Exploring the Non-Visual Acquisition of Targets on Touch Phones and Tablets

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Abstract. Touch-based mobile phones and tablets have started to be shipped with built-in accessibility features, fostering the inclusion of disabled people. Particularly, blind people can use these devices resorting to screen reading software commonly along with a *painless exploration* approach. However, for a large part of the population, a first approach to these devices is still challenging and a future reigned by touch surfaces presents as daunting. The success with such gadgets varies and is highly dependent on the user's abilities. To ease a blind person's experience with mobile devices a better understanding of touch interface demands is required. In this paper, we present a study with 41 blind people where they performed low-level target acquisition tasks with different devices. Results revealed that differences in device size and the simple addition of a physical border are likely to deeply affect user performance. These differences should be further explored to foster inclusion.

Keywords: Blind, Mobile, Tablet, Touch, Demands.

1 Introduction

"*No way, touch screen mobiles are not accessible to us…they have no physical keys, how could we get around?"* - These words were shared with us by a blind person during preliminary questionnaires about the usage of touch screen devices. Indeed, the concerns about this technology are still common among blind people. If on one hand this can be argued as a misconception, i.e. blind people are using touch screen devices with success resorting to screen reading software like *Apple's VoiceOver*, on the other hand, there is still little knowledge about the difficulties these users face in their first approaches with the devices and how proficient they get in the acquisition and performance of simple touch primitives. Further, touch screens come in different flavors: a tablet is larger than a touch phone and the abilities required to explore both gadgets may differ; the amount of information onscreen along with the size of the interactive elements there may also vary. There have been studies in the past to understand how to better parameterize touch interfaces for sighted people [3]. Blind people are faced with similar interfaces as their sighted fellows with an *exploration* layer above enabling them to receive feedback as they wander the screen. Kane et al. presented a study where differences in the interaction with touch screens between sighted

adfa, p. 1, 2011.

and blind people became evident [2]. Several researchers have provided alternatives to current interfaces [5,6,7] but there is an overall lack of knowledge on the benefits of each design and variations within.
In this paper, we explore how blind people interact with three different touch setting: a touch phone, a touch phone with a physical border applied, and a tablet. We focus on the acquisition of targets (i.e., landing-on a target) on different sized grids on all three devices and aim to assess how these settings vary in terms of demand to the blind user. A study with 41 blind people is presented. Results showed that different settings present different demands and these should be taken into account when designing interfaces for blind people.

2 Exploring Touch Accessibility for the Blind

We conducted a controlled laboratory experiment with forty-one (41) blind people to better understand how they cope with touch screen devices and the demands imposed by those. To this end, participants in the study interacted with different devices and several primitives and target sizes therein. In this paper, we focus our attention on the acquisition of targets, in particular, how blind people perform taps on three different settings: tablet, touch phone and touch phone with physical border (Figure 1). In the context of this paper, we define acquisition of targets as the moment where a first contact with the screen is performed, i.e. land-on.

Figure 1. Blind users during the evaluation. *Top-left:* participant performing the trial with a tablet; *Bottom-left:* with a touch phone with a physical border; *Right:* with a borderless touch phone.

2.1 Research Questions

Our research aims at a better understanding of the demands imposed by touch interfaces to blind people. In detail, in this study, we aim to answer the following research questions: 1) How does device size (mobile vs tablet) affect the non-visual acquisition of targets?; How does the presence/absence of physical borders affect non-visual acquisition of targets?; How users cope with different sized grid-based layouts?; Are blind users capable of surpassing the low-level demands imposed by touch devices?

2.2 Participants

Forty-one (41) blind people participated in this study. Their ages were comprehended between 25 and 66 years old (M=45, SD=11.2). The group was composed of 22 males and 19 females. Educational background ranged from participants with the 4th grade and those with a college degree. Only one participant had previous experience with touch screen devices; he owned an Apple IPhone 3GS. Thirty-eight participants used mobile keypad devices in a daily basis. Two participants did not own a mobile phone.

