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A Comparison of List vs. Hierarchical UIs on Mobile Phones for Non-Literate Users

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Abstract. Previous research has shown that low-literate users have difficulty using hierarchical information architectures and that a list design showing all items at once on a PC screen works best for search tasks. However, the limited screen space on phones makes it impossible to show more than a few items at once on a single screen. Does a hierarchical UI work better on a phone? In this study, we compared the performance of non-literate users from Bangalore, India, on a search task using a hierarchical UI (four levels deep) and a multi-page list that had forty items across seven pages of a touch-screen phone. Our results show that participants using the multi-page list perform better both in terms of time taken and percent correct even when the list UI design requires them to browse through multiple pages of items on the phone.

Keywords: Non-literate users, list design, hierarchy, mobile phone

1 Introduction

Traditional computing software is structured in information architectures (IAs) designed in the form of hierarchies, to enable navigation of enormous information systems by concentrating on a few issues at a time. One of the principle benefits of hierarchical IAs is that space needed for navigation can be reduced by nesting. However previous research has shown that hierarchies can be difficult to use [1, 7, 9] particularly for low-literate people [3, 6]. Low-literate users have trouble understanding the concept of nesting or how a top node in a hierarchy represents a group of pages. Prior work showed that in the context of a search task of 40 items, a list UI that displayed items in a grid all at once on a PC screen worked best [6]. But displaying all selections at once is frequently not an option – for example, on a phone UI where screen real estate is constrained. What happens when it is not possible for items in a search task to be visible all at once on a list?

Do low-literate users have challenges with paging, or with hierarchies? Is their challenge cognitive organization and understanding ontologies and representations, or is it that paging itself is the challenge? And, is it ultimately easier for low-literate users to navigate multi-page lists or hierarchical IAs when screen space is limited?

To answer the above questions, we conducted a controlled experiment with 20 non-literate users in Bangalore India, on a search task on a touch-screen phone. Ten of the participants used a multiple-page list UI (where items are listed across seven pages), while the remaining ten used a hierarchical UI (4 levels deep). Both groups were asked to find five out of a total of forty household items. Our results show that participants using the multi-page phone list perform better both in terms of time taken and percent correct even when the list UI design requires users to traverse through multiple pages of items on the phone. As design recommendations in UIs for non-literate users, we suggest keeping navigation linear to the extent possible and to minimize hierarchical depth.

2 Related Work

A previous study showed that low-literate users performed poorly when using hierarchies in a search task [6]. This study compared a single-page list, a shallow hierarchy and a deep hierarchy on a PC. Participants performed best on the single-page list where all search items were visible all at once on the PC screen. Other studies have questioned the suitability of menu-based navigation for low-literate novice users in the developing world context [3, 4, 5]. However, these studies are more qualitative and anecdotal in nature. Studies with literate users have shown other problems related to the usability of hierarchical menus [1, 7, 8, 9]. Particularly relevant for this work, a study based on PDAs compared linear, hierarchical and cross-linked navigation performance in the context of a search task [2]. Results indicated that users performed best when navigating a linear structure, but preferred it mostly because of the ability to go to the 'Home' screen from any page since it allowed them to "start over". However, paging between subsequent screens was actually found to be difficult. Note, that in contrast with the current work, this study [2] was conducted in a Western context with a higher literate group (with 10-14 years of formal education), half of who had previous experience playing computer games or browsing the internet occasionally.

3 Study methodology

The methodology of our study below closely follows that of [6] for the sake of comparison. The reader is referred there for more detail.

3.1 UI prototypes

The domain of choice for this study was commonly occurring household items. These items: a) allowed for graphical representation for the target non-literate population;

b) were widely understood and did not require any domain specific knowledge; c) were gender neutral; and d) allowed for extensive categorization. Forty common household items were selected that included items of clothing, jewelry, utensils, electronics, games and sports, etc. We considered two instantiations for comparison: a list and a hierarchy of items. Each of these UI prototypes were displayed on a Samsung GT-I8350 running Windows Phone 7.5.

