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The impact of age on computer input device use: Psychophysical and physiological measures

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Abstract

This study examined the effects of aging on performance and preferences for two computer pointing devices (e.g. mouse and trackball). Participants made simple point-and-click and click-and-drag movements to targets of varying distance (96 and 192 mm) and widths (3, 6 and 12 mm). The results show that older adults (mean age = 70) moved more slowly than younger adults (mean age = 32), particularly for distant targets, yet their movements were less variable. No age differences were found in movement time or variable error between the two devices. EMG (RMS) recordings from the forearm flexor and extensor muscles showed no age related differences in between mouse and trackball. However, ratings of perceived exertion (RPE) indicated that older adults perceived greater levels of exertion than younger adults when using the mouse during click-and-drag tasks. Given the reduced grip and pinch force of older adults, manipulation of the mouse and trackball required a greater percentage of their maximum voluntary contraction (MVC) compared to younger adults. In addition, the mouse requires a larger range of motion than the trackball. These findings in conjunction with the RPE results imply that the trackball may confer greater benefit for the older computer user.

Relevance to industry

The work force is growing older and the selection of appropriate computer input devices is important to reduce injury and improve or maintain productivity.

Keywords: Elderly; Aging; Computer input devices; Psychomotor performance

1. Introduction

Understanding the effects of aging on the work force is very important in light of the changing demographics of the American population and the work force. Older Americans, who represent the fastest growing segment of the population (National Highway Traffic Safety Administration, 1993), can work longer if they choose to due to the elimination of mandatory retirement in most careers (aircraft pilots being one notable exception).

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However, because of their age the older worker will face more advanced age-associated changes during their working lives.

The older worker must cope with a variety of age-associated changes which impact their working lives. For example, many older persons over age 40 wear optical correction to compensate for a diminished range of accommodation (e.g. presbyopia) (Owsley and Sloane, 1989). Whereas some of the age-related declines in sensory function may be more obvious due to the accouterments associated with their correction, the effects of aging on the motor and muscle-skeletal system may well be less obvious. These changes include reduced muscle strength (Asmussen and Heeboll-Nielson, 1962; Mathiowetz et al., 1985), reduced range of motion (Stubbs et al., 1993) and greater difficulty executing movements (Walker et al., 1997).

Computer use is increasingly becoming an integral part of various workplaces which often requires employees to work in constrained unsupported posture, at repetitive tasks and in precision work with hands, arms and fingers. A combination of these required postures and increased exposure, due to the increase of computer use, have fostered an increase in reports of computer-related upper extremity musculoskeletal pain (Harvey and Peper, 1997). These musculoskeletal conditions involve the entire upper limb, neck, and back, and account for 50% of all office work-related injuries (Harvey and Peper, 1997; Armstrong et al., 1986). These conditions are most commonly known as cumulative trauma disorders (CTDs). CTDs develop gradually over time, and are caused and/or aggravated by repeated exertions or movements on the body. Occupational risk factors of CTDs include, but are not limited to, repetitive movements, forceful exertions, awkward postures, extended task durations, static muscle loads, cold temperatures and vibrations (Armstrong et al., 1986).

Longitudinal studies show that muscle strength and power begin declining by approximately age 40 (Metter et al., 1997). This change is believed to be caused primarily by changes in the number and size of muscle fibers (Lexell et al., 1983, 1986). These changes in combination with a slowing in the speed of conduction of nerve signals (Wagman and Lesse, 1952; LaFratta and Canestrari, 1966), may be related to experimental observations demonstrating that older adults have slower reaction times (Fozard et al., 1994), slower movement times (Fozard et al., 1994; Walker et al., 1997) and greater difficulty producing fine motor adjustments (Walker et al., 1997).

Declines in motor control and the range of motion may be expected to affect the use of computer input devices by the elderly. Current computer operating systems rely heavily on the joint use of a keyboard and some type of electromechanical pointing device such as a mouse or trackball. In windows-type environments 30–60% of the operators' times involves active use of these pointing devices (Johnson et al., 1993). While many studies have examined age-related declines in motor control, very little is known about its impact on the use of pointing devices (Walker et al., 1996, 1997). It is not known whether changes in motor control differentially affect the use of two widely available pointing devices – a trackball and mouse – since they differ in their mode of use. Whereas the use of a mouse requires a greater range of movement of the forearm, the trackball use places greater demand on the coordination and movement of the fingers. Therefore, the goal of this study was to investigate age-related differences in performance and preferences using these two devices by two groups of adults (younger <40 years of age and older >65 years of age).

