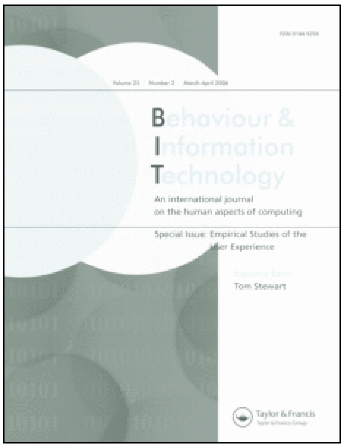

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Using mouse and keyboard under time pressure: preference, strategies and learning*

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Abstract. Visually based point-and-click user interfaces have become very common. This increases the need to understand the mechanics in learning and using pointing devices in order to design appropriate human-computer interaction and thereby to help alleviate musculosketetal symptoms. The paper reports a study of preference, strategies and learning in using keyboard and mouse in a tracking task under time pressure. The keyboard was preferred by 11 out of 12 subjects due primarily to comfort, frustration, and visual strain. One of the most distinguishing features in favour of the keyboard was the opportunity to develop a working strategy facilitating learning.

1. Introduction

With the graphical user interface paradigm the mouse has become as common as the computer. With the Internet the mouse is likely to become even more inevitable due to the visual nature of the World Wide Web. These interfaces imply strong demands to the visuo-motor coordination and it is difficult to develop skills based on automated cognitive processing. With extensive computer usage there are ensuing potential health risks (Punnett and Bergqvist 1997), for example repetitive strain injury. Thus we need to understand the mechanics underlying learning and using pointing devices in order to design appropriate human-computer interaction supporting skilled use, thereby alleviating musculoskeletal symptoms.

In the field of HCI, a number of comparative studies of input devices exist, see (Milner 1988) for an overview, but they focus primarily on task time, errors, and a few also on satisfaction. The motor aspect of pointing and dragging has also been studied, e.g. by Gillan *et al.* (1990), using Fitts' law (Fitts 1954). To the best of our knowledge no studies of preference, strategies and learning in mouse versus keyboard exist.

2. Study design and method

The study was part of a larger study of mental and physical workload using keyboard and mouse (Garde *et al.* 2001; Jensen *et al.* 2001; and Jorgensen *et al.* 2001). Twelve female subjects worked in a within-subjects design with a tracking task for two 1-h periods (with appropriate breaks) – 1 h with the keyboard in the morning and 1 h in the afternoon with the mouse or vice versa (randomized). The Stroop task was used, where subjects were presented with a visual stimulus with two conflicting aspects: A word designating a colour (e.g. red) appearing in another colour (e.g. blue). The subjects were to report the colour, not the word. Four colours were used in randomised order. The

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position of the stimuli on the screen was randomized. Each stimulus was presented for 0.6 to 2.0 s (mean 1.3 s). The subjects were presented with about 1800 stimuli in each 1-h session. The Stroop task was chosen because the load remains fairly constant in these short periods as the task is very difficult to learn.

With the keyboard the subjects depressed one of four adjacent keys J K L Æ associated to the four colours. With the mouse the subjects responded by clicking on one of the four buttons (see figure 1). The subjects were instructed to respond as quickly and correctly as possible. Errors were indicated to the subjects by a beep but the system proceeded with the next stimulus; an error could be failure to respond within the time limit or selecting a wrong colour.

At the end of the day the subjects were interviewed for 10–15 min, covering preference, strategies, and learning. The interviews were recorded with the consent of the subjects and later transcribed.

3. Results and discussion

We first present performance data in Table 1 below in order to illustrate the background for the subjects' comments. It appears that:

- keyboard performance was significantly faster than mouse performance (Wilcoxon);
- there were significantly more correct answers with the keyboard than with the mouse (Wilcoxon);
- there were significantly more incorrect answers with the keyboard than with the mouse (Wilcoxon).

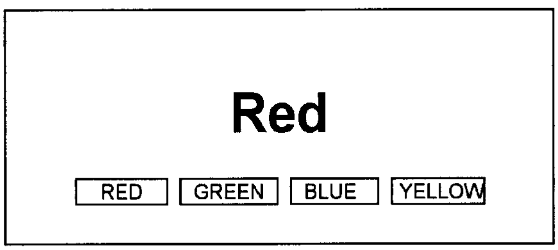

Figure 1. The stimulus word and the four buttons.

Table 1. Performance on tracking task: mouse vs. keyboard.

