Tap or Touch? Pen-based Selection Accuracy for the Young and Old

Juan Pablo Hourcade
Department of Computer Science
University of Iowa
14 MacLean Hall
Iowa City, IA 52242 USA
hourcade@cs.uiowa.edu

Theresa R. Berkel
Princeton University
311 Foulke Hall
Princeton, NJ 08544 USA
tberkel@princeton.edu

CHI 2006, April 22–27, 2006, Montréal, Québec, Canada.
ACM 1-59593-298-4/06/0004.

Abstract

The effect of the decline in cognitive, perceptive, and motor abilities on older adults' performance with input devices has been well documented in several experiments. None of these experiments, however, have provided information on the challenges faced by older adults when using pens to interact with handheld computers. To address this need, we conducted a study to learn about the performance of older adults in simple pen-based tasks with handheld computers. The study compared the performance of twenty 18-22 year olds, twenty 50-64 year olds, and twenty 65-84 year olds. We found that for the most part, older adults were able to complete tasks accurately. An exception occurred with the low accuracy rates achieved by 65-84 year old participants when tapping on targets of the same size as the standard radio buttons, checkboxes, and icons on the PocketPC. An alternative selection technique we refer to as "touch" enabled 65-84 year olds to select targets more accurately. This technique did not negatively affect the performance of the other participants. If tapping to select, making standard-sized targets 50 percent larger provided 65-84 year olds with similar advantages to switching to "touch" interactions. The results suggest that "touch" interactions need to be further explored to understand whether they will work in more realistic situations.

Keywords
Stylus, pen, tap, touch, accuracy, handheld, PDA, PocketPC.

ACM Classification Keywords
H5.2 [Information Interfaces and Presentation]: User Interfaces – Input devices and strategies; Interaction styles; Screen design; Graphical User Interfaces (GUI)

Introduction
The aging of the world's population is likely to bring profound challenges to interaction designers as they will have to increasingly design for users with declining cognitive, perceptual, and motor abilities. While there has been plenty of research on the declining abilities of older adults [1][2][3][5], there has been no research that we are aware of on the performance of older adults using pens to interact with handheld computers. This report aims to address this gap in the literature by providing a summary of early results obtained from a study comparing the performance of young and older adults completing simple pen-based tasks on handheld computers.

Tap or touch
The standard way of interacting with a handheld computer using a pen is to tap on the screen. This has been convenient from a programming perspective because all the libraries developed for mouse-based point-and-click interactions can be reused for tap interactions. One concern with tapping is that it does not reflect the way people use notepads, the closest paper relative to handheld computers. People do not tap on notepads, instead they write, make checkmarks, and so forth.

Touch interactions provide an alternative way of selecting checkboxes, radio buttons, icons and other visual targets. Rather than requiring that the pen touch the screen and be lifted from the screen inside the target, touch interactions only require that the target be touched at some point while the pen is on the screen. Touching, hence, supports selecting visual targets by crossing them, making checkmarks, and even tapping on them. Touch interactions have been previously found to provide higher accuracy than tap interactions for very small targets selected on Wacom tablet-displays [4].

Research questions
We sought to gain insights into the following research questions through this study:

- Do younger and older adults differ in performance when tapping to select visual targets?
- Do younger and older adults differ in performance when touching to select visual targets?
- Which technique works best for each age group when completing selection tasks: tap or touch?

Study setup
Participants
There were 60 participants in the study: 20 between the ages of 18 to 22 (one used handhelds on a regular basis), 20 between the ages of 50 to 64 (none used handhelds on a regular basis), and 20 between the ages of 65 and 84 (one used handhelds on a regular basis). They were recruited in the Washington, DC, USA metropolitan area and were paid $35 for their participation in the study.

