The accessibility and usage of smartphones by Arab-speaking visually impaired people

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Abstract

Purpose – This paper aims to investigate accessibility and usage of mobile smartphones by Arabic-speaking visually impaired people in Saudi Arabia.

Design/methodology/approach – In total, 104 participants with visual impairments were interviewed about their use of mobile phones with the following questions: What is the most commonly used mobile phone? What is the popular domain for which they use mobile phones? What are their favorite applications? What accessibility challenges do they usually face while using mobile phones? How often do they use the Internet via mobile phones and what are the reasons behind that?

Findings – This research is the first study with such magnitude to investigate smartphone usage by Arabic-speaking visually impaired people. The survey has revealed that Arabic-speaking visually impaired people utilize mobile phones in different ways and strategies. Getting assistance in performing daily tasks and navigating independently are two of the most common uses for mobile phones.

Originality/value – Based on the findings, the authors are going to propose some guidelines to developers to improve smartphone accessibility, application design and Internet usage to improve accessibility for visually impaired people.

Keywords Blind, Visually impaired, Internet usage, Smartphones, Mobile applications, Mobiles

Paper type Case study

Introduction

Visual impairment, like other impairments, impacts the life of individuals and can be a hindrance in completing and accomplishing daily activities. Blind people face many challenges when doing simple activities such as moving around safely, dealing with money, dealing with technology and even gaining knowledge. Such challenges restrain and restrict the flow of their lives.

Roughly, 10 per cent of the world's population is visually impaired (Pascolini and Mariotti, 2012). Choosing the visually impaired community to be the object of this research promotes an ethical and humanitarian vision. Considering the fact that this community is growing makes this choice a significant factor in helping Arabic-speaking communities to overcome technical barriers.

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Nowadays, smartphones can largely contribute and make a huge difference in visually impaired people's lives and in their integration into the world. However, visually impaired people still cannot fully benefit from the services smartphones provide. Visually impaired people face many difficulties in using smartphones easily; for instance, it is difficult to control the device or even understand its operating system. Moreover, with the advancement in the services provided by smartphones, benefiting from such services is becoming confusing and more difficult even for the average user (Verstockt and Hoecke, 2009).

Assessing the answers of 104 participants, our research paper aims to investigate the uses of smartphones by Arabic-speaking visually impaired users. It also tries to understand the existing challenges such individuals face and how they adapt to them. This will help us enhance the accessibility of smartphones for visually impaired people in general and for Arabic-speaking visually impaired people in particular. Therefore, the paper is organized as follows: Section 2 presents the motivation behind conducting this research, along with our research questions. Section 3 defines blindness and looks at the interaction between blinds and smartphones. Section 4 discusses some related work in this field. Section 5 presents our research methodology, considering participants, procedure and analysis. Finally, Section 6 discusses our survey results and concludes the paper with remarks about future study.

Purpose and motivation

It is known that a blind person has certain needs that must be met and fulfilled for him or her to live a normal life. Failing to fulfill such needs can bring an undesirable effect on the life of a visually impaired person. Nevertheless, smartphones can contribute significantly in giving visually impaired people independence; however, the devices still carry challenges of their own (Irvine *et al.*, 2014).

Interacting with smartphones likely requires only a look and few clicks from a sighted person. However, this is not the case for visually impaired people. For a visually impaired person to use a smartphone, (s)he needs the help of certain assistive technologies.

For such challenges that visually impaired people face while using smartphones, our intention in this research is to investigate the most common applications visually impaired people use and what applications are helpful to overcome some of these challenges. Our focus will be on Arabic-speaking visually impaired people in Saudi Arabia; with the increasing use of smartphones in the Arab world, developers need to investigate difficulties in accessing the Arabic displays of smartphones for users with visual impairment; this is especially true as when assistive technologies began spreading in the early 2000s, they were universally designed to be accessible in English more than in any other languages.

As an attempt to find how visually impaired people benefit from their smartphones, we designed a questionnaire and distributed it to a number of visually impaired people (males and females). The questionnaire covered different research questions, which are:

RQ1. What smartphone models are the most commonly used among visually impaired people?

RQ2. What are the most commonly used applications and what are their challenges?

RQ3. What are the accessibility challenges visually impaired people face while using smartphones?

RQ4. Finally, how frequently do visually impaired people use the Internet via their smartphones in comparison to desktop computers and what are the reasons behind that?

