Guidelines for Designing Inclusive User Interfaces For People with Visual Impairments

By

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Abstract

There are a lot of people around the world who have access to a good smartphone but cannot make full use of it because they have some form of disability. These days a good mobile is not a privilege but rather a necessity and being able to use it entirely can unlock doors we've never imagined. People with visual impairment often find it difficult to interact with various user interfaces.

The objective of this research was to learn how visually impaired individuals interact with smartphone interfaces and understand the barriers they face in order to come up with guidelines for designing inclusive user interfaces. A series of interviews with four visually impaired adults provided insights to understand the barriers faced on a daily basis when it comes to interacting with smartphone interfaces. Their inputs resulted in 1) newly designed guidelines that address the gaps in the current design system and 2) a wireframe design for a smartphone app that shows the implemented guidelines. The scope of this research study is to design guidelines for making smartphone interfaces and apps accessed through smartphones accessible for users with visual impairments.

The research was conducted upon receipt of ethics approval from the OCAD University research ethics board. REB number: 2021-89.

Acknowledgement

I would like to express my deepest gratitude to my Principal Supervisor, **Dr Kathy Moscou** for being my strongest support throughout and for her resourcefulness. Without her support and kindness, I could not have completed this project.

I would also like to thank my peers, friends and family for being there and helping as and when needed.

I am thankful to each and every person who has impacted my life in some or the other way and helped me reach this stage.

Dedication

I would like to dedicate this paper to my late mother, Kalpana Tak, who was my motivation to pursue this degree and to keep learning in every possible way. She was a learner and a giver and I aspire to become like her.

I would also like to dedicate this paper to every person with a disability out there, who makes the world a better place to live, just by being in it.

Table of Contents

List of Figures

Introduction

About 2.2 billion people around the world suffer from some form of visual impairment. (*Blindness and Vision Impairment*, 2021). Visual impairment is a term experts use to describe any kind of vision loss, whether it's someone who cannot see at all or someone who has partial vision loss. Vision impairment includes but is not limited to blurred vision, near or distant vision impairment, and partial blindness. (Mandal, 2019). These types of conditions are often easily treated with eyeglasses or contact lenses. But when one or more parts of the eye or brain that are needed to process images become diseased or damaged, severe or total loss of vision can occur. In these cases, vision can't be fully restored with medical treatment, surgery, or corrective lenses like glasses or contacts. The American Foundation for the Blind estimates that 10 million people in the United States are visually impaired. (*Blindness Statistics*, 2019).

Cell phones and tablets have revolutionized the way people who are blind or visually impaired interact and use technology. The existing technology depends on either voice or haptic to get tasks done. Adaptive user interfaces can help improve usability and in turn also the quality of life of visually impaired users. Although the use of smartphones has positively affected the life of visually impaired individuals, a lot of content on them remains inaccessible. (Olofsson, 2017). Although a lot of smartphones these days have inbuilt accessibility features in them, they are expensive.

Existing design practices are not totally inclusive of the needs of visually impaired people and often isolate them from the rest. (Stephanidis, 2001). Furthermore, not all design solutions are as simple as choosing the right HTML element for the job. It is important that researchers develop empathy for marginalized groups. Accessibility is one of the major challenges faced while using interfaces. Inclusivity often focuses on optimization for accessibility without compromising the experience of users. (Keating, 2003). Accessibility needs to be taken into consideration while designing any product or service because many devices still lack accessibility. Usability should also be considered while designing a product or service.

The aim of this study was to understand the barriers faced by visually impaired individuals with respect to interacting with smartphones, in order to come up with guidelines for designing inclusive user interfaces. For that, four participants between the ages of 30 to 60 were interviewed. They were asked a series of questions that helped in identifying the barriers. The interviews informed the guidelines that I developed that focus on designing more inclusive user interfaces. These guidelines are intended to be used by designers in order to set a standard for interface design to improve accessibility. The findings of this research will also help in designing an interface that addresses the needs of people with low or no vision.

Through this research, I am trying to answer 3 main questions:

1. What obstacles do people with visual impairments face while dealing with interfaces (smartphones, tablets)? Would "context awareness" help in solving them?
2. What gaps need to be addressed in the current design systems to make them more inclusive of visually impaired users?
3. Which response engagement technology (tactile, visual, speech) would be most effective in making the interface accessible to visually impaired individuals?

Problem Statement

Visually impaired individuals include people with colour-blindness, low vision or complete blindness. (Mandal, 2019) A literature review showed that a lot of articles focus on the problems faced by visually impaired people while interacting with inaccessible interfaces. (Olofsson, 2017). but only a few have provided a possible solution. Providing a solution to the inaccessibility issue will benefit the people with low or no vision to use smartphones to their full potential. In case of an emergency, individuals with visual impairment should be able to call for help just like any other individual. It is my expectation to learn how visually impaired individuals interact with interfaces to come up with guidelines that help designers in building accessible interfaces. A short survey before starting with the research study proved useful and helped me gain preliminary insights into the user's expectations for accessibility in interfaces.

Defining Visual Impairment

Visual impairment, also known as vision impairment or vision loss, is a decreased ability to see to a degree that causes problems not fixable by usual means, such as glasses. (Mandal, 2019). Some definitions also include individuals who have a decreased ability to see because they do not have access to glasses or contact lenses. Visual impairment is often defined as a best-corrected visual acuity (ability to resolve fine detail) of worse than either 20/40 or 20/60. The term blindness is used for complete or nearly complete vision loss.