2. Methods

2.1. Participants

Ten younger (mean age $=31.55 \pm 7.81$) and 10 older (mean age $=70.15 \pm 3.87$) volunteers were tested. All of the participants reported being right-handed and having normal vision or vision corrected to 20/20. All participants reported experience with the use of the mouse, and none of the elderly and half of the young participants reported experience using a trackball.

2.2. Materials

The apparatus used in this experiment included: two Microtech 66 MHz personal computers, two

VGA display monitors (14 in diagonal screen with 640×480 pixels), a Microsoft two-button mouse, a Kensington Expert Mouse trackball, Fitts' Law Model Builder Software (Soukoreff and MacKenzie, 1995), Motion control, Inc. ML-220 preamplified surface electrodes in conjunction with data translation DT-2814 A/D board, and a Tektronix 2430A digital oscilloscope.

2.3. Tasks

Participants were asked to perform simple point-and-click and click-and-drag tasks which are representative of the types of actions typically performed using input devices. Fig. 1 shows a schematic representation of the tasks. The point-and-click task required the participant to move the cursor (indicated by the + sign) back and forth between the two targets (indicated by the 'x'), selecting the target each time with a button-down action. The click-and-drag task required the participant to hold the button down while positioning the cursor between the two targets, and select each target with a button-up action. The size of the targets and the distance between them were varied.

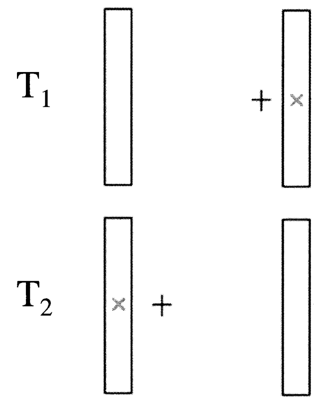

Fig. 1. Pictorial representation of the reciprocal movement task showing the cursor and two targets as a function of time (T_1 and T_2).

2.4. Experimental design

The study utilized a split-plot design with age (younger and older) as the between-participants variable, and device (mouse and trackball), task (point-and-click and click-and-drag), cursor-movement distance (96 and 192 mm), and target width (3, 6, and 12 mm) as the within-participants variables. The target size and distance were similar to those used by other investigators (e.g. Walker et al., 1997).

2.5. Procedure

Participants sat approximately 60 cm from the screen, with either the mouse positioned for right-hand use or the trackball positioned for right-hand use with left-hand button support. Surface electrodes were placed on the forearm flexor and extensor of the right arm. Participants were given a brief "warm-up" period to encourage familiarity with the device. This was followed by the experimental testing. On the display, participants viewed a cross-hair shaped cursor and two rectangular targets of a specified distance and width. The task involved moving the cursor from one target to the other in a reciprocal fashion. The experiment took ~ 1 h to complete. Each participant performed a total of 960 trials (40 trials per each device $\times$ task $\times$ target distance $\times$ target width combination). Device and task were counterbalanced, while target distance and width were randomized.

Performance measures were movement time, variable error (VE), defined as the within-participants standard deviation of the movement end-point coordinates around their own mean, and throughput. VE is an index of variability in movement trajectory and has been shown to be directly related to the amount of force exerted in a movement (Schmidt et al., 1979). Throughput is a variant of Fitts' index of performance (Fitts, 1954), and provides a composite measure of psychomotor performance based on both speed and accuracy (MacKenzie and Oniszack, 1998). It is calculated as follows:

$$\text{Throughput} = \frac{\text{ID}_\text{e}}{\text{MT}},$$

where

$$\text{ID}_\text{e} = \log 2(D/W_\text{e} + 1).$$

ID_e is the effective index of difficulty measured in "bits", and is calculated from D, the movement distance, and W_e, the effective target width. W_e is calculated as

$$W_e = 4.133 \times SD_x,$$

where 4.133 is a constant and SD_x is the standard deviation of the endpoint coordinates along the x-axis.