Materials

We used a Compaq iPAQ 3950 running PocketPC 2002 for the study. The handheld's screen had a resolution of 240 x 320 pixels, with each pixel being approximately 0.24mm in size. The study software presented participants with tasks to complete. It did not require the participation of the researcher to move between tasks. As participants completed tasks, all their actions on the device's screen were logged. Selection tasks started with users seeing a large light green circle. Putting the pen on this circle revealed a red target circle. Participants then had to lift the pen from the screen and tap or touch the red target circle. If participants missed the target, they did not repeat the task. Participants selected circles of three different diameters (16, 24, 32 pixels). Target circles appeared at distances three times, four times, or five times the target circle diameter, and at one of eight angles (0, 45, 90, 135, 180, 225, 270, 315)[1]. The software also presented users with straight and circular steering tasks, but we will not discuss these in this report as we have yet to analyze data from that part of the study.

Procedure

The study was conducted in quiet rooms at the Census Bureau's Usability Laboratory in Suitland, Maryland, and at the Rockville Senior Center in Rockville, Maryland. Participants were instructed to complete tasks quickly and accurately. Before the study started, the researcher collected some basic demographic information (age, gender, handedness, computer experience). During the study, a researcher sat next to the participants and introduced each different type of task as each participant progressed through the study.

Design

Half of the participants in each age group performed tapping tasks first followed by touching tasks, and the other half performed touching tasks first followed by tapping tasks. These tasks were followed by straight-steering and circular-steering tasks. Tapping and touching tasks each offered a set of 72 distinct tasks (3 target sizes, times 3 distances, times 8 angles). Sixteen tasks out of the 72 were randomly picked for each participant to be practice tasks. These practice tasks were not logged. The practice tasks were followed by two blocks of 72 tasks that were randomly ordered. This random order was repeated for each block in which participants performed tapping and touching tasks. The independent variables for the study were age level (between subjects), study order (between subjects), target size, distance, angle, and block number. The dependent variables were accuracy and time.

Results

The analysis of the results presented in this report looks at accuracy rates. In a future publication we plan to include a detailed analysis of completion time results. Average completion times were below one second across all target sizes and age groups. We do not present the results of statistical tests in this report because the participants were not a random sample of a well-defined population. Instead, we present descriptive statistics.

[1] 0 degrees pointed straight to the right with angles increasing in value counter-clockwise

Tapping

table 1 shows accuracy rates across target sizes and age groups. **figure 1** illustrates the difficulty older adults had with 16-pixel targets, the standard size of icons, checkboxes, radio buttons and other visual targets in PocketPCs. Notice how the 65-84 year olds greatly benefited when moving from 16 to 24-pixel targets. Their accuracy reached levels similar to those of the other age groups when tapping on 16-pixel targets. On the other hand, moving from 24 to 32-pixel targets did not seem to provide clear benefits to any of the age groups.

The differences between age groups when tapping on 16-pixel targets are further illustrated by **figure 2**. It shows plots of the taps on 16-pixel targets by each age group.

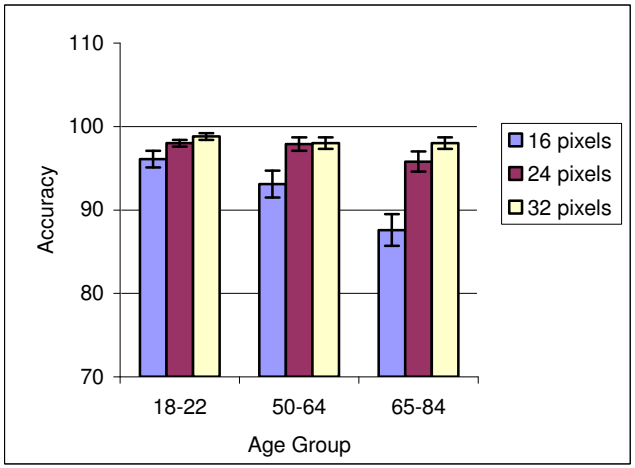

figure 1. Accuracy rates for tap tasks by age group and target size. Error bars are twice the size of the standard error.