Visual impairment is a comprehensive term that describes a wide continuum of loss in visual function. It has a range of causes. The causes can be hereditary, congenital, adventitious or disease or age-related. Some conditions affect the eye itself while others are a result of damage to the optic pathways. (Mandal, 2019).

1. Visual impairment in glaucoma

   Glaucoma is a condition which damages the optic nerve of the eye. It happens when the fluid pressure inside the eyes rises, slowly damaging the optic nerve. Without any treatment, people with glaucoma slowly lose their peripheral or side vision.

2. Age-Related Macular Degeneration

   In this condition, a central area of woolly or cottony opacity obscures the central part of the vision.

3. Cataract

   There is a general clouding of the vision. As the whole eye lens is affected the blurring of vision may be diffused until it is totally lost.

4. Nearsightedness

   Myopia or nearsightedness or short-sightedness means a person can see nearby objects clearly, but distant objects appear blurred. High myopia may lead to vision impairment.

5. Retinitis Pigmentosa

   This condition is often diagnosed in childhood or adolescence. Initially, it manifests as night blindness. As the disease progresses there may be loss of peripheral and night vision followed by complete blindness.

6. Colour blindness

   In this condition, people are not able to differentiate between certain colours. Red-green colour blindness is by far the most common type of colour vision deficiency.

Visual Impairment and Technology

Thanks to the advances in technology, blind and visually impaired people no longer have to depend on others for things such as typing, sending documents and emails, or receiving phone calls. People with low vision can also use screen-magnifying software that helps them see images, letters etc. without having to strain their vision. This technology – commonly known as assistive or adaptive technology – has removed many access barriers for people with vision loss. (Hersh, 2008). It has enabled people to be more independent whether at home or outside.

Smartphones are not usually viewed as assistive technology for visual impairment but only as a means of communication. (Senjam, 2021). They are not viewed as assistive technology because they lack supportive elements like braille and pre-installed screen readers. Operating a smartphone relies on a good visual function and hence it could turn out to be inaccessible to a person with visual impairment. (Senjam, 2021).

Assistive Technology

Various factors influence the usability of interfaces for low vision users. Factors such as colour contrast, and legibility help in engaging users. (Link, 2021). Assistive Technology plays a very important role in the lives of people who totally depend on it. A lot of visually impaired individuals depend on assistive technology to perform basic tasks on their smartphones or laptops. Some of these are

1. Screen reading software

   Screen-reading software like JAWS (Job Access With Speech) and NVDA were developed specifically for users whose vision restricts them from interacting with interfaces. They help users read the screen either with a text-to-speech output or by a refreshable Braille display. JAWS is produced by the Blind and Low Vision Group of Freedom Scientific and works with Windows operating systems (Hersh, 2008.)

2. Navigating using Landmarks

   Users can navigate using landmarks like headings, only if these landmarks use proper semantic markups. (Watson and Moore, 2016). Semantic markup is a way of writing and structuring your HTML so that it reinforces the meaning of the content rather than its appearance.

3. Refreshable Braille displays

   These devices process information on computer displays and electronically raise and lower different combinations of pins in braille cells. (V Argyropoulos et al., 2020). The device changes continuously as the user moves the cursor around on the screen.

Figure 1.1: Refreshable Braille display

Methodology

This research focused on understanding the barriers faced by visually impaired individuals to make mobile interfaces more inclusive for people with visual impairments. Qualitative research methods were used that included user interviews and note-taking. Interview transcripts and audio recordings were reviewed iteratively to gather key insights and understand the obstacles faced by the users.

The research process followed in this study was an iterative, non-linear one, which allows one to go back to any step as and when necessary (Figure 1.2). This is an example of design thinking methodology which is a human-centred, iterative process that helps in tackling real-world problems. Inspired by the design thinking methodology or design-based research, this process involves the following steps: **define the problem, user interviews, creating user personas, coding interview transcripts, analysing the transcripts (data), design ideation, wireframing** and then the **final designs**.

This project has been approved by the OCAD University research ethics board.
REB number: 2021-89.

