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BRIDGING THE VISUAL GAP: USABILITY EVALUATION OF UPI SMARTPHONE APPS FOR USERS WITH VISUAL IMPAIRMENTS

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ABSTRACT

The digital era has ushered in transformative technological advancements that have significantly impacted everyday life, especially for individuals with disabilities. Assistive technologies, such as screen readers and voice-over functions, have empowered visually impaired users to interact with smartphone applications, including digital payment platforms, which play a crucial role in facilitating their financial transactions. However, many of these applications still present usability and accessibility challenges that hinder seamless interaction.

This study evaluates the usability of Unified Payments Interface (UPI)-based mobile payment applications—specifically Google Pay, PhonePe, and Paytm—among visually impaired users in India. A group of fifteen visually impaired participants engaged in structured usability tests, guided by standard accessibility guidelines. The goal was to identify design shortcomings and assess how effectively these applications accommodate the needs of users with visual impairments.

Findings from the study indicate that, although accessibility features are present in these applications, notable issues persist in areas such as screen reader compatibility, inconsistent keyboard navigation, unclear labelling of buttons, and non-intuitive user interface elements. These barriers can create significant friction in the user experience for the visually impaired.

Based on the results, the study offers targeted design recommendations to enhance the accessibility of digital payment applications. These insights aim to support developers, designers, and stakeholders in creating more inclusive digital financial tools, ultimately contributing to greater financial independence and digital inclusion for the visually impaired community.

1.0 INTRODUCTION

According to the World Health Organization (WHO), approximately 16% of the global population lives with some form of disability [1], and nearly 1 billion people suffer from moderate to severe distance vision impairment or blindness [2], [3]. The digital revolution,

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along with the development of assistive technology, has significantly enhanced the independence of individuals with visual impairments by providing greater access to the digital world. Built-in smartphone features such as VoiceOver, TalkBack, and various accessibility-focused applications have enabled visually impaired users to engage more easily with digital devices for their everyday needs [4].

Digital Payment Solutions (DPS) have played a major role in transitioning societies from cash-based systems to cashless, contactless transactions. Traditional payment methods like cash and cheques are no longer sufficient to meet the growing demands of e-commerce and the increasing use of mobile technologies. The COVID-19 pandemic further accelerated the adoption of DPS, particularly those offering contactless transactions [5], [6].

One prominent example is the Unified Payments Interface (UPI), developed by the National Payments Corporation of India (NPCI) [7]. UPI enables simple and accessible peer-to-peer (P2P) cashless transfers using just a smartphone and an Indian bank account. With 4.61 billion transactions processed per month [8], and accounting for 55% of the total volume of digital transactions in 2020–21 [9], UPI has become a cornerstone of India's digital economy and is now being adopted internationally [7]. The Reserve Bank of India (RBI) has also emphasized building a robust payments infrastructure to reduce reliance on cash and foster a cashless economy [10].

The 2016 demonetization, which rendered 86% of India’s currency invalid overnight [11], created a critical need for a unified retail payment system. UPI emerged as the culmination of efforts beginning in 2009, resulting in a secure, scalable digital payment infrastructure [12]. However, the user-facing layer of UPI is managed by Third Party App Providers (TPAPs), who design mobile applications based on NPCI’s guidelines. These apps typically utilize minimalist APIs, granting developers significant control over user interfaces. Unfortunately, the lack of standardization can lead to inconsistent levels of accessibility, particularly for users with disabilities, thus limiting widespread adoption.

To address this issue, a usability study is essential to identify design challenges within these applications. Such a study can also inform broader design principles for digital payment platforms aimed at visually impaired users.

This paper makes the following contributions:

- Analyses accessibility challenges faced by visually impaired users when using digital payment apps.
- Presents a case study evaluating the accessibility of three major UPI-enabled TPAPs: PhonePe, Paytm, and Google Pay.
- Provides actionable assessments and recommendations to enhance accessibility in digital payment applications.
- Suggests design principles based on study findings to improve usability for visually disabled users.

