

Use of Computer Input Devices by Older Adults

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A sample of 85 seniors was given experience (10 trials) playing two computer tasks using four input devices (touch screen, enlarged mouse [EZ Ball], mouse, and touch pad). Performance measures assessed both accuracy and time to complete components of the game for these devices. As well, participants completed a survey where they evaluated each of the devices. Seniors also completed a series of measures assessing visual memory, visual perception, motor coordination, and motor dexterity. Overall, previous experience with computers had a significant impact on the type of device that yielded the highest accuracy and speed performance, with different devices yielding better performance for novices versus experienced computer users. Regression analyses indicated that the mouse was the most demanding device in terms of the cognitive and motor-demand measures. Discussion centers on the relative benefits and perceptions regarding these devices among senior populations.

Keywords: *adults; computers; technology; input devices*

Introducing computer technology for aging populations has been heralded as offering both promise and challenges (Finn, 1997). The promise is that computers could serve as a means for connecting seniors with their

AUTHORS' NOTE: Funding for this research was made available through research grants from the Social Sciences and Humanities Research Council. We would like to thank participants for their support in this research. All correspondence about this article should be directed to Eileen Wood at the Department of Psychology, Wilfrid Laurier University, 75 University Ave., Waterloo, Ontario, N2L 3C5, Canada; e-mail: ewood@wlu.ca.

The Journal of Applied Gerontology, Vol. 24 No. 5, November 2005 419-438

DOI: 10.1177/0733464805278378

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families, friends, and peers, which could enhance their social and emotional lives (Finn, 1997; Needham, 1997). In addition, access to software and the Internet presents an opportunity for maintaining autonomy through the use of online services (e.g. banking), as well as providing an avenue for continuing education, gaining information (e.g., health, news), and entertainment (e.g., Brink, 1997; Kelly, 1997; Morell & Echt, 1997; Sweeney & Chiriboga, 2003). The challenges start with issues related to access, and if access is possible, there are physical, cognitive, and emotional barriers that may inhibit use of the technology. For example, adults who are less familiar and have less training with technology often have greater computer anxiety (Bikson & Bikson, 2001). Computers may pose unnecessary physical and cognitive demands depending on the hardware or software that is selected (e.g., Laux, 2001; Smith, Sharit, & Czaja, 1999). Understanding how seniors navigate the use of technology is a critical first step in overcoming the challenges of computer use.

In fact, one of the first challenges seniors encounter with computers involves navigating the use of the input device. The match between user and input device is critical, as “human interaction with computers is a three-part union, engaging a human, a machine, and an interface” (Price Waterhouse, 1996, p. 51). The interface serves as the crux in the connection of the human and machine. Input devices vary greatly. Some devices are flexible and permissive, allowing for accommodations across users and across uses; others are not (Thimbleby, 2001). Also, different devices vary in the level of cognitive and physical demands placed on the user, with more demanding devices requiring coordination of visual memory, spatial demands, hand-eye coordination, and fine motor dexterity.

Input devices generally fall into two categories: direct or indirect (Scaife & Bond, 1991). Direct devices include all those that involve a direct correspondence between what the user is doing and the goal. For example, a touch screen is a direct input device. When users want to select an icon, they just reach out and touch it. Thus, the touch screen requires little training, little hand-eye coordination, and minimal spatial demands (Thomas & Milan, 1987). An indirect input device is one that is removed from the task. For example, a mouse is indirect because the user must coordinate spatial information, hand-eye coordination, and finger dexterity to employ the device.

The differential demands between direct and indirect devices may affect the user’s ability to use them effectively—with direct devices being easier because of their reduced cognitive and coordination demands (Thomas & Milan, 1987). The differential demands are particularly salient when considering seniors, many of whom would be novices to the devices (and often computer technology in general) and who may experience dexterity and

motor coordination limitations (e.g., Agnew, Bolla-Wilson, Kawas, & Bleecker, 1988; Smith et al., 1999; Spiegle & Moulton, 2001). Given that novices typically experience greater cognitive demands to execute tasks than experts (Schneider, 2002; Schneider & Pressley, 1997) and that older adults often experience a reduction in motor dexterity and coordination (Agnew et al., 1988), novice seniors are particularly at risk to find their first interaction with technology excessively challenging, especially if only demanding input devices are available. As a result, recreation staff, banks, pharmacies, and other service agencies may opt for alternative input devices to those that typically accompany most computer systems, in an effort to make the use of technology less challenging for seniors. The question then becomes, Which device is most appropriate for seniors? In addition, there is a need to determine whether devices might be more or less appropriate as a function of prior experience and cognitive and/or motor demands.