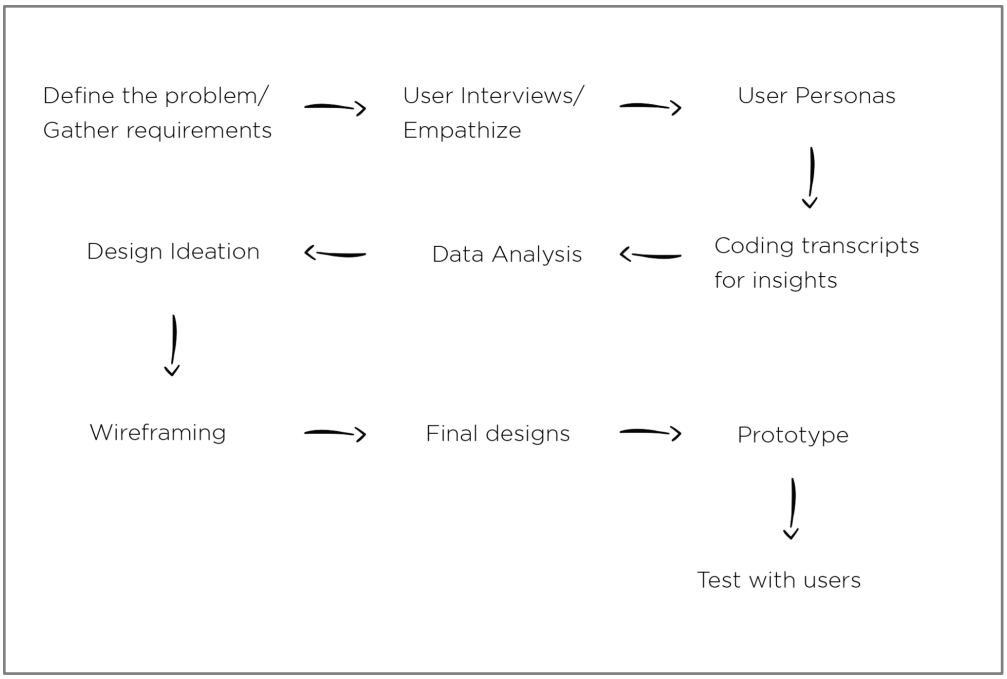

Figure 1.2: Research process

Participants

For this study, visually impaired individuals were recruited to participate in user interviews. The aim was to interview people who frequently deal with interfaces for their job or even for daily tasks. Participants were interviewed to get a better understanding of their struggles while dealing with interfaces and of the obstacles that they face in their day-to-day life because of inaccessible interfaces.

To recruit participants for this study, I reached out to faculty at OCAD University, CNIB (Canadian National Institute for the Blind), and Helen Keller Foundation for the blind and visually impaired. A total of 4 participants between the ages of 40 to 60 were interviewed. Participants were screened using a screening questionnaire and the shortlisted candidates were then invited for an interview via email. Participants were given a gift card (value $15 CAD) as a token for their participation, input and time.

User Personas

In order to better understand the pain points and expectations of the users, personas were created for each participant. A user persona was created based on research of the target user of a particular product or service. The user persona represents their characteristics, goals, needs, and frustrations and may represent the needs of a larger, similar group of users. An understanding of user behaviour and needs makes it possible to define who a product is being created for and what is necessary or unnecessary for them from a user-centred point of view. (Friis & Yu, 2022). Pseudonyms are used for each persona to maintain participant confidentiality.

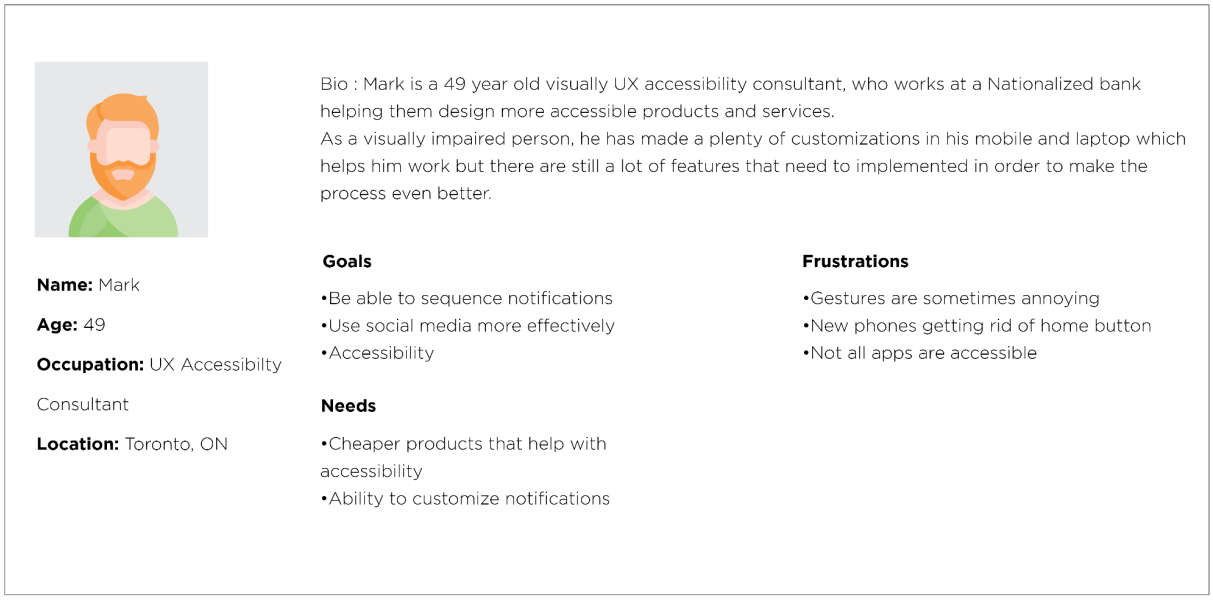

Figure 1.3 User Persona-1

Bio : Sandra is a 55 year old visually impaired retired director at Job services accomodation.
She has accustomed herself with the accessibility features that iPhone has to offer and relies heavily on them. She uses her phone for everything but rarely for phone calls.

Name: Sandra

Age: 55

Occupation: Retired Director

Location: Toronto, ON

Goals

•Ability to afford a new phone
•Experience gaming
•Accessibility

Needs

•Websites to be compatible even if accessed through phone.
•Gaming apps should also have accessibility settings

Frustrations

•Product prices
•Not all apps comply with accessibility

Figure 1.4 User Persona-2

Bio : Tanya is a 33 year old product zone specialist at Apple. During her time at Apple, she taught customers how to use their phones better.
As a visually impaired person, she relies on her voice to use her phone for everything right from writing an email to looking for a recipe. She has a little mouse on her watch that tells her time.

Name: Tanya

Age: 33

Occupation: Product Zone Specialist @ Apple

Location: Toronto, ON

Goals

•Easy screen activation with toggle

Needs

•Websites to be screen-reader compatible.

