# A Comparison of Mobile Money-Transfer UIs for Non-Literate and Semi-Literate Users

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**ABSTRACT**
Due to the increasing penetration of mobile phones even into poor communities, mobile payment schemes could bring formal financial services to the "unbanked." However, because poverty for the most part also correlates with low levels of formal education, there are questions as to whether electronic access to complex financial services is enough to bridge the gap, and if so, what sort of UI is best.

In this paper, we present two studies that provide preliminary answers to these questions. We first investigated the usability of existing mobile payment services, through an ethnographic study involving 90 subjects in India, Kenya, the Philippines and South Africa. This was followed by a usability study with another 58 subjects in India, in which we compared non-literate and semi-literate subjects on three systems: text-based, spoken dialog (without text), and rich multimedia (also without text). Results confirm that non-text designs are strongly preferred over text-based designs and that while task-completion rates are better for the rich multimedia UI, speed is faster and less assistance is required on the spoken-dialog system.

**Author Keywords**
Mobile banking, mobile interfaces, illiteracy.

**ACM Classification Keywords**
**User Studies,** Ethnography, Usability Testing and Evaluation, User Interface Design

## INTRODUCTION

There were over 3.3 billion phone users in 2007 [6], and close to 60% of subscribers live in developing countries [37]. Thus, many entities with a global development focus have turned to the mobile phone as a potential platform for delivering development services [15].


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Among this activity is an interest in delivering financial services to the "unbanked" via mobile phone. The unbanked are people without formal bank accounts who operate in a cash economy; they are limited in their ability to take out loans, maintain savings, or make remote payments, and these constraints can inhibit their economic opportunities. These obstacles could be partially overcome if financial services were delivered over mobile phone, since across the developing world, there are more people with mobile phones than with bank accounts [30]. In some countries, mobile payment services are already available and increasingly popular, and the development community is hoping to capitalize on these services to bring financial services to the unbanked.

Previous research shows, however, that non-literate populations avoid complex functions, and primarily use phones for synchronous voice communication [12]. This brings us to the question of how we can design mobile phone interfaces such that non-literate and semi-literate users can use financial services, if they were provided. Indeed, mobile phones present a number of channels for interaction, including SMS (Short Message Service, or "text messaging"), voice, and data, and each affords different user interfaces, which in turn require different skills from the user, such as literacy, understanding of hierarchical menus, quick decision making, and appropriate cognitive models. These skills exist to varying degrees among low-income populations with little exposure to digital technology, and so much remains unknown about how they would respond to different UIs.

In this paper, we present two new studies that shed some light on whether mobile-phone-based access to complex financial services is enough to reach the unbanked, and if so, what sort of UI is best. In the first study, an ethnographic exploration involving 90 subjects and 100 hours of interviews in India, Kenya, the Philippines and South Africa shows how non-literate and semi-literate populations use (or don't use) existing mobile payment schemes. In the second, a formal usability study with

another 58 subjects in India compared three systems with the same menu structure: text-based, spoken-dialog (without text), and rich multimedia (also without text).

## RELATED WORK

There is fascinating work in fields such as literary history and cognitive science concerning mental traits associated with illiteracy (see, for example, [17] and [8]). Much of this research provides interesting explanations for cognitive patterns among non-literate adults, but it tends to be either based on circumstantial evidence or conducted outside of the context of design. More directly relevant to our work is research in the following: UIs for non-literate and semi-literate users; mobile phones applied to poor communities; and UI issues for mobile banking and banking in the developing world.

### UIs for Low-Literacy Users

Because for the most part illiteracy correlates strongly with poverty, non-literate users are very different from the target users of typical UI designs [13].

Most previous work with non-literate users focuses on the mechanics of the interface, and on PCs or PDAs. Many researchers have recognized the value of imagery, and have advocated extensive use of graphics [16, 17, 23, 24, 27, 28]. More specifically, it appears that static hand-drawn representations are better understood than photographs or icons [23]. Voice instructions and audio annotations are also powerful, and much of the interesting work in this area focuses on the interplay between graphics and audio to generate a usable interface [24]. Some authors note that the use of numbers is acceptable, as many non-literate people can read numerical digits [24, 27, 28].

Other work has focused on ultra-simple navigation as a design goal [16], or on removing anxieties about technology use. For example, looping video clips which include dramatizations of the overall usage scenario have been found to be effective in reducing barriers to usage by first-time users [22]. Voice recordings of "help" information have also been shown to be valuable [24].

These principles have been applied to application domains such as job-information systems [24], health-information dissemination [23], and microfinance [27, 28].

Apart from work that focuses on PCs and PDAs, there is some amount of research that looks at mobile UIs for low-literacy users. Researchers have recognized the value of voice feedback [26, 29] and speech interfaces [9, 29, 33]. Others have questioned suitability of menu-based navigation for novice users [20] and have discussed designs that advocate fewer menus and dedicated buttons for this target group [21]. Again there is work that looks beyond the UI at coping mechanisms of illiterate and semi-literate users when confronted with traditional mobile interfaces [10, 12].

