Ergonomic Test of Two Hand-Contoured Mice

Wanda Smith, Bob Edmiston, and Dan Cronin
Global Ergonomic Technologies, Inc.,
Palo Alto, CA

ABSTRACT

A study was conducted of performance, muscle effort, postures, and preferences of six subjects using two hand-contoured mice: the *Contour* mouse and the Microsoft *Ergonomic* mouse. The study consisted of approximately three hours pointing, selecting, and dragging tasks. User performance was measured from task completion time and errors. Muscle effort was measured from electromyographic recording of the muscles controlling finger abduction, hand extension, ulnar deviation, and arm pronation. Deviation from neutral was also measured for these four postures. Preferences were obtained from independent and comparative ratings of usability, comfort, and design.

Although there were no significant performance differences between the two mice, significantly less muscle effort and postural deviation from neutral occurred with the *Contour* mouse. In addition, the *Contour* mouse was significantly more positively rated for ease of use, comfort, and design.

INTRODUCTION

Recent medical and ergonomic studies have shown that hand extension, wrist deviation, arm abduction, and pronation during mouse use are often excessive (Hagberg, 1994; Karlqvist, et al., 1994; Rempel, Johnson, et al., 1994; Hodes and Akagi, 1986) and that cumulative trauma disorders of the wrists, arms, and shoulders of mouse users are increasing (Armstrong, Martin, et al., 1994; Hagberg, 1994; Karlqvist, et al., 1994; Rempel, Johnson, et al., 1994; Francis, 1992; Franco, et al., 1992; Davie, et al., 1991).

This study evaluated two mice shaped to the contour of the hand to reduce biomechanical problems associated with traditional mouse use. One was the Contour Design mouse and the other was the Microsoft *Ergonomic* mouse.

The Microsoft mouse (see Figure 1) was designed to minimize muscle load during use (Adams, et al., 1994). It differs from a traditional mouse in its higher height, kidney shape, lateral button pitch, and top surface which better conforms to shape of the hand than a traditional mouse.

Figure 1. *Microsoft mouse*

The *Contour* mouse was also designed to minimize biomechanical load and to reduce hand and arm deviations from neutral (Contour Design, 1996). Its top surface has a raised point contoured to the palm of the hand to disperse pressure across the palm during use. The height of one side of the mouse is lower to minimize hand pronation; a support is provided for the thumb (see Figure 2)

Figure 2. *Contour mouse.*

The purpose of the study described in this paper was to determine the effects of the unique design features of these two mice on performance, biomechanical load, posture, and ratings of usability, comfort and design.

With a few exceptions (Harada, et al., 1994; Smith and Cronin, 1993), most studies of mouse use have been limited to the simultaneous evaluation of one or two measures, like performance and preference, or muscle load and comfort (Murata, 1991, 1992; Mackenzie and Riddersma, 1994; Barker, et al., 1990; O'Brien, 1990; Milner, 1988; Moore, et al., 1985). In addition, the test methods in most mice studies vary greatly; they do not follow a standardized protocol. The study described in this paper included four simultaneous measures: muscle effort, posture, performance, and preference ratings. In addition, it utilizes the test method specified in the International Organization for Standardization (ISO) ergonomic standard draft 9241 Part 9: *Non-keyboard input device requirements* (ISO, 1995). Part 9 specifies test subjects, tasks, environmental conditions, furniture adjustments, data collection methods, data analysis procedures, and performance metrics (Smith, 1994). Four of the ISO test tasks were selected to be used in this study: horizontal pointing, multi-directional pointing, horizontal dragging, and vertical dragging. Each task included several levels of difficulty as specified in Part 9.

METHOD

Subjects

Six subjects (one female and five males) participated in this test. The subjects were between twenty to fifty years of age. Each subject had at least two years experience using a mouse. All were right handed. One subject (#1) had a wrist repetitive strain injury and one subject (#5) reported frequent wrist discomfort during mouse use.

Equipment

Mice. The Microsoft mouse had two buttons; the *Contour* mouse had three buttons and was larger than the Microsoft mouse (see Table 1).

TABLE 1. Mouse size

Dimension	*Contour*	Microsoft
Width	3.75"	2.5"
Length	5.75"	4.6"

The activation forces at primary displacement points on the *Contour* mouse buttons were less than the Microsoft mouse button (see Table 2).

