“Experiencing and Integrating:” A standardized Interactive Interface Design for Visually-impaired people in China.

by

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Abstract: With the rapid development of technology, smart phone has become a major platform for people to satisfy their daily demands. In China, the majority of daily activities rely on the using of smartphone. Under such trends, visually impaired people often face great challenges. Among most existing mobile applications in China, there's lack of the effective accessible support. Thus, it is necessary for mobile applications to updates and provide opportunities for visually impaired people. This research aims to convey a demonstration of a standard mobile application interface design with inclusive functions and provide suggestions for designers and service providers to make updates to current mobile applications, using data collected from existing research, for visually impaired people in China to enhance their using experiences in daily life.

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Introduction:

With the rapid development of the Internet in today's era, people's life and entertainment are inseparable with mobile network. Now, the audience of most of the mobile applications in China that facilitates people's life is sighted persons. Visual elements, as the major factor that affects users' behaviors and experiences while using, were also greatly influenced by the companies to match their own profit consideration. Since the majority of the audience of current mobile apps are people without visual disorders, the using experiences of visual impaired people has been neglected by the company. The marginalization of visual impaired people as customers has caused the outcome of the insufficiency of accessible support in the application.

According to the 43rd "Statistical Report on Internet Development in China" released by China Internet Network Information Center (CNNIC) on August 30, 2019, in Beijing as of 2019, the number of Chinese netizens reached 854 million, and the internet penetration rate reached 61.2%; the number of mobile Internet users in China has reached 847 million [(1)]. Although some existing mobile applications in China provide inclusive functions, the lack of standardized design has led to the aggravation of difficulty of visual impaired people to learn and use different apps which carry different essential functions in daily life, for instance, *Alipay* to trade and *Wechat* to communicate. Hence, a design standard for accessible interaction functions is necessary and pressing.

According to WHO, vision function is classified in four levels as follows: normal vision - no visual impairment, moderate vision impairment, severe vision impairment and blindness.

Moderate vision impairment combined with severe vision impairment are grouped under the term “low vision”: low vision taken together with blindness represents all vision impairment. About 15 % of people who are having vision loss cannot see anything at all. The remaining 85-90 % may have residual vision or other types of low vision and may have difficulties with color, light, form or movement perception (2).

Nowadays, at least 2.2 billion people worldwide has either a near or distance vision impairment, however, nearly half of these cases have been prevented or yet to be addressed (2). According to a recent demographic statistic, there are 17 million people who have visual impairment in China. Moreover, WHO indicates that the majority of people who have vision impairments or blindness are aged 50 or older (2). Which further manifest the fact that this group of people might be unfamiliar with the electronic devices comparing with the younger population. Thus, it is essential for mobile app companies and designers to help this vulnerable group and build a customary design standard among accessible mobile applications.

Visual Impairments:

2.1 Total Blindness and Legal Blindness

In order to create an interactive software interface for visually impaired people, it is necessary to understand their physical conditions at the very beginning. There are two major classifications of visual impairment: total blindness and legal blindness [(3)]. For those who have only partial sight loss, they are medically defined as legal blindness. People with legal blindness may suffer from these two types of vision lost:

- Visual acuity of 20/200 or less in the eye you can see out of best (while wearing corrective glasses or contacts)
- A visual field of no more than 20 degrees [(4)]

2.2 Color Blindness

In addition to vision lost, there are also another two representative types of vision disorders, which are called:

- Achromatopsia, which is also named as color blindness
- Anomalous trichromatism, which is also named as color weakness

People with color blindness cannot distinguish the differences between colors; and people with color weakness are those who possess defective color vision.

Purpose of the Study:

3.1 Purpose of the Study

This research aims to create a standard of interface design within a mobile interaction application which could enhance the using experience of visually impaired people and help them better learn and use mobile apps in daily life. This study will be conducted based on other existing research that have been studied in the field of mobile application interface design for visually impaired people.

3.1 Directions of Design

In order to build an interface design that services for the demand of end-users who have legal blindness, there are mainly three aspects that need to be considered: color, interactive button layout, and text size. On the other hand, for end-users who have total blindness, the study will be primarily focusing on the interactive button layout and the supportive sound assistance.

Comprehensively, in this article, three major aspects of an interactive mobile application interface design for visually impaired people will be discussed: 1) color, 2) layout and 3) voice-guidance.

Color within an interactive application for visually impaired people:

4.1 Rules of Color Using

Among all populations of people with visual impairment, only a small percentage of them are classified as total blindness. Hence, visual design is still an inescapable topic for designers. Among all the other people with visual impairments who are not defined as total blindness, color blindness is the most especial group that requires designers to give special considerations during a mobile application interface designing progress.

Only an extremely small rate of people has Monochromacy, which means they could only see in greyscale. In fact, most of people who have color blindness feel difficult in distinguishing differences between shades and brightness levels of similar colors, *figure 1* [(5)] demonstrate the differences between regular people (top left), people with monochromacy (top right), people with protanomaly (bottom left), and deuteranomaly (bottom right) [(5)].