Frustrations

•Widgets are unnecessary
•Apps go missing when widgets are on
•Sensitivity of the phone

Figure 1.5 User Persona-3

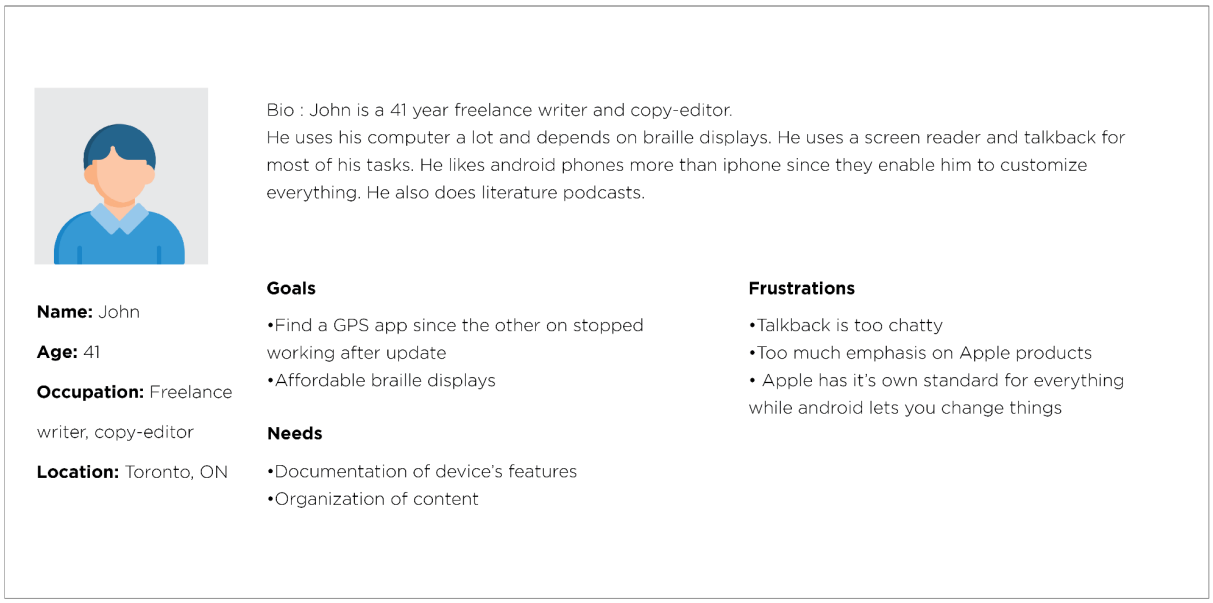

Figure 1.6 User Persona-4

These personas depict the similarities between the needs and frustrations of the users while using the web or mobile interfaces.

Setting

All the conversations and interviews with participants were conducted in a virtual setting. All the interviews were conducted at a Zoom meeting at a time convenient to the participant.

Data Collection and Analysis

Interview data was collected through audio recording and note-taking. Participants were requested to provide consent to be recorded prior to the interview session. The collected data was coded and analyzed to identify key themes. The findings were also discussed with the advisor during weekly meetings. Some general observations or common insights derived from all the participants were separated for

comparative analysis. Similarities and dissimilarities between the needs of participants with respect to interfaces were identified.

Findings

The data analysis concluded that there are variations in which people interact with their smartphones. One point that came up during the conversation was that a lot of appliances including smartphones, microwaves, and tablets for the blind are usually more expensive when they should be the other way round and be more affordable for those who need them in their daily life.

"I'm happy with how the device is performing. If I was to, you know, have an influence on changing anything, it's the price. Oh, the price of iPhones is not cheap. That's one of the reasons I'm not able to afford it(iPhone)." - Sandra

Also, there are various apps available from the Apple app store as well as Google Play store that visually impaired users find useful like Talkback, Speaky, Be my Eyes and navigation apps like Nearby. These help users with simple tasks, but when these apps are updated, they may lose their accessibility function. This is a major issue that needs to be addressed.

The table below shows how each participant has different preferences in terms of the use of certain accessibility features and smartphones.

	Participants	Mark	John	Tanya	Sandra
Common Findings					
Use of screen reader					
Use of keyboard to type					
Use of smartwatch					
Preference to Android					
Preference to iphone					
Use of braille display					
Use of phone for calls					
Gestures					
Complete dependency on voice					
Concern with Affordability of devices					

Figure 1.7: Comparative Data Analysis

According to the table above (Figure 1.7), all four participants depended on a screen reader while using their phones, while only one of them favoured Android over iPhone. Three of them used a keyboard to type while one relies heavily on voice to get everything done. One of the participants works as a UX accessibility expert and has a complete office set up at home. He uses a Bluetooth braille keyboard that makes it easier for him to type and it connects to his laptop as well as his phone. On the other hand, other participants did have a concern about the price of these displays and the fact that not everyone can afford them. One of the findings from this research is that people with visual impairment still prefer to rely on tactile reception on a phone like its home button, but due to new phones removing the buttons, they have to get used to interacting with voice instead.

"I have an old iPhone. It still has the home button, and the physical home button, and that's what I like because you can't just do a finger unlock with the newer iPhones, you have to use your facial recognition or type in a password. I'm not a big fan of that. Because in the newer phones, it will ask me to unlock with voice or fingerprint" - Mark

Participants also shared their positive and negative experiences while interacting with interfaces. The positive aspects were:

1. Ability to look up a recipe easily and get it narrated through a screen reader.
2. Ability to send a text or email effortlessly

While users were generally happy with the overall experience of the interface, there were some setbacks that disappointed them like:

1. Navigational difficulties due to insufficient information about the smartphone's capabilities
2. Certain apps are available only for Apple and not for Android, for example, Soundscape. This is based on a misconception assuming that visually impaired users only use iPhones, according to one of the participants interviewed.

