study was conducted in Czech Republic elderly people [20]. They had introduced "KoalaPhone: touchscreen mobile phone UI for active seniors". Their study consisted of qualitative and quantitative experiments to gather special needs of seniors. From the collected recommendation, they had discovered that elderly prefer advance features differ than young people. Examples of these features are voice recorder, a camera, calculator or even an alarm clock. Furthermore, they designed an accessible touchscreen user interfaces for active seniors. They mentioned the importance of involving their senior in UI design to enhance the old people user experience and make the interface more comfortable for them.

Another research presented in [15], where the authors defined some interface design guideline for smart phones, the guidelines were: to be clear and simple, contains consistent interface elements and prominent icons to make the navigation easier besides helping illiterate persons. In addition, the icons should have meaningful and concise text description that can be read by screen readers. On the other hand, an important component of any smart mobile phone is its soft keyboard. The keyboard is the input interface for answering incoming calls, making calls and typing text messages.

Soft keyboard interaction has been studied on people of various ages; here we present the studies that have been conducted on elderly people interactions with smart phones. The aim is to learn how to design elderly-friendly handheld smart phone keyboard to support our design and propose a design recommendation for the optimal button size and spacing of a touch screen interface for older adults. The research in [21] studied the usability and acceptance of handheld computer devices for the elderly. The research indicated that elderly acceptance and usability are very important since elderly has limited knowledge of computer and decline input ability of smart devices. Furthermore the authors indicated that the acceptance of elderly is persuaded by usefulness, social influence, usability and support. From the finding of the previous study, we considered the usability and acceptance as actors while designing our software.

Recently investigators in [4] examined the effects of smart phones pointing on old people. They conducted various experiments. The experiments consisted of changing the target size, the spacing between target items, and the location of the target item. In addition, they had tested smart phone feedback such as auditory, tactile, and audiotactile. Feedback is essential for elderly because of elderly declining hearing abilities. They conducted an experiment with three different target sizes with 5mm, 8mm, and 12mm button size of QWERTY keyboard. They had discovered the best target size was 12mm. This is because elderly pointing time and errors were less compared to 5mm or 8mm. Furthermore with regards to varying the target size: the researchers in [4] had tested the spacing of 1mm and 3mm with each target size. This is to test if the spacing has effect on the elderly performance. Their experiments indicated that the highest error was with target size of 3mm and spacing with 1mm. However the lowest error was with 12mm target size and 1mm spacing. This indicates that elderly prefers bigger buttons; however, spacing does not have much effect. In their second experiment, they tested the target size with various feedback, such as auditory, tactile, audiotactile, and visual. Interestingly they concluded that elderly performance increased with audiotactile more than other feedback. The authors then recommended that adapting simple smart phone interface with an adequate layout is more attractive to old people than designing special elderly phone. Their finding supports our approach of designing a simplified launcher for smart phones. In addition, we took their recommendation into consideration when we designed our launcher.

From the previous research we can distil some recommendation of the best design of soft keyboards targeting elderly people, such recommendations include: button size, and feedback while typing. Recommendations are presented in section 4.2.

2.2. Elderly Mobile phone applications

To understand the spectrum of touch based mobile phones applications designed for elderly people, we searched for the available launchers and applications in the Android market and iOS store. Various launchers have been found. Thirty-one applications and launchers were designed as a communication solution to help elderly and individuals who face difficulties while using touch screen devices. These applications are compatible with various mobile operating systems such as iOS, Android and Windows phone.

In addition, we noticed some features such as email, calculator, and magnifier. Those could be specific to the culture of the elderly. If elderly can read and write then the option of offering email is possible, otherwise it is not needed. We noticed also some of them have the ability to customize the

launcher and add some applications. Nevertheless, no one has social network applications. To sum up, the above reviewed applications were designed for elderly people; however some of them missed important needs for elderly people.

3 User Research

This section describes and discusses heuristics extraction and questionnaire analysis used in this project to help in developing our proposed launcher. In the first section we reference a new set of proposed heuristics for evaluating the usability of touch-based mobile phone launchers for elderly people published in [8]. In the second section, we describe the result of the structured interview that was conducted on Arab elderly people.

