Research Article

Text-Free User Interfaces for Illiterate and Semiliterate Users

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Abstract

We describe work toward the goal of a user interface (UI) designed such that even novice, illiterate users require absolutely no intervention from anyone at all to use. Our text-free UI is based on many hours of ethnographic design conducted in collaboration with a community of illiterate domestic laborers in three Bangalore slums. An ethnographic design process was used to understand what kind of application subjects would be interested in, how they respond to computing technology, and how they react to specific UI elements. We built two applications using these principles, one for job search for domestic laborers and another for a generic map that could be used for navigating a city. The resulting designs are based on key lessons that we gained through the design process. This article describes the design process, the design principles, which evolved out of the process, the final application designs, and results from initial user testing. Our results confirm previous work that emphasizes the need for semiabstracted graphics and voice feedback, but we additionally find that some aspects of design for illiterate users that have been previously overlooked (such as a consistent help feature). Results also show that the text-free designs are strongly preferred over standard text-based interfaces by the communities which we address and that they are potentially able to bring even complex computer functions within the reach of users who are unable to read.

Introduction

Most computer applications pose an accessibility barrier to those who are unable to read fluently. The heavy use of text on everything from menus to document content means that those who are illiterate or semiliterate are not able to access functions and services implemented on most computer software.

It does not have to be this way. In particular, while there might be limits to what static books can convey without text, computers are the ultimate multimedia device. Through the use of graphics, animation, and audio, they have the potential to be wholly intelligible to a person who cannot read (Huenerfauth, 2002).

The basic features of what we call a text-free user interface (UI) are simple to understand: liberal use of graphics and photographs for visual information, and voice for providing information normally provided via text. However, research to date on UIs for illiterate users remains scant, and existing work presents broad design guidelines that do not address all of the issues.

The work presented in this article was motivated by a single goal: to provide useful applications to communities of illiterate users, with a UI designed such that even novice, illiterate users required absolutely no in-

Figure 1. Site visit: at the houses of our target users.

tervention from anyone at all to use. In particular, we felt that if the UI were designed well, users would not require formal literacy, computer skills, or any external assistance in order to operate the application.

We certainly have not achieved this ambitious goal, but in the process of aiming for it, we have uncovered some of the subtler issues that require consideration when designing any text-free UI. We are also encouraged that the goal is not that far out of reach.

This article presents two applications that were designed using ethnographic or contextual design techniques to ferret out the requirements for a text-free UI. In the first, an employment-search application, the intent is to provide job information to a group of domestic laborers. In the second, we explore a text-free UI for maps that should allow illiterate users to answer questions having a geographic dimension.

Our approach is one of *contextual or ethnographic design* (Crabtree & Rodden, 2002; Wasson, 2002) in which intense interaction with a target community is sought to gain a thorough understanding of their real needs, real traits, and real responses to the interfaces we designed. Ultimately, we spent a total of more than 180 hours working with women in Bangalore slums to get feedback on our UI.

Section 2 of this article describes our target community and Section 3 gives an overview of the ethnographic design process. Section 4 describes a set of core design principles along with examples of many of the design details that we came upon during the iterative design process. Section 5 describes

the final prototypes to which these principles were applied. These prototypes were then tested with subjects who were drawn from the same community but had not been exposed to the applications during the design process.

Target Community

We based our project in three urban slum communities in Bangalore, India. To gain access into these communities we worked with a nongovernmental organization called Stree Jagruti Samiti, which has had an established presence in these three slums for 15 years. Because Stree Jagruti Samiti works primarily with the women in the slums, we also focused on the needs of the women for one of our projects (Figure 1).

Most of the women in the slums are household workers, either illiterate or semiliterate (highest education attained being schooling up to the sixth grade). The male members of the house are usually daily wage laborers like plumbers, carpenters, construction workers, mechanics, bar benders, and fruit and vegetable vendors. Their primary language of communication is Kannada, which is also their native language. Apart from this a few people also spoke Hindi and Tamil. The average household income was INR 800–INR 3,000 (approximately USD 18–USD 67) per month. A few of them also had television sets, music players, and liquified petroleum gas burners. Some of them have seen computers in the houses of their employers, but were prohibited from touching the computer (even for the purposes of cleaning!). None of them had previous experience using a computer. During the time that we interacted with this community, we interacted with no fewer than 80 women and men, who ultimately saw the designs at some stage of their development.

Ethnographic UI Design

In designing the UI, we drew from guidelines of *ethnographic design,* in which techniques of ethnography were used to gain a deep understanding of the subjects, within the context of their specific

goals (Cooper & Reimann, 2003). We held inter-views and conducted subject trials with our target communities. We repeatedly went back to them to evaluate our designs and incorporated the necessary changes in the next prototype we designed. Being accepted and trusted by the community, making the subjects feel comfortable to talk and extracting relevant information from them (Parikh, Ghosh, & Chavan, 2003b), helping them overcome fear and reluctance while using technology (Chand, 2002) were a few of the challenges we faced during the process of design.