### Mobiles for Poor Communities

The phenomenal market penetration of the mobile phone extends even into some of the world's most impoverished regions. Although it would be a mistake to overestimate its penetration in poor communities, in those areas that have mobile phone service, it's safe to say that many of the (comparatively) wealthier households own mobiles. As a result, there has been an explosion of interest in mobile phones and how they can contribute to socio-economic development, and we point readers to the twenty articles recently selected by the GSMA Development Fund [5]. Among the papers cited are those that highlight direct economic benefits to microentrepreneurs, methods of remote money transfer, and entire businesses based on selling talk time directly to neighbors.

### Banking Interfaces in the Developing World

A few studies have examined mobile-banking experiences, without design recommendations. For example, one study notes that since physically wrapping digital money is difficult, gift-giving rituals may not translate to mobile money transfers [34]. A group from Nokia cautions against the metaphor of the cell phone as a digital wallet or purse, because owners have different mental associations and behaviors for mobiles [11].

Another set of work has examined banking interfaces for low-literacy users, but almost all of this is not on mobile phones, but rather for automatic teller machines (ATMs). Two studies propose an icon-based approach for ATMs [19, 35]. Another study looks at attitudes in literate and semi-literate bank-account holders towards ATMs and alternative ATM interfaces (speech-based and icon-based) [36]. Overall, groups showed a tendency to prefer icon-based alternative ATM interface over the alternatives. Evaluations of a pilot trial by one large bank in India make various recommendations for ATMs for low-literacy users: avoid use of text altogether; loop voice instructions in simple, slow vernacular; provide biometric authentication; use consistent visual cues [25].

The work presented in this paper builds on these three streams of research. The complex interrelationships among UI, form factor, and banking as a domain, raise new questions that have not been addressed before to the best of our knowledge, and this paper contributes novel insight both about how existing users interact with mobile-banking services, as well as how mobile-banking UIs could be designed better for non-literate and semi-literate users.

## ETHNOGRAPHY OF CURRENT USERS

To better understand the key challenges of designing mobile-banking interfaces for non-literate and semi-literate users, we first investigated the current situation among existing systems, users, and potential users.

### Mobile Banking Services in Developing Countries

Mobile banking in developing countries is still restricted to a few geographies, largely because of strict banking regulations and large populations of the unbanked. In the

developed world, most of what is billed as mobile banking is simply online banking for regular bank customers extended to high-end mobile phones via data connectivity. In the developing world, however, mobile-banking services have had to find workarounds to enable transfer of funds, as many of the intended customers do not have bank accounts. Doing this while conforming to or sidestepping regulatory policies is a challenge and so only a handful of developing countries currently have established mobile-banking services. Among them are the Philippines, Kenya, South Africa, and India, where we conducted our ethnography.

We studied five mobile banking services – Globe Telecom's GCash in the Philippines, Safaricom's M-PESA and Equity Bank in Kenya, WIZZIT in South Africa, and Eko in India. Each of the services had a different paradigm for mobile banking. Kenya's M-PESA system, for example, permits direct electronic transfer of money from one mobile phone number to another, with cash deposits and withdrawals made at corner shops that sell pre-paid mobile-phone credits [32]. WIZZIT in South Africa, on the other hand, moves money from one bank account to another. The account is linked with the subscriber's mobile phone, as well as, to a debit card. Bank branches are used for cash deposits and ATMs are used for cash withdrawals.

More relevant to our study, however, is that they also have different UIs for their mobile banking services, despite all being text-based.

*GCash's (Philippines) and Safaricom's M-PESA (Kenya) menu-based SIM Toolkit UI :* The SIM Toolkit is a menu-driven service where transactions are conducted by selecting options that appear on the mobile phone's display, organized as hierarchical menu options. Users use 'up' 'down' keys on the keypad to select between options on the menu. Receipts to confirm transactions are received by SMS. At the time of our study, the menu of GCash was available only in English and of M-PESA in English and Kiswahili. The service needs to be activated on any given handset, in the case of GCash by sending a text to a GCash service number or through the menu found on the SIM; and in the case of M-PESA by an M-PESA agent (usually local talk-time vendors of Safaricom) [32]. The interaction is detailed in GCash [4] and M-PESA [3] documentation.

*Equity's single-session SMS UI (Kenya):* Subscribers input keywords in the correct syntax as required by the service and send it as a single SMS message to a specific number for carrying out a transaction. Receipts to confirm transactions are received by SMS. This service is available on any handset and does not require explicit activation. The interaction is detailed in Equity's documentation [2].