3.1. Heuristics extraction

The method we used to develop usability heuristics for touch-based mobile phones for elderly is divided into the following steps. Based on our published work in [9] were we compiled a list design recommendations and then classified them into three dimensions, namely: (1) Look and Feel, (2) Functionality and (3) Interaction. These guidelines were further converted as in [8] to usability problems, and combined similar ones under one category. Afterward, we translated usability problems into heuristics that provide guidelines on how they can be avoided. Finally, we wrote the proposed heuristics as interrogative sentences, this is because interrogative sentences are more intuitive for answering and scoring compared to declarative sentences. After that, we elaborated our heuristics into list of questions. This approach yielded a list of newly proposed heuristics evaluation for touch-based mobile devices for elderly people as illustrated in Table (1). The heuristics are classified into three sections: (1) look and feel, (2) interaction, and (3) functionality. Further information can be found in [8].

We conducted an experimental study in order to assist the appropriateness of the proposed heuristics. The evaluation procedure followed the following protocols: Heuristics Orientation session: this entailed welcoming the evaluators (four senior undergraduate students who have studied HCI course and conducted usability evaluation before) and explaining in detail the goals of the study and testing procedure. A training session was also conducted to explain the list of heuristics and how to assess them. The evaluators were asked to impersonate the two personas which were developed as illustrated in [8] and write their observations. Evaluation scripts were prepared in advanced and distributed among the evaluators.

Heuristics Evaluation session: the usability evaluators conducted the usability evaluation on each of the six Android launchers to identify usability problems, and prioritize them according to Nielsons five-point Severity Ranking scaled from 0-4, where 0-indicates no problem, 1- cosmetic problem, 2- Minor problem, and catastrophic [8]. More explanation of the rating is presented in Table (2). Also in order to avoid order effect, the sequence of launchers evaluation was counterbalanced for each evaluator.

Look And Feel:
1. Make Elements on the page easy to read
1.1. Is the font large enough for older adults?
1.2. Is there any option to enlarge the font size?
1.3. Are the text and background colors have good contrast?
1.4. Is it possible to customize colors?
1.5. Is the amount of text minimized; is the only necessary information presented?
1.6. Does color choices allow for easy readability?
2. Easy Recognition and accessibility
2.1. Are the icons clear, understandable and labeled?
2.2. Are labels described clearly?
2.3. Can the most important or frequently needed functions accessed directly?
2.4. Is the keypad separated into numbers and letters for data entry?
2.5. Is data entry process easy for elderly?
2.6. Are there any visual cues in the launcher that help the elderly know there is more content in a page?
3. Make clickable items easy to target and hit
3.1. Is it obvious, which item is clickable and which is not?
3.2. Are buttons large enough to easily see the image or text on them?
3.3. Is there enough space between buttons to prevent hitting multiple or incorrect buttons?

Table 1: Touch-based Mobile Heuristics Evaluation for elderly people

Heuristics debriefing session: after the usability evaluators have sent the evaluation results, they were asked to describe the experience of the process, i.e. strengths and limitations of using the heuristics to evaluate the launchers [17]. Heuristics Evaluators results: the evaluators stated that the heuristics covered the important needs for elderly people while testing them on various launchers and applications. They indicated that the heuristics were understandable, easy and simple especially for the "Look and feel and interaction" category, as these show the importance of launchers appearance and the impact of the first impression to attract the elderly.

Furthermore, the evaluators also described some limitations of the heuristics. They mentioned that they could include some questions for the types of elderly who can read/write and those who cannot because some of the questions were not useful for literal old person. These feedbacks indicate the need to adapt cultural needs while designing Arab elderly launcher.

3.2. Structured Interview

We conducted structured interviews with Arab elderly; in addition, we distributed an online survey to get more details about the caregiver opinion and suggestions of the elderly usage of mobile phones. Based on what we had found in previous studies, we come up with list of user requirements and formulate a questionnaire to reflect Arab elderly people needs for both literal and illiterate. We also had conducted structured interviews to gather elderly requirements; the interview was structured under three groups. First, demographic information questions (age, education, occupations, etc), the second group is about the experience of the user with cell phones, these questions aim to explore how the participants use their mobile phones, and what type of mobile phone they currently use, lastly, general open question to measure the user satisfaction about their mobile phones. Twenty-Six participants (22 female, 4 male) have participated in the structured interview. Participants' age ranged from 60 to 82. (M= 64.7, SD=6.65).