Structure of the Paper:

- Section II: Reviews prior research on assistive technologies and accessibility for visually impaired individuals.
- Section III: Outlines the motivation for conducting the current usability study.
- Section IV: Describes the study's methodology and details the evaluation of the selected UPI apps.
- Section V: Discusses the study results, user experiences, key observations, and design suggestions.
- Section VI: Examines potential limitations and threats to the validity of the study.
- Section VII: Concludes the paper with a summary of findings and implications.

2.0 RELATED WORK

Globally, an estimated 36 million individuals live with visual disabilities [3], and this number continues to rise each day. Although technological advancements have significantly enhanced the quality of life for visually impaired individuals—supporting their education, employment, and daily tasks—many challenges remain, particularly due to the inaccessibility of digital system designs.

Accessibility research, especially within the domain of Human-Computer Interaction (HCI), plays a crucial role in addressing these challenges. As highlighted in [13], the field has seen a notable evolution, underscoring the growing importance of inclusive design practices. A considerable number of usability studies have been conducted to explore and address accessibility barriers faced by visually impaired users [14]–[19].

For example, Darin et al. [20] conducted a usability study evaluating how multimodal interactive virtual environments can enhance learning experiences for visually disabled individuals. The integration of smartphones, mobile applications, and internet technologies has also improved access to digital content, allowing visually impaired users to retrieve information more quickly and independently [21]–[24].

Kim et al. [25] examined how visually impaired users interact with camera-based smartphone applications and proposed design improvements based on their experiences. Similarly, a study in [22] evaluated mobile device accessibility, identifying 68 accessibility issues and offering 28 recommendations to improve the user experience. These issues included challenges with on-screen keyboards and gesture-based navigation, which are often not optimized for visually impaired users.

In response to these challenges, numerous specialized technologies and applications have emerged. Aizpurua et al. [26] emphasized that web accessibility extends beyond compliance with WCAG 2.0 guidelines, advocating for a more holistic and user-centric approach. Additionally, Martiniello et al. [27] conducted a 2019 survey revealing that many visually impaired users have transitioned from traditional assistive devices to mainstream technologies like smartphones and tablets.

Several special-purpose applications have been developed to support visually impaired users in everyday tasks. Examples include:

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- **Aipoly** and **AudioLabels** for object and color recognition,
- **Ultra Magnifier** for magnification,
- **MessagEase Keyboard**, **AccessNote**, and **BrailleTouch** for text input,
- **Braille Audio Reading Download** and **TalkBack** for reading and entertainment,
- **BlindSquare** and **iMove** for navigation.

Studies indicate that such applications are 95.4% useful and 91.1% accessible for users with visual impairments [24].

Although screen readers allow visually impaired individuals to access general-purpose applications such as e-learning platforms, mobile games, YouTube, and Instagram, these apps are often not designed with accessibility in mind. There remains significant room for improvement to make the digital environment more user-friendly and inclusive. Insights from these studies have driven the development of assistive technologies that cater to the specific needs of visually impaired users, enhancing their independence and quality of life [23], [24].

3.0 MOTIVATION

India is home to a significant proportion of the world's visually impaired population, with nearly one-third of all visually disabled individuals residing in the country [28]. During user testing of the Haptic Encoded Language Framework (HELF) [29] with visually impaired participants, it was observed that application designs frequently overlook accessibility considerations. This often creates barriers that prevent visually impaired users from effectively accessing essential digital services.

At the same time, the rise of digital financial transactions, particularly through the Unified Payments Interface (UPI), presents a valuable opportunity to simplify day-to-day financial activities for all users, including those with visual impairments. However, visually impaired individuals have unique needs when interacting with smartphone applications, which must be addressed to ensure an inclusive experience.

Kameswaran et al. [30] highlighted the challenges faced by visually impaired users while navigating smartphone applications. Rapid advancements and increased complexity in interface design often lead to confusion and usability issues for these users. A major concern with UPI-enabled mobile applications is the lack of a standardized interface. Different Third Party App Providers (TPAPs) implement varying designs and levels of accessibility, resulting in inconsistent user experiences across platforms.