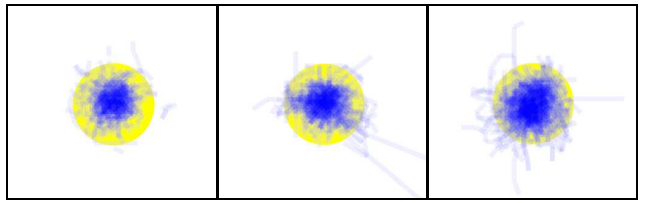

figure 2. Plots of locations where participants from each age group tapped on 16-pixel targets for all distances and all angles. From left to right, tapping locations from 18-22, 50-64 and 65-84 year old age groups. Each tapping point was plotted with a transparency of 0.125 (i.e. eight points at the same location make the color underneath invisible).

Touching

When participants touched to select targets, all average accuracies across age groups and target sizes were above 95 percent (see **table 1**). **figure 3** shows sample plots of the strokes taken by participants when completing 16-pixel touch tasks. The plots show various stroke styles. While some were consistent in the angles at which they created the strokes, other varied the angles. Some tended to make very short strokes while others made longer ones that may not work as well in an environment with other selectable items. Some crossed the target, while others started inside the target and finished their strokes outside. Some decided to make straight-line strokes while others opted to make checkmarks. There were also clear differences between right-handed and left-handed participants. While right-handed participants for the most part had strokes going between the bottom-left and the upper-right, left-handed participants tended to go between the bottom-right and the top-left.

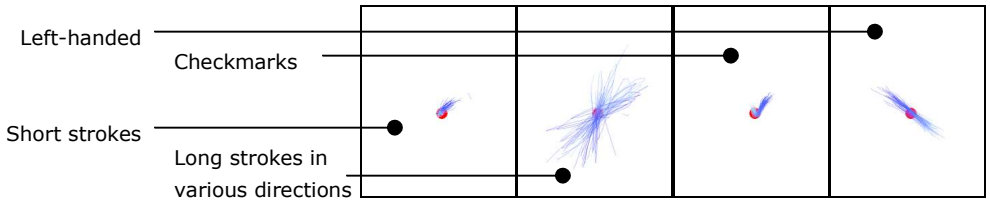

figure 3. Sample plots of strokes taken by participants to touch 16-pixel targets. Each picture shows the strokes for one participant. The strokes have a lighter color towards their start point and get darker as the stroke reaches its end.

Tapping versus touching

table 1 compares the accuracy rates for tapping and touching tasks. The results show that all three age groups were more accurate when touching than tapping 16-pixel targets (see **figure 4**). These differences were most pronounced for the 65-84 year old age group. The differences between tapping and touching accuracy were negligible for larger target sizes.

Target Size	Age Group	Tap	Touch
16	**18-22**	96.1 (1.0)	97.7 (0.8)
	50-64	93.1 (1.6)	97.1 (0.7)
	65-84	87.6 (1.9)	95.4 (1.1)
24	**18-22**	98.0 (0.4)	98.2 (0.8)
	50-64	97.9 (0.8)	98.6 (0.5)
	65-84	95.8 (1.2)	97.2 (0.7)
32	**18-22**	98.8 (0.4)	98.8 (0.5)
	50-64	98.0 (0.7)	98.0 (0.7)
	65-84	98.0 (0.7)	97.6 (0.6)

table 1. Accuracy rates and standard error (in parenthesis) for tap and touch tasks by age group and target size.

Some participants commented on the positives and negatives of tapping and touching. Some mentioned they preferred tapping because they found touching could be tiring on their wrist. Others preferred touching because they said they did not have to have perfect aim, but could instead land near the target and then move towards it to complete a task.

