Towards Designing Adaptive Touch-Based Interfaces

Figure 1. Two child participants from our study using the mobile apps.

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Abstract

As the use of mobile devices by non-typical users increases, so does the need for platforms that can support the unique ways in which these special users engage with them. We posit that, by developing an understanding of patterns in input behaviors for different user groups, we can design and develop interactions that support such non-typical users. We prove this technique with children: we present findings from two empirical studies showing how interaction patterns differ among younger children, older children, and adults. These findings point to a model of how to develop touch-based interactive technologies that can adapt to users of different ages or abilities. Such adaptations will serve to better support natural interactions by user populations with distinctive needs.

Author Keywords

Mobile devices, accessibility, child-computer interaction, touch interaction, gesture interaction.

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms

Design, Human Factors.

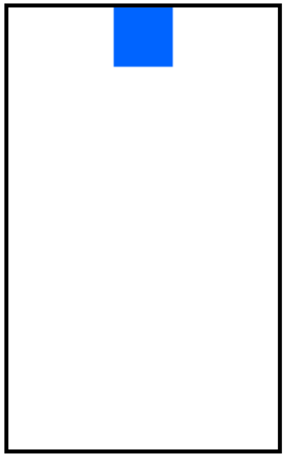

Figure 2. An example of the Target Acquisition application.

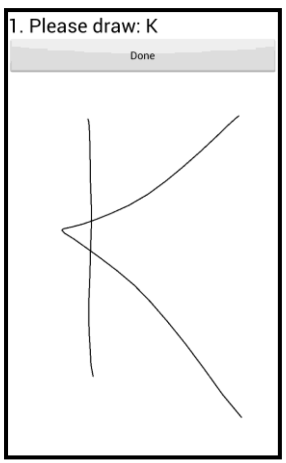

Figure 3. An example of the Gesture Task application (Feedback version).

Introduction

With respect to touch and keyboard interfaces, significant differences in usability have been found among various user groups [7]. Along with research on interaction modes, there have been numerous studies involving a broader range of users such as the very young, i.e., preschool-aged children, and the older user, i.e., senior citizens [6, 8]. In addition to those of different ages, individuals with various physical and cognitive abilities have been a growing segment of mobile device study participants [4, 9]. However, consumer-oriented mobile touchscreen devices have not been designed for users outside the typical age range or for those with varied physical and cognitive disabilities [8]. Thus, research on interactions for these users generally involves the adaptation of existing devices to accommodate these users [5, 11].

We posit that an understanding of user input profiles from non-typical users can reveal the natural ways in which they interact with mobile devices. We prove this approach with children, a population with special cognitive and developmental characteristics [10]. Using this knowledge, we believe developers can design systems to adapt to the user, rather than requiring the user to adapt to the device. In our vision, adaptive systems will streamline interaction across devices, enabling users to transfer skills that they have learned in one platform as they move to new platforms [2]. Adaptive interfaces will become especially critical as devices evolve at a rapid pace and people encounter new devices using different interaction paradigms.

Approach

We conducted two studies to understand the interaction patterns of young children, older children, and adults using mobile devices [1, 2]. Participants engaged in touch-based interaction tasks using Android OS apps (version 4.0.4) designed specifically for this research. All of the studies were conducted using Samsung Google Nexus S smartphones with a 4" screen. Participants completed the study while seated comfortably and either held the devices in their hand or placed them on a table (as they desired, Figure 1).

Participants

The studies were conducted with 74 children and adults. Of the 30 adult participants (*M* = 23.7 yrs, *Range* = 18 to 33 yrs, *SD* = 4.0 yrs), 12 were female. Of the 44 child participants (*M* = 12.1 yrs, *Range* = 6 to 17 yrs, *SD* = 2.4 yrs), 23 were female. The large majority of our participants were right-handed (61 out of 74); 6 indicated they considered themselves ambidextrous, and 7 were left-handed. On a questionnaire regarding touchscreen familiarity, adults generally considered themselves "expert" (20 of 30, or 67%) or "average" (10 of 30, or 33%); nearly all, 93%, of the child participants considered themselves either average or expert proficiency with touchscreen devices.