Visual impairments and mobile phones

Blindness refers to impairment or disability in a person's vision that, even with correction, affects the person's performance. It is defined as a person's loss of vision that would result in the need for outer assistance due to limitation of visual capability. This impairment might be the consequence of disease, trauma or congenital or degenerative conditions that cannot be corrected by any means of refraction, medication or surgery (Arditi and Rosenthal, 1998). Vision impairment has four classifications:

(1) *Low vision*: According to World Health Organization (WHO) (consultation, n.d.), a person with low vision is:"one who has impairment of visual functioning even after treatment, and/or standard refractive correction, and has a visual acuity of less than 6/18 to light perception or a visual field of less than 10° from the point of fixation, but who uses, or is potentially able to use, vision for the planning and/or execution of a task".

(2) *Partially sighted*: People who have some type of visual problems.

(3) *Legally blind*: People whose visions do not exceed 20/200 in the better eye even with correction lenses.

(4) *Totally blind*: Totally blind people are those who have lost sight completely.

Visually impaired people form a significant section in society that cannot be neglected (Pascolini and Mariotti, 2012). When mobile phones started invading the market, they were easy for blind people to use. All a blind person must do is memorize the layout of the phone's keypad, especially the location of the "send" and "cancel" keys. By this, a blind person can use most of the phone's functionality with no ability to see the display (Smith and Chaparro, 2015). However, as mobile phones became more advanced, they became more difficult for blind people to use. So, manufacturers started using speech synthesis systems, which read the content of the phone book and check the phone status with some limitation.

When mobile phones started to run operating systems (services for computer programs), a necessity to develop a screen reader that could be used on the mobile phone arose (Rodrigues *et al.*, 2015). Screen readers at the beginning were not fully practical on mobile phones; they were mostly used on computers.

With the appearance of touch screens, the gap between blind and sighted people in using mobile phones has widened. The keyboard has a major role in the ease of use of mobile phones by blind people. Thus, with the keyboards vanishing, it became increasingly difficult for such individuals to enter information and interact with their phones even with a screen reader.

Screen readers' manufacturers started to provide solutions for the use of touch screens. One solution was to disable the actual touch screen and divide it into four equal parts, as virtual buttons with a particular function assigned to each part. A plastic sheet with holes was another way to divide the screen; after laying this sheet on the phone,

virtual screen areas were created responding to the regular numeric phone pad, which was especially useful with phones that did not have an actual keyboard. A different solution was the on-screen keyboard functionality. By using this solution, when a blind person touches an area of the screen, the key being touched is announced rather than activated. The key will be activated only when the user releases the screen; in other words, a blind person needs to keep his/her fingers on the screen and move around until he finds the desired key and then releases the screen to activate that key (Kane *et al.*, 2009).

Although there were many attempts from screen readers' manufacturers to get closer to the latest developments in mobile phones and provide the best possible solutions, the major problem has not yet been solved. Using a screen reader on a graphical interface, i.e. "big icon with accessibility features", would have more results with blind people rather than using it on a touch screen.

Related work to mobile accessibility for the visually impaired

In this paper, we have looked at previous related research on mobile phone accessibility and its use by people with disabilities. Some previous work has investigated the issues that visually impaired people usually face when using mobile devices. Leonard *et al.* (2005) explored the interaction of visually impaired old people with handheld computers by asking two groups of participants (sighted and blind) to search for a playing card among other distracters and drag it into a new destination with an auditory feedback on any successful drop. From their outcomes, they found that blind individuals can interact with graphic user interfaces effectively when accompanied by a low-cost, easily implemented design intervention. Plos and Buisine (2006) tried to meet the needs of visually impaired, hearing impaired and elderly people by using a user-centered design to create adaptable mock-ups in terms of usability and design style. They came out with a set of recommendations that can be used on mobile devices.