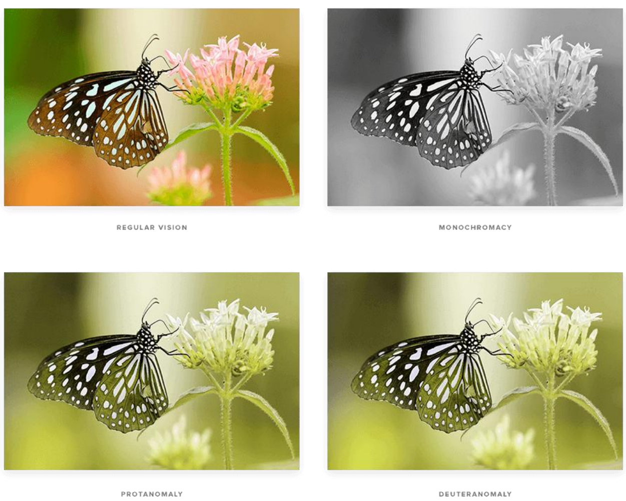

figure 1

Thus, the color chosen of the interactive surface requires avoiding of the colors that could be easily-confused and cause low recognition of colors and text to the end-users.

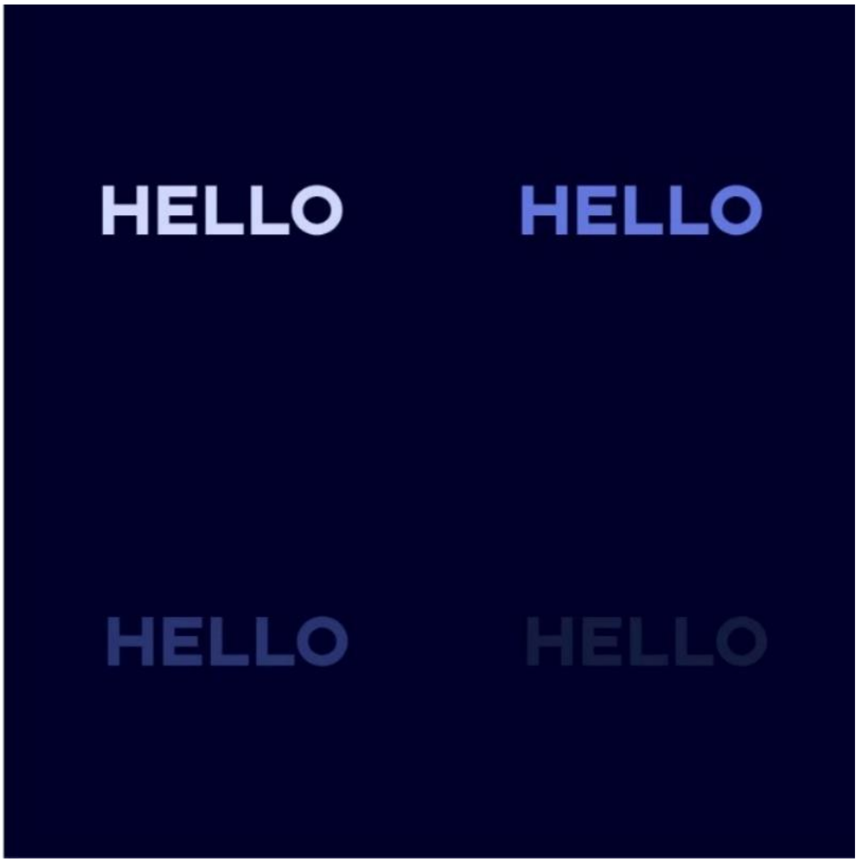

figure 2

Innes [5] has given 6 suggestions on the rules of color arrangement for visually impaired people who have difficulties in distinguishing colors or color recognition: 1) using colors that are contrasting, 2) using different shades of colors rather than multiple colors, 3) using color blindness experience tools while designing, 4)choosing color combinations that can be easily distinguished, 5)applying textures into colors, 6)avoiding using color as the indicator on the pages.

4.2 Contrasting Color & Shades of Color

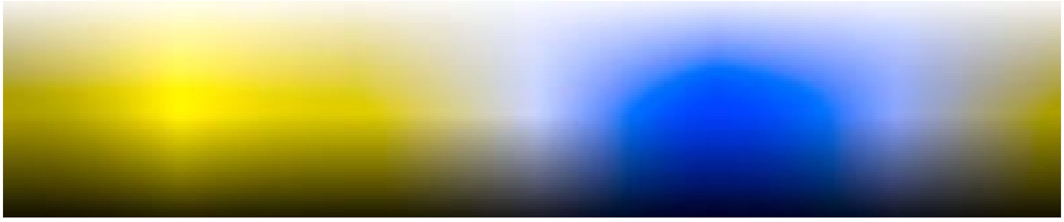

figure 3.1

Even people with complete color blindness can distinguish the contrast between light color and dark color. *Figure 2* is a demonstration of how color contrast could influence the readability and recognition of text. Although people with color vision impairment have alower degree of recognition of hue than normal people, they have a better understanding of color sensitive to differences in color saturation and lightness [(6)].