Considerable research has been conducted during the past 15 years that examines the impact of input devices among younger adult populations. Although research has indicated that some devices are better than others, no one device has been shown to be superior for all tasks or applications among young adult populations (e.g., Bullinger & Shackel, 1987; MacKenzie, Sellen, & Buxton, 1991; Milner, 1988). Even within specific tasks, there are discrepancies as to which device is most effective. For example, in a comparative study of adults using input devices (mouse, trackball, and stylus with tablet, i.e., electronic pen used on a touch pad base), where both error rate and movement time were evaluated in basic pointing and dragging tasks, the tablet yielded the highest performance outcomes for the pointing task, but the mouse yielded the highest performance outcomes for the dragging task (MacKenzie et al., 1991). In another study comparing the touch screen, keyboard, and mouse, novice computer users were found to perform best when using a touch screen, whereas keyboards were more effective for experts (Thomas & Milan, 1987). Furthermore, a review that evaluated studies of input devices for speed, accuracy, user preference, or a combination of these measures indicated that the touch screen was the quickest and most preferred input device for short tasks involving icon selection where the resolution was not high (i.e., the icon was large and easily seen; Milner, 1988). These conflicting outcomes make it challenging to select the most appropriate device or devices for young adults, let alone for seniors who may experience additional physical or cognitive challenges. Indeed, when the performances of younger adults and seniors were compared using a basic mouse, the older participants experienced more difficulty, especially for more complex tasks involving clicking or double clicking the mouse (Smith et al., 1999). Similarly, in a comparison of older and younger participants using two input

devices (keyboard versus a simulated voice-recognition system), older adults preferred the less physically demanding voice-recognition system (Ogozalek & Van Prang, 1986). A concern with much of the existing literature, however, is that the work was conducted early on in the development of input devices, and since that time, further enhancements and refinements may have affected the relative efficacy of some of the devices.

Overall, a review of the literature indicates that the investigation into computer use by seniors remains in its early stages, with only sparse research examining input devices. However, available research indicates a willingness and enthusiasm on the part of seniors to use computer technology (e.g., Ogozalek & Van Prang, 1986; Sweeney & Chiriboga, 2003). Given the prevalence of computers in today's society and the need for seniors to have access to this important tool, it is critical that we investigate mechanisms that make seniors' interactions with technology as positive as possible. This study addresses the impact that four different input devices have on the ability of seniors to effectively and efficiently navigate computer tasks.

The four devices (mouse, touch screen, touch pad, and enlarged mouse) employed in this study represent the range of devices available. They include direct and the more cognitively demanding indirect devices. The devices also vary in the amount of fine motor coordination required (e.g., touch screen versus mouse). The two-button mouse is an indirect input device and requires fine motor skills (for double clicking). The touch screen is a direct device that employs the pressure of touch and requires limited fine motor skill requirements. A review of the advantages and disadvantages associated with the touch screen suggests that although this device takes advantage of the most natural means of communicating (i.e., pointing), physical fatigue results from reaching across to the computer screen for extended periods. In contrast, the touch pad also uses touch technology but is positioned away from the computer screen, thus falling in the category of an indirect input device. The size of the touch pad can affect the level of fine motor skills required. As well, touch pads have buttons that require fine motor skills to click. The enlarged mouse (Easyball), another indirect input device, is a stationary input device (about the size of a grapefruit) that is primarily designed for young users who may lack the fine motor coordination required to operate a standard mouse efficiently. With the EZ Ball, the user is not required to move the entire device, only one component.

This study examines the comparative performance of seniors, who vary in their level of computer experience, when using four input devices (mouse, touch screen, touch pad, and EZ Ball) to perform simple drag-and-drop tasks. Most software requires drag-and-drop capabilities; hence, the need to examine this task. A further objective of this study was to investigate the prefer-

ences of seniors regarding the use of the input devices as well as the level of comfort experienced following use of each of the devices.

