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ABSTRACT

Today the world is experiencing the rapid growth of the older population. The number of older adults who own digital devices such as smartphones is increasing as well. The current smartphone user interfaces, however, appear not optimized for older adults. When designing smartphone user interfaces for older adults, we must consider their age-related physical and cognitive changes, which most likely affect their user experience. The present paper explores smartphone user interface guidelines for older adults and heuristics for evaluating the usability of Android launchers for older adults as well as a research study that developed an Android launcher for older adults.

Keywords

Smartphone, touchscreen, older adults, user interface, Android launcher

1. INTRODUCTION

Today the world is experiencing the rapid growth of the older population — people 65 years or older. Such growth appears more noticeable in developed nations due to low fertility and mortality rates [9]. In the U.S., the older population numbered 43.15 million in 2012, which was 13.7% of the entire population of 313.91 million [10]. The older population in the U.S. is projected to increase to 79.72 million or 21.0% of the total population of 380.01 million by 2040.

The first generation of iPhone and the first commercial Android smartphones were introduced in 2007 and 2008 respectively. Since then, a large number of people have shifted to smartphones from other types of mobile phones. In 2011, merely 35% of American adults had smartphones [4]. The percentage had risen to 77% in 2016 [5]. When we look at the number of smartphone owners by age, 11% of older adults had smartphones in 2011, and the percentage had increased to 42% in 2016. Though the growth rate is smaller for older adults than the entire population, we still see a relatively large increase in smartphone usage among older adults.

Despite such growth in smartphone ownership among older adults, user interfaces (UIs) of smartphones that are currently on the market appear not optimized for older adults [3]. As people grow older, we experience a decline in our physical and cognitive abilities [6]. With these age-related changes, we most likely have a harder time interacting with smartphones efficiently and effectively. For smartphones to be more accessible and usable for older adults, these physical and cognitive changes need to be well considered when smartphone UIs are designed.

The present paper is divided into four sections. In Section 2, we provide background on older adults, more specifically their age-related physical and cognitive changes and their mobile phone usage. In Section 3, we focus on touchscreen smartphone UI guidelines for older adults and a heuristic evaluation of touchscreen smartphone usability for older adults. In Section 4, we explore a research study that designed and evaluated touchscreen smartphone UIs for older adults.

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2. BACKGROUND

To discuss optimal smartphone UIs for older adults, we should learn about older adults and their mobile phone usage. In this section, we first study common age-related physical and cognitive changes in older adults, which are likely to affect their usage of mobile phones. Next, we discuss older adults' needs for mobile phones. Lastly, we go over current mobile phone options that could provide older adults with better accessibility and usability.

2.1 Age-related physical and cognitive changes in older adults

Based on a large variety of research studies, Johnson and Finn [6] introduced UI guidelines for computer and information technologies that are inclusive of websites, desktop and mobile applications, and digital appliances for older adults. In their book, Johnson and Finn also described age-related changes that are likely to affect our user experience with such technologies. In this section, we present some of those age-related changes from their book, that appear to impact especially mobile phone user experience.

Vision. With age, we experience changes in our vision. Our ability to see fine details declines. Though visual acuity begins to decline after our early twenties, it typically declines at a faster pace for those above 50 years old. The decline in visual acuity makes it difficult for us to see information on displays and hit the intended targets. For example, small text fonts reduce reading speed in everyone, but to a greater extent in older adults than in younger ones. [6]

Our eyes take in and register a smaller amount of light at an older age. The reduced amount of light intake causes us to require brighter light to see and read well. For example, an average 60-year-old needs three times more light than a

20-year-old to perceive the same subjective brightness. In addition, older adults experience yellowing vision, which is caused by the lens of our eyes turning slightly yellow. Colors would appear tinted toward yellow to individuals with yellowing vision, making certain pairs of colors harder to distinguish, particularly greens, blues, and violets. Many older adults also experience a decline in contrast sensitivity. As a result, it becomes hard for older adults to see information that poorly contrasts with its background. [6]

Motor control. Growing older, we are able to move our arms, hands, and fingers less precisely than when we are young. Most of us typically experience this decline after the age of 50. Due to this change, we are likely to have a harder time with grasping and manipulating small objects and executing multi-finger gestures such as pinch and spread, which are often required on touch-screen devices. [6]