*WIZZIT's menu-based USSD UI (South Africa):* Transactions are initiated through a USSD short-code entered in a specific syntax including a combination of digits and symbols ("*" at the beginning and "#" at the end). On sending this request, a menu appears in English on the customer's mobile phone, each of which requires entry of additional digits and symbols to choose options [7]. Confirmation receipts are received by SMS. This service is available on any handset without explicit activation.

*Eko's single-session USSD UI (India):* Transactions are initiated through a single-session USSD short-code entered in a specific syntax. The syntax involves the symbols "*" and "#" interleaved with numbers representing phone number, personal identification number (PIN), and amount to be transferred [1]. Confirmation receipts are received by SMS. This service is available on any handset without explicit activation.

Our study did not include WAP-enabled mobile banking services. Even at locations where this service exists, it does not yet appear to have trickled down to the illiterate populations that we were interested in. Also, except in a handful of cases in South Africa and Kenya, our subjects mostly owned basic, black-and-white phones without data functionality. Fancier phones are penetrating further every week, but at the time of our study, they were still rare.

### Methodology for Ethnography

We conducted a total of 90 interviews and qualitative user studies: 26 in New Delhi and Bangalore, India, 11 in Nairobi, Kenya, 30 in Bohol, Philippines, and 23 in Cape Town and Globersdale, South Africa. (Variations in number are due in part to the complexity of identifying customers with the characteristics we were seeking.) Our hope was that by investigating most of the developing geographies with active mobile payment schemes, we could get a better overall sense for the recurring issues.

Our subjects had three common background traits: (1) functional illiteracy or semi-literacy but partial numeracy; (2) low levels of formal education (highest education attained being schooling up to the eighth grade of the K-12 education system or its equivalent across the four countries); (3) zero experience with personal computers.

Apart from these commonalities, we looked for varying degrees of experience with using mobile phones: (a) those who did not use or own a mobile phone; (b) those who owned or used mobile phones but did not use any kind of mobile-banking systems; and (c) those who used mobile banking systems. 40 of our subjects were in the first category, 34 in the second and 16 in the third. These traits make them an ideal user population with which to explore our ideas with regards to creating a mobile phone UI suited for non-literate and semi-literate populations.

It was not easy to find subjects with the traits we were looking for because currently, there are still very few non-literate users of mobile banking services. (In fact, the motivation for our effort is to increase the number of non-literate users who can benefit from banking services.) Thus, to identify subjects with these characteristics, we worked with intermediary organizations that were most likely to be in contact with them. In order to reduce sampling biases based on the nature of the organization, we worked with

for-profit corporations running the mobile-banking services, as well as with non-profit organizations working with poor populations. This is still far from having randomized samples at an individual level, and the appropriate cautions about generalizing from our results apply.

There were some commonalities across all locations that were not intentionally chosen, but nevertheless correlated with our target population. Among the key commonalities, across all four locations, our users strongly and positively associated the English language (which they did not speak for the most part) with wealth and prestige. This was due to a combination of mindset inherited from colonial history, as well as the modern-day fact of greater economic opportunities available to English speakers. Also for the most part, all of our subjects were very open with respect to illiteracy, attaching no shame to the inability to read; this is unlike illiterate individuals in developed countries who often hide illiteracy. Our subjects were typically domestic workers and daily wage laborers like plumbers, carpenters, construction workers, mechanics, vegetable vendors, weavers, farm hands, fishermen, drivers, etc. Household income ranged from USD 20 – USD 200 per month.

Naturally, differences also exist across geographies. The subjects' primary languages were Kannada, Hindi and Tamil in India, Tagalog in Philippines, Afrikaans, Xhosa and Zulu in South Africa and Kiswahili in Kenya. Relevant to our study, all but the Indian languages can be written in the same Latin alphabet that is standard on mobile phones throughout the world. Some of our subjects had television sets, music players and gas burners, but these were not owned by all households. A few had seen computers in person (but again, none had ever used them).

The interviews were one-on-one, open-ended conversations that lasted for at least an hour. Questions and discussion themes included basic demographic information, access and use of financial services, and access and use of mobile phones. The study involved over 100 hours spent in the field. We visited individuals at their homes in order to talk to our subjects in a comfortable environment, and to observe their living environments. We also conducted interviews at mobile banking agent locations where transactions took place.

We conducted qualitative user studies with our subjects for the locally available mobile banking service in which they were given a set of tasks to perform both on their own handsets and on mobile phones provided by us (in order to determine how much of their usage was by rote memorization). These tasks included…

- Dialing a phone number to call a friend.
- Writing a short SMS text message to a friend.
- Depositing a small amount to their account on their own phone.
- Transferring a small amount to a relative from their own phone.
- Diagramming how they perceived the menu structure (for geographies with menu-based UIs).
- Performing the first two tasks above with a phone supplied to the subject (different in model from theirs).

