Smartphone Interface Design: Problems and Improvements

DIS 801 seminar paper

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Abstract

The need for smartphones is an important aspect of daily life. The smartphone is not only used for voice and text communication but also an assistive technology in information retrieval, entertainment, GPS, etc. However, satisfaction for interaction is not high enough. For example, elders' cognitive ability decreases with age increase, so that the convenience for them to interact with the smartphone needs to consider. Therefore, a user-friendly smartphone design is necessary. In this seminar paper, the evolution of the mobile phone is reviewed. Second, the disadvantages of the interface are discussed. After that, the efforts for overcoming these problems are summarized. In the end, future researches are proposed.

Keywords: challenges, evolutions, interfaces, mobile phones, user experiences

Introduction

It is critical to design a user-friendly mobile phone interface to provide a high-quality user experience (Petrovčič et al. 2018). The interface is necessary for the human to interact with mobile phones by exploring and selecting commands in systems and applications (Bailly, Lecolinet, and Nigay 2017). It is common on mobile phones and is used by numerous users. In human-computer interaction (HCI) fields, there are over 60 technologies that were developed in the last 2 decades.

Smartphone interfaces remain inaccessible for humans (Mi et al. 2013). Some individuals have visual impairments, motor control of body movement. Smartphone interface design that focuses on these people is a potential part of the research.

The organization of this seminar paper is as follows: first, the interface development from the functional phone to the smartphone is reviewed according to the chronology. Then, the disadvantages of the smartphone interface are discussed. After that, the efforts for overcoming these problems are summarized. Finally, the conclusion is summarized and the direction of future study is proposed.

The evolution of mobile phone interfaces

1. The era of functional phone

The origin of smartphone app design can be traced back to the year 1996 when the mobile phone called Palm Pilot PDA was released. It was remarkable for the mobile phone app design. It had a 160×160 pixel monochrome screen and became the prototype of the modern smartphone interface. The interaction method is using a touch pen (Kang and Han 2012). The shape is shown in Figure 1.

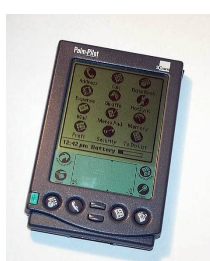

Figure 1: the shape of Palm Pilot PDA

From 1996 to 2000, it's the period of prevailing of monochrome screen functional mobile phones ("History of Mobile Phones | What Was the First Mobile Phone?" n.d.). The way people interact with the phone is by using buttons. The classic device is the Nokia 3310, which is illustrated in Figure 2. In this period, the screen was too small for people to watch. And the monochrome screen didn't provide enough user satisfaction.

Figure 2: Nokia 3310

The problem is overcomed by 2 remarkable achievements in 2000. The first one is the introduction of the coloring screen and enlarging screen size. The other is the interaction by using. One of the examples is the Nokia 9210, which is demonstrated in Figure 3.

Figure 3: Nokia 9210

2. The era of smartphone

The smartphone became mainstream in 2008. This year, the first Android phone came into the world. At the same period, the iOS phone came out. The dramatic feature of the smartphone is the discarding of the physical keyboard and using the virtual keyboard in the touch screen.

This seminar paper will explore the trend of smartphone interface design by using the development of the iPhone as a case of study ("The Evolution of the iPhone: Every Model from 2007–2020" 2017).

The first generation of iPhone was originated in 2007. The most significant feature of the smartphone is it discards the use of the physical keyboard and embedding virtual touchscreen technologies. The first-generation iPhone is shown in Figure 4.

Figure 4: the 1st generation of iPhone

In 2010, iPhone 4 came into the word. It had a 3.5-inch screen. It absorbed the Retina display. The Retina display is a high pixel density display technology on LCD and OLED display ("Retina Display" 2020). Steve Jobs, the former CEO of Apple Inc, claims the Retina display as: At 326 pixels per inch, the resolution of the iPhone 4 Retina display exceeds that of the human eye when held at a distance of 10 to 12 inches (Edwin Hermann, 2010). That is, the Retina display can get high resolution than the non-Retina display. The effect is shown in Figure 5.