Method

Participants

The 55 female senior citizens (M age = 71.9 years, SD = 8.4 years) and 30 male senior citizens (M age = 71.0 years, SD = 7.1 years) were recruited from recreational centers and senior centers in one midsized Canadian city. They ranged in age from 54.8 years to 90.2 years. Participants were asked to indicate their level of experience with computers; 32% of women and 7% of men had no prior exposure to computers, 31% of women and 10% of men had exposure at monthly intervals, 17% of women and 40% of men had exposure at weekly intervals, and the remaining 20% of women and 43% of men had experience on a daily basis.

Participants were asked to identify medical and/or physical complaints that might affect performance using the computers. More than 69% of participants indicated no health or physical complaints, and 2% provided no response to the question. Among the 29% who indicated potential constraints, all indicated mild complaints (e.g., mild arthritis or stiffness, some visual or hearing difficulties, early Parkinson's).

Materials

Three sets of materials were prepared. The first set involved constructing two computer games to be used with the different interface devices. The second set of materials involved constructing a survey to assess experiences when using the computer devices. The third set included a set of standardized tests to assess spatial memory, perception, and motor skills.

Computer hardware. Participants were asked to complete two computer games using the following four different input devices: the Microsoft Easyball (also EZ Ball), the Cirque Smart Cat Touchpad, a regular two-button mouse made by Logitech, and a 17-inch color TTX-brand resistive type touch screen monitor. Two computers were used to accommodate these four input devices. The first two devices were connected to an IBM-PC Pentium computer with a 17-inch color monitor, with 640×480 pixel resolution. The regular mouse was connected to an IBM-PC Pentium computer with a 17-inch color touch screen monitor, also with 640×480 pixel resolution.

Computer software. Two “games” were developed. Each game involved a matching-to-sample task in which participants were asked to match two icons that were presented on the screen. The same two icons (a circular earth design and a yellow circle), both 32×32 pixels in size, were used for each game. The two games constructed allowed for precise calibration of performance as well as examination of the targeted skills without distraction from extraneous images or audio messages that are often found in commercial software.

In the first game, the two icons were stationary and displayed in a random position on the computer screen. The icons appeared within one of the four quadrants of the screen, but the icons were never within the same quadrant. The participant was required to select and drag the earth icon and match it to the yellow circle icon (target).

In the second game, the earth icon always appeared initially in the bottom left corner of the screen and moved horizontally across the bottom of the screen from left to right at a speed of 6 pixels per second. The yellow circle always appeared initially in the top left corner of the screen and also moved horizontally across the top of the screen from left to right at a speed of 6 pixels per second. The initial distance between the two icons was constant for all participants. The participant was required to “catch” the earth icon by selecting it, then dragging and releasing it when it was placed on the moving yellow circle icon.

Response time and errors were counted for each of the 10 trials for each of the devices. Two time/speed performance measures were recorded. The time the icon was in suspension reflected the time required to successfully move the earth icon, once acquired, to the target yellow-circle icon. The total time measure recorded the time required to successfully complete the computer trial. Three types of accuracy errors were recorded. Icon drops reflected the number of times the icon was released from suspension before reaching the target icon. Failed attempts at initially acquiring the icon (clicks on the screen without successfully selecting the icon) were defined as “initial acquisition failures.” Finally, failed attempts at reacquiring the icon after the initial acquisition were defined as “reacquisition failures.”

Computer use survey. Participants were asked to identify their experience with computers on a 4-point scale ranging from 0 = *no experience* to 3 = *daily experience*. After completion of the computer games, participants were asked five questions about their use of the four computer devices. The first two questions asked them to identify (a) the easiest device to use and (b) the most challenging device (i.e., “Which input device did you find the easiest [most difficult] to use?”). Participants also were asked to evaluate the four

input devices on the following criteria: how easy it was to *make mistakes* with each of the devices, how easy it was to *move the cursor* from one point to the next, and how easy it was to complete the games as *quickly* as possible. To answer these three questions, a 7-point Likert-type scale was used where 1 represented *very easy* and 7 represented *very difficult*.