Hearing. Getting old causes us to lose our hearing gradually. Hearing loss typically starts in our late 20s. By age 45-59, about 10% of people experience age-related hearing loss that is significant enough to affect interactions with others. By age 60-65, the percentage is 33% and by age 75-80 it rises up to 55%. Symptoms of age-related hearing loss include reduced ability to hear low-volume sounds, declined sensitivity to high-frequency sounds, and decreased ability to filter out background noise. Due to these changes, older adults tend to have difficulty hearing alert sounds such as ring tones, understanding artificial speech, and discerning the direction or source of sounds. [6]

Cognition. We change not only physically but also cognitively as we age. One of the primary components of human memory is working memory, a system that temporarily stores information and allows us to evaluate, combine, compare, and manipulate stored information. The working memory capacity typically increases from babies into adults and starts to decline in our 30s though different individuals experience different peak capacity of working memory as well as the rate at which the capacity declines and the ages at which the decline accelerates. Declining working memory capacity affects our ability to think, reason, and understand. As a result, we have a harder time with multitasking, remembering, and keeping track of things. For example, performance accuracy for computer tasks among older adults decreases when the number of details to keep track of increases to the degree where it exceeds their working memory capacity. [6]

Another main component of human memory is long-term memory. Within long-term memory, there is semantic memory, which processes concepts, ideas, facts, and the relationships between them. Spatial memory, a type of semantic memory, allows us to navigate around real or virtual spaces by examining a cognitive map that represents spatial and connectivity relationships between places. When we get older, spatial memory also declines. As a result, we experience difficulty navigating in abstract spaces such as menu hierarchies, websites, and applications. [6]

2.2 Older Adults' Needs for Mobile Phones

Balata et al. [3] conducted qualitative and quantitative studies to investigate older adults' behavior and attitudes toward mobile phones. Because the quantitative study was based on the findings of the qualitative study, we mainly discuss the findings of the quantitative study in this section of the present paper.

The study was implemented via online survey with 118 respondents of three different age groups: 50-59 year olds, 60-69 years olds, and 70+ years olds [3]. Below we present the results of their study to gain knowledge of older adults' needs for mobile phones.

Meaning of mobile phone. The vast majority of respondents across all age groups considered the purpose of having a mobile phone to stay connected with their family and friends easily. About one third of respondents across all age groups own a mobile phone also to feel a sense of security, to call an ambulance, and to stay technically up-to-date. [3]

Phone usage. The most frequently used features among respondents were voice call and short message service (SMS) followed by camera and alarm clock across all age groups. Though the frequency of use was not as high as the above features and varied among different age groups, respondents also used features such as music applications, emails, flash light, and the Internet. [3]

Use of advanced features. The majority of respondents felt that their phones had more features than they could use. About half the respondents agreed that they did not understand some of the features on their phones. Nonetheless, the majority of respondents across all age groups disagreed that advanced features should be hidden. [3]

Accessibility issues. Approximately half the respondents have difficulty seeing what is shown on a display. With SMS (i.e., one of the most frequently used features) in particular, the primary issue addressed by respondents was small keys on keyboards. Though there was a variety among different age groups, respondents appreciated large font on their phone. In addition, about half the respondents 60 years and above agreed that they want notifications of receiving new messages to be more apparent visually with visible flash and auditorily with lots of sounds. [3]

2.3 Mobile phone options for older adults

On the current market, when older adults wish for better accessibility on mobile phones that satisfies their age-related needs, there are two approaches that they can take. One is to use feature phones that are designed specifically for older adults. These feature phones are usually designed with large physical buttons and simplified UIs. Their displays, however, are typically small. Moreover, these phones are limited in functionality compared to smartphones, providing only voice call and SMS. [3]

Another approach is to use smartphones with a launcher [3], which will be focused on in the present paper. Launchers are applications that can be used on Android mobile phones. With launchers, which modify the features of the device's operating system without making any permanent changes, users can completely customize their device's UIs [8]. With the customized UIs, users can personalize the home screen and/or application drawer (i.e., a place where a collection of all installed applications can be found) to perform various tasks (e.g., launch mobile applications, make phone calls). Launchers can be pre-installed into the mobile phone as well as downloaded from the Android Market.

There are many launchers on the market, including those designed specifically for older adults and/or individuals with physical impairments such as low vision, which is common among older adults. Such launchers include Big Launcher, Phonotto, EasyPhone, Liv+, Oldroid, and Georgie [2], which we will discuss in more details in the later section.