In addition, electromyographic (EMG) recordings of muscle activity in the forearm flexor and extensor, were recorded and RMS values used in the analysis.

Each condition, was followed by a 3 min rest period during which the participant was asked to complete a rating of perceived exertion (RPE). The RPE is a 10-point scale (0–10), with 0 representing no exertion and 10 representing very, very hard (Borg, 1982).

2.6. Data analysis

Separate one-between, four-within split-plot ANOVAs were used to analyze all of the data except for RPE values which were analyzed using t-tests. Post-hoc analyses were performed using the Tukey-HSD procedure ($p = 0.05$).

3. Results

Tables 1 and 2 show the effects of age, task, device, target distance, and target width on mean movement time and VE. These results are also depicted graphically to aid in interpretation of the tables. Tables 3 and 4 show the effects of age, task, and device on mean EMG (RMS) and RPE values. Note that RPE data was obtained for nine of the 10 younger participants.

3.1. Effects of between and within subject variables

3.1.1. Age

Fig. 2 shows mean movement time and VE as a function of age. Analysis of movement time data revealed that the older participants were slower than the younger participants in acquiring the targets, $F(1, 18) = 29.17$, $p < 0.001$. However, the older adults' movements were also less variable than those of the younger participants $F(1, 18) = 3.76$, $p = 0.07$, (as measured by VE).

EMG recordings indicated higher RMS values for the flexor muscle than the extensor muscle, $F(1, 18) = 7.61$, $p < 0.05$, for both age groups. The

Table 1
Mean (SD) movement time values (ms) as a function of age, task, device, distance, and width

		Younger		Older	
		Mouse	Trackball	Mouse	Trackball
Point-and-click					
Distance	Width				
96 mm	3 mm	1273 (375)	1515 (279)	2254 (712)	2151 (601)
	6 mm	1070 (270)	1357 (363)	1720 (373)	1919 (451)
	12 mm	833 (223)	1174 (268)	1544 (608)	1772 (1014)
192 mm	3 mm	1459 (279)	1851 (337)	2743 (1250)	2533 (575)
	6 mm	1221 (174)	1442 (176)	2127 (655)	2113 (349)
	12 mm	1076 (235)	1261 (161)	1754 (443)	2089 (536)
Click-and-drag					
Distance	Width				
96 mm	3 mm	1530 (282)	1708 (341)	2216 (626)	2561 (1069)
	6 mm	1297 (189)	1437 (197)	1974 (503)	2110 (645)
	12 mm	1160 (232)	1338 (170)	1690 (363)	2048 (568)
192 mm	3 mm	1770 (313)	1997 (395)	2522 (659)	2891 (715)
	6 mm	1559 (322)	1717 (222)	2393 (681)	2422 (516)
	12 mm	1350 (210)	1657 (179)	2151 (502)	2446 (891)

Table 2
Mean (SD) values for VE as a function of age, task, device, distance, and width

		Younger		Older	
		Mouse	Trackball	Mouse	Tackball
Point-and-click					
Distance	Width				
96 mm	3 mm	0.62 (0.08)	0.62 (0.06)	0.58 (0.14)	0.60 (0.18)
	6 mm	1.25 (0.22)	1.20 (0.17)	1.07 (0.24)	1.05 (0.33)
	12 mm	2.46 (0.59)	2.33 (0.37)	2.01 (0.36)	1.94 (0.56)
192 mm	3 mm	0.66 (0.11)	0.66 (0.10)	0.62 (0.16)	0.56 (0.16)
	6 mm	1.30 (0.18)	1.29 (0.14)	1.26 (0.24)	1.11 (0.37)
	12 mm	2.61 (0.53)	2.58 (0.38)	2.18 (0.31)	2.09 (0.64)
Click-and-drag					
Distance	Width				
96 mm	3 mm	0.65 (0.09)	0.62 (0.09)	0.65 (0.13)	0.59 (0.18)
	6 mm	1.20 (0.23)	1.25 (0.20)	1.25 (0.34)	1.07 (0.48)
	12 mm	2.30 (0.44)	2.40 (0.46)	2.16 (0.47)	1.74 (0.53)
192 mm	3 mm	0.67 (0.11)	0.66 (0.14)	0.72 (0.15)	0.65 (0.15)
	6 mm	1.26 (0.18)	1.31 (0.16)	1.28 (0.26)	1.10 (0.37)
	12 mm	2.63 (0.80)	2.44 (0.53)	2.31 (0.41)	1.95 (0.54)