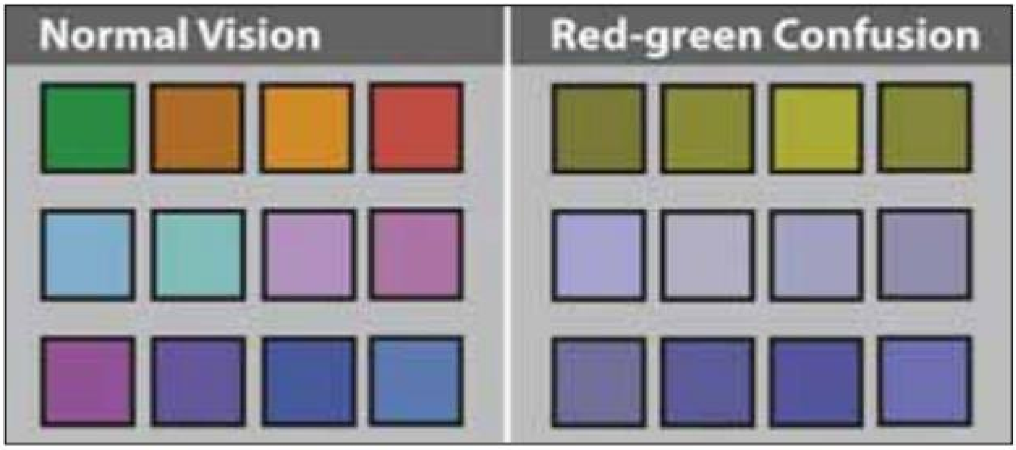

figure 3.2[(7)]

Thus, one of the essential notices which designers should be aware of is, in order to enhance the recognition of text on different backgrounds, bright and dark color contrast is necessary. *Figure 3.1* demonstrates the chromatography of the vision of people with color blindness, and *Figure 3.2* shows colors as they appear to readers with normal vision and to those with red-green vision impairment [(7)]. Blue and yellow are the most significant colors that people with color blindness could easily recognize and distinguish.

figure 4.2

People with color blindness

figure 4.1

People with regular eye sight

figure 4.3

An example of an interactive application in China

Zhu [8] suggested that the interface and functionality of partitioning cannot be completely dependent on color, the purpose is to improve the readability and recognition of information; reducing the colors that exist in the same interface is also helpful in making the interface clear. Hence, another essential element which designer should pay attention to is using different shades of colors, avoiding to make multiple colors as interactive navigation. Among many existing mobile applications in China (*figure 4.3*), colors are designed to be the major navigation of accuracy in interactive actions such as filling in answer boxes. As it is shown in *figure 4.1* and *4.2*, without other elements, the navigation of green and red has become unreliable for people with color blindness; as a result, end-users will not be able to interact effectively. However, in order to avoid producing unnecessary troubles for end-users with color weakness, remaining enough color contrast at the same time while using different shades of colors is extremely important.

4.3 Textures, Icons & Additional Instructions

figure 5.2

figure 5.1

As it is shown in *figure 4.3*, there is additional instructions underneath the text box, which helps users to distinguish the success field with the error field. In addition to colors, icons or additional instructions as a supportive navigation is another efficient approach. Using assistive icons and textures as additional navigators and indicators can increase the definition of multiple interactive buttons. As it's shown in *figure 5.1*, even for end-users who have color blindness, they can still interact with the applications accurately with the help of additional icons on the side.

Additionally, designers or companies can apply textures to help users to distinguish multiple fields on the interface (*figure 5.2*). However, this method requires a guidance of the implications of different textures during the basic using instructions of a mobile applications. Thus, using textures is usually not the primary solution of an interactive interface design for visually impaired people because it requires more progress than using icons/additional instructions beside the interactive areas.

4.4 Color Emotion

According to a Japanese psychologist, Reihito Harada's [(9)], every single color obtains its own property. In her book, Reihito indicated that there are various attributes of colors, and those diversities of colors brings different emotions and psychological pictures. For instance, colors such as red, yellow and orange are classified as warm color, which is considered as enthusiastic, energetic, dynamic and passionate. Warm colors usually make viewers feel pleased, hot-headed, and inspired. On the other hand, colors that are bluish are classified as cool color. Cool colors usually are clam, peaceful and steady. Thus, different adhibitions of warm and cool colors can bring different emotional association and psychological implies to viewers in different circumstances.

Zhang [(10)] has conducted research on visually impaired people's emotional associations to different colors by gathering volunteers with color blindness and let them choose the most appropriate colors that match the emotions given among multiple choices. After participants have all finished questions, Zhang collected all answers and analyzed to build a color chart that shows the colors that most participants have selected for eight typical emotions (*figure 6*).

In *figure 6*, colors on the left are a view from a person with regular eyesight, and on the right is a view from a person who has color blindness.

figure 6

A study Wang [(11)] made in 2019 was also conducted on the purpose of finding people with color blindness's color selection in an application interface. As a result, the following conclusion has been made: 1) People with color blindness have recognitions of color, but some parts of the recognition differ from people with regular eyesight, 2) people with color blindness prefer blue and yellow-like colors, 3) end-users with color blindness have similarities with normal people in choosing interface colors, 4) people with monochromacy and protanomaly have similar results in choosing interface colors.

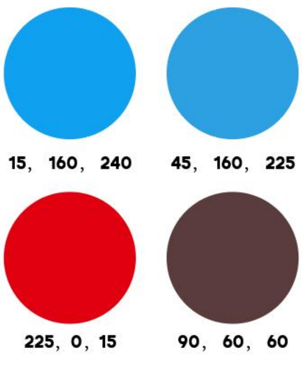

figure 7

Among all colors given in Wang's study, most participants prefer the combination of two shades of blue RGB (15, 160, 240) and (45, 160, 225), almost 0 percent of participants prefer the combination of two red and brown color (225, 0, 15) and (90, 60, 60) (*figure 7*).