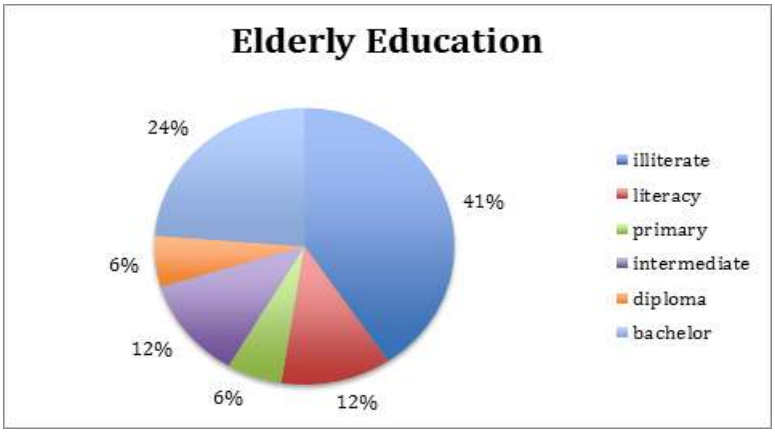

Figure 1 Arab Elderly Education level.

The results of our interview findings and online survey are as follows: Most of our participants have low level of education, and mainly without occupation. Interestingly most of them use touch-based mobile phone such as Samsung galaxy, iPhone, and few are using old Nokia with physical keypad. In addition, all of them use their phone at least once a day. The distribution of level of Arab elderly is shown in Figure (1). The majority of the Arab elderly who participated in the survey were illiterate people, and the highest degree was bachelor.

Arab elderly prefers using Samsung galaxy phone due to the fact that it has larger screen size and it is easier to make calls. More interestingly, older adults prefer using Samsung phones over Nokia even though they used Nokia for a long period of time. This indicates that Arab elderly are able to cope with new technology especially with touch mobile phones.

Moreover, when they were asked about the most used functions in the mobile phone, the order was as follows as Figure (2) shows: answering incoming calls, calling, text messages, displaying data and time, speed dialing, accessing address book, camera, calculator, alarm and email. Nevertheless, elderly has indicated the most difficult function is text messaging. Moreover, elderly expressed their wish to design a special interface in Arabic language and use icons or symbols related to their culture.

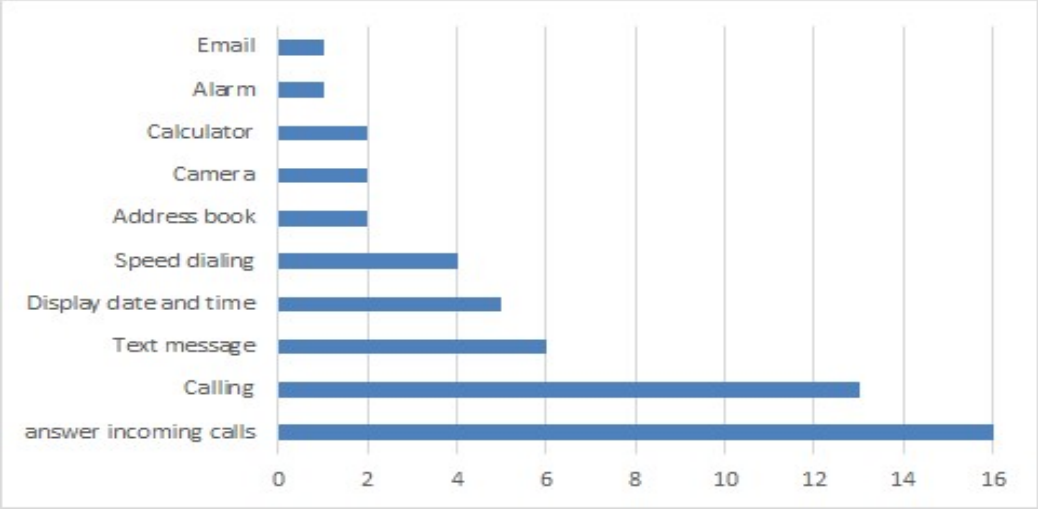

Figure 2 The most used functions among Arab elderly people.

As a result, developers have to take into account these important functions when designing launchers or applications for Arab elderly and eliminate other less important functions. Interestingly, caregivers usually install or download new applications on elderly mobile phones, yet it is not easy to do it by them. Having conducted the structures interview with Arab elderly and searching the available launchers in the market helped us in making informed design decisions for our launcher.