"It's like, oh, it's only available on iPhone, because that's like, yeah, that's what the majority of visually impaired people are using, I guess. But there's no reason for it to be that way." - John

Two of them supported the features in android while the other two advocated the accessibility features in iPhone. Android phones are more customizable in terms of features and they give users the freedom to make changes that suit their needs.

The comparison between the iPhone and Android as stated by Mark and John:

"In iPhone, there's only one home screen that you can use. And it's their proprietary and you can't replace it. And with Android, you can replace the home screen. So, I don't really like the pixel. It's called a launchpad or home screen. So, I've changed to something that's better but not more accessible. It just gives me more liberty of making changes." - Mark

"I expressed some frustration about using iPhone. I always wanted to use an Android phone because I wanted to be more customizable. And so, I kind of, I like the idea of being able to customize even though, to be honest, I don't spend a lot of time on my own way, tweaking it, stuff like that" - John

Interacting with Voice

People with visual impairments rely heavily on their voice to get tasks done especially on their mobile phones. (Olofsson, 2017). Apps like "Google Assistant" and "Siri" listen to commands and do as directed, from calling someone, to tell what the weather is like. But these apps require the internet to function at their best capacity and would be of no use without it. Three out of the four participants in this study preferred to use their voice to do a task on a smartphone while one relied on gestures. The response engagement technology (tactile, visual, speech) varies from person to person.

Do Gestures help?

Amongst the people that I interviewed, two of them rely heavily on gestures while using their smartphones. Gestures generally help while scrolling, and performing a particular task and users rely on them instead of using their voice to perform tasks every time. Gestures are considered one of the most effective ways of interaction among people with visual impairment.

John stated with respect to interacting with voice and gestures:

"A lot of my friends primarily use their voice to do everything. And I tend to not use it as much. I like swiping better and being able to quickly navigate screens and stuff like that. I rely more on gestures because the learning this, the swipe gestures and stuff like that is very important because a lot of apps that don't work with Siri, when you're inside the app"

The gestural activity of persons who are visually impaired differs from that of persons who are sighted. Specifically, people who are visually impaired use more adaptors (especially finger-to-hand gestures) and fewer conversational gestures than those who are sighted. According to one study, people tend to gesture in their native language. (Fulmer, 2016).

Existing Guidelines

Based on the data collected through the interviews and insights received from the participants, it is clear that there are certain gaps in the current interface design guidelines which need to be addressed.

Some of the current design guidelines for a good user experience are

1. Provide simple navigation
2. Make a large touch area
3. Reduce clutter
4. Use touch controls
5. Display large text
6. Use of simple forms
7. Thumb positioning
8. Consistent experience

Gaps identified

According to the WCAG (Web Content Accessibility guidelines), an interface should be perceivable, operable, understandable and robust. (*WCAG 2 Overview | Web Accessibility Initiative (WAI)*, 2021) Although the current guidelines try to incorporate accessibility features to some extent, they do not really help people with visual impairments achieve their goals. People have to rely on external sources like screen reading software, and voice over apps and sometimes they must pay for this software. (Fulton, 2017).

Participants shared the obstacles they face on a daily basis while using their smartphones. Their major concerns were the inability to sort notifications and toggle to activate the lock screen. Below are some of the statements made by the participants that state the gaps and support the newly revised guidelines.

"Accessibility is a big issue for me. So, when I try, whether it be new apps on smartphones or a new program on a laptop, I find that there are a lot of programs out there are a lot of developers out there that

don't consider accessibility. More people are becoming more aware of it. But I find that sometimes you'll try something out and your buttons or fields are not labelled properly, or the interface is just not accessible at all."- Mark

"Maybe the screen could be activated through a toggle switch. That way you're not accidentally clicking on something or calling someone which happens a lot" - Tanya

"So on the Android platform, on the lock screen, you have your notifications, and they're not in a sequence. They don't show up as part of me sequentially. So say, for example, if you receive a bunch of messages, they're all at the top. And then you finally get into the notifications that, you know, are supposedly less important, but I prefer sequential." - Mark

" I would like to see more voice features in apps that don't currently comply with accessibility, and might as well some customization options" - John

"I am not a fan of surfing the web or browsing my phone, but if I could change a few things, I would want some text along with colour rather than just the colour to understand the call to action" - Tanya

These quotes reflect what people with visual impairments face every day while using their interfaces. The newly revised guidelines are an attempt to address these issues to make interfaces more accessible to users with visual impairments.

Bridging the Gap: Design based on revised guidelines

Interviews with the participants and data collected ultimately lead to recognizing the gaps identified in the overall process. The major gaps identified were

1. Not all applications support accessibility features like compatibility with screen readers, voice commands, and the ability to adjust contrast.
2. Inaccessible components like buttons, and search bar.
3. Different accessibility features in android and iPhone apps and smartphones. There are sometimes more features on iPhone compared to the android like vision, voiceover, zoom and display.

Through multiple iterations, I attempted to bridge the gap between the current interface design guidelines and the expected. Taking into consideration the users of your product or service is the first step to being inclusive. Empathy plays the most important role when it comes to designing.

The design below is an example of what a smartphone interface would look like once the newly stated guidelines are implemented.

The wireframe example is of a login page for a bank app. The design is based on an “app” rather than an interface because it can be accessed through a smartphone and the scope of this study also focuses on accessibility in apps. The user has the option to toggle between “Guide me” and “I’ve got this” and depending on their selection, the commands will be activated.