Other works concentrated on the usage of mobile phones by visually impaired people. In Kane *et al.* (2008), ten participants were asked to compare the use of the Slide Rule, an auditory interaction technique, to the use of a button-based pocket PC screen reader, which was slower than the former. They found out that using Slide Rule can improve the touch screen accessibility. Dawe (2007), on the other hand, conducted semi-structure interviews to find out that a simplified navigation menu is one of the common requirements for people with disabilities. In Wentz *et al.* (2015), 129 visually impaired people participated in a Web-based survey to investigate the challenges blind people face when using screen readers for email applications. This survey shed light on the usability problems blind people face when using common email applications and opened doors to designers to improve usability. Likewise, Leporini *et al.* (2012) interviewed 55 blind individuals to analyze the accessibility and usability of Apple touch screen devices for such individuals. In their results, the participants stated that "voice-over" in Apple devices can be of great help to blind people, but that there are still some issues that need to be considered. Therefore, three possible solutions were offered in the paper: to have the punctuation marks on the letter keyboard instead of changing to the virtual symbol keyboard, to add extra reference gestures like a button that has the function of the "tab" and "command" key and to add references to the most common functions at specific points like in the corners or at the edges.

In Azenkot and Lee (2013), speech was explored as an input modality; the survey was carried out on blind and sighted people to examine how often they use speech for input in their mobile phones, as well as why and for what purpose. The results showed that blind individuals use speech more often, especially for long messages, and on this basis, a follow-up study with eight blind individuals was conducted to compare their use of speech to "voice-over" with an on-screen keyboard. Speech led to the participants having more satisfaction despite the frustration due to editing recognition errors.

Some work also discusses the requirements and design of mobile phones. In Miura *et al.* (2013), visually impaired participants were given a questionnaire to find out about the challenges they face and functions they need when using mobile phones with touch screens. This paper showed that most blind individuals want to use mobile phones with touch screens, and if they have one, they use it with the help of screen readers. In Kane *et al.* (2009), the researchers interviewed 20 disabled people to find out about their use, select and adapt to mobile phones in their daily lives. In total, 19 participants provided a one-week diary on using mobile devices; the results showed that people with impairments can adapt to inaccessible mobile phones to help complete their daily tasks.

We can notice from the presented previous work that most studies used surveys or interviews to assess blind people's barriers and requirements via mobile accessibility. Also, none of the previous work investigated the interaction of Arabic-speaking visually impaired users with mobile phones, which will be the focus of our research. In this paper, we provide some suggestion to improve smartphone accessibility, application design and Internet usage for Arabic-speaking visually impaired smartphone users.

Method

This paper focuses on investigating the usage of smartphones by Arabic-speaking visually impaired people in Saudi Arabia using quantitative research methodology.

We used a questionnaire with multiple-choice questions and open questions so that visually impaired people can add their comments and suggestions. The questionnaire was written in Arabic and its questions fall into three main categories: mobile devices usage, accessibility issues and Internet browsing via mobile phones. The mobile device usage questions included: the kind of mobile devices they use and how these devices are used in outdoor activities and why they use these devices. The accessibility issues questions assess whether there are any accessibility problems or challenges they face when using mobile devices. Finally, Internet browsing questions focus on how they surf the Internet via their mobiles. The content of the questionnaire is explained in detail in the Appendix.

The initial list of mobile applications in the questionnaire was chosen from Apptrack Web site where it showed the most popular applications downloaded in the Saudi market as of November 11, 2013. We also have added other applications that visually impaired participants provided during discussion prior to this questionnaire.

To ensure our questionnaire's accessibility and appropriateness for Arabic-speaking visually impaired people, we initially worked with three visually impaired people (two male and one female) to test the questionnaire and get their feedback to enhance its design.

In our first draft of the questionnaire, mobile applications relevant to Arabic-speaking visually impaired people were not included; however, with the help of the three visually impaired people, we have added such applications to the final version of the

questionnaire. The three visually impaired people 's feedback and input helped in making the questionnaire more comprehensive as well as accessible.

As for the participants in this research, they were reached through email, online announcements posted on social networks such as Twitter and meetings that took place at academic institutes and local visually impaired people organizations.

Participants' demographics

In total, 104 visually impaired people with an average age ranges between 19 and 25 years old, most with a high education degree, answered the questionnaire. In total, 55 per cent of them were partially blind and the rest were totally blind. Some of the participants were reached via different organizations: (31/104; 29.8 per cent) from universities, (8/104; 7.6 per cent) from visually impaired people organizations, while the rest (65/104; 62.6 per cent) were reached via the Twitter social network.

For visually impaired people located at universities and visually impaired people organizations, the questions were read to them by a sighted person and the answers were written down. As for the online questionnaire, participants used their mobile phones equipped with screen reader software to read and answer the questions.

Most participants, 63 per cent, were at an average age range between 19 to 25 years old, with 41 per cent being male and 58 per cent being female. There were only a few participants younger than 18 (8 per cent), and there were no participants over 39 (Table I).