To bridge this gap, a user-centred design approach is essential. Applications must be developed with accessibility as a core requirement and should be thoroughly tested and evaluated by visually impaired users themselves [16].

This study is therefore motivated by the need to assess the accessibility of widely-used UPI applications. By identifying and addressing the design challenges faced by visually impaired users, the goal is to enhance their access to digital payment platforms, ultimately contributing to greater financial inclusion and improved quality of life.

4.0 USABILITY EVALUATION

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This section outlines the methodology adopted to conduct the usability study aimed at evaluating the accessibility of digital payment applications for visually impaired users.

A. Digital Payment Applications Selected for Evaluation

To assess the accessibility features of digital payment platforms, the study focused on Unified Payments Interface (UPI)-based applications, given their widespread adoption and convenience in India. The three most popular UPI-enabled digital payment applications—**Google Pay, Paytm**, and **PhonePe**—were selected based on their extensive user base, as illustrated in Fig. 1 [31].

B. Methodology Followed for the Usability Study

The usability study was conducted with **15 visually impaired participants**, aligning with the standard guideline that a sample size of 15 users is generally sufficient to uncover the majority of usability issues in a digital interface [32]. Among these participants:

- **Five** were independent visually impaired volunteers.
- **Ten** were students enrolled in a Computer Training Course at **The Blind Relief Association,** Delhi, India.

All participants were proficient in using smartphones with screen reader tools and had a foundational understanding of UPI-based payment applications. The participant group had a **male-to-female ratio of 2:1,** and most individuals had been visually impaired since birth. Their **ages ranged between 20 and 30 years**, with **9 holding undergraduate degrees and 6 pursuing postgraduate education.**

This study was inspired by methodologies used in previous usability and user experience research [33]–[37]. It employed a combination of **semi-structured interviews** and **usability testing**, conducted over **sessions lasting 4–5 hours**. The interviews were designed to capture relevant demographic data, participants' familiarity with smartphones and digital payments, and their technical proficiency.

Participants were asked to perform a series of common tasks within the UPI applications, including:

- Changing the UPI PIN
- Recharging a mobile number
- Sending money to another mobile number
- Transferring funds to a bank account
- Redeeming a reward

Each session was video recorded to document navigation behaviour and user interactions, while researchers observed and took detailed notes. To ensure privacy, recordings were paused during sensitive inputs such as password entry and private data handling.

C. Evaluation Criteria

The accessibility evaluation was structured around three primary criteria—**Perceivable, Actionable/Navigable,** and **Comprehensible**—which are essential for designing inclusive digital interfaces:

- **Perceivable:** Assessed the ability of users to perceive information via non-visual means such as audio feedback or haptics.
- **Actionable/Navigable**: Evaluated how easily users could interact with and navigate through app elements like buttons, links, and menus.
- **Comprehensible:** Measured the clarity and interpretability of app content, language, and instructions for visually impaired users.

This structured evaluation approach aimed to identify key accessibility challenges within the selected UPI applications. The findings are intended to guide the development of more inclusive, user-friendly, and accessible digital payment systems for the visually impaired community.

To minimize methodological bias and ensure reliability, the study incorporated several best practices recommended by Shade [38].

5.0 OBSERVATIONS AND RESULTS

This section presents the findings from our usability study, beginning with participants' interaction experiences with the three selected UPI mobile applications. A categorical evaluation is then used to score each application's accessibility, followed by recommendations to improve the design of digital payment systems for visually impaired users.

A. USER INTERACTION EXPERIENCES

This subsection details the accessibility observations and issues reported by participants during usability testing of the three UPI applications: **Google Pay, PhonePe, and Paytm**. Participants are referred to as P1 through P6 for anonymity.

1) Google Pay

Google Pay emerged as the most preferred UPI application among participants. Many participants reported using it regularly and found it generally accessible, with minimal issues. According to P2:

“Google Pay has been very easy to use ever since I started using payment mobile applications. Rarely have I faced any major accessibility issue, and even when minor issues occurred, Google usually fixed them in time.”