4 Sahl Launcher

As we have seen in the previous sections, to make a launcher accessible and usable for Arab elderly we need to consider two things: (1) icon design and (2) Arabic keyboard interaction. Therefore, the purpose of this section is to present our design and implementation of Sahl mobile launcher.

4.1. Icon Design

Based on the interview findings, and online questionnaire as well as our review of existing mobile launchers designed for the elderly, the following functions are considered: call, text message, emergency, camera, photo gallery, and contact list. These functions seem important for older people, however, based on the reviewed launchers in Table (1) some functions were not popular such as: alarm clock, calculator, and calendar. We sought to add them in our design since Arab elderly like to be reminded about prayer and fasting. Arab culture uses Hijri calendar. Hijri is a lunar calendar consisting of 12 months in a year of 354 days, and it is used by Muslims everywhere to determine the proper days on which to observe the annual fasting, to attend Hajj, and to celebrate other Islamic holidays and festivals. However this calendar is not available while developing Sahl launcher, therefore, we developed our own Hijir calendar. Furthermore, the calculator though might be useful in their daily life especially for the simple calculation (multiplications, division) as some of the Arab elderly has low level of education.

Figure 3 Version A interface

Accordingly, we had designed three version of touch-based mobile interface. The interface came after several iterations of designing and testing. Firstly, we designed A version of the user interface where the functions icons were not labelled to test if the elderly could recognize those icons Figure (3). After testing it with Arab elderly, we found it was difficult to identify most of the icons. As a result, we took into consideration one of the suggested opinions by the elderly, which was to make the icon similar to those in Nokia interfaces.

Consequently version B was designed so that the icons look similar to those icons the elderly were familiar with; and we also added social networks icon. This is because some elderly stated that they use some of these social networks Figure (4). Then we tested the B version, and we had found that the elderly icon identification improved.

Figure 4 Version B interface

However, still the elderly couldn't predict some icons; and the background colour for each icon was one of the reasons to mistakenly recognize the icons. Eventually, we had designed version C where we changed some icons and the button back- ground colour was set to be white and the icons shapes are coloured, the launcher background colour is selected based on a study result of the most preferable colours for Korean elderly [2] (see Figure 5). Designing the interface especially the icons was based on the gathered information from the structured interview, existing elderly launchers and online survey.

Finally, we tested the proposed interface with elderly volunteers to get their feedback and opinions and to test their ability of identifying the presented icons. As stated before, our design has improved from previous interface design (version A to B). Figure 6 shows the proposed user interface design of our launcher, after many design iterations of design interfaces as shown in ((Figure 3), (Figure 4), and (Figure 5)).

Figure 5 Version C interface

Figure 6 Sahl launcher

4.2. Arabic keyboard interaction

Keyboards are one of the most powerful input methods since the invention of typewriters. Up till now keyboards have survived and still played their own role as a modality of text entry. Most modern touch

screen mobile devices come equipped with soft keyboards for data entry. Many of these soft keyboards resemble the classical QWERTY keyboard layout. Since most soft keyboards take over the same standard layout of physical keyboards, i.e. QWERTY layout; soft keyboards still lack the appearance of physical keyboards due to the limited space available in touch-screen devices. Moreover, the layout design of soft keyboards becomes an issue that attracts designers and developers to think and implement a soft key- board that meets users' expectations. Looking at the application market for soft keyboards, many of them followed a semi-QWERTY layout, examples include: Minimum Keyboard, freely optimized layout e.g. Message Ease or Alphabetical order keyboard.

We had employed eye tracking techniques in our publication [22] to explore the User Experience (UX) of four different soft keyboard layouts selected from the Android market, namely: Fleksy, Swype, Big keyboard and Go. The empirical study was aimed to study mobile phone soft keyboards interaction to help in envisioning the proper layout for our launcher. The experiments were conducted on twenty-five volunteers' participants who were daily users of touch screen devices, and soft keyboards. The findings indicated that there was no one keyboard which excelled among others, yet, the results combination can provide some insights about design recommendations for soft keyboards.

The results also raised a number of questions; the major one is whether any other layout other than the standard QWERTY soft keyboard will improve the typing accuracy. Also, the experiment results showed that the users are not afraid from using another layout that they are not familiar with, since they can move their fingers freely without pressing on a wrong key compared to standard QWERTY layout keyboards. Actually, with some training, users will feel more convenient using new layouts if and only if these new layouts provide users with more typing space and other good features like auto-correction, and better next-word prediction.