In total, 70 participants held bachelor's degrees, representing 67 per cent of the total participants; meanwhile, 21 per cent had a high school certificate. Less than 3 per cent had reached the level of either a master's degree, a diploma or intermediate and primary education (Table II). In terms of employment, 78 per cent of the participants were unemployed.

Table I. Approximate ages of responses

Age range	No. of responses with percentage (%)
30-39	9 (8)
30-26	20 (19)
19-25	66 (63)
Younger than 18	9 (8)

Table II. Educational levels of responses

Education levels	No. of responses with percentage (%)
Primary	1 (0.9)
Intermediate	4 (3)
Secondary	22 (21)
Diploma	4 (3)
Bachelor's	70 (67)
Master's	3 (2)

Results

Mobile device (choosing and using)

This part of the questionnaire asks the participants about the smartphones they prefer to carry and use, bearing in mind that more than one answer is accepted. By analyzing the frequent places where visually impaired people use their smart phones (Table III), we found that 78 per cent of the participants reported that they often use their smartphones everywhere in their daily lives. On the other hand, three participants (2 per cent) reported that they rarely use their smartphones in their daily lives. This is due to the incompatibility of the screen readers with many Arabic applications and to the unsynchronized response of screen readers with the mobile phone.

Regarding smartphones brands (where more than one brand can be chosen), the majority of the participants (82 per cent) have iPhones. Nokia was second with 36 participants (34 per cent), while Samsung came in third with 9 per cent of participants. Sony Ericsson, BlackBerry and HTC received 1 per cent each. None of the participants own Motorola or LG (Table IV).

According to the questionnaire, 91 per cent of the participants prefer phones with a touch screen, while 83 per cent prefer using an Arabic interface (Table V).

The last question in this part was about the different domains for which visually impaired people use their smartphones (notice that more than one choice was allowed). The top three domains are texting (used by 91 per cent of the participants), Web browsing comes second, as 87 per cent of the participants use their phones to access

Table III.
Frequent places for using smartphones

Places	No. of responses with percentage (%)
Everywhere	82 (78)
At home	41 (39)
While traveling	25 (24)
At university	22 (21)
At restaurants	19 (18)
In malls	18 (17)
Almost nowhere	3 (2)

Table IV.
Brands of smartphones

Brand name	No. of responses with percentage (%)
iPhone	86 (82)
Nokia	36 (34)
Samsung	10 (9)
HTC	1 (0.9)
BlackBerry	1 (0.9)
Sony Ericsson	1 (0.9)

Table V.
Language preference

Language	No. of responses with %
Arabic	87 (83)
English	17 (16)

Internet, and the third use is voice chatting (used by 81 per cent). Education, news, religion and entertainment were the domains with average answers, as illustrated in Table VI. On the other hand, the domains with the fewest answers were commerce and weather.

To summarize the findings of this part, we found that visually impaired people prefer using smartphones with touch screens and that iPhone was the most common brand. Using Arabic interface was also common among visually impaired people. As for the most-used daily activities, we can see that: texting, Internet browsing and voice chatting were dominating the daily usage of smartphones.

Smartphone applications (applications used and accessibility challenges)

In the second part of the questionnaire, participants were asked to choose the applications they use in their smartphones. They also were asked to express the accessibility and usability issues they usually face when using these applications.

After analyzing the participants' answers (notice that more than one answer was allowed), we found that the most-used applications fall under the social network category (WhatsApp Messenger, YouTube and Twitter), followed by reference applications (translation and religion). Table VII provides a detailed list of applications used by participants and their category.

When looking at the answers for the accessibility problems faced by Arabic-speaking visually impaired people when using smartphones, we found that 51 per cent have confirmed one of the issues mentioned before in (Dawe, 2007; Watanabe *et al.*, 2008), which include screen reader compatibility with certain applications. One of the participants expressed the fact that most applications have pictures and buttons that cannot be recognized by the screen reader. Another participant stated that the screen reader does not read the navigation of most applications, in addition to the lack of a zooming feature for partially blind people. Participants also noted many other