List. A list UI of 40 items, distributed continually over a total of 7 pages on the mobile phone; there were 6 items per page up to the 6th page (in a 3X2 matrix; 3 columns, 2 rows), and then 4 remaining items on the 7th page (in a 2X2 matrix). We took the layout of the PC list from the previous study [6] and divided up the items into groups of 6 to be placed on consecutive individual pages on the phone UI (the 7th page had the remaining 4 items). This resulted in loose categories of items per page sometimes flowing into subsequent pages. There were forward and backward arrows that had to be tapped to traverse between the pages of the list. To select any item, the test participant had to point to the item with his/her finger.

Figure 1a. 1st page of the list UI on phone with a forward arrow

Figure 1b. 5th page of the list UI on phone with a forward and a backward arrow

Hierarchy. A hierarchy UI of 40 items (4 levels deep and average branching factor of 3). The items in the hierarchy were organized in a top-down navigation tree based on four levels of organization: first level is how the item is used (e.g. things you wear, things you use), second is item category (e.g. Clothes, electronics, jewelry, etc.), third is item sub-category (Men's clothes, living room electronics, hands jewelry, etc.) and fourth is type of item (all 40 items such as shirt, TV set, bangles, etc.). Figure 2 shows the IA of the hierarchy. On the UI, each node of the organization was represented by a photograph that best depicted that node. To ensure that any cultural biases affecting the hierarchy were consistent with those of target participants, the previous study [6] conducted a validation of categories with members of the target community.

To select any given search item, test participants had to make four choices down the navigation tree to arrive at a given item. The interface was completely graphical with no text. Tapping on a certain graphic would take the user to the next level (subordinate categories) of the hierarchy. There was the provision to go back to the previ-

ous page in the hierarchy by clicking on a "back" button at the bottom on any given page (Figure 3).

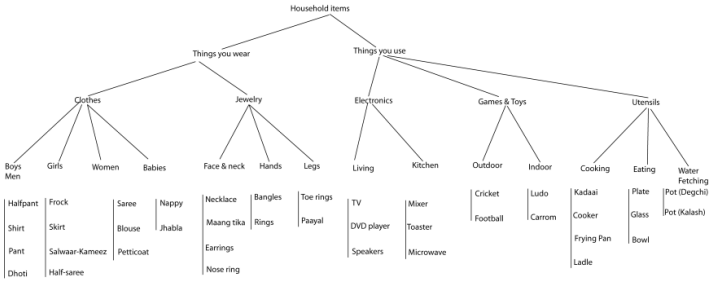

Figure 2. Hierarchy UI architecture on phone

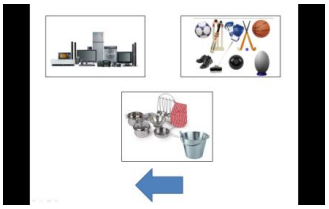

Figure 3. Screenshot of a page from the deep hierarchy UI

Process of administering the UI test. Every participant was randomly assigned one of the prototypes (list / hierarchy). Participants were asked to carry out five tasks: each task required them to find a given household item on the UI that was allotted, such as set of bangles, water pot, a football, a pair of shorts and a mixer-grinder. There was a time limit of 2 minutes for every task. Consecutive tasks were announced only after the previous task was over. There was a standard script of verbal instructions provided at the beginning of the test by the experimenter. We used the timing in the UI test solely as a mechanism for making progress with participants; the fact that participants were timed was not announced to them. This was done so participants did not feel that they were under time pressure – what they experienced was that occasionally, we would simply move onto another task.

Before using the UI prototype, for both the phone list UI and the phone hierarchy, like in the previous study [6] participants watched an instructional video on how to use the UIs on the touch-screen phone interface (of 1 min 58 secs for the list UI video and 2 min 8 sec for the deep hierarchy UI video). The hierarchy UI required more time to explain the concept of nesting. Both the instructional videos also had details about how to tap on the phone screen to go to the other pages by clicking on the arrows, or in the case of the deep hierarchy, on a given graphic (or back arrows). Participants could watch the video as many times as they wanted, up to a maximum of three times. The time taken to watch the video was not accounted for during performance evaluation on either of the UIs. The domain for the instructional video was animals-

birds kingdom instead of household item, so there was no learning effect on the actual tests. There was no assistance provided by the experimenter during use of the UI.