Based on our study [22], we distilled some soft keyboard design recommendations that helped us in the design of Sahl launcher keyboard. The recommendations were as follows:

- Maintain a balanced layout between keyboard area and text entry area.
- Follow recommendations for the appropriate size of touch keys e.g. [4] to prevent users from making mistakes while typing.
- Balance the distance between keys so that they don't consume the keyboard size.
- Provide clear keyboard feedback, which includes color, key enlargement, and voice feedback after each key press.
- Try new keyboard layout to enhance user interaction.

From the recommendation above, we designed the launcher with respect to keyboard and keys size, key arrangement, color contrast and pressing feedback. We adapted the findings from [4], and designed keyboard with the length of the alphabetic keyboard as 316 DS and the key width is equal to 50 DP and the spacing between keys is 10 DP. Moreover, the number-keyboard length is set to be 27 DS, key width is 88 DP and spacing between keys is 10 DP.

We believe that the size of keyboard and keys along with spacing are good enough to fit in elderly fingers however these values are affected by the screen size of the device. In the designed

alphabetic keyboard we chose another key arrangement other than QWERTY layout since it is not appropriate for small mobile touch screens as suggested by [4].

The key arrangements in the designed keyboard were ordered alphabetically with four rows and seven columns to hold 28 Arabic alphabets, and we added a tab to hold the extra characters. Additionally the keyboard contains delete, new line, number tab and space bar. We chose Arabic sequence alphabetical arrangement due to the fact that it is easy to be remembered by Arab elderly. As our findings from the survey, Arab elderly is either illiterate who barely can read or write with low level of education; thus, the way the letters' sequence were taught to them in their preliminary education will be used. We hope this design arrangement will improve the elderly typing performance and encourage them to use the soft keyboard in a user-friendly and convenient way as possible. Figure (7) shows the keyboard design of our launcher.

Furthermore, many studies pointed that giving the appropriate feedback could relatively affect the elderly typing performance. Hwangbo et al. found that the elderly performance was increased significantly when a combination of auditory and tactile feedback provided, this indicates that using multi-sensory feedback is more effective than unisensory feedback for the elderly.

Figure 7 The designed keyboard: (left) the complete letters arrangement, (right) the extra letters are shown

Based on our recommendation above which were suggested as: providing clear keyboard feedback that combines colour, key enlargement, and voice feedback after each key press could be very helpful especially in the elderly case. Thus, we added the colour contrast between keys and spacing along with voice feedback.

5 Evaluation

We discuss here the results obtained after evaluating our launcher design, the evaluation took three approaches: accessibility, usability and eye tracking. In the accessibility approach, our proposed launcher was compared against similar launchers available in the Android market. In the usability and eye-tracking approach, our launcher was tested with real users and feedback was collected.

5.1. Accessibility Evaluation

This section presents the accessibility evaluation for three similar launchers compared to our proposed launcher, in this evaluation we used the checklist of mobile guidelines for older people, this checklist is proposed in previous study by [23] where the authors had collected this criteria from different sources. The authors in [23] obtained some accessibility standards and guidelines established by the W3C [24]. In addition, they obtained more accessibility best practices recommended by Apple and Google in their application developers' guides [25] and [26]. Table (3) shows the list of accessibility barriers.

The launchers involved in this evaluation were, Big launcher version 2.5.5 , Wiser version 1.30.6, Phonotto Senior Phone Launcher version 1.6, and our proposed launcher version 1.0 Figure (6). These launchers are chosen based on customer reviews, number of download, and the launcher support for Arabic language.

Each launcher was evaluated using the accessibility criteria in Table (2), and in order to gain proper results we used a 5-point Likert scale for the evaluation. Table (3) shows the evaluation results.

The results illustrate that all three launchers have high level of accessibility for older adults; Wiser launcher used the default system interface in many functions that was the reason behind its low accessibility compared to Big launcher and our launcher. Our launcher is better than Big launcher in accessibility criteria WDG-UG (Use of unsuitable Graphics or not accessible (Graphics should be relevant, images with alt tag, etc.), because Big launcher uses SOS icon for emergency which is not suitable for Arab users especially older users. Also, Big launcher main icons are not labeled. Finally our launcher achieved a score similar to Phontto, which means that our launcher is comparable to off-the-shelf commercial applications designed for elderly people.