We had to take various actions to accommodate subjects and make them feel at ease. We spent considerable time in the community, attending weekend meetings to understand the context, culture, and practices (Parikh, Ghosh, & Chavan, 2003b). We visited the communities on an average of two to three times a week, for 3–4 hours each session, for several months.

We used this approach to determine the application domain in which to test our user interfaces. Our subjects—mostly domestic laborers—find job information through word of mouth or through agents within the slum that informally connected employers with employees. Most of the women often continued working at the same place for low wages because they were not aware of better opportunities elsewhere. We, therefore, decided first to mock-up a job-search application. Our focus group–style discussions of 40–50 women showed that the women were accustomed to asking the following information about a job: specific tasks requested by the employer, work schedule, break-up of wages by task, address of the employer, number of rooms in the residence, number of people residing, and location within the city.

To ensure that the design principles were not application specific, we also implemented a map application that was meant to provide geographic information. Maps were not common artifacts for the women we worked with, even though geography was a critical factor in the daily decisions they made; as a result, we felt it was a good testbed for text-free UI.

Design Principles

We arrived at a set of design principles as guidelines for text-free UIs as a result of the lessons learned

from extensive field studies we conducted. We shall explain these with examples elucidating each principle in the following section:

Avoid Text (But Numbers Are Okay)

Clearly, less text makes sense for subjects who cannot read. However, as we discovered that subjects could easily recognize numerals ("0", "1", "2", "3", "4," . . .), these numerals can remain in the UI (at least for certain target users). This is consistent with advice in some earlier work (Parikh, 2002; Parikh, Ghosh, & Chavan, 2003a, 2003b).

Use Semiabstract Graphics and Increase Photorealism with Deeper Interaction

We knew that for both applications the information had to be in graphical form, since our target users were not generally literate (Huenerfauth, 2002; Parikh, Ghosh, & Chavan, 2003a, 2003b). While this is an obvious feature, the exact nature of the graphics can make a huge difference, and, below, we outline some of the more subtle findings from the ethnographic design process.

Frequent iterations with the target community are necessary to ensure that graphical elements are interpreted the way they are intended. We observed that subjects recognized semiabstract cartoons and more photorealistic graphics much better than complex abstract graphics. As users delve deeper into an object to get more information, the representation can become more photorealistic to provide more specific information.

In general, subjects were able to identify both photographs and pure cartoons, but there was a general preference for semiabstract cartoons. These cartoons were sketched by us and tested extensively in the field.

Too much abstraction could cause some difficulty. For example, in the map application, animated arrows for depicting one- or two-way traffic were not readily understood. When the arrows were replaced with small icons of cars, subjects immediately understood the meaning (Foltz & Davis, 2001). There was also a tendency to take some abstracted elements literally. Color of the graphical elements, for example, played a role in interpretation of map entities. For example initially we tried to depict roads in 80% black that on mouse hover become yellow. The idea was to highlight and separate the road as an individual entity. We received the feedback from the users that roads can never be yellow and they are
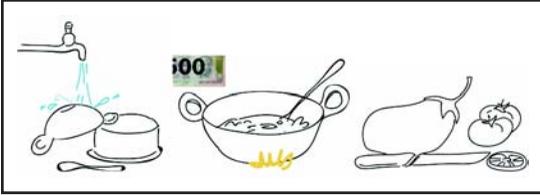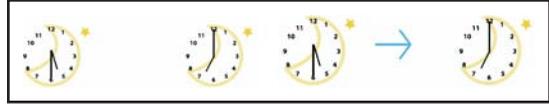
Figure 2. Unabstracted icons with action cues.

Figure 4. Ambiguity in iconic representation due to cultural biases: Our initial design indicating start and end times for a job places the start time at left (left). This is misinterpreted in Muslim culture. Adding an arrow avoids this problem (right).
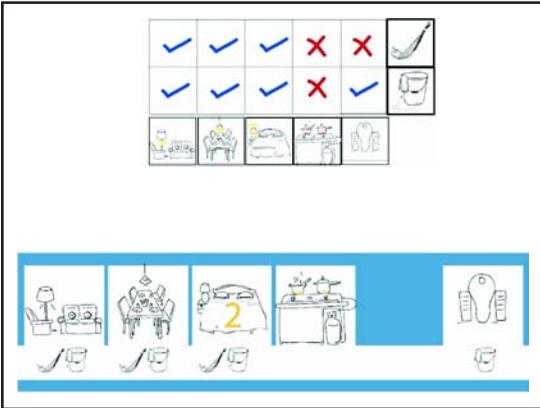

Figure 3. Indicators of which tasks were required in which rooms. The matrix structure (top) was not readily understood.