(a) Retina display on iPhone 4. (b) non-Retina display on old iPhone

Figure 5: the difference between Retina display and non-Retina display

In 2012, the iPhone 5 was developed. The screen was 4 inch which is bigger than the iPhone 4. The iPhone 5 is shown in Figure 6. Although it enlarged the screen size, it still couldn't fulfill the user requirement for interaction.

Figure 6: iPhone 5

To solve this problem, the iPhone 6 comes into being in 2014 by providing multiple versions with different screen sizes. iPhone 6 has a 4.7-inch screen and there is another version with 5.5 inches called iPhone 6 Plus. In the interaction method, it uses a pressure sensor on the screen to create multiple action instruction in the same motion. The exterior of the iPhone 6 and 6 Plus is illustrated in Figure 7.

Figure 7: iPhone 6 and 6 Plus (from left to right)

In 2017, The full-screen technology was first used on iPhone X with a 5.85-inch screen. iPhone X uses the Super Retina display. The iPhone 11, uses the Super Retina XDR display ("About the Super Retina Display and Super Retina XDR Display on Your IPhone" n.d.). Super Retina and Super Retina Extreme Dynamic Range (XDR) use High Dynamic Range (HDR) technology which delivers a broad range of dark and light areas. Another feature is they both use organic light-emitting diode (OLED) technology which delivers an incredibly high contrast ratio and high resolution. Compare to Super Retina, Super Retina XDR has more brightness level and contrast (Olamide 2019). The full-screen iPhone X is shown in Figure 8.

Figure 8: iPhone X

The problems of the current mobile phone interface

There are some disadvantages to the smartphone interface, especially the unfriendly usability for elders (Petrovčič et al. 2018). Two major aspects of the disadvantages of interface design will be discussed: screen display and UI design.

1. **Screen display**

In screen display, the screen-dimming time needs to be extended to ensure that elders have enough time for cognitive processing and executing the required operations (Hassan and Md Nasir 2008). The research also emphasizes the necessity of applying conservative colors and using a high screen contrast between the foreground and background.

The screen display in the natural environment is a problem (Yu et al. 2015). It's difficult for users to see the screen in the strong lighting environment. And the screen shows dazzling in weak light condition. people with vision impair also have the problem in interacting with digital devices, operating a smartphone's user interface and selecting items on a screen (Akif Khan and Shah Khusro 2020).

Another screen display problem is the keyboard of the smartphone (Kang and Han 2012). The screen is blocked by the finger and people cannot see the screen around the finger that is touching the screen. Moreover, it's hard for people to precisely touch the keyboard (Figure 9).

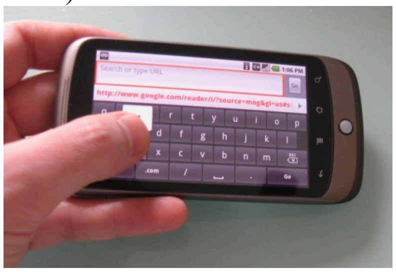
Figure 9: the problem of touching the keyboard (Kang and Han 2012)

2. **UI design**

The problem of UI design are discussed in 6 areas: 1) structure and contents of the menu, 2) user's memory load, 3) match between system and the real world, 4) help and documentation, 5) consistency and standards, 6) information feedback (Salman, Ahmad, and Sulaiman 2018).

1) **Structure and contents of the menu**

In UI design, elders always press the wrong buttons because the buttons are too sensitive to avoid accidental pressing (Kim et al. 2007). Moreover, the study points out scroll buttons should be avoided or at least minimized.

Furthermore, the research proposed some elements of menu and navigation interaction for the older adult. First, they feel stress when the structure of the menu becomes deeper. Therefore, menus should be simplified and flattened. Due to the elder's thinking model is not hierarchical, a one-layer structure menu is convenient for them to operate.