In addition, participants were also asked to judge their comfort with using the devices. Specifically, they were asked if they now felt “comfortable” (yes or no) using each of the four devices.

Measures of Visual Memory, Visual Perception, and Motor Coordination

Each participant completed three tests. Visual memory was assessed using the Finger Windows subtest of the Wide Range Assessment of Learning and Memory (Shestow & Adams, 1990). This standardized measure involved presenting participants with a board with finger-sized holes in it through which the experimenter pointed out increasingly complex patterns that participants were required to replicate. Coefficient alphas for this measure show high reliability, ranging from .71 to .83 for all populations tested with a mean of .81 (Shestow & Adams, 1990). Visual perception and motor coordination/motor dexterity were evaluated through two subtests of the Developmental Test of Visual Motor Integration (VMI; Beery, 1996) and the Purdue Pegboard test (see Purdue Research Foundation, 2003). In the VMI visual perception test, participants were presented with a series of 27 pictures of geometric forms one at a time with an array that contained both matching and nonmatching forms. Participants selected the matching forms from as many stimulus materials as possible in a 3-min time period. In the motor coordination task, participants traced shapes within a set of double lines as quickly and accurately as possible. Reported alpha coefficients show high reliability ranging from .74 to .87 ($M = .81$) and .71 to .89 ($M = .82$) for the visual and motor subscales, respectively (Beery, 1996). In the Purdue Pegboard task, participants were required to place pegs into holes, one at a time, as quickly as possible, using one hand at a time (reported alpha coefficients range from .62 to .89; Purdue Research Foundation, 2003).

Procedure

Participants were tested individually at the recreation or retirement center. At the outset of the sessions, participants completed the three assessment measures: Visual Memory, Visual Perception, and Motor Coordination. The assessment portion took approximately 15 min to complete. The participants

then completed 10 computer trials with each input device for each of the two games. Game 1 preceded Game 2. The order of devices was counterbalanced across participants. Approximately 20 min was required to complete the session. Prior to using each device, a researcher provided a short demonstration and instruction session to introduce the mechanics of the device (about 1 to 2 min per device). Participants were seated in front of the computer screen in a height-appropriate seat. Computers and devices were located on a height-appropriate table. Following completion of the last game, participants were given the survey to complete. The survey took approximately 10 min to complete.

Results

Three sets of analyses were conducted. The first set examined performance using each of the devices. Three measures of performance accuracy (initial acquisition of icons, number of times an icon was dropped, failures to reacquire a dropped icon) and two measures of performance time (amount of time icon was suspended and the total time of the trial) were analyzed. The second set of analyses examined the impact of the cognitive, perceptual, and motor skills on performance measures. Finally, the third set of analyses summarized the survey data regarding participants' preferences for using the four devices.

Performance Measures

For each of the five performance measures a 2 (gender) \times 2 (game) \times 4 (device) repeated-measures ANOVA was conducted. Gender served as the between-subjects factor, and game and devices served as within-subjects factors (see Table 1 for mean performance outcomes). Computer experience was entered as a covariate.¹ A more stringent alpha was adopted ($p = .01$) to accommodate the five analyses.

For each of the five measures, there was a significant main effect for device, smallest $F(3, 80) = 10.64, p < .001$, and computer experience, smallest $F(1, 82) = 7.44, p < .001$ (see Table 1). In addition, for each of the accuracy measures (number of dropped icons, failures to initially acquire and reacquire icons) there was a significant main effect for game, smallest $F(1, 82) = 4.23, p < .04$ for the number of icons dropped, such that performance in Game 2 was less accurate than in Game 1. There were no significant main effects for gender.