Figure 5. Designs for the "residence" icon. Our initial design (left) was perceived as a hut; the final design (right) is more in line with what our subjects interpreted as an urban residence.

always black. Based on this feedback, we changed the color of the road to 100% black and on mouse hover 80% black.

In some cases, an abstract icon worked for a general instance (e.g., hospital) but was not sufficient for indicating a specific instance (e.g., Jayanagar Hospital). To resolve this problem, we used actual photos of specific landmarks to appear on mouse hover.

Pay Attention to Subtle Graphical Cues: User Response May Depend on Psychological, Cultural, or Religious Biases

The devil is in the details. For example, actions may require a visual representation, or they would be taken as static representations of location or object (Huenerfauth, 2002).

We found that they were better able to identify activities as actions when the cartoon included standard visual cues for indicating motion—water running in a faucet, steam puffing out from a kettle, and so forth (Figure 2). Without these action elements, subjects felt the drawings represented objects or locations (e.g., kitchen), rather than the associated action (e.g., cooking).

We had used a matrix of checks and crosses to show what activities needed to take place in which rooms (Figure 3). These were not readily understood by our subjects, echoing results from other work that suggest graphical representations must be kept simple (Parikh, Ghosh, & Chavan, 2003b). We replaced them with explicit associations between room and task without the matrix structure. Sometimes differences in religion or culture caused different interpretations of graphical elements. For example, probably because Urdu is written from right to left, Muslim culture views time as flowing from right to left by default. Where we display work schedules, this required an explicit arrow between our start and end clocks faces, so that there was no misunderstanding (Figure 4).

Some of our initial icons were not interpreted the way we expected (Huenerfauth, 2002; Parikh, Ghosh, & Chavan, 2003b). For example, our initial graphic for a residence is shown in Figure 5 (left), what we thought was a universal symbol for a house. Our subjects, however, perceived it as a village hut and were confused, because they expected that prospective employers would live in a tall apartment complex; with their feedback, we redesigned this logo as shown in Figure 5 (right).
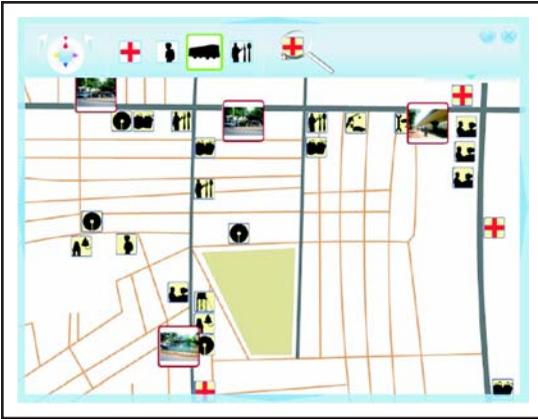
Figure 6. Map application with heavy use of land-marks.

Figure 7. Design of the "Introduction" page of the final prototype of the application.

Provide Voice Feedback for All Functional Units

The clear value of voice feedback is noted in previous work (Huenerfauth, 2002; Parikh, 2002; Parikh, Ghosh, & Chavan, 2003a, 2003b). It is important, however, that this guideline is zealously applied.

Provide "Help" on All Screens

The use of help instructions allows an application to be more autonomously used, even for novice users. Optionally, an on-screen character could be placed so that users can put a visual figure to voice playback.

Miscellaneous

Text-Free but Not Click-Free

As expected from novice users, the subjects did not have fluent control of the mouse and stylus and hesitated to click the mouse or press the stylus, as also mentioned in some previous work (Chand, 2002). At one point, we tried a click-free interface in which actions associated with clicking occurred after a 3-second mouse hover.

However, subjects were as confused by this as by experienced PC users (who typically find such behavior annoying). We therefore ultimately removed the click-free feature and kept click-free actions to be those which were either (a) associated with additional information (e.g., photo display or voice on mousing over an icon) or (b) immediately associated with moving the mouse onto an actionable icon (e.g., panning the map using the borders of the ap-
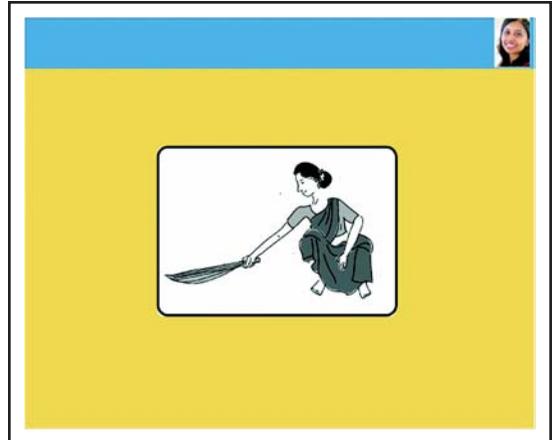
plication). In the latter case, we found it useful to reserve clicking for advanced versions of the same action (e.g., accelerated panning).