All users were compensated for their time, at the end of the study. We consulted the intermediary organizations to establish the right mode and amount. Participants without mobile phones were given gift cards for local stores and those with mobile phones were given talk-time cards roughly equivalent to half a daily wage.

**Observations**

The observations from these interviews relevant to this particular study can be divided into two broad categories:

*Phone Usage*

The mobile phone handsets that our subjects used ranged from basic, black-and-white, second-hand purchases costing USD 12 (common in India and Philippines) to brand new purchases with camera and color screen that cost USD 150 (occasionally seen in Kenya and South Africa). We found high usage of texting in the Philippines, especially among young, semi-literate users with education up to eighth grade (even 100 texts per day), to no usage of texting in Kenya, South Africa, and India. There was strong preference for voice calls in Kenya [32] and India [31], and for texting in Philippines – number of voice calls ranged from 5 calls (India, Kenya, and South Africa) to no calls per day (Philippines). Sharing of phones among family members and friends was common. Overall, the kind of phone usage depended on factors such as age, literacy, and pricing strategy. Older users, who mostly were less literate, tended to use their mobile phones only for voice calls. In the Philippines, where a one-minute call was ~7 times more expensive than texting, we saw strong preference for the latter.

Out of the 90 subjects, 16 users had experience with mobile banking. They used it mainly for the purpose of remittances to friends and family (Kenya, Philippines), and in some cases, paying for talk time (South Africa). Services such as balance enquiry were also used, but other services such as bill payments had never been used by any of our subjects.

Among the 74 non-users of mobile banking services, 59 people expressed money transfer as a frequent need, which they accomplished through a host of informal and formal channels, involving personal visits, friends and family, pawn shop chains, post office transfer service, courier, bus drivers, etc. [14].

*Usability Barriers*

There were a number of challenges encountered by our subjects in interacting with the mobile banking services and navigating through mobile phones in general:

**Hierarchical navigation:** Of the total 90 subjects, 56 subjects were initially unable to understand or navigate hierarchical menus as they currently exist, even for simple tasks such as calling back a number from which a missed

call was received. 40 of these were non-users of mobile phones and 16 were existing phone users. Users instead simply dialed each number from scratch each time.

Diagrams of the perceived menu hierarchy for a specific task, as drawn by semi-literate users, are shown in Figure 1 (for "send a message to a friend in the phone book then call another friend"). It seems clear that few have an abstract hierarchical model in mind. Many who were able to perform the tasks on their own handsets could not accomplish them on other handsets. These observations are consistent with earlier work that mentions challenges representing tree structures among literate, but novice, users of information systems. [38].


**Figure 1. Diagrams produced by semi-literate subjects to represent menu structures for user tasks.**

**Discoverability:** Functions buried in deep hierarchies are known to be less discoverable, and we confirmed this with our subjects. An additional issue arose from poor interaction design, such as when functions were categorized under seemingly un-related functions. In one menu system, registering a new user required navigation as follows: Svcs+ → Prepaid Svcs → [Service Name] → Register. Even literate subjects who were heavy text users, could not find the function, since most respondents did not bother looking beyond the unintuitive "Prepaid Svcs" option.

**Scroll bars:** Vertical scrollbars were not initially understood by 48 out of a total of 90 subjects we interviewed. Out of this 40 were non-users of mobile phones and 8 were voice-only users. Subjects did not realize that there were functions "beneath" what was displayed. Explicit demonstrations were required to teach these subjects what scrollbars were and how to use them. This group coincided almost entirely with users whose mobile use was restricted to making voice calls.

**Soft-key function mapping:** All of our subjects were comfortable handling the "hard keys" (direct number entry and send/end keys), regardless of whether they owned mobile phones or not. However, as many as 45 users had difficulty with soft keys (associating the numerical index with the function in an enumerated list of functions and/or building mental models when buttons located alongside the display resulted in different functions dependent on the application). When they were asked to send a text and were required to traverse the many different layers of the UI, they became lost and had no idea which buttons to press just to navigate. If they managed to get past the first step, they were unable to read the textually annotated steps later. The soft keys were difficult to understand because it required mapping soft keys to the changing functions displayed on screen.

**SMS and USSD syntax construction:** 27 of the 50 mobile phone users we spoke with used their phones for making and receiving voice calls only, and the proportion was higher in India, Kenya, and South Africa. 24 of these subjects were unable to type even a single word, much less an entire text message. For constructing a USSD syntax comprising of digits and symbols ("*" and "#"), our subjects were comfortable typing the digits, but could not locate the symbols.

**Text receipts:** All the services issue SMS receipts for transactions. Messages are always, entirely in English (except in the case of M-PESA where the receipts were in English as well as in Kiswahili). Subjects, most of whom were not fluent in English, had difficulty reading the text portions of these receipts, but almost all could identify the numbers and what they meant. However, subjects still had difficulty with receipts indicating multiple transactions.