3. TOUCHSCREEN SMARTPHONE UI GUIDELINES FOR OLDER ADULTS

In this section we will discuss two research studies conducted by researchers from King Saud University. Al-Razgan et al. [1] implemented the first study to compile touchscreen mobile phone UI guidelines for older adults. Al-Razgan et al. [2] conducted the second study to develop heuristics for evaluating Android launchers for older adults based on the guidelines that were compiled in the first study.

3.1 Touchscreen smartphone UI guidelines for older adults

Al-Razgan et al. conducted a comprehensive review of literature to compile a set of touchscreen smartphone UI guidelines and design recommendations for older adults. The guidelines are classified into three dimensions — look and feel, interaction, and functionality. Below is a condensed version of their guidelines. [1]

1. **Look and feel**
   - Larger mobile phone with 3-D looking buttons
   - Separate keypads for numbers and letters
   - Good spacing between buttons
   - Larger font for text
   - Labeled icons
   - Ability to access most important features via a labeled button, not via menu navigation
2. **Interaction**
   - Easy zoom in and out and pinching
   - Audio confirmation for a tapping gesture
   - More functions with a tapping gesture
   - Fewer functions with a drag and drop gesture
   - Slow motion interface
   - The interface that clearly shows where the user is in the dialogue and which "tasks" are active
   - No slide-out keyboard
   - The object stays where it was when the touch is lost during a dragging gesture
   - The same object is not overloaded with actions performed by tapping and dragging gestures
   - The screen does not go off when being idle, which possibly makes older adults think that the phone is not working
3. **Functionality**
   - Functions of the same type are grouped together
   - Primary navigation buttons are placed in an identical manner on all screens
   - Critical functions always appear on the screen
   - Important functions are placed at the top of the screen to avoid accidental tapping
   - A button to return to the home screen
   - A locking button to avoid accidental dialing
   - A panic button for emergencies
   - A button to place a caller/number into a blacklist
   - Straightforward names for programs and commands
   - Not too many functions but not too few functions

3.2 Heuristics for evaluating launcher UIs for older adults

According to Al-Razgan et al., there was no empirical research that focused on the evaluation of launchers that are designed specifically for older adults. Hence, the researchers conducted a study to propose a set of heuristics for evaluating the usability of Android launchers for older adults and to have usability experts evaluate six Android launchers using their proposed heuristics. [2]

In their study, the researchers also had the usability experts evaluate the effectiveness of their proposed heuristics [2]. We, however, consider that the evaluation of the heuristics is outside the scope of the present paper; therefore, we only focus on the part of their study, which discussed the development of the heuristics and the evaluation of Android launchers using the heuristics.

Methodology. Al-Razgan et al. [2] developed their usability heuristics based on the touchscreen smartphone UI guidelines for older adults that were compiled by Al-Razgan et al. [1] (see Section 3.1). The guidelines were classified into three dimensions — look and feel, interaction, and functionality. First, they converted the UI guidelines under each dimension into usability problems, which were next grouped together into several categories by similarity [2]. They translated the usability problems under each category into heuristics. After that they converted the heuristics into interrogative sentences, which were later elaborated into questions.

Below is a condensed version of their heuristics, which are classified into three dimensions, each of which is further grouped into several categories [2]. Each category consists of heuristic questions — the total of 48 questions across three dimensions. In the interest of space, however, we have omitted those individual questions below and present several of them where necessary in the later section, which discusses the results of the evaluation of the six launchers.

1. **Look and feel**
   (a) Make elements on the page easy to read (e.g, font size, color scheme, amount of text on each screen)
   (b) Easy recognition and accessibility (e.g., icons, labels, easy access to frequently used functions, easy data entry)
   (c) Make clickable items easy to target and hit (e.g., button size, space between buttons)
   (d) Use the elderly language and culture; minimize technical terms (e.g., easy-to-understand labels and icons for older adults)
2. **Interaction**
   (a) Provide clear feedback on actions (e.g., audio/visual confirmation when tapping, helpful and informative confirmation/error messages)
   (b) Provide preferable gestures for older adults (e.g., use of tap gestures for most actions)
   (c) Provide descriptions/instructions wherever necessary to inform the users what they can and cannot do (e.g., an instruction within an application on how to use the application)
   (d) Use conventional interaction items (e.g., consistency in interface design across different pages and different sections of an individual page)

(e) Ergonomic design (e.g., placement of elements)