3.2 Experimental procedure

For consistency, the same researcher acted as experimenter for all participants and followed a standard script. Participants came in one by one. The researcher first gathered information about the participant such as their age, and asked if they had any formal education and technology experience, particularly with touch-screen phones. Then, each participant took a UI prototype test. The dependent variables that we measured are: number of correct tasks (maximum 5), total time taken for correct tasks, total time taken (maximum 10 minutes for incorrect and correct tasks combined). The search items that participants had to find on the multi-page list ranged between pages one to seven such that the average number of page selections was 4, so as to have an equivalent comparison with the hierarchy where the user had to make 4 choices down the navigation tree to arrive at any search item.

We conducted a between-subjects experiment design with a total of 20 participants. There were 2 kinds of UI prototypes-- list and hierarchy. First we paired the 20 participants by age, gender and mobile phone experience and then flipped a coin to decide who uses which UI prototype. This resulted in 10 participants each for the list and the hierarchy. The experimental design is illustrated in Table 1, together with mean and median ages and gender break-up.

Table 1. Between-subjects experimental design with 20 nos. of participants (m=male, f=female)

List	Hierarchy
10 nos. (5 m, 5 f)	10 nos. (5 m, 5 f)
Mean age: 38.8 yrs	Mean age: 38.2 yrs
Median age: 36.5 yrs	Median age: 38.5 yrs
4 nos. phone users	5 nos. phone users

3.3 Participants

Test participants were drawn from two urban slum communities in Bangalore, India. They were recruited through an intermediary organization doing developmental activities in the slum areas. Most people that were recruited were in informal sector jobs: construction workers, vegetable vendors, domestic workers, motor mechanics, etc. The household income of participants was less than about INR 6500 (USD 120) per month. The age range was 18-65 years. None of the participants had any formal education and could not read or write, though all of them were numerate and could recognize Indo-Arabic numerals. Their primary language of communication was Kannada. Apart from this, a few people also spoke Tamil and Hindi. None of the participants had any previous experience using touch-screen phones. Most male participants owned and used personal mobile phones for making voice calls only, dialing numbers from scratch every time. None of the participants with mobile phones used

the phone book. In terms of other technology use, TVs, DVD players and CD players were common items in participant households.

4 Results

4.1 Quantitative Findings

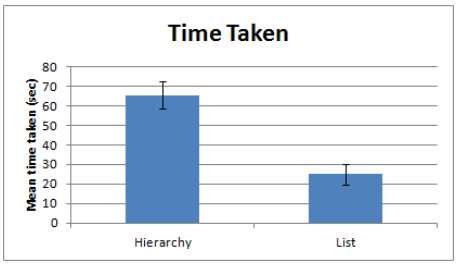

Figure 4a. Mean time taken across UIs (±SEM)

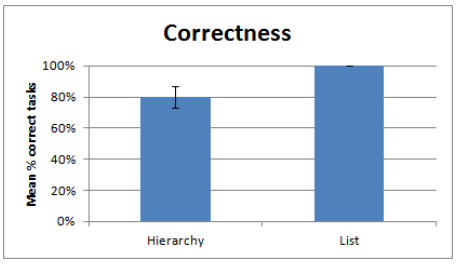

Figure 4b. Mean % correct tasks across UIs (±SEM)

Figure 4a illustrates the mean time taken for correct responses for each of the UIs. Results show that the multiple-page phone list UI required significantly less time to navigate than the deep hierarchy phone UI (average of 25 vs. 65.5 seconds) $t(18)=4.6$, $p<0.001$. This finding is corroborated when we take mean % correct tasks as the dependent measure of performance. Refer Figure 4b. Participants completed more correct tasks on the multiple-page phone list UI than on the deep hierarchy phone UI (average of 100 vs. 80), $t(18)= -3$, $p=0.0077$.