4.5 Suggestions of Color Using

Combining the results of Zhang and Wang, both studies have indicated the preference of blue color among people with color blindness, which is similar to the result of Wong's study in 2011, which supports blue could be most easily distinguished by people with color blindness [(12)]. Thus, as a mobile application interface design standard for visually impaired people, one suggestion is that the dominant hue of the interface should be considered using blue, yellow could be the used as the auxiliary color to help users with color blindness to distinguish the content. Moreover, additional icons, instructions and textures can practically enhance the capacity of people with visual impairment to interact with different buttons. However, using multiple textures requires extra instructions before end-users become able to complete interactive tasks independently; thus, using textures would probably be not primarily suggested for inclusive designers.

Interface Layout Design:

In addition to color using, the layout of the interactive buttons on a mobile application interface is also an essential aspect for designers to consider during a mobile application interface design. The permutation and combination of multiple buttons are the major task for inclusive designers to learn and investigate. In this circumstance, people with color blindness usually are not reported to have major challenge except for distinguishing colors on an interface. Hence, the primary target group that requires specialized interface layout design is for end-users who have vision lost.

Li and Zou [(13)]'s study was conducted on the purpose of testing the accuracy and efficiency of people with visual impairment using existing mobile interactive applications in China and the accuracy of clicking on the interactive buttons within two common layout designs in China.

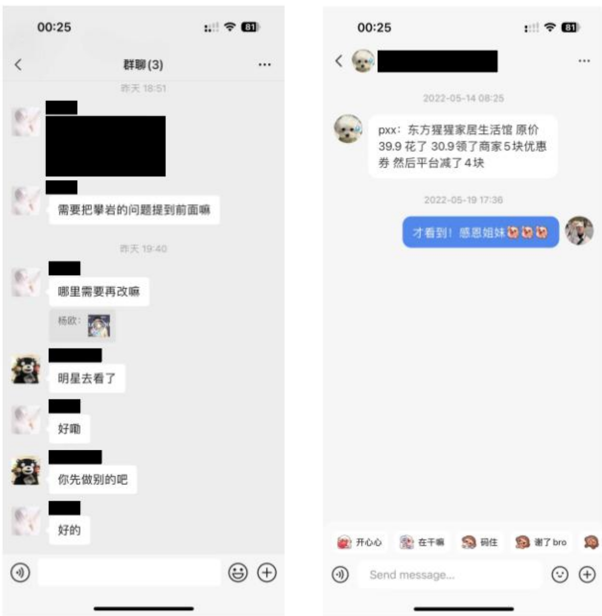

figure 8.1

Screenshots from two popular social media in China, Wechat (the left), RED (the right) on iPhone

5.1 Users with Vision Lost's Accuracy of Interactive Points with Different Applications

In the first part of Li and Zou's study, they have asked 6 observed groups of volunteers with visual impairment to use several existing mobile applications in China. The participants were divided based on their visual lost levels and their personal experiences of using multiple kinds of mobile applications. After the first part of the study, Li and Zou have conducted a conclusion that all participants have positive performance while the researcher asked them to click on basic exiting interactive point and slide-up closing action among different apps; even for those who have 100% vision lost and no using experiences of any kinds of mobile apps, they had a relatively high accuracy completing the two basic instructions.

However, the participants have negative results when clicking on specialized and other individual interaction functions among different apps, the accuracy and efficiencies among all 6 groups of participants were dramatically reduced.

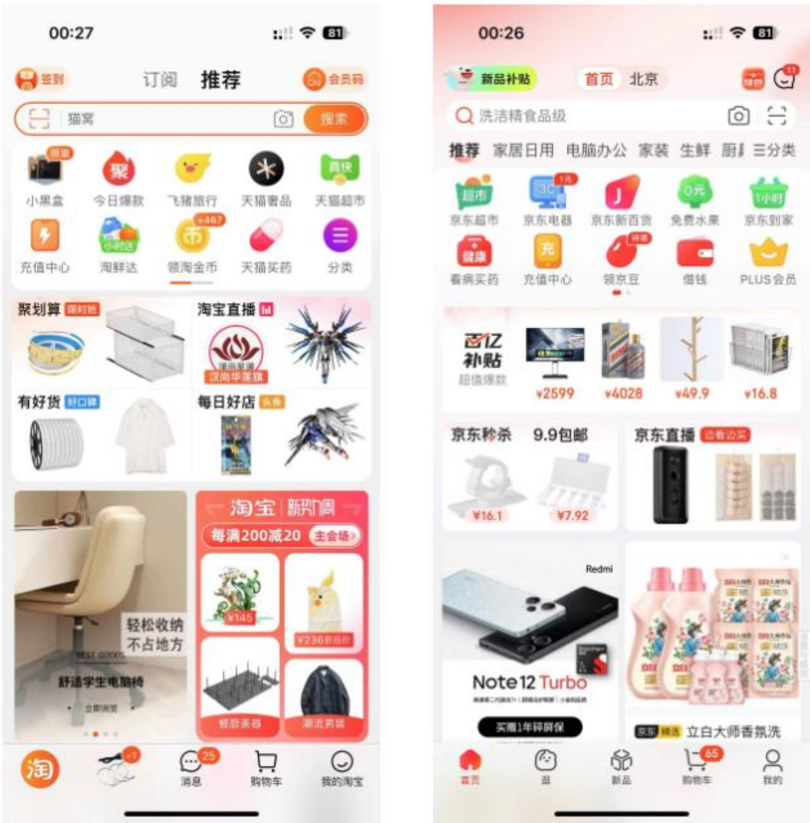

figure 8.2

Screenshots from two popular online shopping apps in China, Taobao (the left), JD (the right) on iPhone