Despite its popularity, our usability evaluation uncovered several accessibility challenges that could be improved to enhance the experience for visually impaired users.

One significant issue occurred during **Task 1** (Reconnecting bank details after re-login). Participant P3, using a dual SIM phone, encountered difficulty when the app defaulted to the

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wrong SIM for UPI verification. The app did not provide a clear error message, leading to confusion. As P3 described:

"I tried multiple times to connect my bank account, and it kept failing. I couldn't understand the issue because the error wasn't clear. I eventually guessed that I was using the wrong phone number."

In **Task 2** (Changing the UPI PIN), participants P3, P5, and P6 struggled to locate the relevant option. The UPI PIN change setting was hidden under the secondary "More" (⋮) menu within the Payment Methods section. According to P5:

"It was difficult to find this option. I had to explore several menus and submenus. It would be more intuitive if this setting was directly available on the Payment Methods page."

During **Task 4** (Receiving UPI payment via QR code), one participant suggested that an **in-app audio alert or voice notification** indicating a successful transaction would be helpful for users actively navigating the app.

In **Task 6** (Redeeming a reward/scratch card), all participants encountered difficulties. The screen reader announced the reward area as "SCRATCH HERE," which led users to believe they had to physically scratch the screen. However, the correct action was to simply double-tap the area, as demonstrated later by researchers. Participant P2 commented:

"I'm visually impaired—how would I know where to scratch without seeing? Google should consider a better approach for this. Maybe change the screen reader text to something like 'CLICK TO SCRATCH'."

After learning this functionality, participants agreed that while the feature was technically accessible, the **terminology and guidance** could be improved to prevent confusion.

Aside from the issues above, participants were largely able to complete all other assigned tasks on Google Pay without major difficulties. The interface was generally considered intuitive and screen-reader friendly, with users expressing overall comfort navigating the app.

2) Paytm

During the usability evaluation of the **Paytm UPI** application, participants encountered a range of accessibility challenges that made navigation and task execution difficult for visually impaired users.

Login Experience:

From the outset, participants reported confusion during the login process. For instance, P2 highlighted that the screen reader announced a confusing prompt:

"Enter Password 15 character. Input Mobile Number."

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This misleading instruction caused uncertainty about whether the user was supposed to enter a password or a mobile number. As P2 explained:

"I'm a fairly experienced smartphone user, so I could guess it was asking for a mobile number based on the numeric keypad. But for a beginner who is visually impaired, this would be really confusing without assistance or multiple attempts."

Task 2 – Changing the UPI PIN:

Similar to the experience with Google Pay, almost all participants faced difficulty locating the option to change the UPI PIN. The setting was buried within several poorly labeled and disorganized menus. Participant P3 expressed frustration:

"The menu structure is very complex, and the descriptions aren't clear. I needed a hint from the researcher—it would have taken me forever to find such a basic setting."

Even participants proficient with screen readers struggled. P2 noted:

"Finding this option felt like a fluke. The menu I accessed said 'change password,' which I assumed was for my Paytm account, not the UPI PIN."

Interestingly, different participants found the same setting in different locations. P2 accessed the UPI PIN change through the Security and Privacy menu under Profile Settings, while P1 found it under Payment Settings > UPI and Linked Bank Accounts. However, in both cases, the menu labels lacked any indication that they housed the UPI PIN change option. As P1 stated:

"I had opened the Payment Settings menu twice but backed out both times because nothing in the descriptions suggested it had the UPI PIN option."

Finding Help & Support:

P1 also struggled to locate the Help and Support section. Despite scrolling past the correct menu item multiple times, they did not recognize it due to the name "24×7 Help and Support," which was partially read out as a number by the screen reader. Reflecting on this, P1 said:

"I got confused when the screen reader started reading out numbers. Only after a hint did I listen more carefully and find the correct option."