Figure 2. Samsung Galaxy S and ASUS EEE Pad Transformer TFT-101

2.3 Apparatus

The experiment comprised the usage of two different-sized devices, a touch phone and a tablet. As a touch phone, we selected the Samsung Galaxy S (122.4 x 64.2 x 9.9 mm) [480 x 800 pixels, 4.0 inches] while as a tablet an Asus EEE Transformer (271 x 171 x 12.98 mm) [1280 x 800 pixels, 10.1 inches] was used (Figure 2). A third setting was used but with the usage of the same touch phone with a physical border applied. Both devices run Android (2.2 and 3.0, on the phone and the tablet, respectively). The evaluation and logging software was developed in Java and was the same for both devices. Svox Classic TTS with the Portuguese language was used for audio feedback. The software was responsible for randomizing the order of the trials in respect to Grid (6 or 12 areas) and targets/directions.

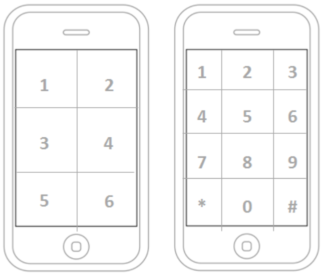

Figure 3. Touch phone with the two grid layouts used in the experiment.

2.4 Procedure

We gathered and performed evaluations with forty one users, with light perception at most. The recruitment of participants was performed in collaboration with a formation centre for blind people. All sessions were performed in the centre installations in a quiet meeting room. The session started with a brief questionnaire to gather the participant's background information. Upon completion, the evaluation monitor explained the goals of the studies along with a description of the study procedure. Each participant performed the evaluation with all three devices. The order was randomized. For each device, the blind person had a preliminary familiarization phase. After *feeling* the device and its elements, the evaluation software was initialized and before each grid-based layout (also randomized), the device prompted the participant for a training session where feedback was offered depending on the touched area (Figure 3). When the participant felt ready, the monitor made the application step to the following screen. The test application started upon a first touch with the screen. Then, with 2- second intervals from the previous trial, a new request (a spoken area) was made by the device (text-to-speech). All areas were prompted only once to each participant mostly due to time restrictions. Upon completion of both grids in each device, a post-questionnaire was applied to assess how the participant rated the difficulty of acquiring targets in the evaluated settings.

2.5 Design and Analysis

A within-subject design was used. Forty-one participants performed interaction tasks with all 3 devices, for both grid sizes. Dependent variable was Incorrect Land On Error Rate. Two-way repeated measures ANOVAs were performed to assess differences between groups (we assumed normality of data given the size of the sample [1]). As to ordinal data, we employed non-parametric alternatives (Friedman tests with Wilcoxon post-hoc multiple comparisons with Bonferroni corrections).

2.6 Results

The success in operating a touch screen is highly related with the ability to acquire a target. For sighted participants, this is achieved through a high visual load. For blind people, this is likely to depend on spatial abilities, tactile sensitivity, memory, along with experience [4]. Here we try to understand how difficult it is to acquire a target without visual feedback and how is this different between different device settings.

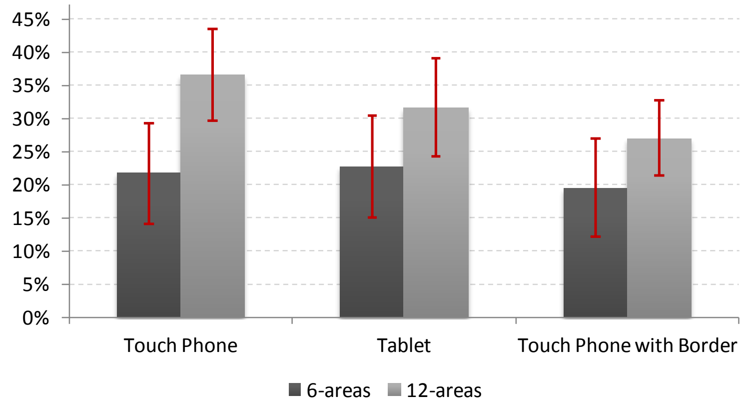

Figure 4. Average Incorrect Land Error Rate for all devices and both grids. Error bars denote 95% confidence intervals.