In *figure 8.1 & 8.2*, it is not hard to find out that the layout of basic functions is relatively similar between two different mobile apps, as long as these two interfaces are designed to run a same function. For instance, in *figure 8.1*, both of the interface in the screenshots are chat windows with others; hence, these two interfaces are quite similar in interactive points layout: typing bubbles at the bottom, “back” button at the top left corner, and “more” button on the top right corner. On the contrast, in *figure 8.2*, both of the screenshots are interfaces of online shopping applications; the major layout is also relatively similar, however, in *figure 8.3* the chatting interactive points are designed to have a completely different layout. In Taobao (the left in *figure 8.3*), the chatting button is at the bottom; and in JD, differently, the chatting button is at the top right corner.

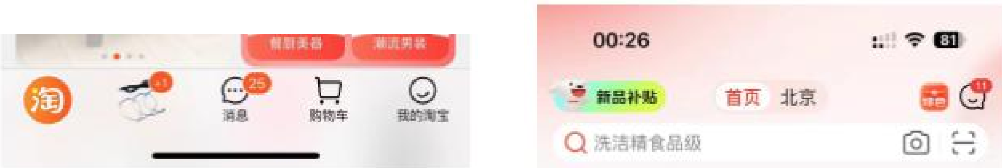

figure 8.3

Screenshots of the chatting function from two popular online shopping apps in China, Taobao (the left), JD (the right) on iPhone

This imperceptible change could tremendously influence the accuracy and efficiency of visual impaired people to accomplish the interaction when their purpose is to chat with the customer services when shopping online. In order to ensure a good user experience, it is important that all applications use the same type of controls for users with visual impairments to interact. Layout of interactive buttons should be similar among different applications [(14)].

As the report of Li and Zou's study claimed, interactive points such as the "back" button and the chatting bubbles that are standardized and unified among multiple applications could help end-users with visual impairment could reduce the time visual impaired people spent on learning the interactive actions; interactive points that have not been unified such as the chatting button on Taobao and JD would significantly increase the difficulty of end-users with vision lost to finish interacting. Thus, in order to make a standardized mobile application interface design, it is necessary for designers to unify the applications with existing applications to reduce the difficulties of visually impaired people to use; avoiding an overly unique layout that has an entirely different interface design with all existing applications in the market.

5.2 Accuracy on Different Arrangements of the Interface

Erroneous sequencing	All-blind with experience				Low-vision with experience				All-blind with no experience				Low-vision without experience			
	Column 1	Column 2	Column 3	Column 4	Column 1	Column 2	Column 3	Column 4	Column 1	Column 2	Column 3	Column 4	Column 1	Column 2	Column 3	Column 4
Row 1	1	2	2	1	1	2	2	1	2	3	3	1	1	2	2	1
Row 2	2	4	4	2	2	4	4	2	2	4	5	2	3	5	4	2
Row 3	2	5	5	3	2	5	5	3	3	5	5	3	2	5	5	3
Row 4	2	5	5	3	2	5	5	3	2	5	5	3	2	5	5	3
Row 5	2	4	5	3	2	4	5	3	3	4	4	4	2	4	4	5
Row 6	1	2	3	3	1	3	3	2	1	2	3	4	1	2	3	3

Table 1

Participants' Accuracy on 6*4 arrangement

Erroneous sequencing	All-blind with experience			Low-vision with experience			All-blind with no experience			Low-vision without experience		
	Column 1	Column 2	Column 3	Column 1	Column 2	Column 3	Column 1	Column 2	Column 3	Column 1	Column 2	Column 3
Row1	1	2	1	1	2	1	2	2	1	2	2	1
Row 2	2	5	2	2	5	2	2	5	3	2	5	2
Row 3	2	4	3	2	4	3	3	5	4	2	4	3
Row 4	1	1	3	1	1	2	1	2	3	1	2	2

Table 2

Participants' Accuracy on 4*3 arrangement

Among all existing mobile applications in China, there are two most common arrangements of interactive points, 4 rows*3 columns and 6 rows*4 columns [(13)]. Li and Zou also conducted an experiment to test the accuracy and efficiency of people with vision lost to interact with all interactive points on these two arrangements.

Table 1 and 2 show the results of 4 observation groups' performance on two different arrangements of an interface. As a result, the interactive points that are arranged at the four corners of an interface took the participants least amount of time to confirm but the longest to locate; interactive points located in the middle of a page took participants shortest amount of time to locate and confirm. However, the accuracy of clicking on instructed interactive points is the highest when the interactive points are located on the corners and edges [(13)]. And overall, participants have better performance on the accuracy and efficiency while accomplishing different interaction tasks on a 4*3 arrangement of interactive points on an interface [(15)].