Code	Description of accessibility barrier
W3CP001	Information conveyed using color (for example, "required material is shown in red") with no redundancy
W3CP002	Non-text objects (images, sound, video) without text alternative
W3CU001	Long words, long and complex sentences, jargon
W3CU002	Content spawning new windows without warning user
W3CU003	Blinking, moving, scrolling or auto-updating content
WDG-TD	Unsuitable Target Design (larger targets, clear confirmation of target capture, etc.)
WDG-UG	Use of unsuitable Graphics or not accessible (Graphics should be relevant, images with alt tag, etc.)
WDG-BWF	Unsuitable design features for browser windows (Avoid scroll bars, only one open window)
WDG-CLD	Not accessible content and unsuitable layout Design (Language should be simple and clear, highlight important information, etc.)
WDG-UCD	Unsuitable design according to cognitive barriers (Provide ample time to read information, support recognition rather than recall)
WDG-UCB	Unsuitable Use of Color and Background (Colors should be used conservatively, background not in pure white or change rapidly in brightness between screens, insufficient contrast, etc.)
Android001	Not providing redundant information for information only auditory (Make sure that audio prompts are always accompanied by another visual prompt or notification, to assist users who are deaf or hard of hearing)
Android 002	Forms difficult to understand. Interface controls have proper labels and these labels are understandable and descriptive
GB001	Opaque Objects. The page contains components (eg. a Flash object) that is totally opaque to screen readers
GB002	Too many links. A large number of links requires that users perform a long and exerting activity when scanning them

Table 2: Accessibility List

Code	Big launcher	Wiser	Phonotto	Our Launcher
W3CP001	4 - Yes but not the font color	**3-** mostly used the system interfaces	**4-** Yes but not the font color	**4-** Yes but not the font color
W3CP002	**5-** Yes	**5-** Yes	**5-** Yes	**5-** Yes
W3CU001	**5-** No long or complex text	**5-** No long or complex text	**5-** No long or complex text	**5-** No long or complex text
W3CU002	**3-** since the pages are within the app itself, but if chosen from the app list it will open without asking	**3-** it notify the user when opening the gallery but the other apps will open without warning the user	**3-** since the pages are within the app itself, but if chosen from the app list it will open without asking	**3-** since the pages are within the app itself, but if chosen from the app list it will open without asking
W3CU003	**3-** there is scrolling in long lists	**3-** there is scrolling in long lists for the app lists	**3-** there is scrolling in long lists for the app lists	**3-** there is scrolling in long lists for the app lists
WDG-TD	**5-** No	**5-** No	**5-** No	**5-** No
WDG-UG	**4-** since it doesn't suit Arabic elderly such as SOS and gallery	**2-** it used the system interface like gallery, messages which is not suitable for the target user group	**5-** No, the icons are clear for Arab users	**5-** No, the icons are clear for Arab users
WDG-BWF	**5-** it is one window	**5-** it is one window	**5-** No	**5-** No, it is one window
WDG-CLD	**5-** it is clear for Arab users	**5-** it is clear for Arab users	**5-** it is clear for Arab users	**5-** it is clear for Arab users
WDG-UCD	**5-** it is easy to recognize	**5-** it is easy to recognize	**5-** it is easy to recognize	**5-** it is easy to recognize
WDG-UCB	**5-** it uses converse colors	**5-** it uses converse colors	**5-** it uses converse colors	**5-** it uses converse colors
Android001	**5-** there is vibration	**5-** there is vibration	**5-** there is vibration	**5-** there is vibration
Android 002	**3-** forms are clear and icons are labeled	**5-** forms are clear and icons are labeled	**5-** forms are clear and icons are labeled	**5-** forms are clear and icons are labeled
GB001	**5-** No flash objects	**5-** No flash objects	**5-** No flash objects	**5-** No flash objects
GB002	**5-** No	**5-** No	**5-** No	**5-** No

Table 3: Accessibility Evaluation Results (1 means strongly disagree and 5 means strongly agree)

5.2. Usability Evaluation

Another important evaluation approach in our project was usability evaluation. Usability evaluation entails three elements: Efficiency (Time on Task), Effectiveness (Task success and Number of Errors) and Satisfaction (participant's opinion). In order to measure the three elements, we defined a list of day-to-day tasks that the participants should try to carry out with the launcher. We did not give them any support while they were carrying out these tasks. Five participants were involved in the evaluation, two of which were above 65 years old (one is with elementary education and the other is well educated); one is 19 year old with elementary education, and two middle age well educated participants. The variation of both age and education levels was meant to have different viewpoints on the usability of our launcher. The experiment conditions, tasks and setup are presented below.