TABLE 2. Button activation forces (in Newtons)

Position	Point	*Contour*	Microsoft
Left	Far	0.5	0.8
	Center	0.8	1.2
	Near	1.6	2.3
Center	Far	0.6	
	Center	0.9	
	Near	1.7	
Right	Far	0.7	0.7
	Center	1.0	1.0
	Near	1.6	1.9

Monitoring equipment. Subjects were tested in an environmentally controlled room. Communication with subjects during testing occurred via an intercom. Subject's actions were viewed from a one-way window and a video monitor in a separate observation room. The viewing monitor was connected to two video cameras in the test room; the cameras recorded postures of the subject's right hand (see Figure 3). One camera was located to the side of the subject's hand during the test to record vertical angulation (extension); the other camera was vertically oriented above the subject to record lateral hand angulation (ulnar and radial deviation). A video mixer allowed both camera images to be simultaneously recorded and displayed on the viewing monitor. Time and date stamping were incorporated into the video image via a character generator. All recording was made on S-VHS video tapes to assure maximum image resolution.

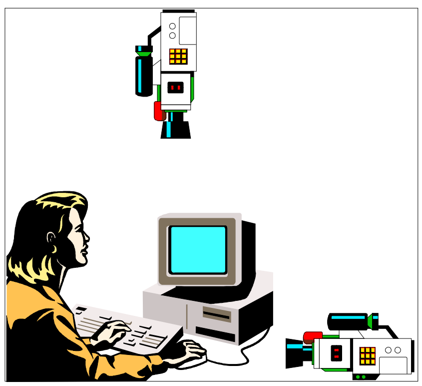

Figure 3. *Video camera locations*.

Muscle load recording. Muscle effort was recorded via a computerized electromyographic (EMG) recorder. EMG activity was sampled at a rate of eight times a second resulting in 2,500 samples during each five-minute test for each of the four muscles monitored (see Table 3). A total of 160,000 EMG samples were thus collected for each subject. The EMG samples were grouped into ten sessions for each five-minute test. Average EMG was automatically calculated for every 30 second session for each muscle monitored. Thus, all muscle load data described in this report are average EMG. Maximum voluntary contractions (MVCs) were measured for each muscle monitored before and after the test.

TABLE 3. Muscles monitored

Muscle	Activity
abductor indicis	finger abduction
extensor communis digitorium	hand extension
extensor carpi ulnaris	hand ulnar deviation
pronator radii teres	arm pronation

Electrodes were placed at one location on the hand and three locations on the arm to monitor the activity of muscles controlling finger abduction, wrist extension, ulnar deviation, and arm pronation. Standard procedures were used for electrode preparation, calibration, placement, and attachment (Marras and Schoenmarklin, 1989).

Preliminary Test Procedures

Subjects were briefed about the test and then asked to complete a questionnaire about their experience with computers, software applications, and input devices.

A computer terminal table - with separately adjustable input device and display support surfaces - and an ergonomic chair were used for the subject's workstation. Each subject was asked to adjust the chair to a preferred comfortable position. The monitor and input device support surfaces were then adjusted to an ISO specified ergonomically correct height that accommodated the subject's chair height setting.

Before the test began, subjects used the *Contour* mouse for 30 minutes, during which time they completed at least one session of each of the tasks (see Table 5) required in the test.

Test Procedures

Each subject participated in the test for approximately four hours. The test procedures included: answering the preliminary survey, electrode attachment, test tasks, breaks, and completing the post-use rating questionnaire. Mouse assignment was alternated between subjects to minimize order effects (see Table 4).

TABLE 4. Mouse use order

	Mouse Assignment	
Subject	First	Second
1	Microsoft	*Contour*
2	*Contour*	Microsoft
3	Microsoft	*Contour*
4	*Contour*	Microsoft
5	Microsoft	*Contour*
6	*Contour*	Microsoft

Test tasks. Each subject completed four different tasks in the same order two times (see Table 5). Each task was five minutes in duration.

TABLE 5. Test tasks, order, and duration

Order	Task	Duration
1	Horizontal pointing	5 minutes
2	Multi-directional pointing	5 minutes
3	Horizontal pointing	5 minutes
4	Vertical Pointing	5 minutes
5	Horizontal pointing	5 minutes
6	Multi-directional pointing	5 minutes
7	Horizontal pointing	5 minutes
8	Vertical Pointing	5 minutes

Rating tasks

After completing all tasks, subjects were asked to rate, on a seven-point scale, twenty seven usability, comfort, and design features (see Table 6) of the mouse they had just used. After subjects completed all the tasks with both mice, they were asked to comparatively rate nine usability features (see Table 7) of the *Microsoft* mouse on a five point scale. They then rated, for each of the ten features, whether the *Contour* mouse was "Worse," the "Same," or "Better" than the *Microsoft* mouse.

