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Office work places with laptop computers: User specific requirements for input devices and software design

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ABSTRACT

In modern offices laptop computers often replace desktop computers. The present paper examines sensorimotor transformations with input devices of laptop computers thereby varying practice and tasks type. Twenty novices performed a point-click and point-drag-drop task with touchpad or trackpoint in 1600 trials. Results showed that the touchpad was used more efficiently than the trackpoint. Performance was improved with time on task, but was still worse especially in the point-drag-drop task. Users of laptop computers profit from 'easy' input devices and simple selection techniques. As a consequence, for stationary office workplaces with laptop computers we recommend using mouse or pen.

Keywords: Sensorimotor transformation, touchpad, trackpoint, input device, practice, task type

INTRODUCTION

Several input devices accomplish for an effective human-computer interaction (e.g. mouse, pen, touchpad, trackpoint). Yet, the user is still confronted with the question, which input device serves the best for one’s purposes. The most commonly used input device with desktop computers is the mouse [5]. In laptop computers touchpad and trackpoint are integrated in the chassis, however, difficulties arise if the input device manipulation (the proximal effect) does not correspond to the cursor action (the distal effect). For example considering the trackpoint: It transforms finger press into a cursor movement and finger force into cursor speed. Consequently, the user has more difficulties to control the device and to interact successfully in comparison to mouse or touchpad [e.g. 1,2,3,7,8,9].

The present study examines performance with sensorimotor transformations inherent in the use of trackpoint and touchpad. Our assumption is that the more corresponding transformation of the touchpad leads to a more efficient usage than the less corresponding transformation of the trackpoint. We further focus on the role of practice in this context. Generally, practice effects for input devices follow the fundamental law of motor skill learning [e.g. 4]. Practice is characterized by an increased optimization of movement execution and a consolidation of cognitive representations. Motor performance improves as a function of time on task and consolidates after 1000-1600 trials (mouse and joystick [3]; touchpad and trackpoint [7]; mouse [10]). In an experiment we survey the impact of sensorimotor transformation and practice for two task types: a simple point-click task and a complex serial point-drag-drop task. The focus is set on characteristic demands of work places following the ISO 9241-9 [6]: We survey very common input actions (e.g. pointing, clicking, dragging or dropping objects) that are applied in different sizes, distances and angles of approach.

The results will provide recommendations for a user-specific optimization of laptop input devices, interfaces and workplaces with laptop computers.

METHOD

Participants

Twenty students from the RWTH Aachen University (7 male) volunteered for the study. They were all highly experienced computer users, but totally inexperienced with laptop input devices.

Apparatus and Stimuli

Participants sat in front of a laptop computer that was connected to an external 15’’ TFT flat screen with a 1024 x 768 resolution (Iiyama TXA 3841J). The input devices integrated in the laptop were a touchpad (Gateway 2000 Solo 9100), a flat 60 x 44 mm touch sensitive panel and a trackpoint (Toshiba Satellite 1700-300), a small force sensitive joystick placed between the “G”, “H” and “B” keys on the keyboard. Two mouse buttons were arranged horizontally in the wrist rest. Taken from the pre-testing procedure [7,9] the medium cursor speed was fixed: The device driver of the touchpad was set at level 6, i.e. 1570 p/s, and that of the trackpoint at level 7, i.e. 1574 p/s.

The point-click and the point-drag-drop task are depicted in Figure 1. On the display a cross-hair cursor and the targets were presented in black color on white background. Each trial started with a self-paced press of the space bar. In the point-click task participants moved the cursor inside the target box, and pressed the left mouse button (Figure 1, left). In the point-drag-drop task participants performed several serial actions (Figure 1, right): First, they had to position the cursor on either side of the underlined target string and to press the left mouse button without releasing it. Second, to move the cursor over the target string, to adjust the cursor on the other end of the target string and to release the mouse button. Third, to move the cursor inside the highlighted target strings and to click and hold the left mouse button again. Forth, to move the cursor inside the target box and to release the left mouse button.

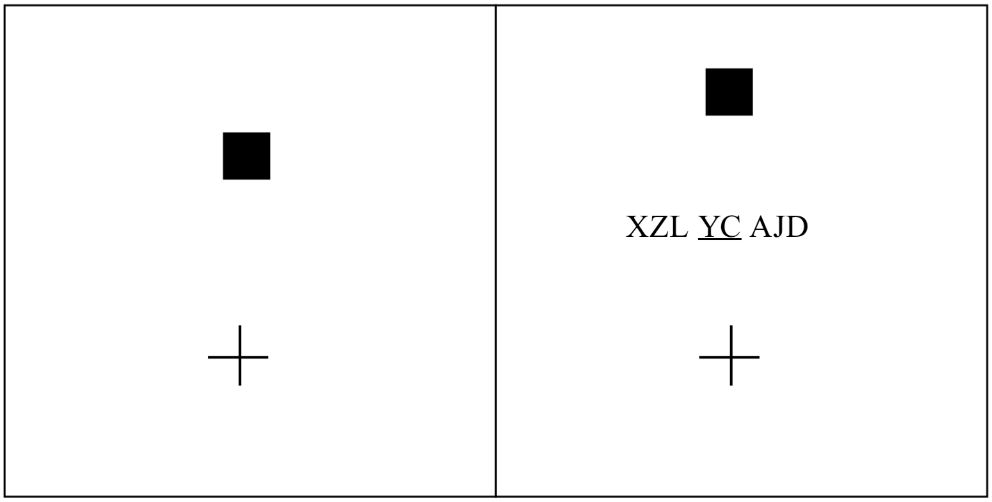

Figure 1. Point-click task (left) and point-drag-drop task (right).