3. **Functionality**

   (a) Provide functions that require less memory load (e.g., direct access to most frequently used functions, grouping of similar functions, easiness to remember functions)

   (b) UIs that do not make older users feel lost or stuck (e.g., presence of primary navigation buttons on all screens, a back button that always goes back to the previous screen)

   (c) Prevent errors (e.g., important functions placed at the top to avoid accidental touches, confirmation messages for critical actions)

   (d) Provide necessary information and settings (e.g., display of remaining battery amount, time, and date, availability of a function for default settings)

Participants and materials. Participants (i.e., usability experts) were four senior undergraduate students who had studied human computer interaction and conducted usability evaluations before. Participants were asked to evaluate six different Android launchers. [2]

1. Big launcher: designed specifically for older adults and individuals with low vision, providing its users with a simple and easy-to read interface.

2. Phonotto: designed to provide its users with only basic phone functions — voice call, address book, and SMS.

3. EasyPhone: designed specifically for individuals with low vision, providing extra large font for dial pads, call history, contacts, and SMS.

4. Liv+: designed specifically for older adults, allowing its users to use their smartphones with only four navigational buttons for simplicity.

5. Oldroid: designed specifically for older adults, providing its users with only basic phone functions but allowing someone other than the phone owner to remotely change the phone settings and edit/add contacts through the specified website.

6. Georgie: designed specifically for individuals with low or no vision, providing its users with large font and allowing for speech and audio interaction with a phone.

Al-Razgan et al. created two personas. The first persona is a 61 year-old female with six grandchildren, who lives with her son. She studies at the Literacy school; and can read and write but with mistakes. She uses a mobile phone with physical keyboard and has never used a smartphone before. She needs glasses to read and has hearing impairments. She also suffers from arthritis, which could be a problem for her to tap on the screen. [2]

The second persona is a 76 year-old male with seven grandchildren, who lives with his wife, son, and grandchildren. He cannot read or write. He experiences memory impairment and has a short temper. He uses a mobile phone with physical keyboard. He thinks that new technologies are difficult and is not motivated to learn to use them. [2]

Procedure. In the orientation session, participants were given explaination about the goal of the study, the testing procedure, and the heuristics to evaluate the launchers. Participants were instructed to impersonate the two personas that are previously described. [2]

In the evaluation session, participants evaluated each of the six Android launchers to diagnose usability problems and prioritize them according to Nielson's five-point Severity Ranking scaled from 0-4 [2][7].

0. No problem — This is not a problem at all.

1. Cosmetic problem — This problem doesn't need to be fixed unless extra time is available on the project.

2. Minor problem — Fixing this problem should be low priority.

3. Major problem — Fixing this problem should be high priority.

4. Catastrophic — This problem must be fixed before the product is released to the market.

In order to avoid order effect, the sequence of launchers to be evaluated was counterbalanced for each evaluator. [2]

Discussion and results. Al-Razgan et al. [2] quantitatively analyzed the data collected from the evaluation. Though their methodology of analyzing the results appears not entirely clear in the article, we discuss their results in the best possible way for the audience to understand the findings of their study.

All six launchers appeared to consider the unique needs of older adults when their UIs were designed as the portion of "No problem" was larger than any other ratings (i.e., cosmetic, minor, major, catastrophic) overall. When looking at the heuristics by dimension (i.e., look and feel, interaction, functionality), the look and feel dimension has the largest number of major and catastrophic issues, followed by functionality and interaction. [2]

Look and feel. The heuristic presented in *Methodology* of the current section, "1 (a) make elements on the page easy to read", includes questions that ask if the launcher provides its users with a function for enlarging font size as well as customizing UI colors. Four of the six examined launchers did not have the ability to let users do so, which requires users perform these tasks in the setting of the device's original UIs, which is likely to be difficult for older adults. The heuristic, "1 (b) easy recognition and accessibility", has the question that asks if the icons used in the launcher are clear, labeled, and understandable. The icons of some of the launchers had text on top of them, which possibly makes it hard for older adults to see what the icons are for. [2]

Interaction. Under the heuristic, "2 (a) provide clear feedback on actions", there is a question that points out the importance for the device to be able to provide its users with audio, visual, or haptic feedback when the users tap on the device so the users know their tasks were complete. Most of the examined launchers did not have the function to allow users to enable such feedback. [2]