Task 6 – Redeeming a Reward/Scratch Card:

When attempting to access and redeem rewards, participants encountered significant issues with unlabelled graphical elements. The screen reader announced the reward card as:

"Zero Graphic,"

indicating a lack of alternative text. As P1 remarked:

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"It says ZERO GRAPHIC—what am I supposed to do with that? I only found the reward details after clicking through. Otherwise, I would've assumed it was just a banner ad."

Overall Navigation and Interface Complexity:

The overwhelming consensus among participants was that **Paytm's interface is not well-suited for visually impaired users.** The abundance of options on the home screen creates an exhausting experience when using screen readers, which process information linearly. As P2 and P6 described:

"Using Paytm as a visually impaired person isn't pleasant. The number of menus, buttons, and sections feels endless. It's overwhelming and not screen reader-friendly."

Based on user feedback, it became clear that Paytm's accessibility issues stem from its attempt to offer too many features in a single app without a logical, hierarchical menu structure. This design choice results in a cluttered interface that is difficult to navigate, especially for those relying on assistive technology.

3) PhonePe

During the evaluation of the **PhonePe UPI** application, all participants experienced significant accessibility challenges, primarily due to **unlabelled** buttons and a complex, poorly structured interface. These issues consistently hindered navigation and usability for visually impaired users across multiple tasks.

Task 2 – Changing the UPI PIN:

All users struggled to locate the side navigation menu, which is critical for accessing the UPI settings. The menu button itself was **unlabelled**, making it invisible to screen readers. Consequently, participants required assistance from the researchers to identify and activate the button (see Fig. 4.1 & 4.2).

Participant P1, who had previously used **PhonePe,** expressed frustration with the app's declining accessibility:

"I've been trying to change the UPI PIN for the last 10 minutes. The older version of PhonePe was more accessible. If it weren't for this test, I would've just switched apps."

Similarly, P2 managed to locate the option independently but had to guess each button's function by interacting with them manually:

"I don't use PhonePe, so the layout is unfamiliar. There are many unlabelled buttons—I've memorized where they are now, but that won't work for everyone. Many visually impaired users won't be able to navigate this easily. The menu structure is also very poorly organized."

P2 also identified an **auto-scrolling carousel ad** on the home page, which is not screen reader-friendly:

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"I can tell it's a carousel because I use an app that notifies me of such elements. But others might get confused since there's no audio cue or label."

Task 3 – Performing a Mobile Recharge:

During this task, P1 encountered multiple barriers. After selecting an operator and circle for their phone number, an **error modal appeared without an exit button**, effectively locking them out of the interface. To proceed, the participant had to force-close the app through the task manager and restart the process.

Additionally, the participant struggled to understand the navigation required to select a recharge plan and needed assistance to complete the task.

Task 4 – Receiving a UPI Payment via QR Code:

Participants again struggled to find the QR code associated with their profile due to the **complex menu structure and unlabelled profile button**. This made it difficult to locate the relevant section without external help.

Help & Support Section:

Most participants were unable to find the Help section, even though the button was present on the home screen. The issue stemmed from the **button being unlabelled**, preventing it from being detected by screen readers. Only P2 managed to locate the section unassisted, having stumbled upon the button previously and memorized its position:

"I've used a lot of inaccessible apps, so I've developed a habit of memorizing button locations. That's how I found the Help and Support section, but that's not feasible for everyone."

Task 5 – Making a UPI Payment:

Locating the **Scan QR Code** button was another major challenge, again due to **missing labels**. Most participants had to explore every menu or rely on researcher guidance to access the scanner.

Even when using a UPI ID to make a payment, the interface posed difficulties. P2 noted that the **tabbed menu** separating "Bank Accounts" and "UPI ID" was not properly announced as interactive elements by the screen reader:

"I guessed these were tabbed menus because I've used similar designs before, but there was no indication that they were clickable. Many users wouldn't know how to proceed."

Task 6 – Redeeming a Reward/Scratch Card:

On the Rewards page, all participants struggled due to the presence of **unlabelled, auto-scrolling carousel ads.** These elements disrupted navigation and confused users attempting to redeem rewards.