To meet demands of ecological validity targets appeared in two sizes (2.5 and 5 mm) and in two distances (25 and 50 mm). Indexes of difficulty according to Fitts' law [6] were 2.6, 3.5 and 4.4 bits. The targets were always centrally located. The starting position of the cursor was placed in eight different directions (45°, 90°, 135°, 225°, 270°, 315°, and 360°) relative to the targets to exclude confounding effects of movement direction.

Procedure

Participants were randomly assigned to two experimental conditions. Throughout the experiment ten participants operated with the touchpad (motion-transformation condition) and ten participants operated with the trackpoint (force-transformation condition). Participants executed 1600 trials of the point-click task and 1600 trials of the point-drag-drop task. They were instructed to work as fast and accurately as possible.

Dependent variables were time of cursor control (movement time) and accuracy of key control (error rate).

The experiment was based on a three factorial design with the independent variables "sensorimotor transformation" (motion vs. force transformation of touchpad and trackpoint, respectively), "practice" (5 blocks with 320 trials each) and "task" (point-click vs. point-drag-drop task). The order of task conditions was counterbalanced across participants. In total, the experiment lasted 6 hours and was split into three sessions. Each session started with a short training period to familiarize participants with input devices and tasks.

RESULTS

Mean movement times are depicted in Figure 2. Data were analyzed with a 2 x 5 x 2 analysis of variance (ANOVA) with the between-subject factor "sensorimotor transformation" and the within-subject factors "practice" and "task type". For the movement times, the ANOVA revealed significant main effects of the factors sensorimotor transformation ($p < 0.05$), and practice and task type (each $p < 0.01$).

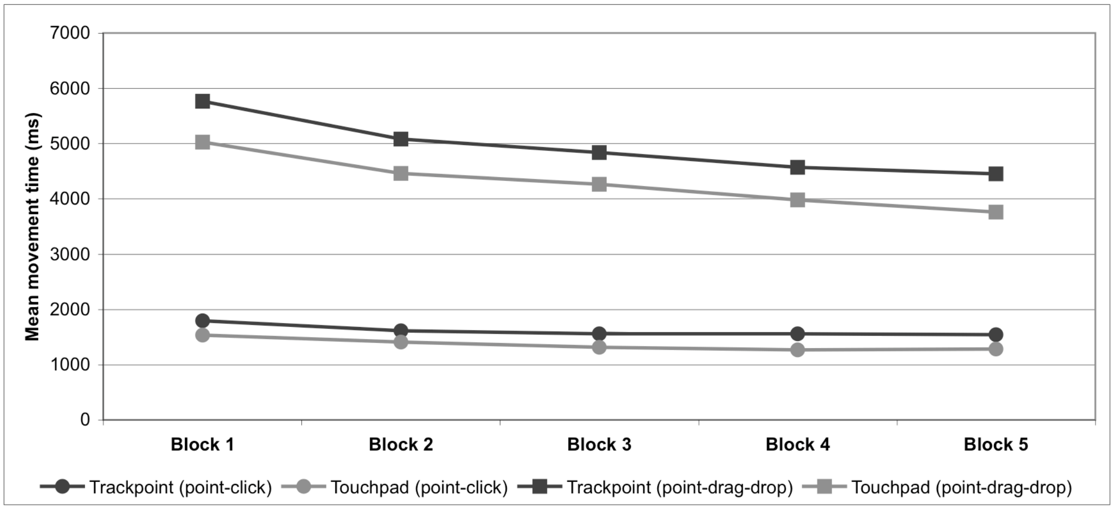

Figure 2. Movement times for touchpad and trackpoint as a function of practice and task type.

Movement times were generally 448 ms shorter with the touchpad than with the trackpoint. Additionally, movement times were higher for the point-drag-drop task when compared to the point-click task and they significantly decreased from the first to the last block. However, this decrease of movement times was more pronounced in the point-drag-drop task with a decrease of 1290 ms than in the point-click task (decrease of 254 ms) yielding a significant interaction between both factors ($p < 0.01$).

The analysis of the error rate revealed significant effects of the factors practice and task type ($p < 0.01$). Error rates were generally lower in the point-click task (4%) than in the point-drag-drop task (23%) and they significantly decreased about 2% from the first to the last block.

CONCLUSION

In the present study the usability of two laptop input devices, touchpad and trackpoint, was evaluated. The focus was set on the impact of sensorimotor transformation of input devices on practice and task type. Twenty novices operated either touchpad or trackpoint over a period of 1600 trials in a point-click and point-drag-drop task. There are two main findings. First, as expected, the touchpad was operated 15% faster than the trackpoint.

Effects of input device are recently more and more discussed in the light of sensorimotor transformations and the correspondence between proximal (hand movement) and distal effects (cursor movement). The findings once more confirm [cf. 2,7,8] that trackpoint users obviously face a rather difficult transformation: When using it, finger force is transformed into cursor speed, which bares no correspondence between hand and cursor movement at all. In contrast, when using the touchpad, hand motion and cursor motion correspond and are linearly related. This leads to an efficient performance in use.

Second, the novices' performance rose distinctly and leveled off after two-third of the practice session in the point-click task [3,4,10]. However, in the point-drag-drop task users were not able to achieve a first consolidation of performance. This indicates at severe difficulties of performing drag and drop actions. These actions are not as fast and easily learned as point-click actions.

In conclusion ergonomic recommendations are derived for the user-specific optimization of work places with laptop computers:

- Users will profit from input device with a high correspondence between hand and cursor movement, e.g. pen, mouse, touchpad.
- Simple interaction techniques enable the user to an efficient performance, e.g. pointing, clicking.
- Input devices of laptop computers fulfill their function in the context for which they are made, which is for mobile applications. However, we recommend substituting the integrated devices by mouse or pen for stationary office workplaces with laptop computers [8].

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