A Study of Mental Workload in Mouse and Keyboard Input

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ABSTRACT

The motivation for this paper is the health risks associated with intensive computer work and the inappropriateness of GUI interfaces for skilled use, partly due to the extensive demands to visuo-motor co-ordination. The work integrates the strong Scandinavian traditions in Occupational Health and Ergonomics with the traditions of HCI and Human Factors. The paper reports an exploratory, experimental study of mental workload in intensive input work using mouse and keyboard, employing subjective and performance measures. The study shows that the keyboard was significantly superior in a large majority of the measures. In addition, 11 of 12 subjects preferred the keyboard.

KEYWORDS

Mental workload, input devices, mouse, keyboard, Stoop task.

INTRODUCTION

Scandinavia has gained world-wide reputation in areas such as Participatory Design, mobile devices and furniture design. This is also true of two other areas relevant to the field of HCI: Occupational Health and Ergonomics. The work reported in this paper has grown out of these Scandinavian traditions and integrates Occupational Health, Ergonomics/Human Factors, and HCI.

The background to the work is the incredible proliferation of computers: 60% of the Danish workforce use a computer every day and more than every sixth employee uses the computer for more than 3/4 of the work day (Burr 1999). The graphical user interface paradigm (GUI) has played a key role in this proliferation as guessability and learnability is strongly supported. However, voices are being raised regarding health risks in extensive computer use, e.g., musculoskeletal disorders (Punnett and Bergqvist 1997) and regarding the inappropriateness of GUI interfaces for expert use (Gentner and Nielsen 1996) as development of highly skilled performance based on automated processing is hampered due to the strong visuo-motor co-ordination demands when using the mouse.

Against this background, the work reported in this paper aims at identifying essential factors in mental workload and their interplay in mouse and keyboard input work. Our long term research goal is firstly to investigate the role of automated cognitive processes in mental workload in using input media (in particular mouse and keyboard), secondly to identify the potential role of these processes in developing or alleviating health risks such as musculoskeletal disorders, thirdly to inform design of suitable input mechanisms to computers, and finally to inform organisation of computer work, in particular heavy input work.

STUDY DESIGN AND METHOD

In a laboratory study we had twelve right-handed, healthy women performing intensive input work using mouse and keyboard in a within-subjects design. The subjects had extensive experience with computers, including keyboard and mouse. Each subject spent a full day in the lab with two intensive 1-hour input sessions, interspersed with rest, instrument calibration, eating, etc. The subjects' primary task was the Stroop-task (Stroop 1935) where a stimulus, a word designating a colour, e.g., 'blue', is presented on the screen in another colour, e.g., red. The subjects are to report the colour of the stimulus word, i.e. ÒredÓ here. We employed four colours: blue, red, green, and yellow. The stimuli were presented at pre-set intervals between 0.6 and 2.0 seconds with a mean of 1.3 seconds; thus, the subjects worked under considerable time pressure. With the mouse, the reporting was done by clicking one of four buttons on the screen and with the keyboard by hitting one of four adjacent keys $\boxed{j}$ $\boxed{k}$ $\boxed{l}$ $\boxed{æ}$ with one of the four typing fingers on the right hand. Each subject worked with the Stroop task for one hour (with 5x2 min breaks) with the mouse and one hour with the keyboard in balanced order. As the mental workload remains fairly constant for a long time with the Stroop task and as it is highly attention-demanding, it has gained wide acceptance in studies of physiological effects of mentally demanding work.

We applied a range of measures of the workload as our preceding analysis had suggested (Jørgensen et al, 1999):

- Subjective preference
- Performance (correct answers, erroneous answers, and time to answer)
- Subjective measures
  - TLX: Task Load Index (Hart and Staveland 1988)
  - RPE: Rating of Perceived Exertion (Borg 1990)
  - Time-estimation (a dual-task measure)
- Various physiological measures.

RESULTS AND DISCUSSION

Due to space constraints we only address the most salient aspects of the subjective and performance measures. The results on the physiological measurements will be reported elsewhere.

The table below summarises the principal findings, shown as the p-values of the statistical tests (binomial test for preference, otherwise Wilcoxon ranked sign test). The p-value appears in the column where the input medium is superior. As an example, 11 out of the 12 subjects preferred the keyboard; this is significant at the 0.006 level.

Measure	Mouse superior	Not significant	Keyboard superior
Preference			0.006
Correct answers			0.003
Erroneous answers	0.003		
Time to answer			0.003
TLX total			0.003
- mental		0.35	
- temporal demand			0.013
- performance			0.031
- effort			0.010
- frustration			0.013
RPE right hand-wrist	0.036		
- right forearm-elbow		0.11	
- right shoulder		0.40	
- neck		0.67	
Time Estimation		0.15	

The table shows a considerable superiority associated with the keyboard. Not only did 11 subjects prefer the keyboard, but of the remaining 9 significant measures, 7 were in favour of the keyboard. This includes two aspects of performance, where for example the mean time to answer with the mouse was 1.09 ± 0.08 s and with the keyboard 0.70 ± 0.06 s (avg. ± s.d.) – a very considerable difference.

The same pattern was seen with the TLX components (except the mental component), where for example the rating of the frustration component on an 18 point scale (where 1 is low load) in the mouse condition was 13.4 ± 3.0 and in the keyboard condition 9.2 ± 4.0 (avg. ± s.d.).

As to the RPE measures only one component was significant: the right hand-wrist region where the rated exertion was lower in the mouse than in the keyboard condition. This may be due to the rather fixed position of the right hand in the keyboard condition whereas in the mouse condition the hand was moved around.

Finally, it should be noted that at a first impression, the keyboard may seem to be favoured by the set-up of the task. This is not the case as the primary tasks were identical in the two conditions. In addition, note that there was a considerable ÒhiddenÓ obstacle in the keyboard condition, namely learning the four keys on the keyboard corresponding to the four colours which took place under considerable time pressure.

In conclusion, the study is an indication that in input-intensive, highly attentive IT-work the keyboard has definite advantages over the mouse in terms of mental workload as measured by performance and subjective measures.

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