Summary:

Participants described the PhonePe app as **frustrating and inaccessible**, mainly due to:

- Unlabelled buttons throughout the app
- Poorly structured and inconsistent menu layouts
- Inaccessible modal dialogs with no exit option
- Lack of visual cues or alternative text for screen readers
- Over-reliance on memory to navigate the interface

These design flaws significantly hindered usability for visually impaired users and created a disjointed, error-prone experience—particularly for those unfamiliar with the app or new to screen reader technology.

B. Categorical Analysis

This study evaluates the accessibility of three major UPI applications based on the principles outlined by the **Web Content Accessibility Guidelines (WCAG)** [39], [40], published by the **World Wide Web Consortium (W3C)** under its **Web Accessibility Initiative (WAI).** According to WCAG, user interface components and content must be designed to be **Perceivable, Operable, and Understandable**—three key pillars that form the foundation of accessible digital experiences.

The evaluation conducted in this study aligns with these three categories, as described below:

1) Perceivable

A perceivable interface ensures that users can recognize and process information effectively. Key aspects of perceivability include:

- Providing **text alternatives** for non-text elements (e.g., images, icons, graphical content)
- Maintaining a **meaningful content sequence**
- Avoiding reliance on **sensory characteristics** (e.g., color or sound alone)
- Identifying the **purpose of input fields**
- Offering **audio controls** for any automatically playing media
- Avoiding the use of **text embedded within images**

Failure to implement these features can hinder visually impaired users from understanding and interacting with interface content.

2) Operable

Operability refers to the ability of users to interact with and navigate the application using various input methods, particularly screen readers and keyboard navigation. Operable interfaces must:

- Allow all components to be **accessed via keyboard or screen reader cursor**
- Provide controls to **pause, stop, or hide** blinking, auto-scrolling, or auto-updating content

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- Support **intuitive gestures** and navigational mechanisms for mobile users, especially those dependent on assistive technologies

3) Understandable

An understandable interface presents information and functionality in a way that is predictable and easy to comprehend. This includes:

- Ensuring **clear language usage** and identifying the **default language**
- Providing **context-sensitive help** and error **identification**
- Facilitating **predictable navigation**
- Using clear **instructions for input fields**
- Preventing input errors through appropriate design
- Ensuring **readability** of content and **visibility of critical elements** without excessive scrolling
- Distinguishing actionable elements from non-actionable ones
- **Grouping** components with similar functions

Evaluation Methodology

To quantify the accessibility of the three UPI applications, a **categorical scoring system** was developed. Each app was evaluated under multiple parameters within the three main WCAG categories, and scores were assigned out of five for each parameter based on the **frequency and severity of issues** encountered by participants during task performance.

For instance, **PhonePe** received a low score (1 out of 5) under the "meaningful sequence" parameter due to the significant number of issues related to illogical content flow and poor screen reader navigation, as observed during the user testing phase.

These scores were compiled into **Table 2**, and a graphical representation is provided in **Figure 5**, which illustrates the average score for each app across the three accessibility categories.

Summary of Findings

The graphical analysis clearly indicates that:

- **Google Pay** demonstrates relatively stronger adherence to WCAG principles, offering better accessibility features for visually impaired users.
- **Paytm follows**, but its interface complexity and inconsistent menu hierarchy reduce its accessibility performance.
- **PhonePe**, however, was rated the lowest across nearly all categories, primarily due to unlabelled buttons, poor navigational structure, and a lack of support for screen readers.

These results reinforce the importance of designing mobile financial applications with inclusive practices that align with recognized accessibility standards to ensure equitable digital participation for all users, especially those with visual impairments.

