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Barbara S. Chaparro, Editor

Ergonomic Mice: Comparison of Performance and Perceived Exertion

by Deborah Scarlett

Summary: This study reports a psychophysical comparison of four ergonomic mouse-type devices to the standard mouse. It was hypothesized that muscle activity transferred from the distal to proximal limbs for some of the ergonomic mice may result in increased load on the shoulders and declines in target acquisition performance. Results revealed a potential tradeoff between performance and safety with the devices as participants performed the best with the standard mouse but reported more wrist exertion with this device.

INTRODUCTION

There are many studies comparing alternative input devices to the mouse (see Epps, 1986; Card, English, & Burr, 1978). Results of these studies indicate that the standard PC mouse performs better (i.e. lower movement times and errors) and is often the most preferred among the devices tested. However, the mouse design requires excessive hand extension, wrist deviation, arm abduction, and pronation (Smith, Edmiston, & Cronin, 1997). The increasing incidence of repetitive stress syndrome and complaints of shoulder, neck, and wrist pain by mouse users (see Fogleman & Brogmus, 1995; Jensen et al., 1998; Oberg & Astrom 2000; Peper & Tibbetts, 1994; Punnett and Bergqvist, 1997; Sauter, Scheleifer, & Knustson, 1987) have prompted manufacturers to develop different "ergonomic" designs that promise increased comfort and safety. These devices promote reduction in forearm twisting, muscular effort, and decrease the risk of upper extremity muscular discomfort.

This experiment compares psychophysical measures for four alternative mouse-type devices to the standard Microsoft mouse. The alternative devices evaluated include the Vertical Mouse (Evoluent LLC), Renaissance Mouse (3M), Quill Mouse (Appliances, Inc), and Contour Mouse (Contour Design, Inc). Three of the devices, Quill Mouse (QM), Renaissance Mouse (RM), and Vertical Mouse (VM) hold the forearm in a neutral position with two of them (QM and RM) constraining wrist movements. The other two, Contour Mouse (CM) and Microsoft mouse (MS), require a pronated forearm to manipulate the device.

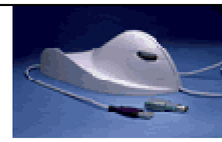
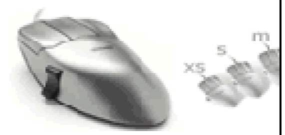
 Vertical Mouse (Evoluent LLC, CA)	 Joystick (3M, US)	 Quill-Well Mouse (Designer Appliances Inc, Mineola, NY)	 Contour Mouse (Contour Design, Inc. Windham, NH).

Figure 1. Four alternative input devices compared to the standard Microsoft mouse.

The purpose of this study was to determine whether there are differences (trade-offs) in performance, perceived exertion, movement characteristics, and preference between the five different mice designs. It was hypothesized that muscle activity transferred from the distal to proximal limbs for some of the ergonomic mice may result in (i) an increase in static loading on the shoulder muscle and (ii) performance declines with longer movement times to acquire a target.

METHOD

Participants

Thirteen participants, 9 men and 4 women, volunteered for the experiment. Average age of the participants was 26.2 years (range 22 - 39 years) and average computer experience was 10.77 years (range 5 - 25 years).

Procedure

Participants sat in front of a 21-inch monitor (control/display ratio 1:4) displaying a standard Fitts' Law target aquisition task. Cursor movement and target appearance (2.5mm circle) began with a click and ended by clicking within the target area. There were sixteen combinations of two distances (37.5mm & 127.5mm) and 8 angles (0°, 45°, 90°, 135°, 180°, 225°, 270°, 315°) for each of the 5 input devices. The distances, angles, and devices were blocked and counterbalanced. Participants performed 12 trials of each condition for a total of 960 trials each. Participants completed subjective ratings of device preference, and a Borg 10-point Rating of Perceived Exertion (RPE) scale for the upper and lower arm components.