Comparing devices and target sizes. Figure 4 presents the average land-on error rate for the three devices and grid settings where it is visible that in the 12-area trial differences were larger between devices. For all devices, there is an observable difference between the 6-area and 12-area settings.

A two-way repeated-measures ANOVA showed no main effect of Device [**Tablet vs Touch Phone**] on Incorrect Land Error Rate for Tapping. Conversely, a main effect of Grid was found ($F_{1,35}$= 11,34, p<.005). No significant interaction between Grid and Device were identified suggesting that the aforementioned main effect was consistent across both devices. In sum, the amount of targets onscreen seems to have an impact on land-on error rates as new demands are imposed to the user. However, a smaller or larger device, and hence smaller or larger targets, does not seem to have an impact on the users' ability to land on a target.

To assess the impact of a physical border on user performance, a two-way repeated-measures ANOVA was performed and revealed a main effect of Device [**Touch Phone vs Touch Phone with physical border**] on Incorrect Land Error Rate for Tapping ($F_{1,39}$=5.77, p<.05). A main effect of Grid was also found ($F_{1,39}$=9.37, p<.005). No significant interaction was found between Device and Grid. These results suggest that the presence of a physical border decreases the demands imposed to blind people and enable them to perform better. Also, independently from that, the number of elements in a grid also has an impact on user performance. Figure 5 shows the distribution of land-on points in all three devices. It is visible that a more sparse distribution happens on the touch phone in comparison to the touch phone with physical border. Indeed, the border works as a reference and the hit points are closer. The tablet due to the larger size of the targets also shows a larger amount of samples closer to the border.

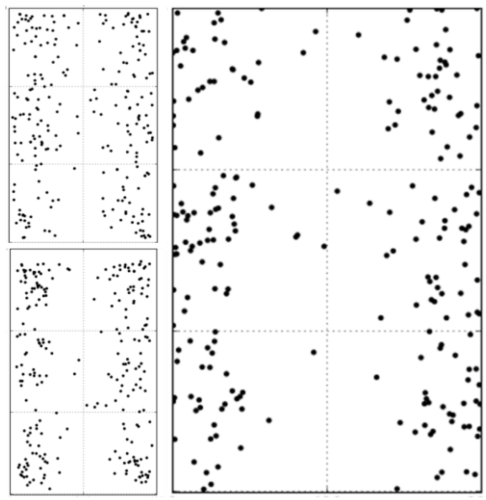

Figure 5. Scatter plot with all land-on events in all 6-grid tapping trials: Touch Phone (*Top-left*); Touch Phone with Physical border *(Bottom-left)*; and, Tablet (*right*).

Position within devices. Figure 6 presents the error rate associated with each area on the 12-area grid setting for all devices. A two-way repeated measures ANOVA was performed to assess if it was easier to acquire a corner target (*Area*) and how did this change among devices (*Device*). Significant main effects were found for Device ($F_{2,70}$=4.62, p<.05) and Area ($F_{1,35}$=43,199, p<.001). No significant interaction was found. Post-hoc tests showed that tapping on a corner target is less erroneous and this is consistent across all devices. The same test was applied but this time comparing target rows (*Rows)* and significant effect of *Rows* was once again found ($F_{2.461, 86.12}$ = 26.602, p<.001) between the 1^{st} and both the 2^{nd} and 3^{rd} row as well as between the 2^{nd} and the 4^{th} row and between the 3^{rd} and 4^{th} row. The first and the fourth row (edge-rows) seem to be the less erroneous although an interaction was found between *Device* and *Row* suggesting that the presence of a physical border affects mainly the acquisition of the first row (worse in the borderless setting; the fourth row is consistent between all settings).