Table 3
Mean and standard deviation values for RPE as a function of age, task, and device

	Younger				Older			
	Mouse		Trackball		Mouse		Trackball	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Point-and-click								
Hand	2.06	1.13	1.17	0.97	2.30	1.06	1.60	0.84
Wrist	2.56	1.72	1.17	0.83	2.25	1.40	1.40	0.84
Forearm	2.33	1.30	2.06	1.24	2.75	2.04	1.90	1.85
Elbow	0.94	0.88	0.78	0.79	1.55	1.74	0.80	1.03
Upper arm	0.89	1.36	0.61	0.96	1.45	1.46	0.80	0.63
Shoulder	0.89	1.36	0.56	0.68	0.80	1.03	1.00	1.22
Click-and-drag								
Hand	2.47	1.15	1.22	0.62	2.50	1.18	1.70	0.82
Wrist	2.15	1.78	1.22	0.91	2.60	1.17	1.45	0.90
Forearm	2.99	1.48	1.94	1.18	2.75	2.35	1.90	1.60
Elbow	1.75	1.24	0.72	0.83	1.05	1.30	0.95	0.96
Upper arm	1.20	1.40	0.78	1.09	1.67	1.66	1.05	1.01
Shoulder	0.86	1.17	0.56	0.73	0.85	1.00	1.05	1.46

difference between the groups was not significant. There was no significant main effect of age on RPE values. However, when broken down by device and task, there were age effects (see subsequent Device and Task subsections).

3.1.2. Device

Participants were significantly faster in acquiring the targets with the mouse than with the trackball, $F(1, 18) = 6.00$, $p < 0.05$ (see Fig. 3). Moreover, this effect was true regardless of age group ($p = 0.25$).

Table 4
Mean (SD) emg-rms values (mV) for flexor and extensor muscles as a function of age, task, device

	Younger		Older	
	Mouse	Trackball	Mouse	Trackball
Point-and-click				
Muscle				
Flexor	0.0319 (0.0025)	0.0317 (0.0017)	0.0318 (0.0013)	0.0313 (0.0012)
Extensor	0.0221 (0.0018)	0.0216 (0.0020)	0.0232 (0.0017)	0.0233 (0.0028)
Click-and-drag				
Muscle				
Flexor	0.0322 (0.0029)	0.0315 (0.0017)	0.0334 (0.0022)	0.0317 (0.0047)
Extensor	0.0219 (0.0019)	0.0221 (0.0019)	0.0234 (0.0021)	0.0239 (0.0033)

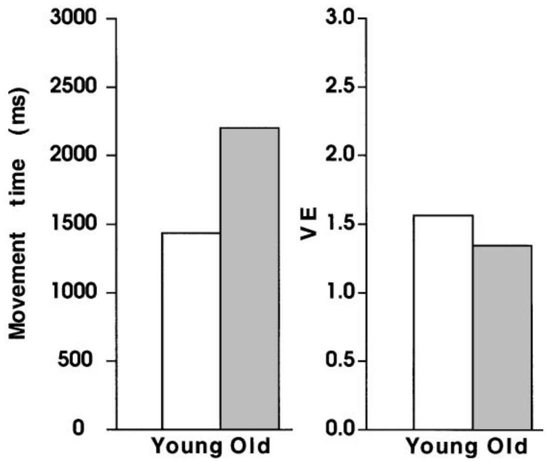

Fig. 2. Mean movement time and VE values as a function of age.

VEs did not differ significantly as a function of device ($p = 0.14$).