4.2 Qualitative Findings

We had a number of qualitative observations during the phone UI tests and follow-up informal conversations with the participants, some of which are consistent with the observations from the previous study [6] with respect to use of the hierarchy: First, some participants who could not complete tasks correctly or took more time on the hierarchical UI did not seem to understand the concept of nesting, or that the top graphic in a hierarchy represented a group of pages. The video instructions shown before the use of the hierarchy explained how (subordinate) items were "contained within" (super-ordinate) item categories, represented by a related graphic. It further explained how selecting that graphic would take the participant to the items contained within that category. But during the UI tasks, some participants seemed to guess randomly. They selected unrelated graphics on any given page in the hierarchy in efforts to find an assigned item.

Second, some people did not remember how to navigate back to higher levels once they had gone down the incorrect path in the hierarchy. Follow-up conversations revealed that they had forgotten the use of the "back" button from the instructional vid-

eo. This could be because of problems with short-term memory, inattention during the video instructions, lack of understanding about how "back" corresponds to moving up a level in the hierarchy, or the challenge of the additional cognitive load that navigating a hierarchy imposes. However, our study does not allow us to distinguish between these possibilities.

In the case of the list UI, however, participants seemed to understand the "back" button better. When participants needed to go to the previous page, they pressed the button without much hesitation. We suspect the recall was helped by the placement of "back" right beside the "forward" button (refer Fig. 1b) that they already had to use in any given task (except in the final task where the item was on the first screen and neither the forward or back button had to be used). The difference between the two arrows was indicated by their directionality.

On the phone list UI, we observed that even though the items were spread across 7 pages and not all of the items were visible at once, participants did not hesitate to move about quickly through the pages. Once they realised that the task item was not available on the first screen, unlike in the hierarchy UI they seemed to remember instructions from the video; they would promptly press the arrow ("forward" in this case) to move to the next page to find the task item. Even though none of our participants had any previous experience using a touch-screen phone, they seemed comfortable using this device. We suspect this could be because of general familiarity with the form factor of a phone, even though the interaction was through the touch-screen.

5 Discussion

In general, we had expected the test participants on the multiple-page phone list to perform poorly since, unlike a single-page list, not all items were visible at once. Finding task items on the phone list required participants to traverse through multiple pages (total 7 pages). But we found that test participants, despite having no previous experience using touch-screen phones, seemed fairly comfortable moving about the pages using the forward and back buttons. After watching them use the phone list with such comfort, we suspect a multiple-page list design might work better than a single-page PC list UI as it can be overwhelming to scan all 40 items listed at once. Further work is needed to determine if a multi-page phone list is in fact better than a single-page PC list. If the multipage phone list performs better, it would be interesting to investigate the reasons: fewer items for scanning per page, general comfort with form factor of phone versus a PC, etc.

Since this work, unlike the previous study [6], shows that it is not the paging itself that causes the problems, there seems to be something inherent in hierarchical navigation that poses a challenge. Further work is needed to investigate why this might be. We suspect it is because list navigation really does not require a user to remember much – it is just moving back and forth. At most, the user has to remember where he/she is along a single line. Hierarchical navigation seems more complex – the user has to remember that he/she is in a hierarchy, and has to hold the hierarchy from the root in their thinking. It is possible that literate users also would perform relatively

poorly on the hierarchical UI, given the circumstances of our trial. But our study does not allow us to deduce this given there was no control group of literate users; we recognize this is a potential limitation of our study.

6 Conclusions

Previous research has shown that in the context of a search task, a list UI design that displays all items at once on a PC screen works better than a UI where items are categorized under a top-down navigation tree of a hierarchy. But displaying all search items at once on a screen is frequently not an option for devices such as mobile phones where screen space is limited. We investigated the trade-off of paging through multiple pages of a list UI on a touch-screen phone, compared to a hierarchy where all of the items at a given level are all visible at once. 10 non-literate users used the multi-page list while another 10 non-literate users used the hierarchical UI. They were asked to search for five out of forty household items. Our results showed that both in terms of time taken and percent correct, non-literate users using the multi-page list UI perform better even when the list design required them to browse through multiple pages of the phone. Based on this, we suggest keeping navigation linear to the extent possible and to minimize hierarchical depth in UIs for non-literate users.

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