RESULTS

Movement Time. Results from a 5 x 8 x 2 analysis of variance showed that there were main effects for movement time (MT), device ($p<0.001$), angle ($p = 0.003$), and distance ($p < 0.001$). There were significant interactions between device and distance ($p = 0.001$). The MS had the fastest movement, the RM and QM showed the slowest MTs (Figure 2). Pairwise comparisons showed that the VM and CM had similar MTs but they were significantly different from the other devices, which were also significantly different from each other. Angle 315° was significantly different from most of the angles, which may be related to its reliance on the upper arm reducing movement velocity and accuracy. Regression analyses to determine MT fit to Fitts' equation showed R2 ranging from 92% to 96% indicating that MTs for the devices can be predicted with little variance.

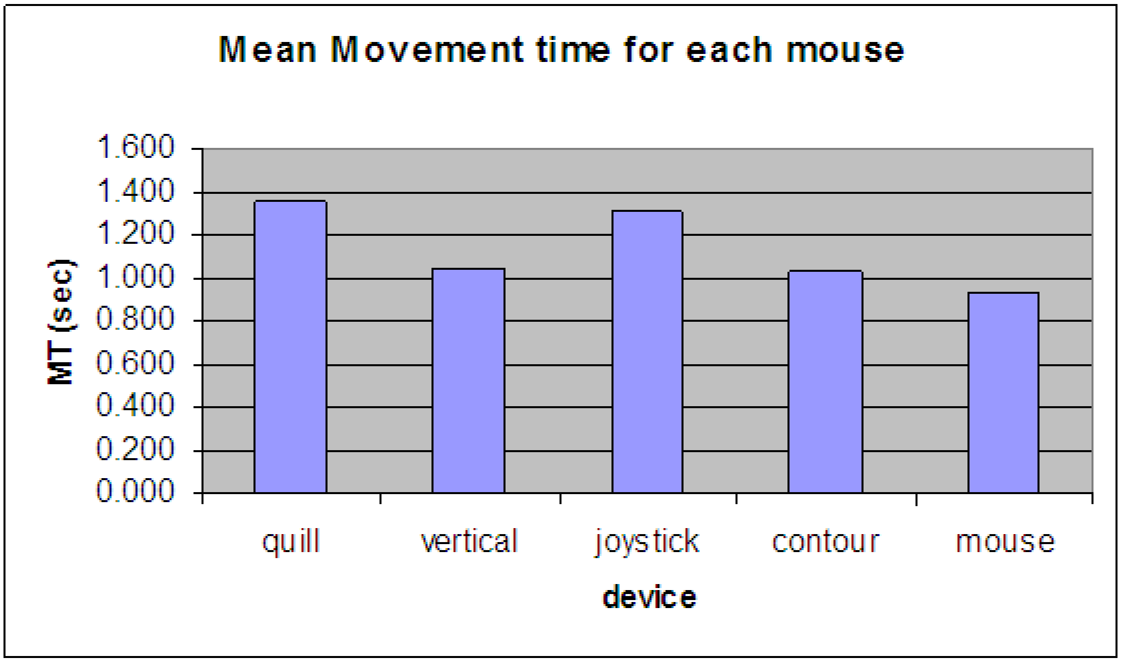


Figure 2. Mean movement times for each input device

Peak Velocity. Mean peak velocity (PV) of the movement was significantly different for device ($p < 0.001$), angle ($p < 0.001$), and distance ($p < 0.001$). The MS and the CM were similar in PV, with the RM, QM, and VM significantly different from each other. The MS showed the greatest PV and the QM showed the lowest. Mean PV along the diagonal angles (45°, 135°, 225°, 315°), horizontal angles (0°, 180°) and vertical angles (90°, 270°) were similar within the groups; however, they were significantly different from each other.