The RPE values were significantly higher for the mouse than for the trackball, but only for the hand [$t(1, 18) = 4.54$, $p < 0.001$], wrist [$t(1, 18) = 3.89$, $p < 0.01$], [$t(1, 18) = 6.08$, $p < 0.001$], elbow [$t(1, 18) = 2.36$, $p < 0.05$], and upper arm [$t(1, 18) = 2.09$, $p < 0.05$]. Moreover, there was a significant device by age interaction whereby the younger participants reported higher perceived exertion in the hand [$t(1, 8) = 3.68$, $p < 0.01$] and wrist [$t(1, 8) = 2.49$, $p < 0.05$] while using the mouse, and the older participants reported higher perceived exertion in the hand [$t(1, 9) = 2.70$, $p < 0.05$], wrist [$t(1, 9) = 3.25$, $p < 0.05$], and forearm [$t(1,9) = 3.08$, $p < 0.05$] while using the mouse. The EMG (RMS) values were significantly higher for click-and-drag

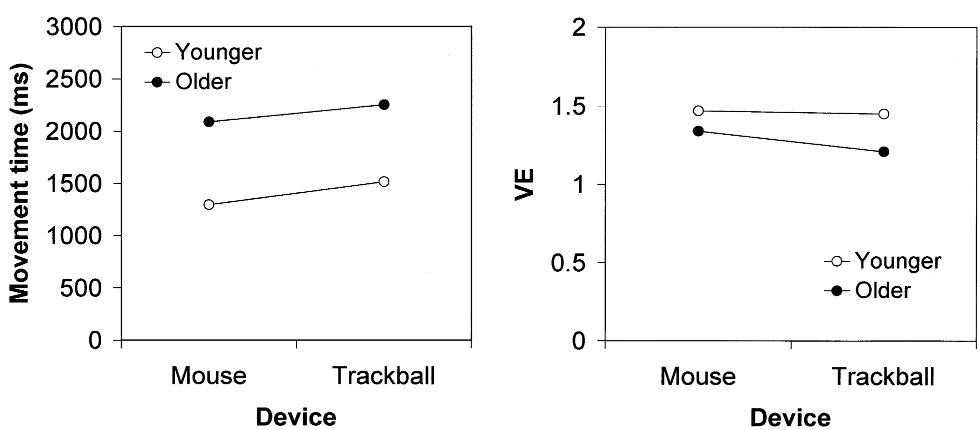

Fig. 3. Mean movement time (left) and VE (right) values as a function of device and age.

motions made with the mouse, $F(1, 18) = 7.61$, $p < 0.05$.

3.1.3. Task

Analysis of movement times revealed that click-and-drag motions were significantly slower than point-and-click movements, $F(1, 18) = 13.17$, $p < 0.01$ (see Fig. 4). The difference between the groups was not significant ($p = 0.75$). There was no significant effect of task on VE ($p = 0.41$), nor a significant age by task interaction ($p = 0.35$). Finally, EMG (RMS) values were higher for click-and-drag motions than point-and-click motions when using the mouse (refer to Device subsection).

There was no significant main effect of task on RPE values. However, there was a two-way interaction between task and device whereby participants reported greater levels of exertion in the hand [$t(1, 18) = 3.88$, $p < 0.01$] and wrist [$t(1, 18) = 3.33$, $p < 0.01$] during the point-and-click task with the mouse, and in the hand [$t(1, 18) = 4.02$, $p < 0.01$], wrist [$t(1, 18) = 4.12$, $p < 0.01$], forearm [$t(1, 18) = 2.42$, $p < 0.05$], and elbow [$t(1, 18) = 2.09$, $p < 0.05$] during the click-and-drag task with the mouse. There was also a three-way interaction (age $\times$ task $\times$ device) whereby the younger adults reported higher levels of exertion on the hand [$t(1, 8) = 2.69$, $p < 0.05$] and wrist [$t(1, 8) = 2.44$, $p < 0.05$] while performing point-and-click motions with the mouse, and on the hand [$t(1, 8) = 3.88$, $p < 0.01$] and elbow [$t(1, 8) = 3.42$, $p < 0.01$] while performing click-and-drag motions with the mouse. The older participants reported greater levels of exertion in the hand [$t(1, 9) = 2.69$, $p < 0.05$], wrist [$t(1, 9) = 2.23$, $p < 0.05$], forearm [$t(1, 9) = 2.51$, $p < 0.05$], and elbow [$t(1, 9) = 2.42$, $p < 0.05$] during point-and-click tasks with the mouse, and in the wrist [$t(1, 9) = 5.44$, $p < 0.001$], and forearm [$t(1, 9) = 2.74$, $p < 0.05$] during click-and-drag tasks with the mouse.