Table 1. Means and Standard Deviations of Performance Variables for Each Device by Game

	Mouse		Touch Screen		Touch Pad		EZ Ball	
	Game 1	Game 2	Game1	Game 2	Game 1	Game 2	Game 1	Game 2
	M	SD	M	SD	M	SD	M	SD
Icon suspended								
M	7.63	8.53	4.61	18.82	13.38	15.48	9.53	8.13
SD	4.93	3.10	3.89	9.32	8.16	7.04	3.66	2.65
Total time								
M	14.00	16.15	20.19	23.44	29.63	28.87	17.89	17.66
SD	11.04	6.85	8.98	10.67	11.19	10.58	8.53	4.87
Number of drops								
M	0.64	1.20	4.29	5.13	1.89	1.93	0.78	0.90
SD	0.57	0.52	3.06	3.24	1.22	1.33	0.71	0.58
Failures to acquire								
M	0.48	1.06	2.24	2.41	0.93	0.92	0.55	0.99
SD	0.75	0.88	1.84	1.81	0.55	0.65	0.67	0.75
Failures to reacquire								
M	0.35	0.38	7.24	10.30	0.48	0.41	0.27	0.33
SD	0.55	0.41	6.74	7.99	0.62	0.59	0.45	0.40

The main effects for all of the measures, however, were qualified by significant two-way interactions, and three of the five measures were qualified by a significant three-way interaction. Specifically, there were significant two-way interactions for Device \times Computer Experience for every measure of accuracy and one of the two speed/time measures (total time), smallest $F(3, 80) = 5.41, p < .001$ for the number of icon drops.

There also was a significant two-way interaction for Devices \times Game for the number of failures to reacquire an icon after dropping it, $F(3, 80) = 7.99, p < .001$. There were no two-way interactions involving gender. There were significant three-way interactions involving Devices \times Game \times Computer Experience for the two measures of speed/time and for the number of failures to reacquire a dropped icon.

Subsequent analyses involved exploring the two-way interactions of Devices \times Computer Experience for the number of initial failures to acquire the icon, $F(3, 80) = 8.62, p < .001$, and the number of icons dropped, $F(3, 80) = 5.41, p < .001$, and exploring the three-way interactions for the measures of speed/time and for the number of failures to reacquire a dropped icon.

With respect to the two-way interactions, the relative outcome of using each device was compared for each level of computer experience. A series of six paired t tests were conducted for each measure for each level of computer experience (corrected $p = .008$ to match the number of comparisons within each set). When assessing the number of icons dropped, for every level of computer experience the mouse and the EZ Ball yielded fewer drops than the touch pad and the touch screen, smallest $t(20) = 2.98$ for the mouse versus touch screen with weekly computer experience. In only one case, where participants had no prior computer experience, did the EZ Ball yield fewer drops than the mouse and the touch pad fewer drops than the touch screen, smallest $t(19) = 3.41$ for the EZ Ball versus mouse. With respect to the number of initial failures to acquire an icon, significant differences between the devices were only found for the daily experience and no experience groups. In the daily experience group, the mouse yielded fewer initial failures to acquire the icon than either the touch screen or touch pad, smallest $t(23) = 4.38$ for the mouse versus touch screen. Among those who had no computer experience, the touch pad yielded fewer failures to acquire than the mouse, $t(19) = 4.34$.

The three significant three-way interactions for the time/speed measures and one accuracy measure (failures to reacquire icons) were analyzed across devices for each game within each of the four levels of computer experience. A series of six paired t tests were conducted for each measure within each game and level of computer experience (with a corrected $p < .008$). A summary of the pattern of outcomes for the data is depicted in Table 2.

Table 2. (continued)

Game Performance Measure	Computer Experience	Mouse < EZ Ball	Mouse < Touch Pad	Mouse < Touch Screen	EZ Ball < Mouse	EZ Ball < Touch Pad	EZ Ball < Touch Screen	Touch Pad < Touch Screen	Touch Screen < Touch Pad
Failure to reacquire icon	None					X	X	X	
	Monthly						X	X	X
	Weekly			X			X	X	X
	Daily			X			X	X	

NOTE: X's denote significant comparisons.

Overall, the pattern of performance was different for the time/speed items versus the accuracy measure (failure to reacquire a dropped icon). In addition, the pattern of performance varied as a function of the participants' computer experience. As can be seen in the summary Table 2, the EZ Ball was more effective than the mouse in only two instances. Both instances involved participants with no computer experience (reacquiring a dropped icon in Game 1, $t(19) = 3.25$, and total time in Game 2, $t(19) = 3.33$). In comparison, the mouse was more effective than the EZ Ball for both time and speed measures in both games for those participants with more computer experience, especially those with daily experience, smallest $t(23) = 6.40$.