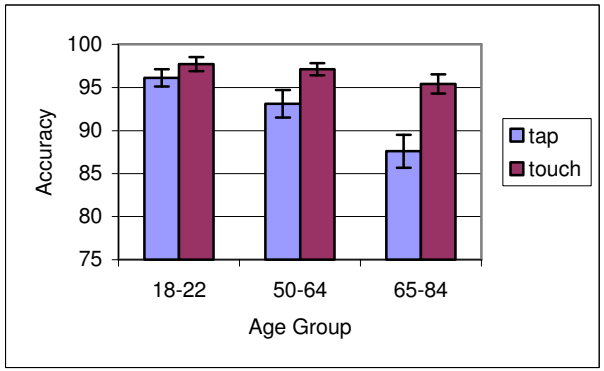

figure 4. Accuracy rates for tap and touch tasks by age group for 16-pixel targets.

Discussion

The results of the study suggest that older adults are capable of completing selection tasks with a pen at reasonable levels of accuracy. Results provide evidence that these kinds of interactions do not pose a barrier against older adults operating handheld computers. Even in the case of 65-84 year old participants tapping on 16-pixel targets, the accuracy rate was at an adequate 87.6 percent.

The results also suggest that touch interactions need to be further investigated in terms of their possible advantages over tap interactions. Given the length of some the participants' strokes when completing touch tasks, it is unclear whether the advantages found in

this study would translate to more realistic situations with multiple possible options to select on the screen.

The plotting of the paths participants took when creating strokes in touch tasks provides some evidence that it may be possible to identify left-handed from right-handed users given the orientation of their strokes. Such information could be used to optimize user interfaces to favor use by one hand or the other. This is particularly important in handheld computers as part of the computer's screen is likely to be obscured by the hand holding the pen.

Independent of the possible advantages of touch over tap techniques, the study also suggests that targets 50 percent larger than standard-sized targets may enable 65-84 year olds to achieve similar accuracy rates to those achieved by the other age groups when tapping on standard-sized targets. This could be a relatively easy fix for software designed for older adults: make the targets larger.

Another possible way to address the issues the 65-84 year old age group faced with standard-sized targets is to design software where every possible action can easily be reversed. While such designs can benefit all age groups, they can become crucial if users are likely to miss the target they intend to tap on more than one out of ten times. Providing a consistent and easy to access way to reverse actions could make missed targets into a minor annoyance rather than a costly detour.

Conclusion

We compared the accuracy of groups of young and older adults selecting targets with pens on handheld computers. The results showed that for the most part the groups of older adults could complete these tasks accurately. An exception occurred with the low accuracy rates of 65-84 year olds tapping on targets the same size as standard PocketPC icons. The results suggest that larger targets might help older adults achieve similar accuracy rates as those of younger participants. The results also showed that all age groups, and in particular 65-84 year olds, were more accurate when touching than when tapping on targets. Given these results, we recommend that touch interactions be further investigated.

Acknowledgements

Thanks to the staff at the US Census Bureau's Usability Laboratory for their support in conducting this study.

Citations

[1] Berg, C. A. (2000). Intellectual development in adulthood. In Robert J. Sternberg (Ed.), *Handbook of intelligence* (pp. 117 - 137). Cambridge, England: Cambridge University Press.

[2] Horowitz, A. The Prevalence and Consequences of Vision Impairment in Later Life. *Topics in Geriatric Rehabilitation, 20*(3) (2004), 185-195.

[3] Patten, C. Reeducating Muscle Force Control in Older Persons through Strength Training. *Topics in Geriatric Rehabilitation, 15*(3) (2000), 47-59.

[4] Ren, X. and Moriya, S. Improving Selection Performance on Pen-Based Systems: A Study of Pen-Based Interaction for Selection Tasks. *ACM Transactions on Computer-Human Interaction, 7*(3) (2000), 384-416.

[5] Worden, A., Walker, N., Bharat, K. and Hudson, S. Making Computers Easier for Older Adults to Use: Area Cursors and Sticky Icons. In *Proc. CHI 1997*, ACM Press (1997), 266-271.