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Research Report

Improving the Usability of a Mainstream Cell Phone for Individuals with Low Vision

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This study investigated improving the usability of a mainstream cell phone for use by individuals with low vision by providing a means to display the text of the keys in large print on the phone's screen. No functionality was removed and no special equipment was required, and thus access was provided at no extra cost, which is a different paradigm from other forms of assistive technology, which usually require individuals with disabilities to purchase special models or external adaptation to use available models. The enlargment techniques we tested were designed to be transparent and accessible by users whenever they need extra assistance in dialing.

This study was based on the hypothesis that the accuracy of dialing mainstream cell phones by people with low vision would

improve with the provision of enlarging techniques. The enlargement techniques were expected to be of greater assistance when users with low vision were dialing telephone numbers with letters rather than when dialing digit-only number sequences.

METHOD

Instrument

The commercially available Kyocera 7135 "smartphone" (a cell phone plus personal digital assistant) was chosen for the study because of its programmability. Although the cell phone was turned off during the dialing tasks, the tones associated with key presses were reproduced to simulate the typical experience of using the cell phone. The cell phone used in this study is pictured in Figures 1 and 2.

The Kyocera 7135 is a flip cell phone with a color screen and a 7/8-inch by 1 7/8-inch "Graffiti" touch panel at the base of the screen. A white label with a blue diamond (BD) was placed over this touch area to create a single button, the BD-button. Because of the lack of contrast between the background and the numbers and letters on the phone's keys, white labels with black text containing each key's information were placed over the keys.

Enlarging techniques

Two enlarging techniques (suspend and display and delay and display) were developed, and the programs were loaded into the cell phone. The two techniques used the same degree of enlargement on the cell phone's screen. Both were designed to function with the BD-button that was described in the Instrument section.

The techniques differed in the way that a number is entered into the cell phone after a key is pressed. The suspend-and-display technique suspends operation of the dialing function and displays, without dialing, the enlarged key labels. When using this feature, the caller holds down the BD-button and presses another key. The

number and letters associated with that key are then enlarged and displayed on the screen (but the key is not "dialed" or activated). When the caller finds the key that he or she wants to include in the number or letter sequence to be dialed, he or she releases the BD-button and pushes the desired key again to input the number or letter of the key (see Figure 1).

The delay-and-display technique involves a time delay for activation of a depressed key (Vanderheiden, Law, & Kelso, 1999), in which the user again holds down the BD-button, and the selected key is again enlarged and displayed. However, with the delay-and-display mode, the number is entered into the dialing queue only when the key is held down for a prescribed period of time (the duration of the dialing delay can be adjusted according to user preference). A progress bar at the top of the screen indicates the length of time before the number will enter the dialing queue (see Figure 2). Both the suspend-and-display and the delay-and-display techniques work for all keys on the cell phone. For both techniques, when the BD-button is released, the cell phone returns to standard operation.

Experimental design

The experiment was divided into four stages. In each stage, the participants used a different dialing mode:

1. Control mode, in which dialing tasks were done as they would be if the phone had no special features.

2. Suspend-and-display training mode.

3. Delay-and-display training mode, initially set at two seconds.

4. Composite mode, in which the user had the option of using either enlargement technique or a combination of the techniques.

The participants dialed digit-only numbers and digit-letter combination sequences (such as 800-MADISON) using the enlarging techniques. Introduction of the two enlarging

techniques was counterbalanced. Data on dialing errors and time were logged. Time was measured from the time that the first key in a new trial was pressed to the time when the Send button was pressed. A program recorded each keystroke and the time at which it was made. It also compared the number in the dialing queue to the target number and identified whether the correct number was dialed. In addition, the session was videotaped.

The study had one independent variable (mode), with two levels (control and composite) and two dependent variables (dialing accuracy and time to complete the dialing task). Dialing accuracy was recorded as either correct or incorrect, and time to complete the dialing task was recorded to the nearest second. The values for dialing accuracy and time to complete the dialing task were compared for each participant's performance in the control and composite modes.