The mouse was a faster device than the touch pad for all participants who had some experience with computers, but it did not differ significantly on the accuracy measure. The EZ Ball, on the other hand, yielded faster performance times than the touch pad for all users regardless of computer experience and also yielded fewer failures to reacquire an icon than the touch pad for the most inexperienced computer users in Game 2, smallest $t(19) = 4.14$ for monthly experience for the EZ Ball versus touch pad. The mouse consistently yielded faster performance times than the touch screen for the most experienced computer users across all measures. The EZ Ball produced fewer failures to reacquire the icon than the screen regardless of computer experience but only improved performance time/speed for the least and most experienced computer users for one measure of time in Game 1.

Comparisons of the touch pad and touch screen indicated that the touch pad yielded more favorable accuracy scores for most computer users, whereas the touch screen yielded more favorable time/speed performance, especially in Game 2.

Another way of summarizing the outcomes in Table 2 is to look at who was best facilitated by each device. The EZ Ball yielded better performance than other devices for seniors who had no computer experience for 10 of the 18 total comparisons. The mouse only achieved this for 2 of the comparisons with inexperienced seniors. On the other hand, the most experienced computer users benefited from the use of the EZ Ball for 7 of the comparisons, whereas the mouse enhanced performance in 14 of the 18 comparisons. Clearly, familiarity with the mouse translated to higher performance for the experienced computer users, whereas less experienced users showed a greater number of benefits when using the EZ Ball.

Assessment Measures

Four regressions were conducted to examine whether visual perception, visual memory, motor coordination, and motor dexterity predicted perfor-

mance on each of the input devices. Performance scores were aggregated to yield one accuracy measure (i.e., number of icons dropped, failures to initially acquire the icon, and failures to reacquire the dropped icons) and one time/speed measure (i.e., total time and time that icons were suspended). To accommodate the number of regressions, p was set at .0125.

For the EZ Ball, touch pad, and touch screen, none of the assessment measures predicted accuracy of performance. For the mouse, the time taken to complete the pegboard task predicted both performance accuracy and time/speed ($R^2 = .50$, $\beta = .97$; $R^2 = .55$, $\beta = 20.97$, respectively). For all other devices, the time taken to complete the pegboard task was a significant predictor only for time/speed performance scores ($R^2 = .76$, $\beta = 11.23$; $R^2 = .55$, $\beta = 20.97$; $R^2 = .27$, $\beta = 14.35$, for the EZ Ball, touch pad, and touch screen, respectively). In fact, the time taken to complete this finger-dexterity task was the only significant predictor of the time taken to perform the computer games for the touch screen and the mouse. Time/speed using the EZ Ball also was predicted by performance accuracy on the finger windows ($\beta = 2.67$) and visual perception tests ($\beta = 3.03$). That is, accuracy in visual memory and visual perception predicted performance when using the EZ Ball. Also, performance time with the touch pad was predicted by accuracy in the visual memory/finger window ($\beta = 9.03$) and the finger dexterity/pegboard ($\beta = 12.76$) tasks.

Survey Responses

Seniors were asked the five questions regarding the ease and difficulty associated with the various input devices and their comfort with the devices.

When asked to identify their favorite device to use, just greater than half (53%) identified the mouse as the easiest device, with about a third nominating the EZ Ball (31%) and 13% and 4% choosing the touch screen and touch pad, respectively. The reverse order of these nominations matched the pattern for the least favorite device.

When asked which device they found easiest to make errors with, the seniors clearly identified the touch devices as the most problematic ones (55% touch pad, 26% touch screen), with the EZ Ball (11%) and mouse (6%) receiving few nominations. Apart from these broad questions, the seniors were asked to use the 7-point Likert-type scale to identify the ease (1 = *very easy* to 7 = *very difficult*) with which each device permitted movement of the cursor or icon and the speed of use that the device afforded them (see Table 3 for a summary of the means). The seniors' responses to these two questions were analyzed using two repeated-measures ANOVAs. There was a significant main effect for both the movement of the cursor/icon, $F(1, 84) =$

Table 3. Seniors' Ratings of Devices for Ease of Cursor and Icon Movement Use, and Speed