5.3 Layout Suggestions of Multiple Interactive Points

To avoid the augment of the challenge of users with vision lost, less complexity of the general arrangement of all interactive points on single interface is strongly recommended. Interactive points could be set at the corners of the page or along the edges of a screen to help end-users with vision lost to better locate the interactive buttons. Moreover, interactive buttons should be arranged at similar position on an interface with other buttons that carry the same functions within mobile applications that are already being popularly used in the market, this method would reduce the cost for users with vision-lost to learn using a new mobile application.

Accessible Voice Guidance

For end-users who have 100% vision lost, accessible voice assistant is the most efficient method to have access to simple information by using smartphones. There are some successful mobile apps that have been invented and successfully applied into the market for blind people and low vision people to have easier using experience with mobile phones.

figure 9

Screenshots of a food delivery app which has accessible voice control function (in the red box)

There are plenty of apps that are designed or installed accessible functions; among these apps, there are two major functions that distinguished them: voice control and screen reader. Screen readers app such as VoiceOver for iOS users and TalkBack for Android users are not put into widespread use in China; instead, many applications that are frequently used in daily life have developed voice control for blind people and low-vision people to use (*figure 9*).

However, to turn on this function, end-users need to finish several interactive tasks to find the icon of accessible mode: tap on the “Mine” button at the bottom right corner (shown in green box) and scroll down to find the accessible function (shown in the red box) among plenty of interactive buttons. Without others’ assistance, or additional accessible guidance, “finding the icon and turn it on” could also become a challengeable mission for end-users with visual impairments.

Hence, as a mobile application interface that is conducted to help all people with visual impairment, voice controlling function and screen reading function could both be considered being installed in the app to maximize the convenience that the app could bring to end-users with visual impairment.

Surveys on User Experiences

6.1 End-Users' Perceptions/Frequencies on using Mobile Apps

The literature shows that there is very little research on the using experiences of mobile applications, or 'apps', by people with visual impairments. For this reason, Nora Griffin-Shirley et al. have conducted research by developing online surveys for 259 participants with blindness or low-vision to explore their current use of mobile devices and apps as well as their perceptions of the apps (16). The results of the experiment include the following aspects: using frequencies among different types of mobile applications (i.e., e-mail, tools for visual impairment, social networking etc.), perceptions of the overall usability and accessibility of user-friendly apps and specialized apps for visual impairment, as well as the perceptions of overall accessibility between iOS and Android systems. Results are analyzed by age, visual functions, annual income and device types.

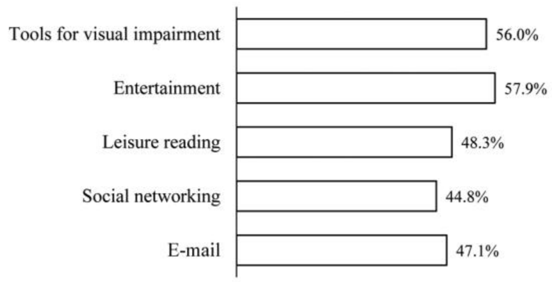

figure 10(16)

Top 5 most frequently used Apps

As it is shown in *Figure 10* (16), among all participants, there are five specific types of mobile applications that are being most frequently used by visual impaired people: tools for visual impairment, entertainment, leisure reading, social networking and email. The result of the high using frequency of e-mail, social networking, and entertainment apps demonstrates the similarity of using demands with regular sighted users as Aaron Smith [(17)] studied in 2015. This has implied that visual impaired people also need using mobile phones to reach their daily demands and they could be more independent and convenient with the help of mobile apps that are designed for visual support, especially for users who have blindness or low-vision, compared with other visual impaired users.

6.2 Existing Mobile Applications Designed for Visual Impaired People

As it was studied by Nora Griffin-Shirley et al., special mobile apps that are designed for visually impaired people could greatly improve their experiences of achieving daily activities. There a re also plenty of producers and designers have proposed different mobile applications to reach different daily demands of visually impaired people. Most of these applications support both Android and iOS systems.