Participants

To be eligible to participate, individuals had to be able to read text that was slightly larger than the number as it appeared when enlarged on the screen of the cell phone (80-point Tiresias font was used). If a participant was able to read text that was smaller than that on the keys (5-point Tiresias font was used), he or she was excluded. The decision was made on the assumption that the enlarging features would be of little or no assistance to someone who could see the text as printed.

Approval to work with human participants was granted by the University of Wisconsin–Madison Health Sciences Institutional Review Board. Following the guidelines for administration, binocular visual acuity was estimated by using a Sloan Letter Near Card at 16 inches (40 centimeters) (Good-lite). This card was selected because the short viewing distance--the participants were asked to read the card from a distance of 16 inches--made it suitable for individuals with low vision. The visual acuity of the participants who completed the study ranged from approximately 20/60 to 20/320. In addition, the participants reported various

types and levels of visual impairment or diagnoses, including macular degeneration (4 participants), multiple sclerosis (1 participant), lost vision in a sudden manner (1 participant), varying visual acuity (1 participant), and unknown (1 participant).

Four people started, but did not finish the session. The first had photophobia and reported that her eyes hurt after completing the control mode task; the second said that looking back and forth between the phone and the phone number on the card was too difficult; the third withdrew because of a time constraint; and the fourth had difficulty dialing digit-letter combinations.

A total of eight participants (six women and two men) successfully completed all the trials. These participants ranged in age from 25 to 87 (average age 61, $SD = 25$), and all reported some education beyond high school. Five used a cell phone only "rarely" (defined as once or twice), one used a cell phone "occasionally" (defined as once per month), and two used a cell phone frequently (at least once a week).

Procedures

At the beginning of the session, the researchers introduced the participants to the device and its pertinent features. For the introductory part of the session, the participants dialed two practice numbers, followed by two digit-only and two digit-letter combinations for each of the four test modes. In all the modes, as the participants dialed, numbers (not letters) appeared at the bottom of the screen.

The control mode was the first to be completed. In modes two and three, the participants were instructed in the use of the enlarging techniques. This introduction was counterbalanced. The participants were asked to use the prescribed dialing techniques for all the entries they made. The trials completed during this time were considered training, and were not included in the analysis of the results. After training in both techniques, the participants completed the composite model, in which each participant was

allowed to dial according to his or her preference, using any combination of the enlarging techniques and regular dialing.

A statistical analysis compared the participants' performance in the control mode and in the composite mode. The participants were also asked which technique they preferred. Trials were dichotomously coded as correct or incorrect. The individual keystrokes were not analyzed for accuracy, so an incorrectly dialed trial could consist of one mistake or several misdialed digits. Time to complete the dialing tasks was also examined.

Both dependent variables--dialing accuracy and the amount of time required to complete the dialing task--were analyzed. The Wilcoxon signed ranks test was used to test the null hypothesis that the median difference in dialing accuracy before and after the introduction of the enlarging techniques was zero. Data on time to complete the dialing task were analyzed parametrically, using a paired *t*-test.

Classification of errors

Videotaped recordings of the sessions were analyzed and errors were described. Two researchers reviewed the videotapes and classified the errors independently. There were three types of errors: unable to see the keys, error recovery, and misdialed. For the unable-to-see-the-keys error, the participants indicated that they were not able to see any key; for the error-recovery error, the "clear" and "clear all" or "end" keys appeared to be used incorrectly; and for the misdialed error, one or two digits were entered incorrectly (these errors did not seem to follow any pattern, and no explanation was reported by the participants).

QUANTITATIVE RESULTS

Across the eight participants, a total of 21 trials (out of 32) were completed correctly in the control mode, and a total of 27 trials (out of 32) were completed correctly in the composite mode. Four participants dialed all eight trials (control plus composite mode)

correctly. Two participants increased their dialing accuracy by one trial from control to composite mode, and two participants had a two-trial increase.