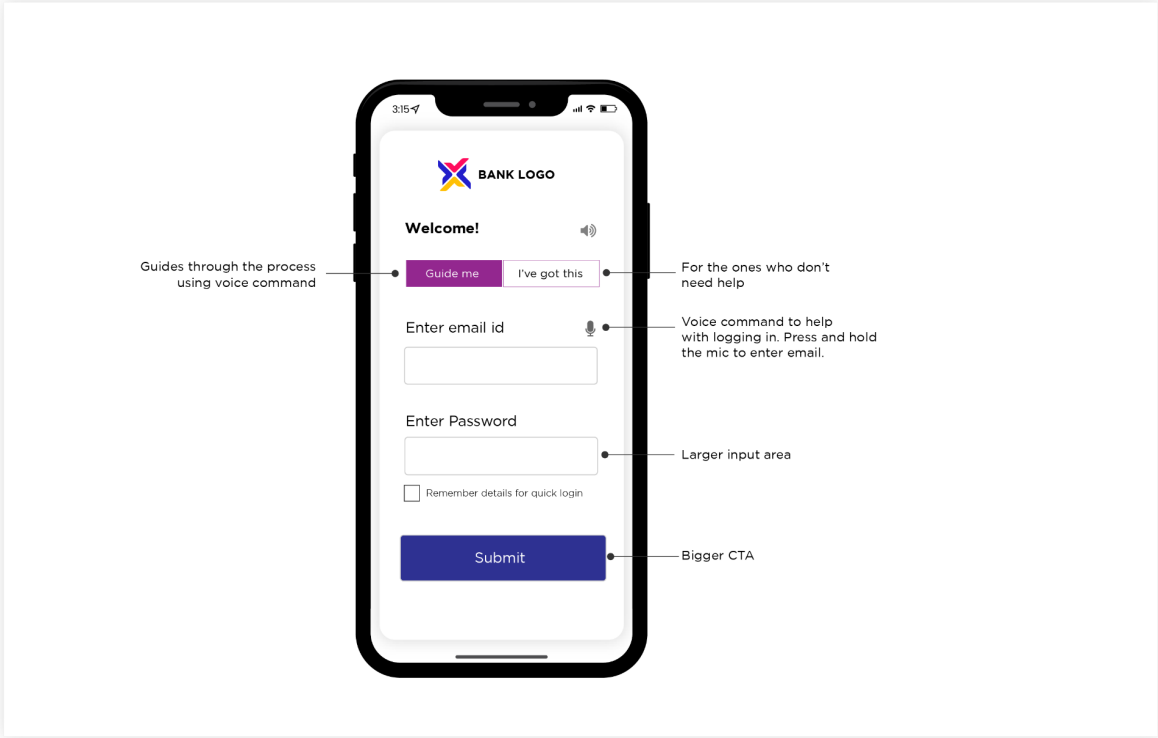

Figure 1.8: Login screen with implemented guidelines

When a visually impaired user tries to log in to an internet banking app, it generally would not give them a voice command feature to help with logging in. In this scenario, the toggle between “Guide me” and “I’ve got this” helps the app to understand when a user needs help logging in and when they can help themselves.