Importance of Landmarks in Geographic Navigation

Throughout all of our queries about physical location, one abundant piece of feedback was that our subjects relied primarily on landmarks—and not absolute (north–south–east–west) direction or addresses and street names—for navigation. Thus, in our employment-search application, we restricted our attention to an almost purely landmark based interface; whereas in our map application, we explored additional map functions while keeping a landmark-based presentation (Figure 6).

Final Prototype

We put these design principles into use as thoroughly as possible in designing our two applications. The final prototypes are as follows (voiced help instructions for the employment application are in the appendix):

Employment Search

Introduction Page

The first page consists of an icon that represents job information for employees. This page is intentionally simple to avoid overwhelming first-time users (Figure 7). Even "decorative" text was removed so as not to

Figure 8. Design of the "Location" page of the final prototype of the application.
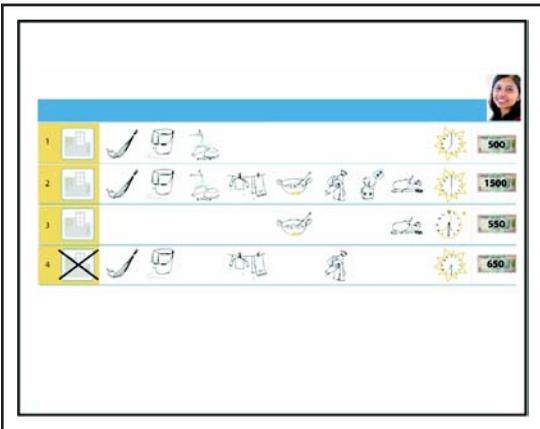

Figure 9. Design of the "Job Listing" page of the final prototype of the application.

intimidate illiterate users. On clicking this icon, one arrives at the "Location" page (Figure 8).

Location Page
The user can retrieve information about how many jobs are available in each area. On mousing over a landmark, the placename is called out, and the rectangular icons animate into an enlarged image of the landmark. A click on one of these rectangles on the map allows the user to navigate to the "Job Listing" page (Figure 9).

Job Listing Pages
In these pages, the jobs available in a neighborhood are listed along with the basic information about each job. In order to proceed to detailed job descrip-
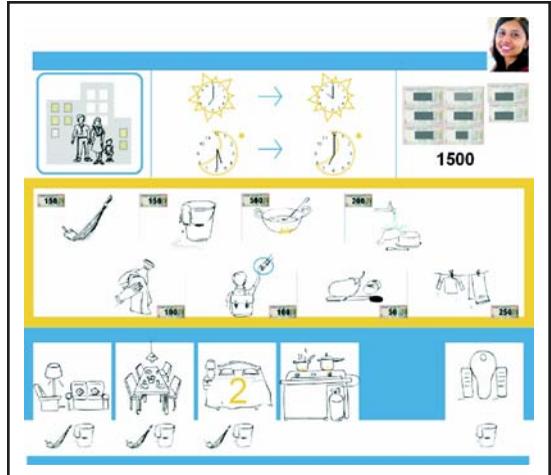

Figure 10. Design of the "Job Description" page of the final prototype of the application.

tions, the user must click anywhere within a particular row of information.

Job Description Page
This page compiles all of the relevant details about a particular job—address of the potential employer, wage break-ups, chores to be performed, number of rooms in the employer's house and the work timings with voice descriptions on mouseover. On every page, there is a "back" button to return to the previous page (Figure 10).

Map
The final prototype for map application consisted of one screen having all the major landmarks and roads. It allowed its users to pan, rotate, and zoom the map from any point (Figure 11). The additional features applied in this application are panning on mouse hover using a border of 16 pixels on all the four sides, rotation of map, visual filtering of landmarks, and virtual companion.

Experiments and Results

We performed preliminary subject testing with both applications to get a sense for the following questions, before proceeding with a large-scale study:

1. Can illiterate or semiliterate users use traditional text-based UIs at all?

2. Do the proposed design principles for text-free UIs allow illiterate users to use computers, and to what extent?
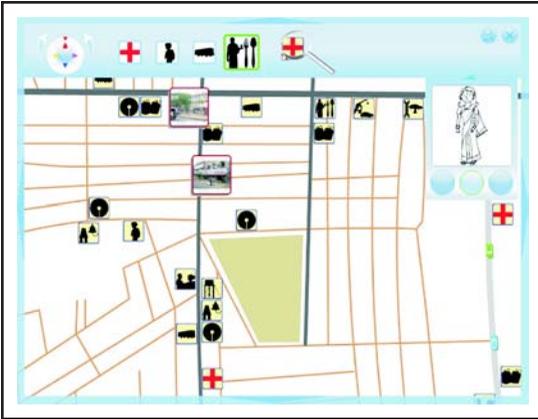
Figure 11. Design of the final prototype of the map application.