Data Collection. Results of muscle activity and mousing actions were stored and later analyzed on a computer. Posture deviations from neutral were measured from the video images with a goniometer. Performance was calculated from trial completion time and error rates. Multivariate analysis of variance (MANOVA) was used to determine main effects and interactions between subjects and conditions. Preferences were assessed from the ratings of usability features and analyzed with the Kruskal-Wallis ANOVA and the Median Test.

RESULTS

TABLE 10. Independent features ratings

Feature	*Contour*	Microsoft
1. Sideways movement effort		✧
2. Forwards movement effort		✧
3. Backwards movement effort		✧
4. Button activation force	✧	
5. Use effort	✧	
6. Accuracy	✧	
7. Overall impression	✧	
8. Overall size		✧
9. Length	✧	
10. Width	✧	
11. Height		✧
12. Angle	✧	
13. Shape		✧
14. Contour	✧	
15. Button size	✧	
16. Button shape	✧	
17. Button location	✧	
18. Overall impression of usability	✧	
19. Operating posture	✧	
20. Grip comfort	✦	
21. Top surface comfort	✧	
22. Finger fatigue or soreness	✦	
23. Hand Fatigue or soreness	✦	
24. Wrist fatigue or soreness in wrists	✦	
25. Arm fatigue or soreness in arms	✦	
26. Shoulder / neck fatigue or soreness	✦	
27. Operation hand posture	✧	

Legend:
✦ indicates significantly better
✧ indicates slightly better

Comparative ratings. The results of the comparative ratings after both mice had been used demonstrated that the *Contour* mouse resulted in significantly higher ($t = -6.9$, $p < .001$) overall ratings than the Microsoft mouse (see Table 11).

TABLE 11. Comparative features ratings

Feature	Contour	Microsoft
1. Touch / feel	✧	
2. Activation effort	✧	
3. Aches / pains	✦	
4. Tiredness / fatigue	✦	
5. Posture	✦	
6. Awkwardness	=	=
7. Efficiency	✧	
8. Comfort	✦	
9. Intuitive operation	✧	

Legend:
✧ indicates slightly better
✦ indicates significantly better
= indicates equal rating

Subjective vs. Objective Measures

Ergonomic research on input devices often demonstrates low correlation between subject choice, performance, and biomechanical load (Smith and Cronin, 1994; Milner, 1988; Bishu, et al., 1993; Han, et al., 1990; Bendix and Jessen, 1986). In addition, user's comfort and usability ratings and product choices are often biased by the appearance of a product or familiarity with it. In this study, significant differences between the two mice were more salient for biomechanical load than for preferences and more salient for preferences than for performance. In addition, significant preference differences of the usability features occurred only for comfort factors, and not for design features. This indicates that user's opinions of design and effort did not agree with measures of biomechanical load. Thus, the studies that have used single, or simultaneous, measures of performance and preference as ergonomic quality criteria may not be appropriate. These results indicate that mice studies should therefore include simultaneous measures of muscle effort, posture deviation from neutral, performance, and preferences.

SUMMARY

In this study, the *Contour* mouse resulted in significantly less overall muscle effort than the Microsoft mouse for most of the test tasks. Finger abduction and ulnar deviation resulted in the highest muscle effort - almost twice that for hand extension and arm pronation. The average muscle effort for finger abduction, ulnar deviation and arm pronation during *Contour* mouse use was significantly less than muscle load during Microsoft mouse use.

In general, deviation from neutral was slightly less with the *Contour* mouse than with the Microsoft mouse. The posture which resulted in the most deviation from neutral was ulnar deviation; the least was radial deviation. The task which appeared to cause the most deviation from neutral was horizontal dragging.

There was no significant performance differences between the two mice. However, the *Contour* mouse was rated higher than the Microsoft for most usability features and functions: the *Contour* mouse was independently rated significantly higher for comfort and comparatively rated significantly better for posture and comfort.

In conclusion, this study appeared to demonstrate that the Contour mouse met its design objectives of reducing biomechanical load and discomfort compared to the most commonly used ergonomic mouse without sacrificing user performance.