For example, in the setting menu of the iPhone, one of the important functions is the back-up contacts information into iCloud. However, there are 3 layers. Users must click their account name, then they could be able to find the iCloud setting. The process is demonstrated in Figure 10.

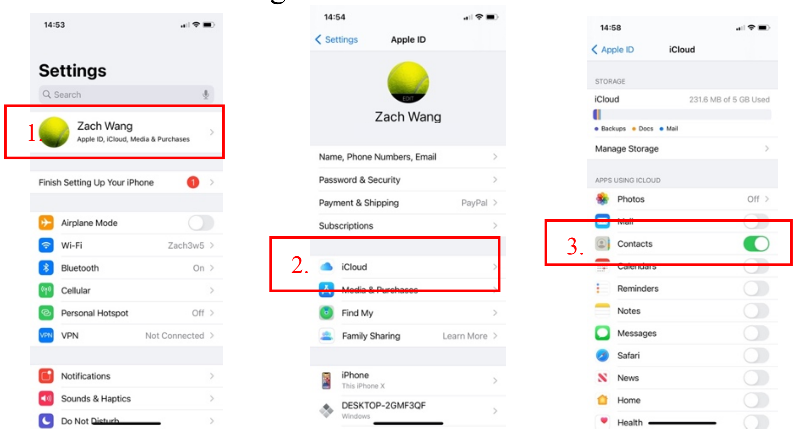

Figure 10: the process of iPhone backup setting

Second, the use of the icon is unfriendly for them. When elders see an image button, they don't have clue about the function of it. Function naming should be semantic understandable and minimal ambiguity. In Figure 9, users might don't understand which items will be included under the button of their account name. It's better to extract items from the second layer and recategorize them into the first layer.

Third, the order of the button is a problem. For example, under the General button in the iPhone, the setting of data, time, keyboard, fonts, and language are more frequent than airdrop. Thus the airdrop block should be arranged behind. The inappropriate menu setting is shown in Figure 11.

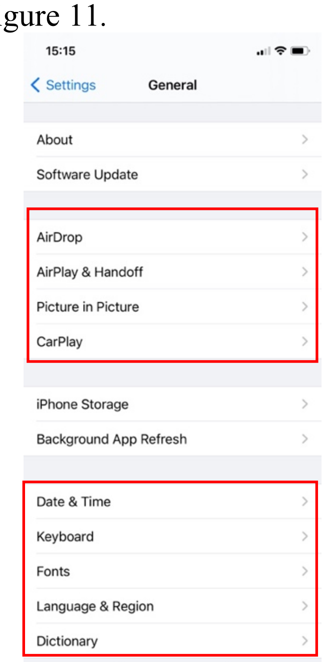

Figure 11: the inappropriate arrangement

2) user's memory load

In the user's memory load, the checklist summarized visible objects, actions and options should avoid users memorizing unless and irrelevant information. There are 3 violations in the Android phone. The first one is the "contact" menu, the search bar is too narrow and too pale on the color for elders to use and recognize (Figure 11a). Second, the contrast color between the unlock screen and the background is too low to perceive. Moreover, the small font size of the unlock instructions is hard for elders to read (Figure 12b). Another problem is the instruction vanished when the phone is in the charging process (Figure 12g).

It’s important to put sensitive information in a visible spot. However, in Figure 12d, the greater area is given to the apps icons on the center of the screen but a limited area on the top of the screen for SEARCH, A-Z, and EDIT buttons. In Figure 12e, the “SAVE” button is on the top which is opposite of the task of saving contacts. The paper suggests putting the button on the bottom of the screen. In Figure 12f, notifications and alerts are separate between the notification panel. The problem is they are not assembled and organized in a visible area in the interface.