3. Which of the design principles make the most difference for a text-free UI?

The answer to the first question would seem an obvious "no," and our results verify this, but to the best of our knowledge this is the first time that this question has been formally tested. The other two questions are broader and the tests were intended to reveal the value of the proposed design principles.

Experimental Set-Up: Cultural Considerations

In traditional user studies, subjects are generally familiar with computers and live in economic conditions similar to their testers. Because of this, tests can be conducted in usability labs with controlled environments, and little attention needs to be paid to the mental comfort of the subjects. In our case, however, our subjects were not habitual users of PCs (hence, our terminology below will refer to them as "subjects" not "users"), and, more important, they were drawn from communities that often fear testing of any kind and find air-conditioned office environments alien and possibly intimidating. Thus, we needed to make a number of modifications to ensure that subjects were as comfortable in the environment and testing scenario as possible.

First, in all cases, we performed the testing in a physical setting that was routine for the participants. In most instances, we visited subjects in their own homes (in slum neighborhoods of Bangalore); in a few cases, we conducted tests in the homes of their employers. Second, for all of our participants, we

reached out through contacts whom they trusted, and who were in almost all cases present through the duration of the study. Although this was less than ideal for thorough randomized testing, we could not find an easy way around the fact that most subjects would not feel at all comfortable undergoing technology tests with strangers. The critical aspect of the subjects—that they were illiterate or semiliterate—however, was preserved.

Third, while most (though not all) user studies tend to focus on isolated tasks, we found this was inadequate, as subjects had a poor understanding of the capacity of the computer overall, and almost no sense for what kind of tasks could be accomplished. We used a methodology termed the "Bollywood Method" (Shaffer, 2004), in which tasks are embedded in dramatized stories involving the subject, which has been found to be better at motivating subjects toward the desired tasks, even for computer novices. Particularly in an Indian context, where subjects tend to be reserved about giving feedback to people they perceive to be in authority—as test administrators were perceived to be—this was an invaluable tool for encouraging honest feedback.

Experimental Set-Up: Application

We tested both the employment-search and map applications with two interfaces: one that was text-based and another that was text-free. The text-based and text-free versions of both applications had the same content, so that we could isolate the differences due to interface design.

Employment Search

For this application, we actually tested three configurations, as follows:

- Text-based version: A standard text-based web interface, with routine structuring and indenting of data for ease of reading.

- Text-free version with help instructions: the text-free employment-search UI as described in the "Final Prototype" section.

- Text-free version without help instructions: the text-free employment-search UI as described in the "Final Prototype" section, but without the help feature.

Script

We first began with a (very) basic overview of computers and introduced the application to the user.

Once we were satisfied that they understood the capability of the application, we then told them the following story: A friend of theirs who lived in their neighborhood was in trouble and desperately looking for a job. Their objective was to find the best-paying job in a nearby neighborhood and to be able to report the address of the potential employer. (We initially started by asking them to find a job for themselves but switched to this scenario after one woman in one of our earlier trials seemed agitated by the idea that she would need to find herself a job.) This was broken down into two subtasks for testing purposes: (1) reach the point where they can identify their own neighborhood and (2) respond with the address of the highest-paying job in their neighborhood.

Map

In this we compared our text-free digital map UI with one commercially available text-based digital map of Bangalore.

Script

We took a commercially available text-based digital (MapCue Bangalore, 2001) and our text-free map of Bangalore to the users for final user testing. Unlike the more open methodology used in the user studies, here we defined three tasks for each of the users and embedded them into three stories. The goal was to test both maps in lifelike situations that may occur and to compare the degree to which subjects could complete the tasks. Each time, we presented one of the maps to the users first and asked them to accomplish the task on it. Once they completed the task (or had given up), we then presented the other map and had them try the same task on that map. Half of the subjects saw the text-based map first; the others, the text-free map.

Experimental Set-Up: Subjects

Our subjects were drawn from the same community as described in the "Target Community" Section. The subjects were illiterate and semiliterate (could write their names, read isolated words and do some basic addition) adults living in slums who had no previous exposure to computers. All have used pay phones and TVs. We chose a range of such participants varying in age, environment in which they lived and worked at present, and their familiarity and comfort with technology. The taxonomy with an

example from our test participant of each of the categories is as follows:

1. Has never seen a computer: Newly migrated into the city from the village; has never seen a computer before.

2. Has only seen a computer rarely, but never one being used: Typical of part-time domestic helper who has seen a seen a computer at an employer's house but has never touched a computer, even to clean one.

3) Regularly sees people using a computer: Full-time house-keeping staff member at an office with PCs; has never used PCs; possibly came into contact while cleaning.