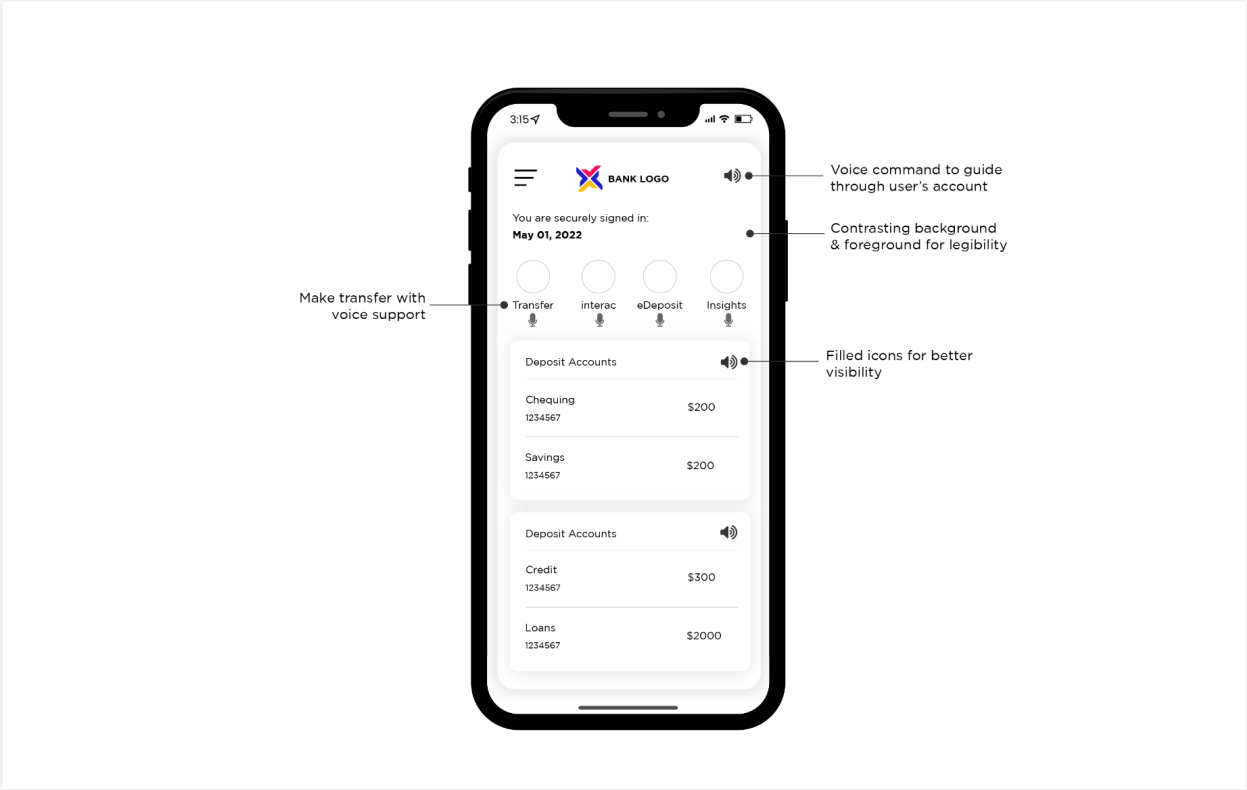

Figure 1.9: Home screen with implemented guidelines

When the user has successfully logged in, the voice command feature on the home screen will help them to know their balance and guide them through their account. The interface includes filled icons for better visibility and a voice option in each feature.

New revised/recommended guidelines

The gaps identified in the current design systems lead to creating newly revised guidelines for designing inclusive user interfaces.

- **Clearly label the input field**

  Each input field should have a clear label that reduces confusion and is legible.

- **Add text with colour as a means of conveying information**

  For colourblind people, it is difficult to distinguish certain colours. Hence, text along with colour could be a better means of conveying information.

- **Give a voice command option in each feature**

  Not all features support accessibility which makes it difficult for visually impaired users to understand what is the CTA. Having a voice command option for the same would make the process a lot easier.

- **Give users the ability to sort notifications by preference**

  This is a user-specific condition. Some users would like to see the first notification at the top rather than the bottom.

- **Toggle to activate lock screen**

  Due to the iPhone's sensitive interface, users often don't realize if the screen is unlocked and so a toggle to activate or deactivate the screen would solve the problem.

- **Make components more accessible**

  Making the components accessible at the root itself will set the stage for accessible user interfaces quite early in the process.

- **Reduce use of keystrokes**

  Wherever possible, it is recommended to minimize the use of keys for most common interactions like reading or posting a message.

- **Separate foreground from background**

  Users should be able to see and hear the content. This can be achieved by separating the foreground from the background by using contrasting colours.

- **Provide an option to change font size**

  Users should have the ability to increase or decrease the size of fonts as per their needs. This functionality can be added by letting the user pinch into the screen or a "+" sign.

Comparing Existing and New Guidelines

Guidelines that would benefit Visually Impaired individuals	Existing Guidelines	Revised Guidelines
Provide simple navigation	●	●
Make a large touch area		●
Reduce clutter	●	●
Use touch controls	●	●
Display large text		●
Use of simple forms		●
Thumb positioning	●	
Consistent experience	●	
Clearly label the input field		●
Add text with colour as a means of conveying information	●	●
Give a voice command option in each feature		●
Give users the ability to sort notifications by preference		●
Toggle to activate lock screen		●
Start by making components accessible		●
Reduce use of keystrokes		
Separate foreground from background		●
Use explicit and descriptive labels for links and buttons	●	●
Grant keyboard accessibility	●	●

Figure 1.10: Comparing new and existing guidelines

The table (Figure 1.8) above is a comparison between the guidelines that would benefit visually impaired individuals, existing guidelines and new guidelines. The revised guidelines are more comprehensive and focused on accessibility for people with visual impairments. The circle next to the guideline denotes that the particular guideline is met.

The guidelines that are unmarked in the revised guidelines column are on least priority for the participants interviewed. Since the users are visually impaired, they do not pay much attention to consistent experience, thumb positioning and use of keystrokes.

"I wouldn't really care about the stuff like the consistency of layout and such because I rely more on voice and cannot clearly see the interface, so it doesn't matter to me" - John

The table below shows the categories into which the guidelines can be divided based on their applicability.

Guidelines for Interface	Guidelines for Apps
Clearly label the input field	Give a voice command option in each feature
Add text with colour as a means of conveying information	Start by making components accessible
Give users the ability to sort notifications by preference	Separate foreground from background
Toggle to activate lock screen	Provide an option to change font size
Reduce use of keystrokes	Reduce use of keystrokes
Separate foreground from background	Option to change font size
Provide an option to change font size	Add text with colour as a means of conveying information
Give a voice command option in each feature	
Make components accessible	
Option to change font size	
Ability to sort notifications	

Figure 1.11: Grouping of guidelines by "interface" and "app"

Guidelines in the table (Figure 1.11) are divided into two categories based on where they would be applied. Some guidelines are a part of both the categories since they can be applied both to an interface or an application. The research investigated each of these issues because they are interconnected with the user experience.

Discussion

I started this journey with one goal in mind which was to understand the barriers faced by people with visual impairments while interacting with the web and mobile interfaces and come up with guidelines that will enable designers to design more inclusive user interfaces. Through a series of interviews with participants, their insights and inputs, I was able to answer the three main research questions and come up with guidelines that will help designers in building more inclusive and accessible user interfaces. I believe this research study was an important step in understanding the obstacles faced by people with visual impairments while using interfaces. Visual impairment may cause difficulties with normal daily activities such as reading and walking without adaptive training and equipment. But Due to the advances in technology, blind and visually impaired people no longer have to depend on others for things such as typing, sending documents and emails, or receiving phone calls.

The research suggests that by implementing the following features, any interface could be made accessible: Speech recognition, accessible keyboards, ability to customize. It was clear from the literature review and this research that there are solutions that would make interfaces inclusive for people with visual impairment. (Batista et al., 2014,). During the interviews, the participants shared their daily obstacles while using interfaces and what changes they would like to see in terms of accessibility.