Throughput. Throughput, a metric standard to evaluate different devices and their performance, was significant for device ($p < 0.001$) and angle ($p < 0.001$). The mouse showed the highest throughput at 6.4 with the QM and RM measuring the lowest at 4.8 and 5.0. The CM and the VM performed similarly; however, the other devices were significantly different from each other. The main effect for angle was similar to that for MT.

Percentage of Error. A main effect for errors was found for device ($p < 0.001$), angle ($p = 0.014$), and distance ($p = 0.004$). The percentage of error ranged from 3.5% to 8.8% with the MS and the short distance showing the lowest error rate and the QM and RM demonstrating the highest (Figure 3).

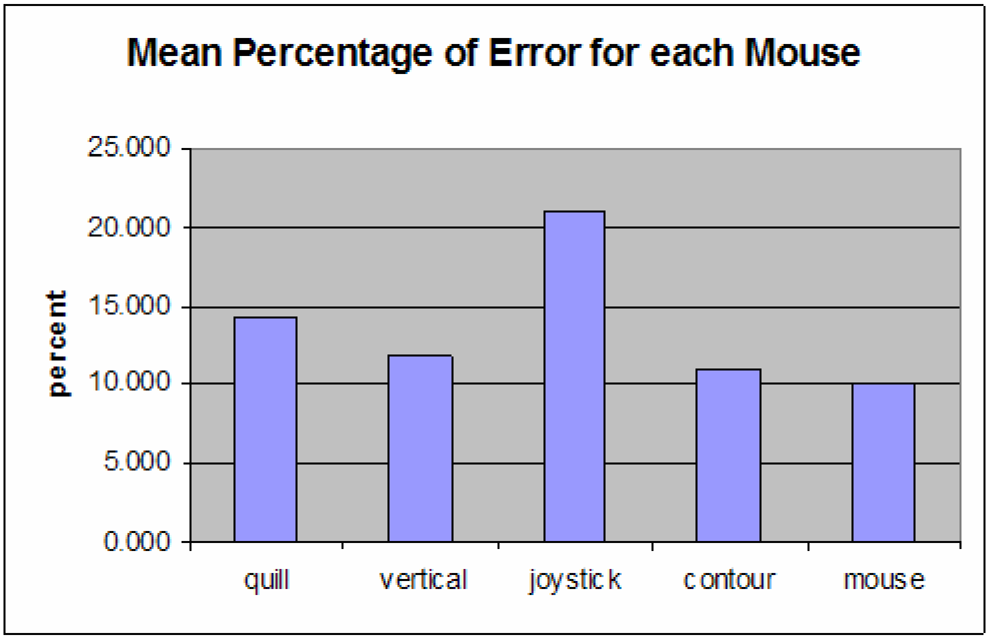


Figure 3. Error rates for each input device.

Perceived Exertion Ratings. RPE ratings from the participants were not significantly different across the mice condition; however, it is interesting to point out that the QM rated the highest among the devices for upper body exertion. This is not surprising since it is specifically designed to reduce movements about the wrist. The standard mouse had the highest perceived wrist exertion, which was expected. Even so, the participants preferred the mouse to the other devices, with the QM and RM least preferred.

CONCLUSION

This data revealed a potential tradeoff between performance and safety in these particular devices as well as a tradeoff between lower arm and upper arm exertion. Ergonomic design mice had the highest muscle activity on the shoulder rather than the hand/wrist muscle. Ergonomic mice may reduce the hand and wrist motion, but increased muscle activity to the shoulder muscles. Movements may be less efficient with mice that use the larger muscle groups of the shoulder in lieu of the fine musculature of the hand. Further research needs to be done to examine the impact of training and repeated usage of the ergonomic mice on movement strategies. In addition, detailed examination of wrist movements with each mouse would lead to a better understanding of how each device is used by different populations of users, varying in age, gender, and level of disability.

Note: For additional information,, please see the proceedings of HCI-International 2005 in July. For more information see http://www.hci-international.org/.

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