For the employment-search application, we tested four single participants and two collaborative groups of five women each. All subject sets were tested on all three versions of the application (text-based, text-free with help, and text-free without help), in randomized order. For the map application, three individuals were tested on both the text-based and text-free UI.

These numbers are admittedly small, and the quantitative results (presented in Appendix) do not achieve statistical significance. However, over the course of our design iterations, we interacted with more than 80 women and men of varying ages (the majority were adults, but some of the tests included children who were only 13 years old, but had adult work responsibilities) for a total of more than 180 hours spent with subjects, and, although most of this time was not spent in formal subject testing, these interactions provided a significant amount of informal data, which was consistent with what we found in our formal tests—if not quantitatively, at least qualitatively.

The two collaborative subject tests had two groups of five participants (with one person controlling the stylus) interact with the employment search application. We noted significant differences in individual and group tests which are discussed in the qualitative section of the results below.

Quantitative Results

Results are given in Tables 1 and 2. Our tests answered the first of our questions decisively. Overall, participants were totally unable to make any sense of the text-based user interfaces for either applica-

Table 1. Comparison of Results between Text-Based and Text-Free Employment-Search UI in Subject Testing

	Task 1: Find Neighborhood			Task 2: Get Address		
	Task Completed	Prompts Required until Subjects Gave Up	Completion Time (min)	Task Completed	Prompts Required for Completion	Completion Time (min)
TEXT-BASED						
Subject 1	No	18	—	No	—	—
Subject 2	No	19	—	No	—	—
Subject 3	No	16	—	No	—	—
Subject 4	No	5	—	No	—	—
Average	0%	14.5	—	0%	—	—
Group 1	No	15	—	No	—	—
Group 2	No	17	—	No	—	—
Average	0%	16	—	0%	—	—
TEXT-FREE WITHOUT HELP						
Subject 1	no	—	—	no	—	—
Subject 2	yes	11	21.0	no	—	—
Subject 3	yes	10	17.0	no		
Subject 4	no	—	—	no	—	—
Average	50%	12	19	0%		
Group 1	yes	7	12	yes	19	25
Group 2	yes	8	13.5	no	—	—
Average	100%	7.5	12.7	50%	19	25
TEXT-FREE WITH HELP						
Subject 1	yes	5	14.0	yes	11	28.0
Subject 2	yes	3	12.8	yes	7	25.0
Subject 3	yes	2	11.0	yes	6	23.5
Subject 4	no	8	—	no	—	—
Average	75%	4.5	12.6	75%	8	25.5
Group 1	yes	1	5.0	yes	3	12
Group 2	yes	2	6.0	yes	5	13.5
Average	100%	1.5	5.5	100%	4	12.7

tion. None of the seven individual subjects nor any of the subjects tested in groups were able to navigate the text-based UIs, even with 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. For the map application, none of the participants were even able to locate the important landmarks for any of the tasks in the text-based map. Moreover, without the voice feedback, even users who had seen the text-free UI first did not realize without significant prompting that one could click on text to cause an action (and with prompting, they still did not understand what they were clicking on).

Table 2. Comparison of Results between Text-Based and Text-Free Map UI in Subject Testing

	Prompts		Completed		Time taken (in min)	
	Text-Free	Text-Based	Text-Free	Text-Based	Text-Free	Text-Based
Task 1: Find all the Hospitals in the Vicinity and Then Look for a Cardiac Care Hospital						
Subject 1	7	24	yes	no	9.0	19.5
Subject 2	5	20	yes	no	12.0	20.0
Subject 3	7	27	yes	no	10.5	25.0
Average	6.3	23.6	100%	0%	10.5	21.3
Task 2: Locate Your Position, Find the Nearest Bus Stop, and Direction of Traffic on Roads						
Subject 1	8	25	yes	no	11.0	23.0
Subject 2	7	25	yes	no	11.5	25.0
Subject 3	7	24	yes	no	14.5	21.5
Average	7.3	24.6	100%	0%	12.2	23.2
Task 3: Recall the Map Interface and Describe Its Behavior without Seeing It						
Subject 1	11	27	partially	no	17.0	19.5
Subject 2	10	23	partially	no	12.0	15.0
Subject 3	15	25	partially	no	18.0	18.0
Average	12	25	NA	0%	15.7	17.5

Qualitative Results

Throughout our design iterations and formal subject studies, we made a number of informal qualitative observations, which we have so far not followed up with quantitative tests. Many of these were rolled back into later redesigns. The others we offer here as possible hypotheses for future verification or for application to future work with text-free UIs.

Immediate Comprehension of Voice Feedback

With almost no exception, we found the same reaction to those who were exposed for the first time to voice feedback in their own language: Most were thrilled to hear a computer speak in their native language and went as far as to call others in the vicinity to hear for themselves. In fact, voice feedback appeared to make the applications *fun* for subjects, who seemed more engaged and eager to explore the application.