C. Implications for the Design of Digital Payment Applications

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Based on the findings of this study, it is evident that several design shortcomings in digital payment applications can significantly hinder accessibility for visually impaired users. To address these limitations and enhance the overall user experience, the following recommendations are proposed for incorporation into the design of all digital payment mobile applications. These design considerations aim to foster greater inclusivity and ensure equal usability for all users globally:

1) Clear Identification of Errors and Warnings

- **Recommendation:** Applications should provide distinct and accessible error and warning indicators when users input incorrect or incomplete information. This can include a combination of color cues, icons, and descriptive audio messages.
- **Rationale:** Visually impaired users depend on auditory and tactile feedback. Clear alerts ensure users can identify issues promptly and take corrective action, thereby reducing frustration and improving usability.

2) Enhanced Discoverability of Key Options

- **Recommendation:** Relocate frequently used functions—such as "Change UPI PIN"—to more prominent positions on the main interface instead of burying them within deep or hidden menus.
- **Rationale:** Important features should be easily accessible to screen reader users to improve navigational efficiency and reduce cognitive load during task execution.

3) Integration of Sound Alerts and Voice Announcements

- **Recommendation:** Implement auditory alerts or voice notifications for key app events such as incoming payment requests, completed transactions, and new rewards.
- **Rationale:** These audio cues keep users informed in real-time and support transaction management without relying on visual prompts.

4) Improved Clarity on Coupons, Rewards & Scratch Cards

- **Recommendation:** Clearly identify interactive reward components such as scratch cards as buttons, along with brief instructional prompts.
- **Rationale:** Due to their visual design, visually impaired users may not recognize these elements as actionable. Clear labelling enhances usability and user engagement with rewards features.

5) Use of Descriptive Menu Labels

- **Recommendation:** Provide intuitive and descriptive names for menu options (e.g., simplify "24x7 Help & Support" to "Help & Support").
- **Rationale:** Better labelling aids screen reader interpretation, improving menu comprehension and helping users locate features quickly.

6) Text Alternatives for Graphical Elements

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- **Recommendation:** Add alt-text or descriptive labels for all visual components, including icons, carousels, and unlabelled images.
- **Rationale:** Screen readers rely on textual descriptions to interpret visual elements, enabling users to understand the function and context of graphical content.

7) Reduction of UI Clutter

- **Recommendation:** Streamline the user interface by minimizing unnecessary elements and organizing content in a clean, linear structure suitable for screen reader navigation.
- **Rationale:** A simplified layout improves accessibility by allowing users to focus on key tasks without distraction or confusion.

8) Provision of Context-Sensitive Help

- **Recommendation:** Incorporate in-line assistance or tooltips that provide guidance based on the user's current location or task within the app.
- **Rationale:** Tailored help empowers users to proceed independently without losing their place or requiring external support.

9) Proper Labelling of Input Fields

- **Recommendation:** Clearly label all form inputs (e.g., phone number, password, OTP) on login and sign-up screens.
- **Rationale:** Accurate labelling ensures that screen readers can correctly announce each input field, facilitating accurate data entry and enhancing security.

10) Simplified Menu Hierarchy

- **Recommendation:** Redesign nested menus to follow a simpler, flatter structure with logical grouping of options.
- **Rationale:** A well-organized menu system improves orientation and reduces navigation time for visually impaired users, allowing them to reach desired features more easily.

CONCLUSION

By adopting these accessibility-focused design improvements, digital payment applications can significantly enhance their usability for visually impaired individuals. These recommendations promote inclusivity and support the creation of user-friendly, equitable digital services. App developers can draw valuable insights from this research to inform accessibility strategies, ultimately contributing to a more inclusive digital ecosystem for all.

6.0 THREATS TO VALIDITY

This section outlines the potential limitations that may affect the validity of the results obtained from evaluating the applications in a controlled environment with selected participants.

A. Threats to Internal Validity

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The internal validity of the study could have been influenced by the following factors related to the experimental conditions:

1. Participant Selection Bias

- **Limitation:** All participants were recruited from a single organization, which may limit the representativeness of the findings.
- **Mitigation:** To enhance internal validity, future studies should include a larger and more diverse sample drawn from multiple organizations and demographic backgrounds.