Experiment conditions:

- Device: Samsung Note 4
- OS: Android 5.0.1
- Alpha version of our launcher.

Experiment Tasks:

1. Make a call by dialling a number
2. Search for a number from contacts
3. Add a contact
4. Text a contact
5. Take a picture
6. Look for the picture you just took
7. Search for more apps
8. Add speed dialup
9. Make a call through speed dialup
10. Change background colour

Experiment setup:

1. Ask the participant to identify the main elements of our launcher. Once finished, present the tasks one by one with a break between each task to have time to discuss the participant's opinion about the task, i.e. was it easy or hard.
2. During the task we observed the participant interaction and record the time it takes to do the task. We also counted the number of times the participant made errors until (s)he reached the goal of the task.

Task	Efficiency (Time on Task in Sec.)	Effectiveness	
		(Task success)	(Number of Errors)
1	20.25	Completed with ease	0
2	40	Completed with ease	0.25
3	32.67	Completed with difficulty	0
4	175.25	Completed with ease	0
5	18.5	Completed with ease	0
6	15.75	Completed with ease	0
7	24.25	Completed with ease	0.25
8	25.67	Completed with difficulty	0.33
9	10	Completed with ease	0
10	25.75	Completed with ease	0

Table 4: Usability Evaluation Results

Table (4) summarizes the obtained results after conducting the previous tasks; notice that the results are presented as averages for both the time and error rate. We can observe that the efficiency (time) of the tasks ranged between 10 to 175 sec., however if we excluded the largest value (175.25) this

is when all participants were asked to type a text message, we will get a range between 10 to 40 sec., which indicates a reasonable time for conducting the major tasks on a launcher.

On the other hand, effectiveness of the launcher was measured using task success and number of errors. In terms of task success, all tasks were completed with ease expect Task no. 3 (Add a contact) and no. 8 (Add speed dialup) where at least one participant failed to complete the task. In terms of number of errors, Task no. 2, 7 and 8 had encountered errors while performing the task, yet the error rate was less than 0.5 which indicates that the task were successfully accomplished.

On the other hand, the satisfaction was measured using System Usability Scale (SUS) questionnaire. The average SUS scores for all the participants was 86.5, which is acceptable as it is above the typical average SUS score that has been found in previous research [27], which is 68. We can also see from Figure (8) that all participants scored above 80 except for participant 5, however, participant 5 still provided a score above the 68 threshold, this mean that our launcher was easy to use by all participants.

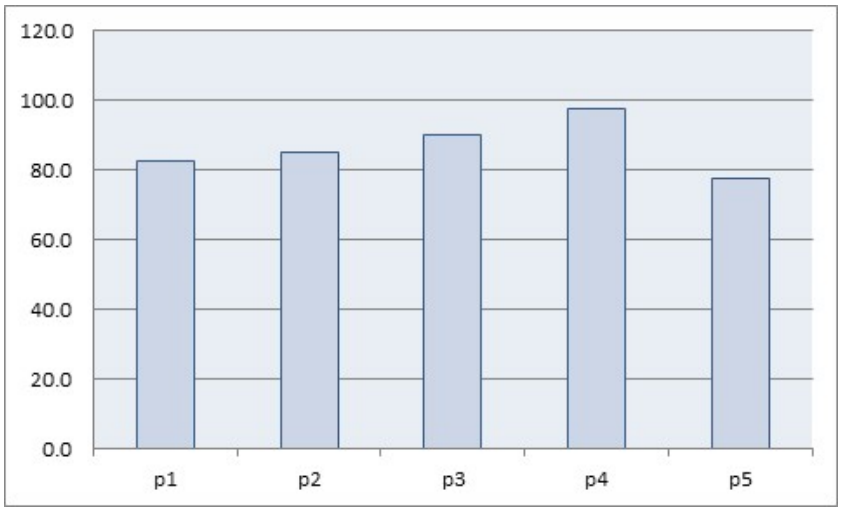

Figure 8 SUS Scores

Furthermore, while talking to participants they have shown good impression about the launcher and would like to recommend it to their friends, with some comments for improvements. Participants said that the launcher is easy to use, with consistent functions except for the speed dial-up. They suggested adding pictures or text to indicate that the top list is used for speed dial-up.