3.1.4. Target parameters

As shown in Fig. 5, participants were slower in acquiring the smaller targets, $F(1, 18) = 36.38$, $p < 0.001$, and more distant targets, $F(1, 18) = 93.89$, $p < 0.001$. Furthermore, the effect of movement distance was exacerbated by age, $F(1, 18) = 5.75$, $p < 0.05$. The interaction between age and target width was not significant ($p = 0.44$).

Analysis of VE shows that VEs were greatest for larger, $F(1, 18) = 15.19$, $p < 0.01$, and more distant targets, $F(1, 18) = 20.82$, $p < 0.001$. Distance and width interacted in their effects on VE, whereby the resulting values were higher for longer amplitude movements made to larger targets, $F(2, 36) = 7.63$, $p < 0.01$. Furthermore, movement variability at the larger targets were greater for the younger group, $F(2, 36) = 7.02$, $p < 0.01$. Finally, EMG (RMS) and RPE values did not vary significantly as a function of movement distance.

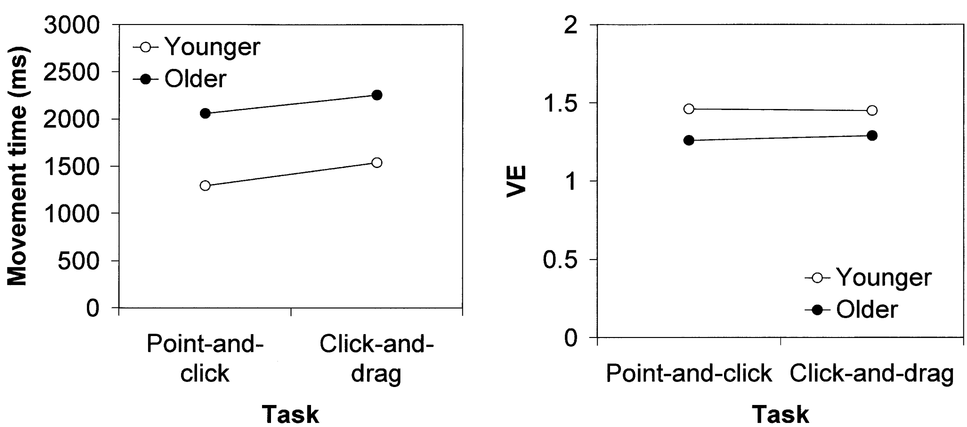

Fig. 4. Mean movement time (left) and VE (right) values as a function of task and age.