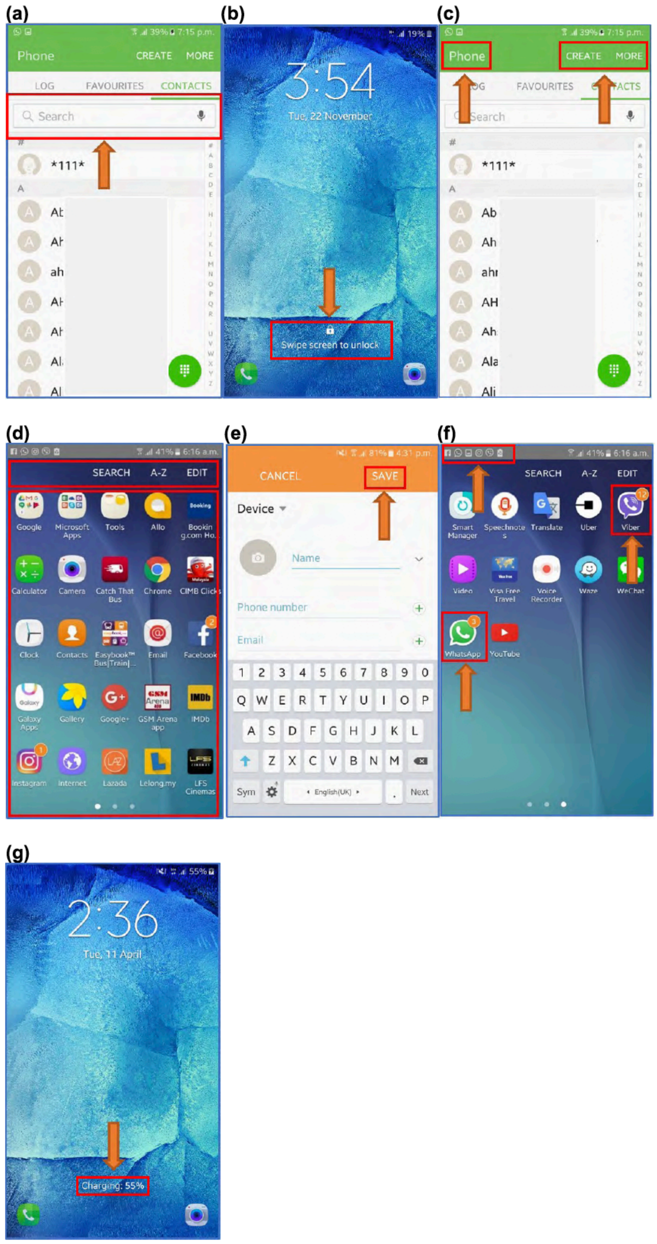

Figure 12: memory violations (Salman, Ahmad, and Sulaiman 2018)

3) match between system and the real world

In the match between the system and the real world, the search function is presented as an uppercase word on the top of the screen. The upper case word usually is seen as the title so that it is difficult for elders to understand the function rather than the icon used to represent the function (Figure 13a).

Another disadvantage is the use of terminology in computer science. For example, the “PIN” word on the home screen is incomprehensible for elders (Figure 13b). And vague button should be avoided. In Figure 13b, the “OK” button is the same as the enter key on the computer keyboard. But for elders, replace the “OK” by using “Enter” is easier for them to understand. In Figure 13c, some words don't deliver the meaning of the button to users, such as "Bluetooth" and "Data usage".