4.3. Eye Tracking Evaluation

The eye tracker was used to complement our usability findings and reveal problems to help us understand what interface elements have most influence on the elderly interaction. The eye tracking evaluation was performed using Tobii X-60 mounted on a mobile device stand paired with camera to record users' interactions. Also, the Tobii Enterprise studio (version 3.3.2) was used to record the user interaction with the mobile phone and analyze the eye movements. Testing was performed on a Samsung S4 Note with Android 5.0.1. Figure (9) illustrates the experiment setup.

Figure 1: Experimental setup

Figure (10) shows the generated heatmap after interacting with the launcher. Varying colors show the levels of fixation duration with red indicating the longest fixation, followed by yellow and green showing less amount of fixation; this indicates the effectiveness of the interface design and shows the balanced view off the interface elements. The figure also reveals that most participants missed the settings icon as part of the launcher interface, which verifies the issue found in the usability evaluation step.

On the other hand, Figure (11) shows the movement sequence and order of gaze fixation while typing using the soft keyboard. The gaze sequence helped us in understanding the user eye movement and where (s)he is focusing while typing. The figure shows even distribution of participants' gaze while typing, which indicates that participants have spent more time focusing in order to look up for keys to press, however, the order of focus was the same for all participants given the fact that the keyboard layout is organized alphabetically.

Figure 10 Heatmap showing the balanced and symmetry view of the main icons in the launcher interface; also it shows that there is no focus on the settings icon

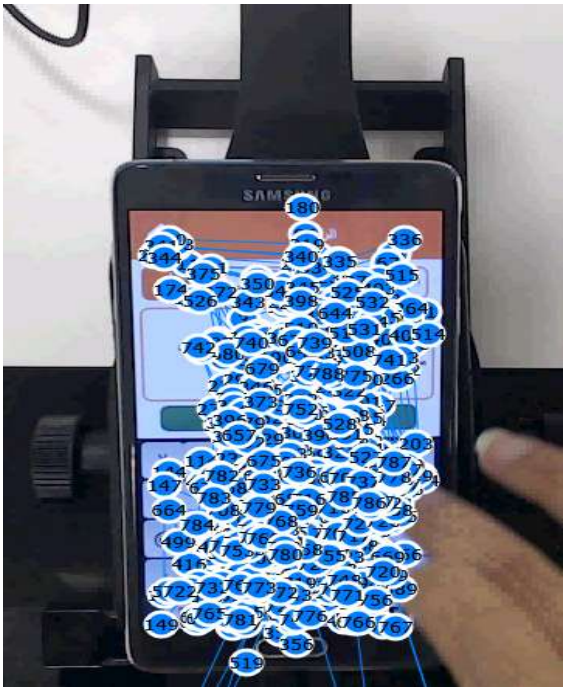

Figure 11 Picture showing the even distribution of Gaze plots while typing

6 Conclusion and Recommendations

This project was undertaken to propose a set of heuristics that covers touch based mobile phone launchers targeting elderly people, in addition to design and implement a launcher that follows these heuristics, and then evaluate the usability of the proposed launcher. To accomplish these target tasks we had to divide the work to multiple phases, which we presented as individual sections.

As we had shown in this paper, Arab elderly has shown interest in adapting new touch-based devices, however they had complained mainly about the soft keyboard while writing text messages. As a result, we had designed and implemented specific keyboard layout for our launcher. The keyboard follows Arabic alphabetical letters order to make it easier to remember. In addition, we had increased the size of each letter in the keyboard. We also, tried to design an interface that is more suitable to Arab elderly people by conducting an interview and distributing a questionnaire among them and their caregivers. Doing so helped us in designing the interface elements of our launcher that targets the elderly needs.

We hope that the results obtained after conducting this project will contribute to the advancements of touch-based mobile phones customization research area, especially for Arab elderly people.

Finally, we expect that this research project will serve as a base for future studies and suggest further direction and recommendation of this research. Our future plan will include:

1. Improving the current version of the launcher and adding more functions to it.
2. Conducting another round of evaluation on representative sample of users.
3. Making our launcher easy to adapt by different cultures by allowing old people to change the icons for something familiar to them.
4. Including suggested messages and error correction recommendations; i.e. not automatic suggestion as it is available nowadays in existing soft keyboards.
5. Providing an iOS version of the launcher.

Acknowledgements

This project is supported by grant no. D-C-12-117 from King Abdulaziz City for Science and Technology.

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