21,62%	24,32%	24,32%
32,43%	43,24%	35,14%
45,95%	48,65%	59,46%
13,51%	18,92%	13,51%

27,50%	35,00%	30,00%
35,00%	65,00%	62,50%
55,00%	50,00%	47,50%
10,00%	10,00%	12,50%

12,20%	19,51%	12,20%
26,83%	63,41%	46,34%
31,71%	46,34%	37,50%
12,20%	9,76%	7,32%

Figure 6. Incorrect Land Error Rate per Area: Tablet (*left*); Touch Phone *(center)*; and, Touch Phone with Physical Border (*right*).

Users' opinions.

A 5-point Likert scale questionnaire was applied after each setting showing small differences between the 6 and 12-area grids, particularly in the borderless settings.

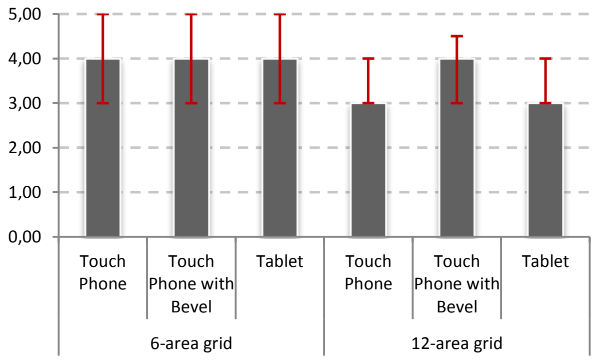

Figure 7.*Users' opinions. Median and quartiles are presented.*

However, regarding the size of device some participants stated to have difficulties with the tablet. One participants said *"We, the blind, dominate two spaces: the finger-tip and the hand palm. Thus, it is easier to use the touch phone which is smaller than the tablet despite the targets being larger".* About the tablet, another told us *"It is such a large area. It is harder"* while other said *"This one [**tablet**] is larger but I feel lost...although the areas are very big, it gives a certain insecurity.*

As to physical borders, one participant stated that *"the border helps with the localization and it is also a safe place to rest the fingers"* while another said that *"the border makes our life easier but it also induces self-confidence and then we miss the targets".* In the overall, the participants did not think the trial nor do they find large differences in the settings presented. However, results show otherwise. Particular volunteers showed concerns about specific settings revealing preferences for different solutions.

3 Conclusions

Touch screen devices come in different shapes and sizes. The demands imposed by different layouts to blind people are likely to diverge across devices. A better understanding of touch interfaces in general is required. Our study enabled us to answer the aforementioned questions as follows:

How does device size (mobile vs tablet) affect the non-visual acquisition of targets? Most blind participants showed less confident with the tablet due to the large space they had to handle with. However, no differences were found in landing error rate showing that they can locate targets similarly in both smaller and larger devices if the space on screen is used accordingly.

How does the presence/absence of physical borders affect non-visual acquisition of targets? The presence of a physical border showed a positive effect on the acquisition of targets onscreen. Also, participants stated that the border helped with localization and with handling the touch device.

How users cope with different sized grid-based layouts?

The amount of targets onscreen decreases the size of each target and decreases the confidence in locating the desired one. Significant effects of grid size were found in all settings showing that this is true independently of physical cues and device size. Further studies are required to understand which grid sizes guarantee the best ratio between accuracy and number of onscreen elements.

Are blind users capable of surpassing the low-level demands imposed by touch devices? Results showed that high error rates for all settings showing that the *raw* touch approach is not feasible for blind people. Painless exploration approaches diminish this issue as the user is able to explore the screen until the desired feedback is received but getting closer to a target is still relevant. Further, those that fail the most landing on the target are likely to be the ones that have difficulties in navigating in the touch area to find the desired item. Large standard deviations were found showing that these abilities vary among the population, fact that justifies the inclusion of some and exclusion of others.

Acknowledgments

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