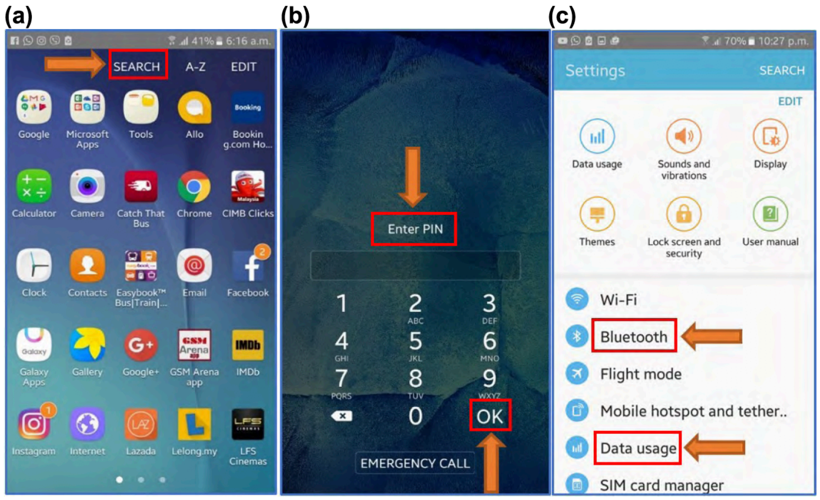

Figure 13: match violations (Salman, Ahmad, and Sulaiman 2018)

4) Help and documentation

The item of help and documentation means the interface should provide easy-to-find interaction instructions. However, in Figure 12a, the search function has multiple meanings in contact search, internet search, etc. Therefore, it's difficult for elders to understand what exactly it means. In Figure 12b, elders might don't know swipe up or swipe down. Even the instruction disappears in the charging process (Figure 12g). The swipe interaction is obvious for younger but harder for elders to recognize. In Figure 14, the setting of the wifi is swiping down. But there are no instructions.

Figure 14: help violations (Salman, Ahmad, and Sulaiman 2018)

5) consistency and standard

The consistency and standard show interface design must follow with the user's familiar manner. One of the disadvantages is the "phone" button. When users click it, it shows the last tab accessed. The example is illustrated in Figure 15. When the user clicks the "phone" button, it remains at the "contacts" tab that the user visited last time. When the user clicks the "favourite" tab and exit, next time it will automated go to the "favourite" tab. This setting might confuse the elders. Instead, it should open the same page when the button is clicked.

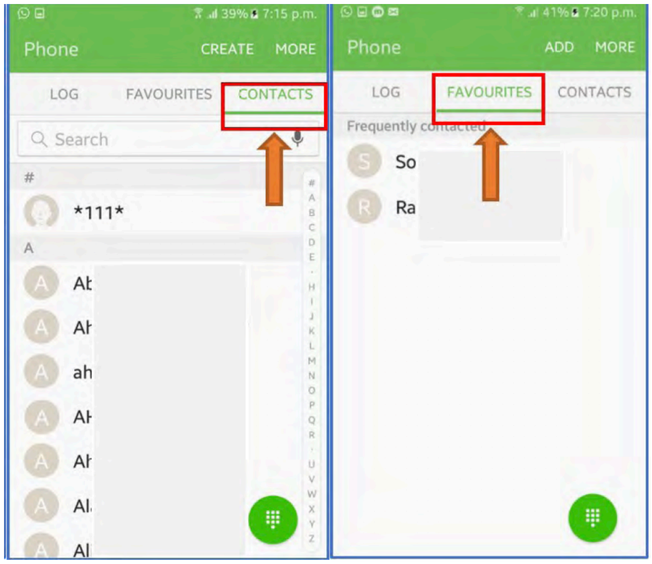

Figure 15: consistency violations (Salman, Ahmad, and Sulaiman 2018)

6) Information feedbacks

The information feedbacks are lacking when users try to change status. For instance, visual feedback lacks when the user changes the ringtone. Moreover, notifications and alerts need to be managed concentrically. However, in Figure 12f, the notifications are scattered in the icon so that it's hard to manage by elders.

7) Other interface challenge based on the empirical research

The usability is defined to find the interface challenge based on empirical research (Muslim, Fadillah, and Rizquita 2019). The usability is measured by the satisfaction of 5 factors: understandability (successful task), operability (task processing time), frustration (errors in performing the task), efficiency (the successful task in one minute), and learnability (time difference between 1st trial and 2nd trial). The between-subject test is used for iPhone and Samsung. On the one hand, the Samsung phone is superior in understandability, frustration, and learnability. It demonstrated Samsung can get more errors in tasks. On the other hand, the iPhone is superior in operability and efficiency.

The Pearson correlation shows the frustration has the highest correlation to the users' evaluation. Frustration is the priority factor that needs to be considered in the interface design.

