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Effects of slanted ergonomic mice on task performance and subjective responses

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ABSTRACT

The biomechanical benefits (e.g., muscular activity) of slanted ergonomic mice have been comprehensively identified; however, their effects on task performance and subjective responses have not been fully investigated. The present study examined the effects of two slanted mice (slant angle = 30° and 50°) in comparison with a conventional mouse (slant angle = 0°) in terms of task performance (task completion time and error rate) and subjective responses (perceived discomfort score and overall satisfaction score). Experimental results showed that all of the task and subjective measures worsened as the slant angle of the target mice increases. For example, the task completion time (unit: ms) and overall satisfaction score (unit: point) of the 30° slanted mouse (time = 0.71, satisfaction = −0.09) and 50° slanted mouse (time = 0.73, satisfaction = −0.79) significantly deteriorated than the conventional mouse (time = 0.65, satisfaction = 1.21). The slanted mice seem to compromise biomechanical benefits with task performance and subjective responses.

1. Introduction

The computer mouse is commonly used with graphic user interfaces. Using a computer mouse comprises one- to two-thirds of total computer usage time (Cook et al., 2000; Lee et al., 2008). In addition, the most frequently used input device among computer users is the computer mouse (Cook and Kothiyal, 1998; Jensen et al., 2002; Muller et al., 2010).

The conventional computer mouse has been identified as a risk factor for upper extremity musculoskeletal disorders (WMSDs) and localized pain. The conventional mouse requires a user to pronate the forearm and to extend the wrist during operation (Gustafsson and Hagberg, 2003). The pronation of the forearm may result in the development of WMSDs (Zipp et al., 1983; Hagberg, 1997; Liao and Drury, 2000). The extension of the wrist increases carpal tunnel pressure (CTP), which would be a potential risk factor for carpal tunnel syndrome (CTS) (Keir et al., 1999; Fogleman and Brogmus, 1995; Bower et al., 2006; Mogk and Keir, 2007). In addition, the conventional mouse may lead to micro lesions in the low-threshold motor units because they have been continuously activated while using a computer mouse (called Cinderella Hypothesis; Crenshaw et al., 2007). Therefore, prolonged awkward posture and monotone movements can induce localized pain and discomfort on upper extremities (Muller et al., 2010; Cook and Kothiyal, 1998; Hedge et al., 2010).

Slanted ergonomic mice have been introduced to reduce the negative effects of the conventional mouse in terms of arm posture, muscular activity, and CTP. The key feature of the ergonomic mice is the slanted angle of the top surface from the left side to the right side. The slant surface, contacted with the palmar side of the hand, can significantly reduce forearm pronation and wrist extension (Muller et al., 2010; Chen and Leung, 2007; Hedge et al., 2010) as well as reduce demands on muscle recruitments in the upper extremities and CTP at the wrist (Gustafsson and Hagberg, 2003).

The slant surface of an ergonomic mouse can restrict performance during mouse usage tasks and can affect the level of subjective preference. Gustafsson and Hagberg (2003) reported that use of a vertical mouse (slant angle = 90°) decreased productivity by 24% in comparison with a conventional mouse. Furthermore, their subjective preference results showed that most of the participants preferred the conventional mouse more than the vertical mouse. Similarly, Scarlett et al. (2005) has revealed that use of a vertical mouse showed worse completion time and error rate than a conventional mouse by 10% and 20%, respectively.

Although the slant angle of a computer mouse seems to negatively affect the task performance and subjective preference, its effects haven't been comprehensively studied yet. Chen and Leung (2007) studied the relationship between slant angle and upper

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extremity muscle use, and suggested that the optimal slant angle is between 20° and 30°. However, they did not consider performance or subjective measures in the determination of optimal slant angle, although the results on physiological measures (e.g., EMG) may be different from performance and subjective measures (Niesen and Levy, 1994; Gustafsson and Hagberg, 2003). Therefore, to understand the benefits of the slanted ergonomic mouse in comparison with the conventional mouse, the effects of slant angle on task performance and subjective responses should be examined.

The present study investigated the effects of two slanted ergonomic mice (slant angle: 30° and 50°) on task performance and subjective responses in comparison with a conventional mouse (slant angle: 0°). To compare the performance and subjective responses among the target mice, an experiment consisting of two mouse-intensive tasks (pointing and dragging) was conducted with 40 participants.