Domain	No. of responses with percentage (%)
Texting	95 (91)
Web browsing	91 (87)
Voice chatting	85 (81)
Education/learning	65 (62)
Religion	64 (61)
News	64 (61)
Entertainment	63 (60)
Music	56 (53)
Photography	56 (53)
Books	56 (53)
Services	49 (47)
Lifestyle	46 (44)
Games	45 (43)
Health	32 (30)
Navigation	32 (30)
Sports	21 (20)
Travelling	23 (22)
Commerce	9 (8)

Table VI. Domains of smartphone usage

Applications	No. of responses with percentage (%)	Category
WhatsApp	92 (88)	Social networking
Messenger		
Twitter	83 (79)	
Skype	69 (66)	
Tango	62 (59)	
Viber	54 (51)	
Voxer	40 (38)	
Facebook	36 (34)	
Foursquare	11 (10)	
+google	9 (8)	
Fring	9 (8)	
LinkedIn	1 (0.9)	
Prayer Times	58 (55)	Religious app
Hisn Al-Muslim	36 (34)	
Qibla	33 (31)	
Tafsir Quran	27 (25)	
Calender	48 (46)	Productivity
Dropbox	33 (31)	
Gmail	2 (1)	
Applications News	48 (46)	News
Sabq	39 (37)	
Applications Basket	34 (32)	
iPhone Islam	30 (28)	
i4Blind	27 (25)	
Al Jazeera News	13 (12)	
Yahoo	8 (7)	
Google	69 (66)	Reference
Translation	59 (56)	
YouTube	86 (82)	Photo and video
Instagram	1(0.9)	
Cartoon Zaman	19 (18)	Entertainment
AlmareAlazraq	14 (13)	
Podcasts	8 (7)	
NetTV	8 (7)	
Safari	74 (71)	Utilities
STC	18 (17)	
Chrome	12 (11)	
App3ad	12 (11)	
Tafaseel	9 (8)	
MBC FM	16 (15)	Lifestyle
GPS	24 (23)	Navigation
Saudi Match	5 (4)	Sports
iBooks	15 (14)	Books
Samba	6 (5)	Finance
King Saud University	17 (16)	Education

Table VII.
Applications used by participants

challenges, like moving between applications, typing, browsing, downloading and reading PDF files.

Another accessibility challenge reported by most participants indicates that there are not many accessible Arabic applications or games for Arabic-speaking visually impaired people, and if they exist, they are mostly outdated. In addition, participants said that Arabic screen readers do not have a clear voice and pronunciation.

Other technical issues raised regarding screen readers were: the battery drains fast and slow mobile performance; these issues go unnoticed by sighted people, as they do not use screen readers.

Internet usage

To understand how Internet is used by visually impaired people through their smartphones, participants were asked about their skills with using the Internet on their smartphones. Overall, 46 per cent of the participants said that their skills are excellent, 32 per cent said their skills are good and 12 per cent said their skills are average. Meanwhile, 8 per cent said that their skills are weak (Table VIII).

Participants were also asked to comment on how often they use the Internet on their mobile phones and to give reasons for that. In total, 63 (60 per cent) participants said that they always surf the Web through their smartphones, and 23 per cent said that they sometimes use the Internet on their smartphones. Meanwhile, 11 per cent said that they rarely use it, while only 4 per cent said they had never used the Internet on their smartphones (Table IX).

The questionnaire also asked which Web browser blind individuals prefer to use. Safari was the most common browser, chosen by 85 participants (81 per cent). Chrome was chosen by (12 per cent), followed by Internet Explorer (10 per cent), Android (6 per cent), Nokia Browser (5 per cent) and Firefox (4 per cent) (Table X).

Visually impaired people were also given open questions to identify the main drivers for using and not using the Internet with their mobile phones. Through their comments, we found that some participants prefer surfing the Internet via their mobile phones because it is easier and faster than surfing with desktop computers. Another reason is

Ability	No. of responses with percentage (%)
Excellent	48 (46)
Good	33 (31)
Average	13 (12)
Weak	8 (7)
No answer given	2 (1)

Table VIII. Participants' ability to use internet via smartphones

Frequency	No. of responses with percentage (%)
Always	63 (60)
Sometimes	24 (23)
Rarely	12 (11)
Never	3 (2)
No answer given	2 (1)

Table IX. Frequency of using internet through smartphones

the fact that mobile phones are available to them everywhere and at all times. On the other hand, some visually impaired people prefer surfing the Internet on computers because they can obtain better results while navigating. In addition, it is easier for them to type on computers compared to mobile phones. Also, some visually impaired people indicated that the interface on mobile phones is not user-friendly. Other participants also pointed out that they do not know how to use the Internet via mobile phones.