The research study and interaction with participants helped me discover elements that directly answer my research questions about obstacles faced by visually impaired users, gaps in interface design systems and response engagement technology. The design systems are comprised of components that are a part of the user interfaces and making these components accessible will further make the interfaces accessible. Interviews with participants showed a few common themes about how they interact with smartphone interfaces. They were generally happy with their phones, but everyone had a different set of inconveniences such as apps going missing, and insensitivity of the interface with respect to the smartphones they are currently using. The results also showed how they wanted to interact with their smartphones, depending on the context like checking the time, sending an email, calling or texting

someone. The participants narrated their obstacles while using smartphone interfaces which were about receiving notifications, missing voice command features, and keyboard accessibility. These obstacles arise as a result of gaps in design systems which need to be resolved. The newly revised guidelines address each of these gaps leading to a better response engagement technology which right now is just voice and tactile only in certain conditions (button to feel or braille). General improvements such as clear navigation, clear labelling of input boxes and large or legible text could lead to satisfaction in their use of smartphones. Most of them depended on Apple products because of their inbuilt accessibility features but also wished to see how android would take this up in the next few years because of its ability to let users customize.

Conclusion

The main objective of this study was to understand the barriers faced by people with visual impairments while interacting with mobile interfaces and develop guidelines that will enable designers to design more inclusive user interfaces. The findings derived from this study might be used in addressing the gaps in the existing design systems. Additional research is needed in this scenario for a first-hand understanding of the problems faced by the users. With accessibility being considered in almost every product and service today, smartphone interfaces might soon see more accessibility features. Future research should focus on implementing and testing the stated guidelines. Other areas that should also be the focus of future research are advancements in voice user interfaces, and gestures to interact with phones. The newly revised guidelines incorporate the features of accessibility so that designers can refer to them while developing user interfaces.

To summarize, the findings of this study and the revised guidelines were derived as a result of lived experiences of the participants and will further help in making interfaces more accessible to users.

Limitations

One of the limitations of this study was the inability to test the newly stated guidelines due to the time-sensitivity of the project. Another limitation was virtual interactions with the users. In-person interaction would have let me observe users while interacting with phones. Users will benefit directly from this study once the guidelines are standardised and implemented.

Bibliography

Batista, C.R., Ulbricht, V.R., & Goncalves, M.M. (2014). Inclusive Design: An Interface for Users with Disabilities. *Communications in Computer and Information Science*, (HCI International 2014).

Friis, R., & Yu, T. (2022, February 23). *Personas – A Simple Introduction*. Interaction Design Foundation https://www.interaction-design.org/literature/article/personas-why-and-how-you-should-use-them.

Fulmer, D. (2016, April 25). Blind adults' gestures resemble those of other native speakers.

Fulton, G. (2017, December 3). Accessibility Basics: Designing for Visual Impairment. https://webdesign.tutsplus.com/articles/accessibility-basics-designing-for-visual-impairment--cms-27634.

Hersh, M. (2008). Assistive Technology for Visually Impaired and Blind People. *Springer*. https://doi.org/10.1007/978-1-84628-867-8.

Keating, S. (n.d.). Inclusive Design in User Interface | by Shauna Keating. *Moonfarmer*. https://dispatch.moonfarmer.com/inclusive-design-in-user-interface-64fa1e29681c.

Link, J. (2021, May 11). *Accessible UI Basics for Users With Visual Impairments*. Built-In. https://builtin.com/design-ux/accessibility-visual-impairments.

Mandal, A. (2019). Types of visual impairment. https://www.news-medical.net/health/Types-of-visual-impairment.aspx

Olofsson, S. (2017). Designing interfaces for the visually impaired. In *Contextual information and analysis of user needs*.

Senjam, S. S. (2021). *Smartphones as assistive technology for visual impairment.* https://doi.org/10.1038/s41433-021-0149

Stephanidis, C. (2001). User Interfaces for All: New perspectives into Human-Computer Interaction. *User Interfaces for All - Concepts, Methods, and Tools*, 3-17.

V Argyropoulos, A., G, S., & Nikolaraizi. (2020). Refreshable braille displays and reading fluency: A pilot study in individuals with blindness. *Springer*.

Watson, L., Watson, L., & Moore, C. (2016, May 27). *Using navigation landmarks - Accessibility in government*. Accessibility in government. https://accessibility.blog.gov.uk/2016/05/27/using-navigation-landmarks/

WCAG 2 Overview | Web Accessibility Initiative (WAI). (n.d.). W3C. https://www.w3.org/WAI/standards-guidelines/wcag/

Blindness and vision impairment. (2021, October 14). WHO | World Health Organization. https://www.who.int/news-room/fact-sheets/detail/blindness-and-visual-impairment

Blindness Statistics. (2019). National Federation of the Blind. https://nfb.org/resources/blindness-statistics

Blind/Visual Impairment: Common Assistive Technologies. (2021, November 13). https://guides.library.illinois.edu/c.php?g=526852&p=3602299

Appendix: Interview Guide

1. Do you depend on any assistive technology while using your smartphone or laptop?

2. What else do you use a smartphone for other than making phone calls? For example: Ordering food, and using social media.

3. Do you face difficulty typing? Could you elaborate on it?

4. How do you answer phone calls?

5. How do you unlock your phone screen?

6. How do you feel about the existing smartphones' brightness and contrast settings?

7. Does your phone allow you to adjust font size and colour?

8. What do you like about your existing phone?

9. If you were to change one thing about your smartphone, what would that be?

10. Are there any additional barriers/experiences with respect to user interfaces that you would like to describe?