**Banking concepts:** Since most of our subjects were unbanked, they were not familiar with the vocabulary of banking. "View last transaction," "Get balance", "Change PIN", and so forth, were all alien concepts, in the absence of detailed explanation.

**Paper manuals:** All of the services provide instruction manuals and information brochures for assisting users. Most of these manuals are overloaded with textual information, mostly in English. For non-literate users, these are all but useless, since the accompanying visuals often are not self explanatory. Some of the services offer local-language manuals, but these too are complex and laden with banking jargon. For the most part, we found that our subjects did not even attempt to read these manuals, and human mediation is critical for successful transactions.

### Design Recommendations

Broad lessons from this exercise led to the following design recommendations:

1) Provide graphical cues.
2) Provide voice-annotation support wherever possible.
3) Provide local language support, both in text and audio.
4) Minimize hierarchical structures.
5) Avoid requiring non-numeric text input.
6) Avoid menus that require scrolling.
7) Minimize soft-key mappings.
8) Integrate human mediators into the overall system, to familiarize potential users with scenarios and UIs.

The first four items echo design recommendations from previous work [24]. Items 5-7 were identified as a result of working with mobile phones. The last item is consistent with the literature on computing technology for development [39].

## EXPERIMENTING WITH UI OPTIONS

The recommendations above make sense, but to satisfy all of them, a richer platform that can display graphics and audio is necessary. Yet, richer platforms come with their own drawbacks, including greater complexity, greater cost, and less platform universality. Therefore, our goal in this second phase of research is to compare how non-literate subjects react to a three different UIs that make tradeoffs between cost and richness: (1) a text-based UI, (2) a spoken-dialog UI, and (3) a rich multimedia UI that incorporates what is known about text-free designs for non-literate users.

For the purposes of this study, we limit our attention to the dominant usage scenario that we found among our subjects, namely, remittances or remote money transfers. The three functions critical for any money-transfer service are: (1) money transfer, (2) withdrawal of funds (in the presence of a retail agent), and (3) account-balance inquiry. All three UIs were designed with the same information architecture so that we could compare task performance and preference among the UIs.

### *Information Architecture*

Fig. 2 shows the information architecture of the mobile banking UI design. To access the application, as a first step the user is required to enter his/her PIN. On entering the correct PIN, the user reaches the main menu where he/she gets a choice of three functions- check account balance, withdraw received money and send money. This is the only point in the menu where the user must use soft-keys (map numeric keys with functions in an enumerated list of functions) to make a decision among three options. The rest of the interaction only requires "yes/no" responses, number entry, or acknowledgements.

### *Interaction Designs*

**Text-based UI:** This was a menu-based USSD design where the options on the menu were in text in the native language of the subjects, Kannada. To initiate the service, the user had to dial a USSD short code (with "*" at the beginning and "#" at the end). On sending this request, a menu appeared on the user's mobile phone, each of which required entry of additional digits and symbols to choose options in the menu. The user thereafter had to follow the menu prompts in a similar manner to complete the transaction. Fig. 3 illustrates some selected screenshots.

In order to interact with this UI, the buttons on the mobile phone keypad which the user was required to use were #, * and the numeric keys.

Currently, Kannada USSD services are not available and hence our design was actually a simulation on a graphics-capable phone.

**Voice-based UI:** This was a menu-based spoken-dialog system meant to converse with users through voice prompts in Kannada. The user was required to dial a phone number to initiate the service and then speak the option in the menu which they chose. The user thereafter had to follow the menu prompts in a similar manner to complete the transaction.

In order to compare user responses under "ideal" technological conditions, we used a Wizard-of-Oz set up for the spoken-dialog system (which would otherwise have incurred the conflating issue of accuracy of automated speech recognition). On the system side, an experimenter in one office operated a system on a PC that consisted of buttons with voice feedback for each of the functions of the information architecture. The voice feedbacks were prerecorded human speech segments. The subjects were in a partner organization's office and were asked to dial the experimenter's phone number. The experimenter would play the recorded files from the PC and through the telephone speaker the system responses would be available on the user's phone earpiece. The experimenter followed the same information architecture as mentioned earlier, while playing the responses.