When we combined the digit-letter trials and digit-only trials, we found that the participants' median performance in dialing accuracy was better in the composite mode than in the control mode ($N = 8$, $p < .05$). Following the combined analysis, the digit-letter trials and digit-only trials were separated. Neither of these results was significant ($p > .05$). In addition, no significant difference in dialing time was demonstrated between the composite mode and the control mode. The participants' average time to complete the dialing task ranged from 10 seconds to 59 seconds in the control mode and from 10 seconds to 57 seconds in the composite mode. The average dialing time was 32 seconds ($SD = 16$) in the control mode and 38 seconds ($SD = 15$) in the composite mode.

Sixteen errors were made in the control mode and the composite mode. Of these, 9 errors were determined to be a result of a participant's inability to see the keys (as evidenced by 2 or more incorrect entries), 6 were simple misdials (an otherwise uncategorizable mistake, such as dialing a "4" instead of a "7" but entering the rest of the number correctly), and 1 was caused when the participant pressed "clear" (not "clear all", which deletes the last digit entered), and then started the full dialing again.

QUALITATIVE RESULTS

Comments were solicited from the participants on the two enlargement techniques, the cell phone, and the acceptance time for the delay-and-display technique. The participants generally agreed that the enlargement features were nice to have, especially when dialing the digit-letter sequences. Two stated that regardless of the type of sequence dialed, their preferred method of dialing was delay and display, and one person preferred regular dialing. Five participants stated that their preferences were dependent on the type of sequence being dialed. They all preferred regular

dialing for digit-only sequences (one person added that it was a close call between regular dialing and delay and display). However, they were divided in their preferences for the letter sequences; two preferred delay and display, two preferred suspend and display, and one did not have a preference between the two enlargement techniques.

The participants' comments on the phone's keys included observations on the shape, tactile feedback, contrast, and layout of the buttons. Several participants commented on the difficulty in pressing the keys. Two participants remarked that it would be better if the graffiti panel were easier to press. One participant noted that many older people have difficulty with finger movements because of arthritis. This comment was supported by the researchers' observations that the participants had difficulty keeping the BD-button down when using the enlarging techniques.

DISCUSSION

A significant improvement in dialing accuracy was observed between the control and the composite mode. It was hypothesized that dialing accuracy would improve after the introduction of the enlarging techniques because the techniques enable users to check their entries as they dial. If an error is made, there is a way to recover. Everyone did the same or better in the composite mode, compared to the control mode. The resulting improvement in dialing accuracy after the introduction of the enlarging techniques was significant when the digit-letter and digit-only trials were considered together. The data support the hypothesis that an enlarging interface can help individuals with low vision place telephone calls with fewer errors.

When completing trials in the composite mode, seven of the eight participants used one of the enlarging techniques. Six used a combination of regular dialing with one of the techniques, one used only delay and display for dialing, and another used only regular dialing. Generally, the participants chose to use the

enlarging techniques for the digit-letter trials. Five participants said that their preference changed, depending on whether they were dialing digit-letter or digit-only combinations. It was expected that the time to complete the dialing task would increase after the introduction of the enlarging techniques because the techniques require either extra key presses or extra time to activate the key; however, it did not change significantly.

Limitations

One limitation was the size of the sample. There may not have been enough participants to detect a difference between the control and the composite groups when the numbers dialed were statistically evaluated for digit-only and digit-letter combinations. Another limitation is that each participant tried the techniques on only one make of cell phone.

CONCLUSION

As the population ages, the number of people who will experience vision-related problems is expected to increase. This growing segment of the population will also need telecommunications equipment to maintain the lifestyles to which they have grown accustomed. Auditory feedback may be compromised (depending on the environment), so programs and techniques that allow individuals with low vision to make use of their residual vision may be beneficial. The current trend to employ larger, color screens in cell phones makes the use of residual vision more plausible than in the past, when both the screen and the text were poorly illuminated. It would be beneficial for the enlargement programs tested by this study to be evaluated on additional cell phones. The usability of cell phones may be improved with activation techniques, such as those reported here.

REFERENCES

Vanderheiden, G. C., Law, C. M., & Kelso, D. (1999). EZ access

interface techniques for anytime anywhere anyone interfaces. *Proceedings of the Association for Computing Machinery Conference on Human Factors in Computing Systems* (ACM CHI 99), pp. 3–4. New York: Association for Computing Machinery.

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