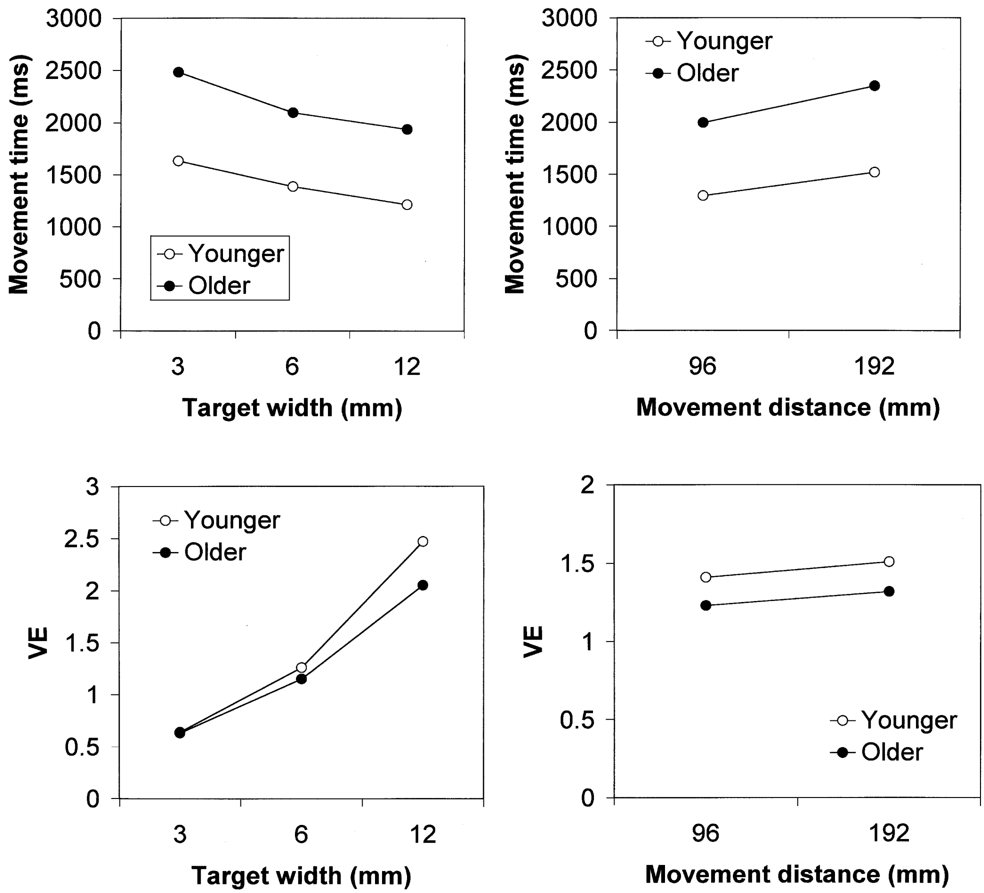

Fig. 5. Mean movement time (top panels left and right) and VE (bottom panels left and right) values as a function of target width, movement distance, and age.

3.2. Analysis of throughput

Fig. 6 shows the mean throughput values as a function of age, device, and task. As can be seen, lower throughputs were observed for the older participants than for the younger participants, $F(1, 18) = 41.66$, $p < 0.001$. Lower throughputs were also observed for the trackball than for the mouse, $F(1, 18) = 15.56$, $p < 0.01$, and for the click-and-drag motions than for the point-and-click motions, $F(1, 18) = 34.31$, $p < 0.001$. However, there was a significant interaction between age and device, $F(1, 18) = 5.44$, $p < 0.01$, which indicated that although the younger adults produced significantly lower throughputs when using the trackball versus the mouse, the older adults' throughputs remained

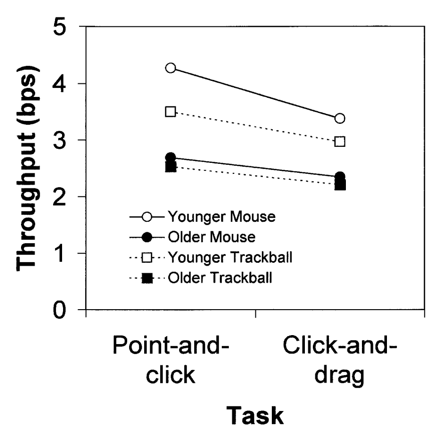

Fig. 6. Mean throughput values as a function of age, device, and task.

constant across devices. Furthermore, there was a significant age by task interact, $F(1, 18) = 4.66$, $p < 0.05$, in which the performance of the younger participants was more degraded when the task changed from clicking to dragging, while again the older participant's performance remained constant.

4. Discussion

In this study the effects of age on the use of a mouse and trackball were examined. There was an interest in determining if one device might offer some advantage to the older computer user. Age-related differences in movement time were observed whereby the older participants were slower than younger participants regardless of device or task (point-and-click vs. click-and-drag). Furthermore, both age groups were slower using the trackball than the mouse, and slower performing click-and-drag motions than point-and-click motions. However, analysis of VE indicated that the older participants' movements were no more variable than the younger participants' movements for small targets, and were in fact less variable for the larger targets. A potential explanation for this apparent speed/accuracy tradeoff in the older group is considered below. Finally, both age groups reported greater levels of perceived extertion in the lower arm (regardless of task) using the mouse.