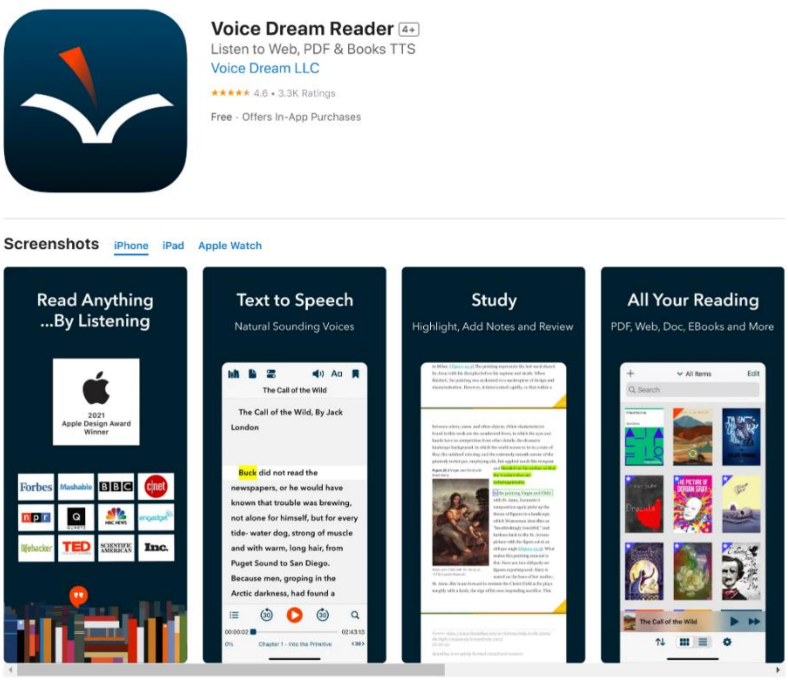

figure 11.1

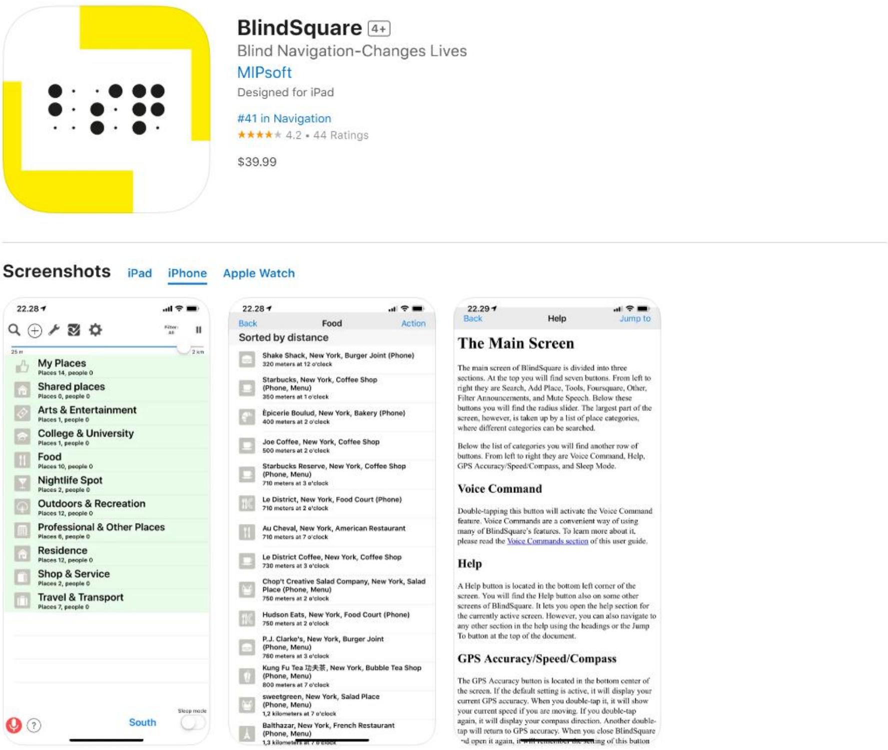

figure 11.2

There are roughly two categories of mobile apps being used in the market: navigator and accessible readers. *Figure 11.1* and *Figure 11.2* are two examples of special mobile apps that are designed for visually impaired people on iOS, Voice Dream Reader [(18)] and BlindSquare [(19)]. Voice Dream Reader is a text reader that support users to easily read and listen to multiple formats of text. BlindSquare is a mobile application that combines your phone's compass and GPS with FourSquare [(20)] data to explain what's going on around you and provide navigation.

Both of these two applications are designed to be concise and clear. However, comparing to Voice Dream Reader, the layout of text and interactive buttons on BlindSquare is much more compact and intensive, which might increase the difficulty of end-users with vision lost to distinguish and finish interactive actions while using the app.

Example of a Mobile Application Interface Design

7.1 Overall Review

Summarizing the studies that former researcher had made, as the three major aspects that this article has discussed, a testing version of a standardized mobile application interface could be developed.

hue: the dominant hue of the app will be blue RGB (15, 160, 240) and yellow RGB (235, 219, 95), as it's shown in *figure 10*.

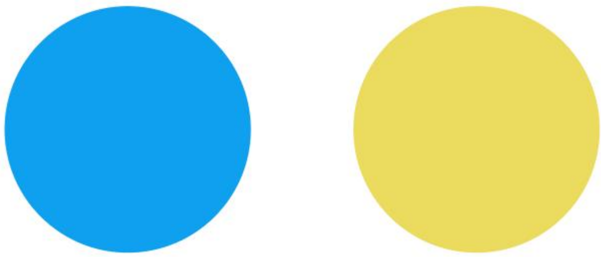

figure 10

These are the two colors that were discussed in Zhang [10] and Wang [11]'s studies, blue (15, 160, 240) was selected as the most preferred color by volunteers with visual impairments (*figure 7*) and yellow (235, 219, 95) is a complementary color of the blue.

7.2 Font

figure 11

As a mobile application designed for visually impaired people, text need to be perspicuous and easy to distinguish (*figure 11*).