2. Experimental methods

2.1. Participants

Forty participants in their 20s were involved in this study. Twenty of them were male and 20 were female. The average ages for male and female were 23.2 (SD = 2.6) and 21.7 (SD = 1.8) years, respectively. The dominant hand of all participants was the right hand. No participant had any muscular symptom or discomfort on the experimental day. The average hand lengths of male and female were 18.1 (SD: 7.5) cm and 17.2 (SD: 7.7) cm, which are similar to those of Korean male (mean: 18.6, SD: 8.1) and female (mean: 17.5, SD: 7.8) in their 20s. None of them had experience using a slanted mouse before this experiment.

2.2. Experimental design

This study included two independent variables: mouse type (3 levels) and mouse task (2 levels). The mouse type consisted of three levels (Fig. 1): *CM* (slant angle = 0°), *SM30* (30°), and *SM50* (50°). The two slanted mice (SM) with different slant angle at the top surface were selected. As the conventional mouse (CM), a popular and common mouse was chosen. The target mice had slightly different specifications in overall size and weight as displayed in Table 1.

The mouse task was comprised two levels: pointing task (*PT*) and dragging task (*DT*). The PT as shown in Fig. 2a is to move a mouse arrow toward a target button (size: 1 cm × 1 cm) and then click it. The DT as displayed in Fig. 2b is to move a mouse arrow to a movable object (size: 1 cm × 1 cm), and to drag that object into the target region (size: 1 cm × 1 cm). The positions of all the objects in the PT and DT were randomly decided.

There were four dependent variables in the present study: task completion time (*Time*), error rate per 15-trials (*Error*), perceived discomfort score (*Discomfort*), and overall satisfaction score (*Satisfaction*). The Time was measured from the starting time to the ending time of a task. The Error was calculated by the number of errors made during 15 trials of a task. The Discomfort was obtained for each part of the arm (Fig. 3a) with Borg's CR-10 scale (Fig. 3b; Borg, 1998; Kwon et al., 2009). Lastly, the Satisfaction was obtained using a 7-point bipolar scale (Fig. 3c; Tuorila et al., 2008).

Table 1
Specifications of the target mice.

Mouse type	Slant angle (°)	Size (cm)			Weight (g)
		Width	Length	Height	
CM	0	5.5	11.0	3.5	80
SM30	30	7.3	10.6	5.2	120
SM50	50	8.2	10.0	8.0	130

Experimental software was developed using Visual Basic 6.0 (Microsoft, USA), which automatically randomizes the presentation order of experimental conditions and records the task performance (Time and Error). In order to confirm that the positions of the button and movable object, presented in the PT and DT, were randomly decided across the experimental conditions and participants, the software was designed to record their positions.

A desktop computer, operated by Window XP, was used in the experiment. A computer screen (19 inch) was located on about 60 cm from the eyes, and a standard keyboard was placed on about 40 cm from the participant. The experimental mouse was set on the right side of the keyboard. The table height was 70 cm from the floor and the seat height was adjusted by the participants to fit their body sizes.

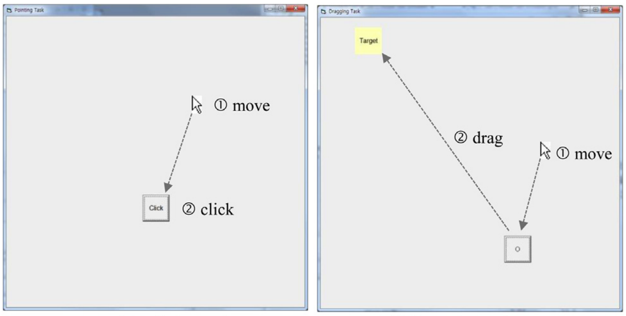
The experimental procedure followed four steps. In the first step, informed consent was secured and the experimental purpose was well informed to the participant. In the second step, sufficient practice (180 trials: 3 (mouse) × 2 (task) × 30 (repetition)) was allowed to accustom each participant to the experimental tasks and the target mice. In the third step, two sessions of the main experiment (360 trials: 2 (session) × 3 (mouse) × 2 (task) × 30 (repetition)) were conducted. A 5-min break was allowed between sessions to minimize fatigue effect. The presentation order of all experimental conditions was randomized by the experimental software. During the second session, the Discomfort on each part of the arm was obtained. In the final step, the Satisfaction on the three mice was surveyed and an in-depth debriefing was completed.

2.3. Statistical analysis

All statistical tests were conducted by Minitab v16.0 (Minitab Inc., USA) with a 0.05 confidence level. Two-factor (mouse type and mouse task) within-subject ANOVA on the task and subjective measures were conducted to test the effects of mouse type and mouse task. Partial eta^2 (η^2_{partial}) on significant factor has

(a) CM (b) SM30 (c) SM50

Fig. 1. Target mice used in the experiment.



(a) Pointing task (b) Dragging task

Fig. 2. Experimental tasks.

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