Throughput calculations revealed that the younger participants performed better than the older participants regardless of device or task. Moreover, the younger participants performed better with the mouse, particularly when making point-and-click motions. This result is consistent with previous published findings (e.g. MacKenzie et al., 1991). However, the older participants performed equivalently with both devices and tasks. This result may indicate the use of a device-independent strategy (by the elderly) which emphasizes accuracy over speed of movement as a means to compensate for a diminished ability to control their movements. The movement accuracy of the elderly is degraded (Fozard et al., 1994) by a number of factors including an increase in the noise-to-force ratio in neural muscular control (Walker et al., 1996). This noise (random error arising in the transmission of signals to muscles controlling movement) increases with the amplitude of the movement, and at a given force, the motor noise is greater for the older adults. Thus, in order to achieve a level of accuracy equivalent to a younger person, an older person must move more slowly. The younger participants with a lower noise-to-force ratio can move faster yet as accurately. This hypotheses provides a parsimonious explanation for the throughput results, the movement time results, and the VE results of the elderly participants. This argument is not inconsistent with the EMG results showing that older and younger participants produced equivalent muscle force. Under conditions where a person makes a single movement, the EMG (RMS) values reflect the force output and hence the speed of movement. However, it is possible that subjects may have produced multiple submovements to acquire the target as was found by Walker et al. (1997) under similar experimental conditions.

Interestingly, the elderly performed equally well using the mouse and trackball, but they preferred the trackball over the mouse. This preference may be related to differences in the level of perceived exertion associated with the use of the two input devices. The older participants' ratings of levels of perceived exertion (RPE) were significantly higher for the mouse than the trackball.

This finding may be important given the significant declines in grip strength of older adults. For example, Mathiowetz et al. (1985) report a 60% drop in grip strength by age 75 relative to age 25. So, although the elderly and younger participants produced equivalent levels of muscle force when using the mouse (as indicated by the EMG values) the force represents a greater working force percentage of the elderly participants' maximum voluntary contraction (MVC).

It is important to consider the potential effects of changes in muscle strength. First consider an example of how declines in strength may affect the use of the two input devices. The maximum palmar pinch force (thumb pad to pads of index and middle finger) which can be exerted by younger (age 30) and older (age 70) adults are 24.7 Ibs and ~18.1 Ibs, respectively (Mathiowetz et al., 1985). Using a mouse, a typical button press requires

0.34 Ibs for a point-and-click task and 0.39 Ibs for a click-and-drag task (Johnson et al., 1994). Thus, the percent working force of the MVC for a younger computer user would be 1.38% and 1.58%, respectively. The values for older adults engaging in these tasks would be 1.89% and 2.15%. Consequently, the older computer users may be prone to an earlier onset of fatigue since they will use a greater percentage of their maximum force. This earlier onset of fatigue could possibly be related to he increased risk of CTDs.

Currently, there is no data on the range of motion for older adults similar in age to the participants in the present study. However, the available maximum range of motion data for the wrist (representing the sum of wrist radial and ulnar deviations) shows a 16% reduction between the age ranges of 25–34 and 45–54 (Stubbs et al., 1993). This finding would imply that the reduction in range of motion for persons comparable in age to our older participants may be greater. Moreover, the use of the mouse, which requires a larger motion of the wrist, may be affected more by these changes than the trackball.

While this study provides new insight into the effects of aging on the use of computer input devices, a number of issues still need to be addressed. For instance, range of motion data for adults greater than 55 are not yet available, and so it is not clear how further declines in this area affect the use of these devices. Furthermore, we do not know how these age-related declines may be offset by design features in hardware and software. For instance, a number of alternative devices (e.g. ergomouse, a variety of trackball designs, and so on) are available that may offer some advantage to the older computer user. We are currently investigating these devices, as well as potential software solutions including dynamic control-display gain and alternatives to the point-and-click methods of selecting on-screen targets. In addition we are obtaining normative data on the range of motion for adults older than 54 years of age.

5. Conclusions

Our findings suggest that tasks requiring the frequent and prolonged use of the mouse, may be associated with greater levels of discomfort (i.e. earlier onset of fatigue and greater perceived exertion) for the older computer user, and consequently, possible increased risk of CTDs. Additionally, because older adults move more slowly, they may be at a particular disadvantage in tasks where responses or movements are constrained by shorter time frames. Based on preferences, including levels of perceived exertion, and considerations of range of motion of the wrist, the trackball may represent a better input device for older computer users.

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