	<i>Mouse</i>	<i>EZ Ball</i>	<i>Touch Screen</i>	<i>Touch Pad</i>
Ease of moving cursor				
<i>M</i>	1.48	2.22	3.66	4.42
<i>SD</i>	0.85	1.40	2.09	1.92
Speed				
<i>M</i>	2.36	2.55	3.92	4.85
<i>SD</i>	1.86	1.59	2.33	1.84

35.96, $p < .001$, and speed of use, $F(1, 84) = 36.29$, $p < .001$, among the devices. A set of six follow-up paired t tests was conducted for each measure ($p = .008$ to accommodate the number of comparisons). For both the ease of moving the cursor and the speed of movement, the mouse and EZ Ball did not differ significantly. Both the mouse and EZ Ball were perceived as easier to move and faster devices than the touch pad and touch screen, smallest $t(84) = 4.72$ for the ease of cursor movement comparing the EZ Ball and touch screen. The touch screen was perceived to be a faster device than the touch pad, $t(84) = 3.29$, but the devices did not differ significantly with respect to the ease of moving the cursor.

Following the trials using each of the devices, the vast majority of seniors indicated that they were now comfortable using the mouse (88.2%) and the EZ Ball (81.2%), with fewer comfortable with the touch screen (52.9%) and the touch pad (38.8%). Seniors who indicated they were uncomfortable with a device were asked to explain the reasons for their ratings. Of the few responses available for the mouse and EZ Ball, the need for more practice was cited for both devices. In addition, some seniors found the mouse challenging for coordination and the EZ Ball difficult to use with only one hand. Given that the majority of participants favored the mouse and EZ Ball, there were few reported challenges, and these challenges were cited by only a small sample of participants. The reasons for reported challenges with the touch screen were disparate, ranging from frustration with their performance using the device when they "kept dropping the icons," to finding it "too hard" to use or requiring "more practice." Seniors also indicated concerns about the "pressure needed," their "hand being in the way" and the device "not being sensitive" enough. With respect to the touch pad, a number of participants identified that the "screen was not proportional to the touch pad," that they found it "hard to tap," and that they needed "more practice" to stop "dropping the icons."

Discussion

Consistent with early research, experience was an important factor in seniors' effectiveness and efficiency with the input devices (Milner, 1988). In general, seniors who had frequent daily experience with computers were most efficient and accurate when using the mouse, the device with which they had the greatest experience. Similarly, previous research with younger adults also found that the mouse was most effective for dragging tasks such as the one used in this study (Mackenzie et al., 1991). Novice seniors, however, showed much more favorable performance when using the less demanding EZ Ball. In fact, the EZ Ball yielded greater accuracy performance than the mouse for novice seniors on three occasions. Clearly, the reduced demands afforded by the EZ Ball had a positive impact on the performance of novice seniors, indicating that experience with computers is a critical issue in the selection of the most useful input device.

Based on early research (e.g., Thomas & Milan, 1987), it had been expected that the touch devices might be effective especially among novice seniors, as these devices require fewer cognitive and spatial demands. Overall, however, the touch devices did not yield the best outcomes. In fact, performance using touch devices typically fell far below the performance afforded when using the EZ Ball or mouse. In only one instance did any touch device yield higher performance than the mouse—in the case in which novice computer users produced fewer accuracy errors using the touch pad than the mouse. The touch devices never exceeded the outcomes available when using the EZ Ball. Overall, however, the touch devices simply were not as effective as the mouse and EZ Ball. Examination of the seniors' preferences helps to explain why the touch devices were not as effective.

Consistent with their performance, seniors found that both the EZ Ball and mouse allowed them to complete their tasks more quickly and more easily. There were many frustrations identified with the use of the touch screen and touch pad. Notably, the seniors identified as a problem the need to sustain pressure when using the touch screen. They also commented that their hand got in the way. In previous research with adults, the touch screen has been identified as most useful when using a static display, unlike the moving display in the two games in this study (Milner, 1988). The limited benefits of the touch screen may reflect the gross motor requirements inherent in using the touch screen with a moving display (Thomas & Milan, 1987). Specifically, when seniors pointed at one quadrant of the screen, their arm would block the view of other quadrants (Thomas & Milan, 1987). This would make it more challenging to track the moving targets and would explain the increase in