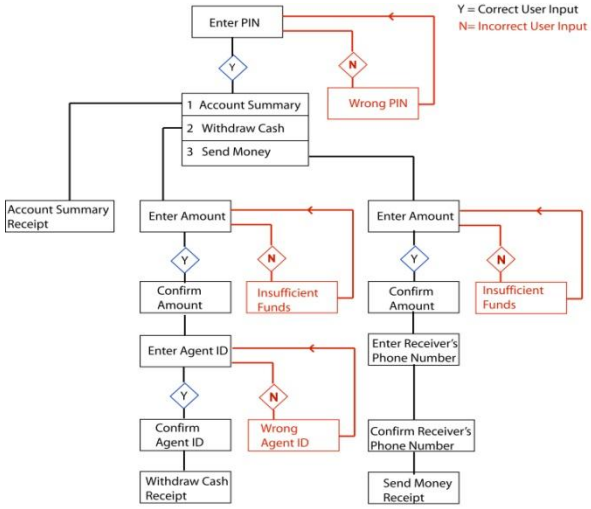


**Figure 2. Information architecture of the mobile-banking UI design**

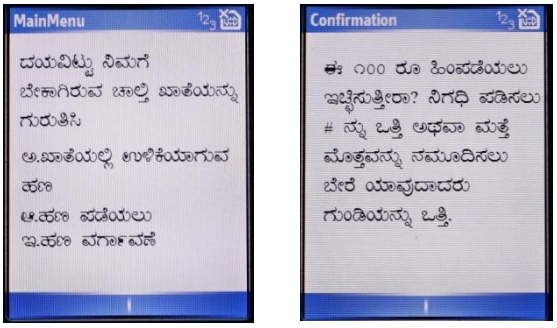


**Figure 3. Screen shots of text-based prototype**

**Rich-client UI:** This was a menu-based design with options appearing as audio-visuals on the mobile phone's display, organized as hierarchical menu options. Every graphic was a static hand-drawn representation. There were voice instructions associated not with every graphic but with the overall screen and played automatically on screen load.

These voice instructions were prerecorded human speech segments in Kannada explaining each menu option and what numeric key had to be pressed to accomplish these.

For this design we applied the design principles from previous text-free UI research. For designing the graphics we went through iterations with non-literate subjects from slum communities adjacent to those from where our subjects were drawn, Bangalore, India.

We made this design available as a menu-based SIM Toolkit application. In order to interact with this UI, the user was required to use the OK soft key and the numeric hard keys.

We also included a full-context video at the beginning of the application which in addition to a tutorial of the UI, included dramatizations of what the mobile banking service was, how a user might register for the service and use the application.

Fig. 4.a. illustrates the main menu which shows the three functions available to a user- account balance; withdraw received money and sending money options. Fig. 4.b. shows the screen where the user is asked to enter the phone number of the person he/she wishes to send money to. It consists of a numeric field where the user is required to make a numeric entry for the phone number to the receiver.


Fig 4. a. Main menu


Fig. 4.b. Enter phone number of receiver

**Figure 4. Screen shots of rich client prototype**

**Experimental Set Up**

The three prototypes that we tested had the same content and information architecture so that we could isolate the differences due to interaction design. Given that a full-context video was not provided for the text-based and voice-based UIs, before testing these two prototypes, subjects heard a verbal explanation that mirrored the content in the full-context video.

Across all the three prototypes, once we were satisfied that our subjects understood the capability of the application, we then told them the following story: A sibling of theirs who lived in a different town desperately needed money urgently. Assuming that the sibling also had a mobile banking account, their objective was to send Rs. 400 to that sibling.

The above task was to be considered incomplete when either of these two things happened: 1) Despite repeated prompts, subjects gave up on the task, 2) Subjects committed a fatal error (e.g. checked 'account summary' when they were asked to 'transfer money' of Rs. 400) and could not navigate their way back to the 'transfer money' menu despite repeated prompts.

*Subjects*

Our subjects were drawn from one of our project locations, Bangalore, India, from the same community as described in the target community section. The subjects were non-literate and semi-literate (could write their names, read isolated words and do some basic addition) adults living in 5 urban slum communities. We chose a range of such participants varying in age, environment they lived and worked at present and varying levels of experience in using mobile phones. Participants ranged in age from 25 years to 65 years. The taxonomic structure which we followed in choosing our participants was (a) no experience using mobile phones, (b) experience with using mobile phones but only for basic functions such as receiving and making calls, (c) experience with using mobile phones for more complex functions such as sending text messages.

There were a total of 58 participants (60 initially, but two did not show for the voice-based trial), 28 male and 30 female. Each of the prototypes was tested on one-third of the total participants, *i.e.*, 20 participants, 10 male and 10 female in the case of text-based and rich-client and 18 participants in the case of voice-based, 8 male and 10 female. The tests were conducted in the NGO office, in an environment they were familiar with.

*Device and Documentation tools*

The device where the applications were tested was a graphics-capable phone. This phone was selected because of higher quality graphics and for ease of prototyping. This phone did not seem to have an impact on our results for any of the UIs, in a manner that could well have been different had we used a low-end device, because: a) the device was used in a normal phone only mode, b) this device was used to test all of the three UIs.

The technique for data collection was detailed notes taken by us in-situ while the participants were performing the task. This included recording total time-taken and total number of prompts required for task completion.

**Results**

The tests confirmed that non-literate subjects were unable to make sense of the text-based UI. More interestingly, they showed that while completion rates were much better for the rich-client UI, speed was faster and assistance was less needed on the voice-based UI.