Target Acquisition Task

The Target Acquisition task (Figure 2) required participants to perform interactions similar to those required when engaging in tasks such as tapping in a game or pressing an interface widget (e.g., checkbox, menu item) [1, 2]. To complete the target task, participants were required to touch 104 targets of 4 different sizes: very small (3.175 mm), small (6.35 mm), medium (9.5 mm), and large (12.7 mm), in 13 different positions on the screen (e.g., along edges, in corners, and in the center of screen). Half the targets along the edges included edge padding (they appeared

Figure 4. The 20 gestures used in the Feedback (FB) and No-Feedback (NO-FB) application tasks.

Age Group (years)	Miss Rate
7-10	26%
11-13	23%
14-17	22%
18+	16%

Table 1. Target task miss results grouped by age.

Age Group (years)	FB	NO-FB
7-10	76%	78%
11-13	82%	85%
14-17	88%	87%
18+	91%	91%

Table 2. Gesture recognition rates grouped by age.

slightly inset from the edge), whereas the other half were drawn exactly aligned with the edge of the screen.

Gesture Interaction Task

The Gesture Task (Figure 3) required participants to generate surface gestures similar to those used when engaging in direct manipulation tasks [1, 2]. To complete this task, participants were prompted to draw each of 20 gestures 6 times (Figure 4). Prior to completing the gesture tasks, participants were asked to draw each of the gestures on a sheet of paper to serve as a reference for use during the study session. We employed two versions of the gesture task. In the Feedback condition a trace was shown to users as they completed each gesture (Figure 3). In the No-Feedback condition, there was no trace. Participants in one study completed both gesture tasks, while participants in the other completed only the No-Feedback task.

Analysis

For data quality reasons, data from 8 participants were excluded from analysis [1, 2]: 3 due to technical issues with recording the data logs, 1 due to not completing the full task set, and 4 had used a different device than the other participants as a pilot. Our analysis covers the remaining 66 participants (29 adults, 37 kids).

Target Tasks

On average across participants, 78.3% of the targets were hit successfully on the first attempt; the other 21.7% of targets required multiple attempts (M = 1.53; SD = 1.79). Overall, children (M = 23%, *Range* = 10% to 39%, SD = 7%) generally missed more targets than adults (M = 16%, *Range* = 11% to 29%, SD = 5%). This difference is statistically significant by an independent samples t-test on per-user miss rate ($t(64)=4.48$, $p < 0.01$). Further, when considering specific age groups, target acquisition accuracy rates increased for older children and adults (Table 1).

Gesture Tasks

The gesture data was analyzed via *user-dependent* gesture recognition with the $N-Protractor recognizer [3]. Results indicate that child-generated gestures tend to be less accurately recognized. The recognizer had more trouble classifying children's gestures (M = 83%, *Range* = 61% to 96%, SD = 7%) than adults' gestures (M = 91%, *Range* = 75% to 98%, SD = 5%), regardless of age. This difference is significant by an independent samples t-test on per-user recognition accuracy ($t(64)=4.53$, $p < 0.01$). Further, when considering specific age groups, gesture recognition accuracy rates also increased with age (Table 2).

Implications of the Study

Our findings show that children are less accurate when acquiring touch targets than adults and that accuracy increases for older children. We have also found that children's surface gestures are less likely to be recognized than adults, *even when trained on the same user's gestures*, and that recognition accuracy also increases for older children.

Based on these findings, we believe that recognition algorithms that are tailored to children's gestures must be developed. Ideally, systems would be able to detect whether a user is an adult or child and then choose an appropriate recognition algorithm dynamically. With respect to touch target acquisition, we note that interface designers must balance the small screen sizes of mobile devices with reasonable widget sizes for users. We believe probabilistic models of which target is intended, based on touch input patterns, should be developed to improve touch accuracy for children.

Conclusion

Our research was conducted on children as a special user population. We have identified differences in how interaction patterns differ for younger children, older children, and adults. We believe that, if user interaction patterns can be characterized effectively, systems can be designed to dynamically adapt to expected input, increasing the success of user interactions with mobile touchscreen devices. We believe that this concept and approach can be extended to users with different abilities as well, by creating similar input profiles. The overarching goal of this work is to design systems that adapt to users, rather than vice versa.

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