Discussion and recommendations

The findings from this research have revealed many facts concerning the accessibility and usage of smartphones by Arabic-speaking visually impaired people in Saudi Arabia. The participants in this research were chosen randomly from different places to obtain different experiences in using smartphones. In our research, we tried to gather information from individuals of different ages; however, most responses were from people between 19 to 25 years of age, who represent 63 per cent of the total responses. This might be attributed to the fact that older visually impaired people do not use smartphones. The majority of the participants had high educational degrees and were unemployed.

Throughout working on this research, we have found answers relating to the three main aspects of our research:

(1) *Smartphones*: To answer what the characteristics of mobile phones used by visually impaired people are, we found that 83 per cent of the participants have their interface in Arabic; this was expected, as Arabic is the mother tongue in Saudi Arabia. Overall, 91 per cent of participants own smartphones with touch screens. Unfortunately, although it is difficult to get acquainted with using touch screens, i.e. it requires practice, visually impaired people did not have a lot of choices for mobile phones; the majority of VIP have phones with touch screens due to their advanced features and their Arabic support. Overall, 82 per cent of the participants own an iPhone because its screen reader supports Arabic, which makes it easier for the visually impaired people to use the phone. Also, our findings show that blind people use their phones mostly to browse the Internet and connect with others.

(2) *Applications*: To answer what the most commonly used applications by visually impaired people are and the reasons for this, we presented the most downloaded applications in Saudi Arabia, according to Apptrack rankings. The applications

Table X.
Browsers participants prefer to use

Browser	No. of responses with percentage (%)
Safari	85 (81)
Chrome	13 (12)
Internet Explorer	11 (10)
Android	7 (6)
Nokia Browser	6 (5)
Firefox	5 (4)
Not stated	5 (4)
Other	2 (1)
BlackBerry	1 (0.9)
Opera	1 (0.9)

used by more than 40 per cent of visually impaired people were the ones with the following features: ease of use, depends on voice command, ability to connect people, easy to search the Internet, easy to navigate, provides zooming feature, better display readability, updates availability and provides Arabic support.

(3) *Internet usage*: To answer how often the participants use the Internet in their smartphones, 83 per cent of the participants said they use the Internet through their smartphones, and 46 per cent of them have excellent ability to access it via their smartphones. In the questionnaire, VIP pointed out that the most important obstacles they face while browsing the Web via their smartphones are Web page accessibility and difficulties of using the application for browsing. Overall, 81 per cent of the participants used Safari to surf the Internet on their mobile phones. This information leads us to the following result: the accessibility of iPhone devices is the most appropriate for Arabic-speaking visually impaired people in Saudi Arabia.

This research has shed light on the uses of smartphones by Arabic-speaking visually impaired people in Saudi Arabia and the accessibility obstacles they usually face. It also has highlighted the importance of smartphones in helping visually impaired people expand their perceptions and facilitate their daily lives. Smartphones accompany visually impaired people most of the time; however, such individuals have not profited from all the features that these phones provide, such as Global Positioning System (GPS) and camera. We also found that visually impaired people are still left behind in terms of technology, and the available assistive technologies are limited especially when dealing with Arabic content. To find solutions for these issues, we suggest the following:

- Developers should pay more attention to accessibility features when building new applications in any mobile platform (iOS, Android, etc.).
- Another feature that needs to be taken into consideration more often is Arabic language support with frequent application updates.
- When building Web pages, there should be a mobile version with accessible features to facilitate Web browsing for blind people.
- As learning to use new technology is difficult if you cannot see it and as, most participants stated, visually impaired people are not aware of new technologies coming into the market, we strongly believe that visually impaired people must be educated and aware of the correct ways to use these technologies to help them be more productive.

When applying these suggestions, we expect an enhancement in smartphone usage by Arabic-speaking visually impaired people, which would result in a better lifestyle and more independence.

Limitations and conclusion

Mobile phones are essential in everyone's lives, even for visually impaired people. Yet, there are still some improvements that can be done to help them benefit from the services provided by smartphones. After analyzing the data of this research, we realized some of the difficulties and obstacles Arabic-speaking visually impaired people usually face

when using their mobile smartphones. This information can be used to build useful and usable mobile applications for such individuals.