During our trials, there were a few cases when subjects had heard from previous subjects that there were both text-based and text-free versions of each application. If they were given the text-based UI first, they would frequently ask for the text-free version, on which they felt they could perform better.

Collaborative Use

At one point when we were conducting subject studies, a group of women began playing with the application between our formal test sessions. As they seemed more animated, we allowed them to continue for some time. In our individual tests, subjects appeared nervous and uncomfortable, probably because they were being videotaped and scrutinized in isolation in front of researchers. The group, on the other hand, seemed more confident, suggesting ideas to one another, discussing the purpose of the application, advising each other, and interacting more boldly with the computer. Their faces beamed and their voices were louder compared with single-subject tests. This prompted us to do the collaborative studies cited above, but we feel there is the potential for future design taking into account a collaborative user model, as well.

The Value of Help

In addition to the fact that the help feature shortened the time that tasks were completed in the employment search application, they were also found to be a constant source of reassurance to users. There were occasions when before performing a

task on a particular page they referred to help three or four times. As with voice feedback, the help feature made them eager to explore the text-free UI, whereas without help the response was more subdued; participants did not seem as interested in exploring. In one of the sessions, we observed that subjects went to the help icon themselves without any prompting and performed the actions exactly as told by the help. The same pattern continued for forthcoming screens, and before taking any further action they referred to help.

This was brought out in our map application, which, although it provided functional help for each icon, offered no overall help feature. Throughout the study, we found that we needed to prompt and encourage subjects to try out things on screen. It is possible that a few encouraging voice instructions telling users how to operate the tool would be helpful.

Navigation Metaphor

In our employment-search application, we felt that subjects were quicker to understand hypertext navigation when they were told to think of the pages as pages in a book. Although no quantitative studies were performed, the most recent version of the help recordings that made this analogy seemed to help more than earlier versions that did not.

No Faith in Technology

For at least two of our subjects, it took a significant effort to explain to them that a computer could provide them with the information they were asked to find in their scenarios. One test subject, in particular, was ultimately not convinced about a computer's ability to deliver job-related information and was apathetic to the point that she refused to continue with the study.

Subject Involvement Among Test Subjects

One thing we found repeatedly among our more comfortable subjects was that they were eager to give us advice about design and potential features (Parikh, Ghosh, & Chavan, 2003a, 2003b).

Related Work

The existing body of research that investigates user interfaces for illiterate users work is recent and few research groups have looked at designing for this population. Early researchers in this area place emphasis on the need for contextual design methods to explore this problem, as illiterate users are very different from the target user imagined by most UI designers (Cooper & Reimann, 2003). We follow this lead, and have spent literally hundreds of hours in the field, working with illiterate women. Most previous work with illiterate users suggests the use of graphical information. In particular, researchers immediately intuited the value of imagery in place of text, and extensive use of graphics is advocated by most of this work (Griesdale, Graves, & Grunsteidl, 1997; Huenerfauth 2002; Parikh, Ghosh, & Chavan, 2003a, 2003b; Medhi & Kuriyan, 2007; Medhi, Pitti, & Toyama, 2005; Medhi, Prasad, & Toyama, 2007).

Some research groups have also investigated the value of voice annotations and instructions, which are of obvious value to illiterate users (Parikh 2002; Medhi & Kuriyan, 2007; Medhi, Pitti, & Toyama, 2005; Medhi, Prasad, & Toyama, 2007). Separately there is a body of research that looks at the use of voice auditory interfaces for information communication. However most of this work does not specifically target illiterate populations. In this stream there are research papers that have demonstrated the utility of auditory icons in addition to standard graphical feedback in communicating information to users (Blattner, Sumikawa, & Greenberg, 1989; Gaver, 1989). This confirms our finding that graphical icons with voice annotation generally help users in speed of comprehension. Existing literature also suggests that auditory icons are an intuitively accessible way to use sound to provide multidimensional, organized information to users (Gaver, 1989a, 1989b).

Some authors researching illiterate populations note the plausible inclusion of number, as illiterate users are often numerate (Medhi, Pitti, & Toyama, 2005; Parikh, 2002; Parikh, Ghosh, & Chavan, 2003a, 2003b). Others focus on the need for ultra-simplified navigability as a design element (Griesdale, Graves, & Grunsteidl, 1997).

Our work builds on many of these findings of this previous work but also evolves the ideas further, particularly in approach, design elements, and final implementation. Because this is a relatively new area of research for user-interface designers, interaction with the target user groups is essential. Using contextual design methods similar to that used by the research in rural microfinance (Parikh, Ghosh, &

Chavan, 2003b), we also spent a considerable amount of time with our subjects. For each of our applications, we went through at least eight iterations each of redesign and subject feedback. (Here we are counting instances when there were fundamental changes in the UI; there were many additional separate occasions when small groups were consulted for minor changes.)