The research also tests the eye movement on the value of fixations and saccades. Both fixations and saccades in the iPhone are higher than the Samsung. The research implied the iPhone is harder to find icons on the home screen than Samsung.

Efforts for overcoming problems

1. Screen display

To solve the watching difficulty under the bright and weak light, an automated color change system called ColorVert was proposed. It uses DKL color space to adaptively change color.

To solve the display problem for people with vision impairment, smartphone-based assistive technologies were proposed. Text to speech technology was used in 3 types of assistants: the grocery shopping assistant, the currency identifier, and the transportation assistant (Narasimhan, Gandhi, and Rossi 2009). There is an accessibility-inclusive universal user interface for blind people called BlindSense (Akif Khan, Shah Khusro, and Iftikhar Alam 2018). The layout of BlindSense is shown in Figure 16.

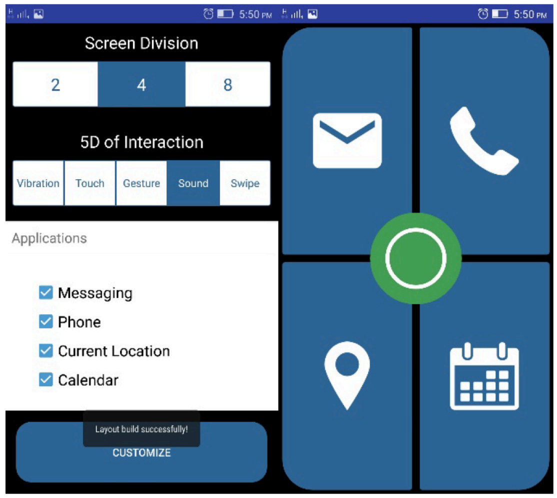

Figure 16: BlindSense (Akif Khan, Shah Khusro, and Iftikhar Alam 2018)

Another solution for vision impairment is using the wireless keyboard (D'silva, Parthasarathy, and Rao 2016). A smartphone app is used to pair the keyboard with the user's cellphone by using Bluetooth.

To solve the screen keyboard touching problem, the AR marker interface was developed (Kang and Han 2012). A marker was stuck on the user's fingernail and placed in front of the scene of the phone camera. The study separately used 2 methods: method using the orientation of a marker only and method using the position of a marker and touch commands. The first method used the marker position to define the location of the mouse cursor and used the marker rotation to represent the actions. The flow gram is shown in Figure 17.

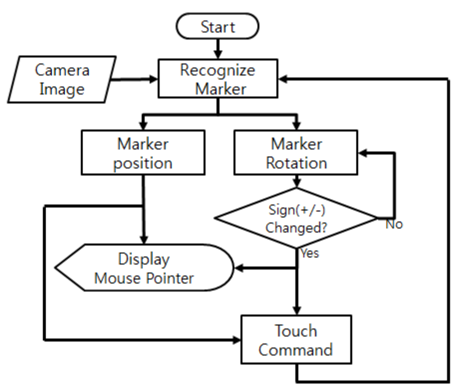

Figure 17: the method of using the marker's orientation (Kang and Han 2012)

The second method used both marker's location and the touch commands. The advantage of this method is improving the accuracy of clicking. The click command happens at the location of the marker and regardless of the touchpoint. The example is demonstrated in Figure 18, the mouse cursor is on the left and the touchpoint is on the right, but the click command is still working.

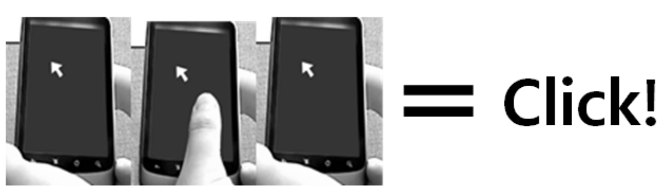

Figure 18: the method of using the mark's location and touch commands (Kang and Han 2012)

2. UI design

Some general design checklists for mobile phone menu design are proposed. The aim to characterize the design space was proposed (Bailly, Lecolinet, and Nigay 2017). It discussed the design possibilities and compared the similarity and differences among menus by refining menu performances and reviewing existing analytical and empirical methods for quality evaluation. The type of users was classified and the evaluation methods of performance were proposed. A taxonomy of menu properties was concluded. A heuristic checklist for accessible smartphone interface design was provided by reviewing existing design standards and guidelines and validating these guidelines with user involvement (Mi et al. 2013). A set of preliminary user requirements with 59 items was extracted and re-organized into 44 statements in six general categories.