drops and time taken to complete the tasks, as the seniors may have needed to lift or move their arm momentarily to see the blocked areas of the screen. When they raised or shifted their arms, the resulting change in pressure would have resulted in a momentary loss or change of contact with the screen and, hence, produce an increase in drops. Similarly, there would be an increase in failures to acquire icons if participants were looking for a target that was blocked from their view by their arms. Some seniors indicated concerns about the amount of pressure required to use the touch screen or that the touch screen was not sensitive enough. These concerns reflect two shortcomings of the touch screen technology. The first shortcoming involves physical strain and fatigue. To complete the nonstatic games, seniors were required to suspend their arms and sustain contact with the screen for longer time intervals than is typically required for static displays (such as those at bank machines, which only require one press on the screen). The extended suspension may have resulted in fatigue in this population. In addition, concerns about pressure and sensitivity of the touch screen may be indicative of these physical demands, but they may also reflect the reduction in cutaneous sensitivity that many seniors experience as they age (Laux, 2001). Specifically, seniors often experience a reduction in sensitivity to pressure that reduces their ability to detect and interpret tactile information (Abramson & Lovas, 1988; Laux, 2001). So, although the touch screen may make accommodations for cognitive and hand-eye coordination demands, the physical demands required to use this device may make it inappropriate for activities that require continuous or ongoing contact, such as those used in this study for seniors.

The touch pad also proved to be a challenging device. Seniors were quick to identify the mismatch between the size of the screen and the size of the touch pad as a problem affecting their ability to perform the games. In addition, they also identified challenges with the complex small motor tasks involved in tapping the touch pad. The complexity of this device was particularly salient, as it yielded poorer performance relative to other indirect devices, with the exception of the one instance mentioned above. Clearly, the coordination, pressure, and spatial demands of this device made it less than ideal.

At the outset, it was expected that the different devices might vary in the cognitive and motor demands. The speed of completion of the tasks was reliably predicted for each of the devices by the amount of time taken to complete the finger dexterity task. This motor dexterity task was the only variable that predicted performance for the touch screen device, indicating the relatively few demands that this particular device imposed on the seniors. In

comparison, the time seniors took to complete the games while using the touch pad was affected both by visual memory and dexterity. The complaints that the seniors had regarding the mismatch between the proportion of the touch pad and the actual computer screen, and the challenges they faced in trying to tap the pad, are reflected in the visual memory and dexterity variables. Similarly, the time taken to complete tasks with the EZ Ball was related to visual perception and visual memory supporting the higher visuospatial demands required when using this indirect device. It is not surprising that the only device in which both performance accuracy and performance speed were predicted by cognitive and motor measures was the mouse. Clearly, as suggested in previous research, this device exacts higher demands on the user and presents seniors with the greatest challenges (Smith et al., 1999).

Computer technology is present everywhere in the lives of seniors, and they are a population most at risk to have limited or no training with computers (Rogers, Campbell, & Pak, 2001). To maximize their potential to function effectively and efficiently in a technological world, it is important to provide opportunities for seniors to engage technology in a comfortable way. The first step to ensuring the successful introduction to computers is to ensure that the first direct contact is positive. Clearly, the choice of input device for seniors must be placed in the context of the task and the experience of the senior. Experienced technology users have already gained familiarity and ease with even the more challenging indirect devices such as the mouse; therefore, the mouse is a suitable choice as an input device. However, although computer savvy seniors use the mouse well relative to other devices, it must be remembered that their performance using the mouse is often not at the same level as younger adults (Smith et al., 1999). Novice users can be supported in their initial introduction to computers through less challenging devices such as the EZ Ball, which reduces demands and allows other aspects of the interaction with technology to take precedence. Given the general enthusiasm with which seniors tend to greet technology (e.g., Ogozalek & Van Prang, 1986; Sweeney & Chiriboga, 2003), it is important to provide them with optimal learning and interaction experiences that will foster rather than frustrate them when they interact with computers.

Note

1. As expected, there was a strong correlation between age and computer experience ($r[84] = -.455, p < .001$) and, as a result, only computer experience was used as the covariate.

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Article accepted April 12, 2005.

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