None of the subjects (0 out of a total of 20 subjects) were able to navigate the text-based UI even with significant prompting and encouragement. Most of the subjects were simply unable to read the text at all, and even those who could read isolated words were not able to read fluently

enough to put what was written into the context of the scenario. This was as expected, and we concentrate the remainder of the analysis on the non-text-based UIs.

Among the non-text designs, overall task completion for voice-based UI was 72% (13/18), whereas in the rich-client UI, it was 100% (20/20). Time taken for task completion by subjects in Rich Client UI was more than twice the time taken by subjects in Voice-based UIs. Single factor ANOVA test conducted shows statistical significance ($F$=21.485 > $F_{crit}$=4.160, $p$ < 0.05). Prompts required for task completion by subjects in Rich Client UI was more than thrice the time taken by subjects in Voice-based UIs ($F$=30.478 > $F_{crit}$=4.160, $p$ < 0.05).

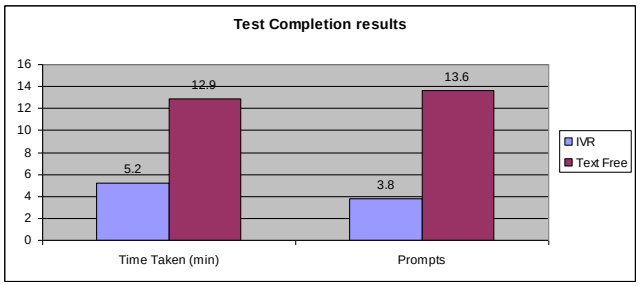


**Figure 6. Time taken and prompts required for task completion in Voice-based and Rich Client UIs**

Based on this, voice-based UI seemed for effective in terms of accuracy and task completion time, as compared to rich-client UI. Observations during the test and post-trial interview revealed that this could be due to a number of reasons: For the voice-based UI, the interaction through voice seemed comfortable and came naturally to our subjects- Subjects just had to speak the option which he/she wanted to choose. This seemed easier than in the case of rich-client UI, where the subject had to press a key as a user input to proceed to the next page. In general we observed that our subjects required significant prompting and encouragement to press any key. They were nervous that they might "break" or "spoil" the phone.

Again the information architecture which we had designed had minimal hierarchically structured options- users were required to choose between options at only the main menu level. For the voice-based UI, the subject had to speak the option, e.g. "Account Summary", "Withdraw Money" etc. Whereas in the case of rich-client design, the subject had to map numeric keys to functions as a user input, *e.g.*, the user had to press 1 for choosing the option of Account Summary, 2 for withdrawing money etc. Mapping numeric keys to functions was difficult when compared to merely speaking the option as it was.

For the rest of the interaction, there were no hierarchically structured options. There was only one way to accomplish a task and the user was not required to make any decisions. For the voice-based UI this interaction was almost like an informal telephone conversation with "yes/no" questions, unlike in the rich-client UI where the subject was required to press buttons to accomplish a task.

We also observed that for the voice-based UI, 60% (6 out of 10) of female subjects could complete the task, whereas for male subjects it was approximately 88% (7 out of 8, 2 male subjects did not show up). Overall for task completion, female subjects took twice the time to complete the test compared to men ($F$=14.6 > $F_{crit}$=4.8, $p$ < 0.05). But in terms of accuracy both male and female subjects took similar number of prompts for completing the test ($F$=0.05 < $F_{crit}$=4.8, $p$ < 0.8). Details are in Figure 7.

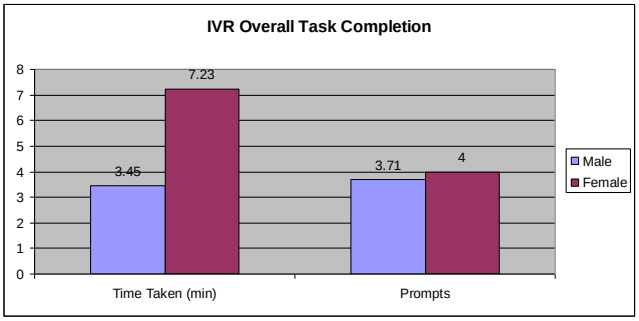


**Figure 7. Analysis of performance by gender in Voice-based UI**

We note that 7 out of the total of all 13 subjects who completed the task on voice-based UI, had prior experience using voice-based UIs for functions such as mobile phone recharge, setting caller tunes, etc. 100% (7/7) subjects, who were exposed to existing voice-based UIs earlier could complete the task in Voice-based UI.