It was explored that the usability dimensions of mobile phone design and related changes (Petrovčič et al. 2018). Eight mobile phone design guidelines and checklists were demonstrated. It focuses more on dealing with visual and haptic issues and hardly addresses various elements of the textual interface.

The detailed checklist for designing the mobile phone for elders was illustrated. The usability of mobile devices for an older audience was assessed by analyzing literature on age-related physical and cognitive changes impacting smartphone usability, and gathering information on how older adults use cell phones through interviews and an online survey (Calak 2013). It proposed a heuristic evaluation framework on vision, hearing, attention, memory, and motor control. It demonstrated that the strength of support for some heuristics increases with age. The accessibility of mobile phone app for elders was also considered (Silva, Holden, and Nii 2014). It concluded with a heuristic list of 35 items.

In the challenges of interfaces revealed above (Salman, Ahmad, and Sulaiman 2018), it used the SMASH checklist as a reference (Inostroza et al. 2016). It can be summarized as:1) minimize the user's memory load; 2) match between system and real-world; 3) provide easy-to-find documentation and help, centered around the user's current task and recommending concrete steps to follow; 4) follow established conventions, allowing users to do tasks in a familiar, standard and consistent manner; 5) avoid displaying unwanted information which could overload the screen.

The source of the survey and descriptive research methods were provided (Mi et al. 2013). The 2 types of mobile phone interface layouts for elders were proposed (Díaz-Bossini and Moreno 2014). They are demonstrated in Figure 19.

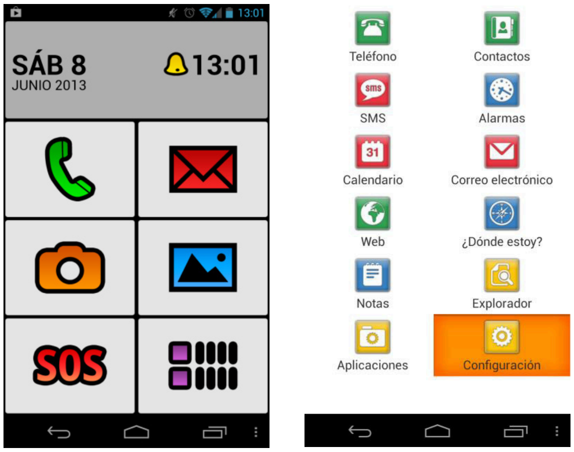

Figure 19: 2 layouts design for elders (Díaz-Bossini & Moreno, 2014)

Another interface prototype called PhonAge was developed by combining the 2 layouts above (Farah Arab, Yasir Malik, and Bessam Abdulrazak 2013). The research result illustrated it was adequate for elders. Moreover, the study provided evaluation feedbacks to improve the interface design. The interface of PhonAge main screen and icon design are illustrated in Figure 20.

(a) (b)

Figure 20: PhonAge (Farah Arab, Yasir Malik, and Bessam Abdulrazak 2013)

Concluding remarks

At first, this paper provided a synthesis of the evolution of the mobile phone interface. Then it analyzed some disadvantages of the current interfaces. Finally, it reviewed some researches that propose methods to improve the usability of the mobile phone interface.

It can be concluded from the synthesis and discussion that there is huge potential to improve mobile phone usability for elders. Numerous researches focus on the design checklist, guidelines and provide design layouts. In the future study, these research achievements will be combined to design a high usability mobile phone, develop the interface, and evaluate by empirical methods.

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