7.2 Logo & Icons

figure 12

Using simple language as the name of the app helps all age ranges of people with visual impairments to understand the meaning and recognize the logo (*figure 12*).

icons*: figure 13.1 & 13.2*

figure 13.1

figure 13.3

Display of iSEE's start page

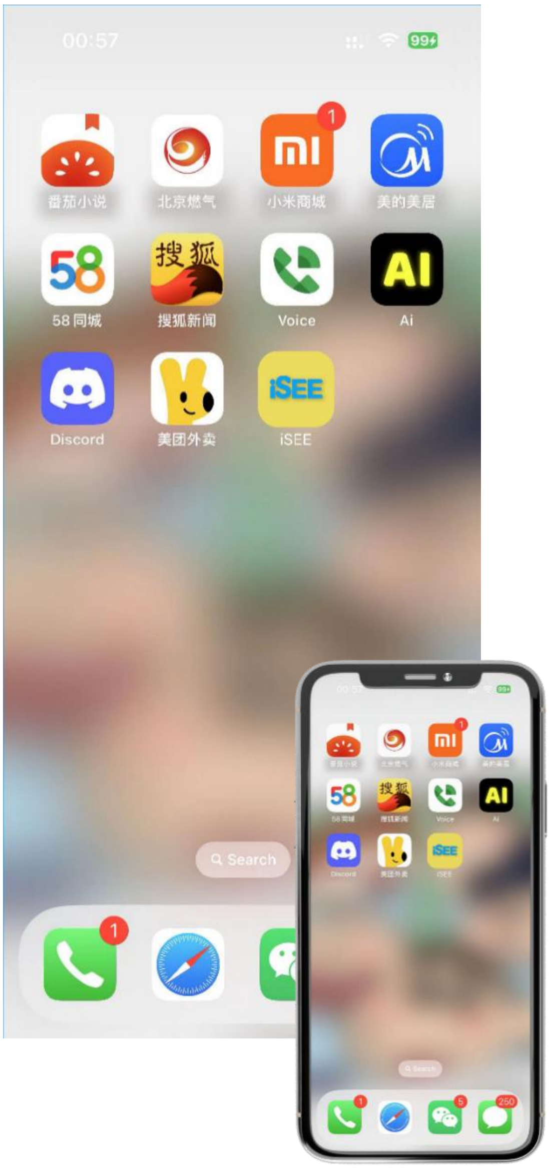

figure 13.2

Display of iSEE on the homepage of iPhone

7.3 Customized Services

In order to distinguish the users' groups, iSEE stared interaction missions as soon as users open the app; however, instead of instructing end-users to accomplish complicated missions, this interaction is conducted to help the app to provide two sets of different services according to the results of the interaction. For users who are not total blindness, they will be able to see the instruction of the interaction and be able to finish it, hence the app will run regularly. On the contrast, for users who have 100% vision lost, they will not be able to see the instruction, thus, as they randomly click on the bottom part of the interface, the app will automatically switch to blind mode (*Figure 14.1 & 14. 2*).

figure 14.1

Regular mode of iSEE

figure 14.2

Blind mode of iSEE

Under regular mode, the basic functions are listed by a 3*2 format, and all interactive points are located along the borders of the phone; hence, end-users with visual impairment do not require over amount of time to learn to use and interact with each button. Moreover, other basic functions such as "Chat Boxes" and "My Info" are represented by icons that could be easily understand and located in similar places in which other apps usually locate their buttons with the same functions; thus, the time cost on learning to use this app is further reduced. Also, users can choose to turn on Voice assistant as assistive screen reader or manually turn on voice control.

On the contrast, when users failed to interacted successfully with the instruction listed on the start page, the app will automatically switch to blind mode. Under blind mode, the screen reader will be activated automatically as well. The only interaction action which users could make is turning up or turning down the volume by simply slide side to side at the bottom of the screen. Moreover, users who accidentally turn on blind mode could easily go back to the start page by clicking on the arrow at the top left corner as most of other mobile applications do.

Conclusion

8.1 Conclusion

ISEE currently is designed to have four major functions: map to navigate, friends to chat with others, payment to trade, and the last but not least, shopping to order food delivery or go online shopping. These are the major four activities that being most frequently applied in China. ISEE, in fact, is an intermediate platform for end-users who are visually impaired to get direct access to all other apps invented by companies that provide such services.

Also, iSEE is designed to be a mobile application that demonstrate the comprehensive results of many research that have been accomplished all around the world in this field. It is an opportunity for visually impaired people who have been marginalized in the market for a long period of time to be noticed by companies and designers. iSEE could not be successful without the technical supports by others; more importantly, iSEE will not be successful without the society's support to the whole population of visually impaired people.

8.2 Limitations & Next Steps

This study has several notable limitations. This study does not involve participants during the entire process, which means this study is lack of testing feedback from end-users with visual impairments. Thus, a test run of the mobile app is necessary in the future for the researcher to collect feedback and make improvement. In addition, all data used in this study are collected from existing literatures in this topic. Literature reviews are subject to bias introduced by the researcher, who may selectively choose studies to include or exclude based on their own biases or preferences. Also, the limitation of existing study in this topic that has been made in China can limit the reliability and validity of the findings. Moreover, the data used in this research might lack of effectiveness according to the date which references in this study was conducted and finished. Thus, iSEE can only provide suggestions and examples of a standardized mobile application interface design for companies and designers.

Additionally, in order to successfully put the application in use, social support and technical supports such as gather testing volunteers and interactive functions between iSEE and other applications are required.

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