Among the subjects who were not exposed to Voice-based UIs earlier yet could complete the task, it is interesting to note that 66% (4 out of 6) were women and 33% (2 out of 6) were men. However for these subjects, in terms of time for task completion, female subjects took more than twice the time taken by male subjects. Single factor ANOVA shows statistical significance ($F$=8.152 > $F_{crit}$ = 6.607, $p$ < 0.05). One qualitative observation here is that female subjects were more patient, attentive and slower when interacting with each of the functions in the voice-based UI. But in terms of accuracy both male subjects and female subjects took almost similar number of prompts for completing the test ($F$=0.170 < $F_{crit}$=6.607, $p$ > 0.8). Details are in Figure 8.

For the 28% (5/18) subjects who could not complete the task in Voice-based UI, observations during the test and post trial interviews revealed this was because they: (a) Did not understand the concept of mobile banking at all (b) Did not understand the technical terms used in the local language, (c) Did not understand the concept of speaking with a voice that responded only in a certain, fixed manner e.g. Subjects would keep saying "What Sir"?, "Yes Sir", "Can't understand what you are saying, Sir", thinking it was a real person. These subjects had never been exposed to Voice-based UIs earlier.

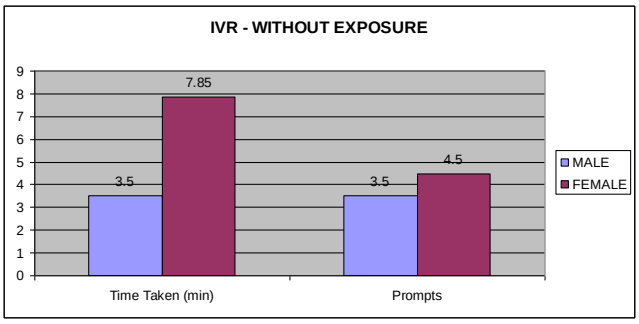


**Figure 8. Analysis of performance by gender in Voice-based UI for subjects without previous exposure**

Compared to this, 100% (20/20) subjects who were not exposed to any rich-client UIs earlier completed the task on Rich Client UI. Our sense is that, the visuals along with voice helps in overall comprehension. This provides additional information since subjects do not have to rely entirely on voice alone like in voice-based UIs. Post trial interviews also revealed that Full-Context video in Rich Client UI helped in better understanding of the concept of mobile banking and the scenarios in which it could be used, as compared to a verbal explanation that mirrored the content of the same, in the case of Voice-based UI.

There were no major differences in terms of time taken and accuracy between male and female subjects for task completion on Rich Client UI. Male and female subjects took the same time for completion ($F$=0.003 < $F_{crit}$=4.413, $p$ > 0.08). Male and female subjects also took almost the same number of prompts for task completion on the Rich Client UI ($F$=0.289 < $F_{crit}$=4.413, $p$ > 0.08). Details are in Figure 9.

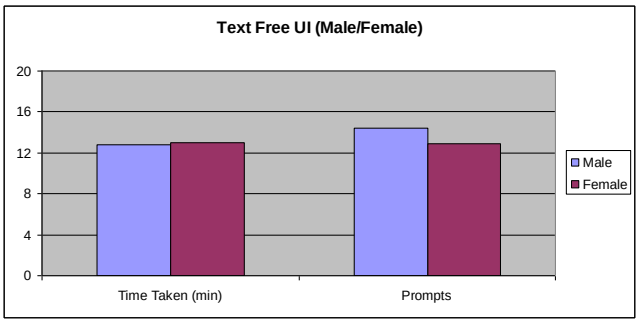


**Figure 9. Analysis of performance by gender in Rich Client UI**

Over and above, with regards the money transfer service, subjects saw it as very convenient and exciting. Many of them said if the service took off, they would use it since this would mean no longer having to wait for friends to take money home to their families, or waiting in long queues at the Post-office to send money orders.

## CONCLUSIONS AND FUTURE WORK

In this paper, we presented two studies that explore whether electronic access to complex financial services is enough to bring formal financial services to the "unbanked", and, if so what sort of UI is best.

We first investigated the usability of existing mobile payment services through an ethnographic study involving 90 subjects in India, Kenya, the Philippines and South Africa. We found that our subjects encountered a number of usability barriers in interacting with these services and navigating through mobile phones in general, including difficulty in: scrolling and hierarchical navigation, soft-key mapping, syntax construction, understanding receipts, manuals and banking concepts, etc. Broad lessons from this ethnography resulted in developing design recommendations. This was followed by a usability study with another 58 subjects in India, in which we compared non-literate subjects on three systems that incorporated the design recommendations: text based, spoken dialog, and rich multimedia. The tests confirmed that non-literate and semi-literate subjects were unable to make sense of the text-based UI and that while task-completion rates were better for the rich multimedia UI, speed was faster and less assistance was required on the spoken-dialog system. We caution readers in generalizing the results of our study beyond its original context even though there are grounds to suspect that much of the UI findings will transfer.

In future work, we would like to explore if the preliminary findings from these studies could be applied to domains other than money transfers.

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