Functionality. The heuristic, "3 (c) prevent errors", includes a question that asks if the launcher has the ability to display a message when users are about to perform some critical tasks (e.g., delete contacts) so the users could confirm that they mean to perform the task, not by accident or mistake. None of the examined launchers, however, had the ability to return such messages when tasks such as deleting

messages and contacts were about to be made. Under the heuristic, "3 (d) provide necessary information and setting", there is a question that points out the importance for the launcher to be able to let the users change some settings of the mobile phone (e.g., ringtone) easily. None of the launchers had the ability to let the users do so, which requires the users to change the setting in the device's original UIs, which is possibly hard for older adults. [2]

4. KOALAPHONE LAUNCHER

Balata et al. designed a launcher, called KoalaPhone, to address the issues of Android launchers designed specifically for older users that are available on the current market. They identified issues of current Android launchers for older adults as follows. First, functions and applications that can be used through the launchers are limited to the level of a feature phone (i.e., voice call, SMS, occasionally camera). Due to the limited applications available through the launchers, users are required to open unavailable applications (e.g., photo album, email) externally through the un-customized UIs, whose designs are not only optimized for older adults but also inconsistent with those of the launchers. Switching between the launchers and the external applications is most likely complicated for older adults. Besides the limited functionality issue, the keyboards are too small. In addition, system notifications are too small and confusing. [3]

4.1 Low-fidelity prototype

Balata et al. created and evaluated low-fidelity prototypes through three iterations. At each iteration, ten different individuals from a group of older adults evaluated their prototypes. Below are their findings from the iterations. [3]

Participants had a hard time reaching buttons at the right top corner. Participants found navigation buttons confusing when they were moving between different screens, where the meaning and size of the buttons differed. The menu button needed to be modified to be labeled "Menu", instead of a menu icon, because participants didn't understand the meaning of the icon. [3]

The original design for vertical navigation was to use two buttons labeled "Previous" and "Next", replacing a vertical scroll bar. This design was not intuitive, however. Participants used the "Previous" button to return to the previous screen as well as the previous part of the current screen. Moreover, participants found it confusing when they saw the "Previous" button and the "Backspace" button on one screen at the same time. Balata et al., therefore, decided to use a simple, large scroll bar on each screen. [3]

Initially the contact page had two different screens – one for all contacts and the other for favorite contacts – but the design was not very intuitive. Some functionality such as adding a new contact was doubled in two different locations. In addition, the task of setting a contact as a favorite was confusing for participants; they accidentally removed the contact from the phone when they just wanted to remove the contact from favorites. Balata et al., therefore, changed their design of the contact page to have only one screen, instead of two screens, placing the favorite contacts at the top of all contacts. They also automated the selection of favorite contacts by the user's phone call history. [3]

4.2 High-fidelity prototype

Balata et al. designed a high-fidelity prototype, KoalaPhone Launcher, based on their findings from their low-fidelity prototype iterations and their previous study, which was presented in Section 2.3 of the present paper. Below are the design features of the launcher. [3]

Overall designs. All elements (i.e., keypad, text, icons, labels, buttons) are enlarged. Most buttons are located at the bottom of the screen so they are easier to reach. The main keypad is designed with small inactive margins on the sides to avoid accidental presses of buttons. All buttons have a vibration and sound feedback. [3]

Home and menu screens. The home screen consists of two parts; a clock with the battery and reception signal indicators at the top of the screen and a numeric keypad for dialing numbers at the bottom. The keypad has the SOS button for the user to make an emergency call. There is a green button with a people icon, which opens the list of contacts. Tapping on the menu button opens the list of all applications, which is organized in the order of importance. In the menu screen, items are listed with easy-to-understand icons as well as meaningful descriptions (e.g., for the camera feature, a camera icon with a description "Camera"). [3]

Functions and applications. In addition to basic phone functions (i.e., voice call, SMS), the launcher allows the users to use applications such as camera, photo gallery, alarm clock, and flashlight through the launcher UIs. Within each application's screen, the name of the application (e.g., "Contacts", "Photos", "Alarm") is displayed on the top of the screen. For applications that could be complicated to use, short instructional information is given on the screen so that users would know what to do. [3]

Navigation buttons. Every screen has three navigation buttons. The left button is to navigate to contacts, to save a user's input (e.g., a time for the alarm clock, contact information), and to send an SMS. The middle button navigates to the previous screen and to remove the last character from the text (i.e., a backspace button). The right button returns to the home screen. [3]