	Mouse	Keyboard	p-value
Response time	1.1 ± 0.08 s	0.69 ± 0.06 s	0.003
Correct answers	$54 \pm 12\%$	$82 \pm 9\%$	0.003
Wrong answers	$2.2 \pm 1.6\%$	$7.5 \pm 3.0\%$	0.003

The reason for this apparent contradiction is that the subjects responded to more stimuli with the keyboard, but there were also far more erroneous answers; and the subjects responded to far less stimuli with the mouse, but there were far more correct answers. There was a significant preference for the keyboard: 11 of the 12 subjects (binomial test, $p = 0.006$).

Let us recap the tasks the subjects faced. They had to:

- cope with the task visually and cognitively;
- establish a learning strategy, including developing a visuo-motor control scheme and to learn the positions of the four buttons (mouse) and four keys (keyboard);
- cope with the considerable time pressure;
- cope emotionally with the difficult task.

A few telling quotes illustrate the multifaceted nature of the task:

- 'I expected the mouse would be easiest, the keyboard was in fact easier';
- 'I was desperately chasing that target with the mouse!';
- 'Even though you're sure you have hit the right button with the mouse, it beeps!';
- 'Possible to develop a workable learning strategy with the keyboard';
- 'With the keyboard it was like the fingers did the work'.

3.1. *Learning*

One of the most distinguishing features of the keyboard was the opportunity to develop a working strategy that facilitated learning – not only manifesting as increased speed or accuracy, but also as less mental and physical strain. As an example, many subjects initially only tried to react to every other stimulus or only react to the red and yellow stimuli, later including the blue and green; the latter strategy made little sense with the mouse. Most subjects found that learning did take place with the keyboard, making it easier, more comfortable or more satisfactory, while many found that the difficulty even increased with the mouse.

Initially the keyboard was experienced as most difficult as the subjects had to learn the relative positions of the four colours and to manage to press the right key. This problem hardly exists with the mouse as the subjects can rely on a 'label-following' strategy. Thus, as time went on, the subjects learned the four keys, while the basic task with the mouse remained the same throughout: chase the buttons with the mouse.

3.2. *Strain and discomfort*

Five of the subjects used (dis)comfort as the main rationale for their preference. The principal rationales were mostly in favour of the keyboard – just one in favour of the mouse. However, with the rather fixed position of the right hand in the keyboard condition, the strain in the hand was outspoken. One subject put it like this: '*With keyboard strong strain in the hand, with mouse strain everywhere'*. However, several of the subjects preferring the keyboard admitted that they avoided static work postures with the mouse. In general, the subjects found it easier to relax with the keyboard. One subject experienced considerable itching in the eyes after the mouse session in the morning. However, after the keyboard session in the afternoon no eye problems were experienced.

3.3. *Visual strategy*

The task is highly visually oriented. A key focus was not surprisingly handling the two conflicting stimuli. Indeed, subjects either applied a strategy of squinting in order to avoid to read the stimulus word or to focus on the top or bottom of the screen and rely solely on identifying the colour using peripheral vision. This strategy worked generally well with the keyboard as little visual perception was involved beyond the perception of the stimulus. Thus, one subject was able to operate in the keyboard condition with almost closed eyes. In the mouse condition the subjects had to find the target (the four buttons under the stimulus word) and position the cursor on the right button. This could easily result in reading the colour words on the buttons – leading to distraction (if the subjects learned the four buttons spatially) or to reinforcement (if the subjects relied on verbal coding of the colour). Indeed, several of the subjects described how they stated the colour to themselves internally in order to keep focus on the colour, not the word, and thereby facilitate the transformation from the visual code to verbal code.

3.4. *Visuo-motor coordination and motor control*

This is closely related to the visual strategy, as a workable motor strategy can alleviate unnecessary visual and motor strain. Indeed, many of the subjects employed a 'badminton' strategy in the mouse condition, where they positioned the cursor near the middle of the screen while preparing for their next answer in order to minimize the movement – like badminton players in singles use the middle of the court as 'home base'. One aspect particularly frustrating was the feeling of closure with the mouse: to hit the right button – and nevertheless hearing a beep because the hit was slightly imprecise or the button disappeared in the very moment the button was clicked: '*Even when you are sure you have hit the right button with the mouse, it beeps!'*

4. Conclusions

In this tracking task performed under time pressure, 11 out of 12 subjects preferred the keyboard over the mouse although it involved a substantial amount of learning. The reasons were primarily comfort, frustration, and visual strain. One of the most distinguishing features in favour of the keyboard was the opportunity to develop a working strategy facilitating learning.

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