2. Time Constraints During Testing

- **Limitation:** The duration of the testing sessions was limited, yet participants were required to complete a comprehensive set of tasks. This constraint may have influenced performance and behaviours.
- **Mitigation:** Allocating more time for task completion in future studies would allow participants to explore the applications more thoroughly and provide more reliable results.

B. Threats to External Validity

The generalizability of the study's findings may be affected by the following:

1. Prior User Experience

- **Limitation:** Several participants had prior experience using UPI-based digital payment applications, which may have influenced their ability to navigate the interface and locate certain features.
- **Impact:** This familiarity could result in an overestimation of the application's usability and may not accurately reflect the experience of new or less-experienced users.
- **Mitigation:** Including participants with varying levels of familiarity with digital payment apps would improve the external validity and provide a more balanced perspective.

7.0 CONCLUSION

Visually impaired individuals have unique needs when interacting with smartphones, especially when using essential services such as digital payment applications. These applications play a critical role in supporting the daily financial transactions of visually disabled users. However, their usability can present significant challenges due to design and accessibility limitations.

This study aimed to identify the specific barriers faced by visually impaired users while navigating digital payment mobile applications and to propose actionable design improvements. Through a usability evaluation of three widely used digital payment apps in India—Google Pay, PhonePe, and Paytm—it was observed that, although these platforms

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include some accessibility features, there remain numerous design flaws that hinder seamless user experiences for visually impaired individuals.

The findings underscore the need for more inclusive and user-friendly design practices. Detailed recommendations have been presented to address key accessibility issues such as unlabelled buttons, complex menu hierarchies, and a lack of feedback cues. These insights aim to guide developers and designers in creating more accessible and efficient mobile payment solutions.

Ultimately, this research highlights the importance of adopting a user-centred design approach to ensure that digital financial tools are inclusive for all users, including those with visual impairments. It is anticipated that the outcomes of this study will inform the development of more accessible digital payment applications, not only in India but globally, fostering greater digital inclusion and independence for the visually impaired community.

APPENDIX

User Screener Questions

- **Name of the User**
- **Age of the User**
- **Type of Visual Impairment (Multiple Choice)**
  - Complete Blindness
  - Partial Blindness
  - MDVI (Multiple Disability Visual Impairment)
  - Night Blindness
- **Duration of Visual Impairment (in years)**
- **Proficiency in Using Smartphone Accessibility Features (Scale: 1–5)**
- **Proficiency in Using UPI Payment Applications (Scale: 1–5)**
- **Educational Background**
- **Current Employment Status**
- **Occupation Domain**

Semi-Structured Interview Questions

A. Tasks Conducted Using UPI Mobile Applications

1. Login/Signup

- Ask the participant to log in or sign up on the assigned mobile payment application (Paytm, Google Pay, or PhonePe) using their own device.

2. Navigate to Change UPI PIN Setting

- Ask the participant to locate and open the option to change their UPI PIN.

3. Mobile Recharge

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- Ask the participant to navigate through the process of recharging their mobile number (without initiating the actual transaction).

4. UPI Payment – Receiving Money

- Step 1: Ask the participant to display their QR code for receiving a payment.
- Step 2: Researcher initiates a payment to the participant.
- Step 3: Ask the participant to verify and confirm receipt of the payment.

5. UPI Payment – Sending Money

- Send ₹3 to a given mobile number via UPI.
- Send ₹3 to a given bank account via UPI.
- Send ₹4 to a given mobile number by scanning a QR code.

(Participants may return the amounts received earlier for these tasks.)

6. Redeem a Reward

- Ask the participant to locate and redeem a reward (e.g., a scratch card).

7. Help & Support Section

- Ask the participant to navigate to the "Help & Support" section of the application.

B. Feedback Questions

- How would you rate the ease of navigation throughout the app? (Scale: 1–5)
- How accurate and clear was the content and information provided by the app? (Scale: 1–5)
- How understandable and user-friendly was the content? (Scale: 1–5)
- How descriptive was the graphical content with respect to accessibility? (Scale: 1–5)
- What issues (if any) did you encounter during testing?
- Do you have any suggestions to improve the app's accessibility?

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