Color scheme. The entire interface is designed with a black background with white text labels. All buttons with icons are in bright colors with white iconography. For the home button and notifications, violet is used. Red is used for removing items. This color scheme is to provide a sufficient contrast and avoid glaring users with the display illumination. Color themes can be changed under setting. [3]

4.3 Evalution of KoalaPhone Launcher

Balata et al. evaluated KoalaPhone Launcher by measuring error rate of selected tasks performed on the launcher and comparing that of the same tasks, but on Android 4.4 UIs with the large text feature activated. [3]

Participants. Fifteen participants participated in the evaluation session. Participants ranged from 61 to 85 years old; the mean age was 69.6 years old. All participants used computers regularly, but not smartphones. No participant claimed to experience any severe visual, hearing, motor, or cognitive impairments. [3]

Apparatus. The evaluation used an LG Nexus 5, a touchscreen smartphone with 4.95 inch (1920 × 1080) LCD Display, whose operating system was Android 4.4. The launcher was developed in C# with Xamarin.Android framework. The UI was designed with MonoGame game framework. The evaluation recorded the video screen using An-

droid Debug Bridge with visualized touch positions. [3]

Procedure. Prior to the evaluation, the experimenter instructed to participants how to perform basic tasks (e.g., returning to the home screen, scrolling, displaying contacts) for each UI. On each UI, participants were asked to perform six tasks and return to the home screen after each task. After completing the tasks on one UI, the participants were asked to perform the same six tasks on the other UI. Below are the tasks. [3]

1. Add a new phone number for Joseph.
2. Send an SMS "Hello" to Thomas.
3. Set the alarm clock to 14:37.
4. Take a photo of an arbitrary scene.
5. Find a picture of a castle and send it via email.
6. Open a map application.

There was no time limit for participants to complete each task. They were also allowed to quit trying to complete the tasks if they wanted to. The evaluation lasted for 45 to 60 minutes. [3]

Experiment design. The experiment was 2×6 within-subject design. UIs (i.e., KoalaPhone, Android 4.4) and tasks (i.e., the six tasks that are previously described) were the independent variables. The order of UIs and tasks were counterbalanced. The total number of tasks to complete was 180 tasks (15 participants $\times$ 2 UIs $\times$ 6 tasks). The experiment measured the following:

- Completion rate of an individual task by participant for a given UI
- Completion rate of all six tasks combined by participant for a given UI
- Error rate, the portion of uncompleted tasks to all six tasks, by participant for a given UI

For statistical analysis, McNemar Exact Test was used for completion rate of individual tasks and all tasks combined by participant for a given UI. Repeated measures ANOVA was used for error rate by participant for a given UI. [3]

4.4 Results

Completion rate. As for the completion rate of individual tasks, participants appeared to have performed better with KoalaPhone than with Android for task 2 (i.e., send an SMS "Hello" to Thomas) and task 5 (i.e., find a picture and send it by email) in particular. The completion rate of task 2 was 86.67% with KoalaPhone and 60.00% with Android. This result suggests that there is a 96.88% chance that the likelihood of a given individual to complete this task is higher when using KoalaPhone Launcher than using Android. The difference in the completion rate between the two UIs is even more apparent for task 5; 93.33% with KoalaPhone and 20.00% with Android. Given this result, 99.98 percent of the time a given individual is more likely to complete this particular task with KoalaPhone Launcher than with Android. [3]

The completion rate of all six tasks combined was 40.00% with KoalaPhone Launcher and 6.67% with Android. With this result, there is a 98.44% chance that the likelihood of a given individual to complete all six tasks is higher when using KoalaPhone Launcher than using Android. [3]

Error rate. The average error rate was 14% with KoalaPhone Launcher and 33% with Android. The difference between the two UIs was statistically significant. [3]

5. CONCLUSION AND FUTURE WORK

In the present paper, we explored optimal touchscreen smartphone UIs for older adults, with an emphasis on Android launchers. We discussed age-related changes in older adults, which most likely impact their user experience with smartphones, as well as older adults' needs for mobile phones. We introduced research studies, which developed touchscreen smartphone UI guidelines for older adults and the heuristics for evaluating the usability of Android launchers for older adults. We also discussed a research study that developed an Android launcher for older adults.

As the older population is rapidly growing, there will be more and more people who require digital devices such as smartphones, which have become a large part of our daily lives, to accommodate age-related special needs. It is important for us to include all types of users when designing UIs so that everyone can take advantage of and enjoy digital devices with great accessibility and usability.

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