This close interaction leads to some subtle and not-so-subtle differences in design elements. The subtle elements tend to be specific to the application domain and the target subjects. Previous work, for example, does not cite action cues in graphics to indicate actions, but this may not arise in applications where icons only represent static objects. Our reliance on landmarks in maps is also something we chose when subjects were repeatedly unable to comprehend standard map representations. A significant requirement that previous work does not mention is the need for abundant and consistently available help instructions. As we found ourselves repeating the same background material and instructions to our subjects each time we visited them, we thought that this material could be encapsulated into the application itself, and this addition had a profound impact on the subjects' sense of autonomy.

Finally, while all previous work suggests design elements, none mention the importance that these elements must be applied thoroughly across the application. Even a single icon missing voice annotation, for example, causes confusion, as subjects expect to be able to point to any graphical component and find out what it represents. Similarly, help, if it is made available, must be available all the time, or it will cause a loss in confidence among subjects who tend to blame themselves for the interface's shortcomings.

Conclusion and Future Work

In this article, we have presented two text-free user interfaces applied to the particular applications of providing information about employment opportunities for domestic laborers and a digital map designed for illiterate and semiliterate subjects. Through an extensive ethnographic design process involving more than 180 hours with 80 women and men from three Bangalore slum communities, we discovered several design elements that were incorporated into the final design, that we believe could

be applicable to other user groups that are illiterate and new to computer use. These include obvious and previously cited features such as graphical icons, voice feedback on all functional units, minimal use of text, and active visual response on mouseover, but also thus far unnoted features such as semiabstracted, instead of purely iconic graphics, and consistent help for all application "pages." Results also showed that the text-free designs were strongly preferred over standard text-based interfaces by the communities we addressed.

Toward the end of our work, for example, we discovered that some users fundamentally doubted the ability of a cold piece of technology to deliver the information they were interested in. We observed that in spite of our subjects' understanding of the UI mechanics, they experienced barriers beyond illiteracy in interacting with the computer: lack of awareness of what the PC could deliver, fear and mistrust of the technology, and lack of comprehension about how information relevant to them was embedded in the PC. We addressed these challenges with full-context video, which includes dramatizations of how a user might use the application and how relevant information comes to be contained in the computer, in addition to a tutorial of the UI (Medhi & Toyama, 2007).

Separately we also conducted research toward an understanding of the optimal audio-visual representation for illustrating concepts for illiterate and semiliterate users of computers by comparing different representational types in a way that fairly stacked one representational type against the others (Medhi, Prasad, & Toyama, 2007). While we are not yet at a point where we have achieved the goal of a truly assistance-less user interface for novice, illiterate user, we believe this work takes us one step closer. ■

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Appendix

The help instructions provided in the final prototype of employment search application in section 5 were as follows:

Instruction 1: Are you looking for a well paying domestic help job in Bangalore and do not know where to get job information from? This computer application will help you find one. Now, how do you interact with this computer/computer application?

This application is like a book and you can go from page to page. . . . I'll tell you how, now. . . . Hold the object which you have, like a pen. Do you see the big icon/picture at the center of the screen? Hold the head of the pen a very little away from the computer. You will hear the sound saying "Job information." To know more about where all you can get jobs, press the head of the pen on the picture with a little pressure.

And always remember, if you get lost or need help using this page, hold the pen over my picture.

Instruction 2: This is the map of Bangalore and here you can find your favorite job based on location.

Do you see the little pictures on the map? Each of them represents a particular locality.

To know which locality it is, hold the head of the pen a very little way from the computer. You will hear the sound saying the name of the place. To know more about what all jobs are available in that particular locality, press the head of the pen on the picture with a little pressure and you will move to the next page.

And always remember, if you get lost or need help using this page, hold the pen over my picture.

Instruction 3: This shows you the jobs that are available in this locality at present.

Each row of pictures shows the kind of work you will have to do in each house.

Hold the head of the pen a very little away from the computer. After hearing sound, press the head of the pen on the picture with a little pressure to move into the next page and know the details of this particular job.

If you want to choose a different locality at any point of time, click on the blue bar on the top of the page.

And always remember, if you get lost or need help using this page, hold the pen over my picture.

Instruction 4: This page represents the particular job in which you showed interest just now.

This page gives you information about your potential employer's address, the time you will need to get to work, the wage you will get paid, the chores you will have to perform and also in which rooms you would have to perform them.

Do you see the little pictures on the page? Each of them will play a sound explaining the picture when you hold the head of the pen a very little way from the computer.

Remember that if you do not like this particular job, you can move on to the previous page, where the other jobs are listed. You can do that by pressing the pen head on the blue bar at the top of the page.

And always remember, if you get lost or need help using this page, hold the pen over my picture.

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