With all the improvements in technologies that we have been having recently, the biggest obstacle that still exists is accessibility. To reach our goal of improving smartphone accessibility for VIP, we made conducted research that promotes a better understanding of how Arabic-speaking visually impaired people use smartphones in a country such as Saudi Arabia.

Relating to this topic and to support our ultimate goal of improving accessibility of smartphones for visually impaired people, we are planning to carry out the following goals in our future research:

- continue researching this topic for better ways to enhance mobile phone accessibility for visually impaired people;
- study and inspect the problems of smartphone application accessibility with the help of expert smartphone visually impaired people users;
- carry out more research to discover different possibilities for visually impaired people to benefit from smartphones' features; and
- examine the usability of smartphones and their applications for visually impaired people and methods to improve it.

In this study, we used a questionnaire as the main instrument to get as many participants as we could in a short time; however, due to using this instrument, some limitations arose. One of the limitations was the accuracy of the participants' information, namely, the participants were reached through social networks where there might have been some outliers (claiming to be visually impaired people, which might have influenced our results. Another limitation is the fact that most participants are educated and none were over 40, so we were unable to reach elderly or illiterate visually impaired people. For future reduction of such limitations, structured interviews must be used to get comprehensive and accurate results. On the other hand, the main contribution of this research is being the first study to investigate smartphone usage by Arabic-speaking visually impaired people.

In conclusion, all the data obtained in this research and to be obtained in future studies should reflect the importance of further research into improving mobile accessibility for Arabic-speaking visually impaired users. Moreover, it is important to facilitate visually impaired users' frequent actions by minimizing the number of required steps to do something on the smartphone and correcting the existing errors by giving the visually impaired people an efficient and satisfying experience.

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Appendix: survey structure

This section presents a text description of the survey structure. The survey had mainly four parts: demographics, type of smartphone, applications used, and Internet usage. Only one answer is allowed for most of the questions; the ones that allow more than one answer are preceded by an asterisk.

Demographics:

(1) What is your gender?
- Male
- Female

(2) What is your approximate age?
- Less than
- 19-25
- 26-30
- 30-39
- 40-49
- 50-59
- 60-69
- 70 and more

(3) What is your educational level?
- Primary
- Intermediate
- Secondary
- Diploma
- Bachelor's
- Master's

(4) Are you employed?
- Employed
- Unemployed

(5) What type of blindness do you have?
- Total
- Partial

Type of Smartphone:

(6) What type of smartphone do you have?
- iPhone
- HTC
- BlackBerry
- Nokia
- Samsung
- Sony Ericsson
- Motorola
- LG

(7) Which language do you use?
- Arabic
- English

(8) Does your phone have a touch screen?
- Yes
- No

(9) *When do you mostly use your phone?
- Almost nowhere
- At university
- At home
- In malls
- At restaurants
- While travelling
- Everywhere

(10) *Which areas do you use your smartphone for?
- Education/Learning
- Web browsing
- Commerce
- Games
- Entertainment
- Voice chatting
- Texting
- News
- Health
- Life Style
- Music
- Navigation
- Photography
- Sports
- Travelling
- Services
- Weather
- Religion
- Books

Applications Used:

(11) *Which mobile applications do you use?
- WhatsApp Messenger
- Twitter
- Skype
- Tango

- Viber
- Voxer
- Facebook
- Foursquare
- +google
- Fring
- LinkedIn
- Prayer Times
- Hisn Al-Muslim
- Qibla
- Tafsir Quran
- Calender
- Dropbox
- Gmail
- Applications News
- Sabq
- Applications Basket
- iPhone Islam
- i4Blind
- Al Jazeera News
- Yahoo
- Google
- Translation
- You Tube
- Instagram
- Cartoon Zaman
- AlmareAlazraq
- Podcasts
- NetTV
- Safari
- STC
- Chrome
- App3ad
- Tafaseel
- MBC FM
- GPS
- Saudi Match
- iBooks
- Samba
- King Saud University

(12) *What are the problems you usually face when using mobile applications?

Internet Use:

(13) How often you browse the Internet in your smartphone? Why?
- Always
- Sometimes
- Rarely
- Never

(14) How well are you at using your mobile for browsing the Internet?
- Weak
- Average
- Good
- Excellent

(15) *Which browser do you use in your smartphone?
- Android
- BlackBerry
- Firefox
- Internet Explorer
- Nokia Series
- Opera
- Safari
- Chrome

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