Ergonomic Evaluation of Multi Display Type VDT

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Abstract
The aim of this study was to evaluate working conditions using multi display VDTs in terms of work performance, head movement and EMG activities of the neck. A comparative study using single, multi and large display type VDT workstations, was undertaken to obtain ergonomic data applicable to the guidelines and recommendation for VDT operations using multi displays. Subjects comprised 10 healthy volunteers who performed data search and entry tasks for 5 min on each workstation. Work efficiency of the single display was inferior compared to multi and large displays. Head movement was greater with multi and large displays than with a single display. EMG activities did not differ significantly between multi and large displays.

The characteristics of a multi display type VDT work is increased efficiency by dividing software into 2 displays. Workload, sense of incongruity, skills required for operation and other possible problems must be examined before spreading this approach becomes widespread in workplaces.

Keywords: Visual Display Terminals, VDT, Multi display, Single display, Large display, EMG

Introduction
Multi display VDTs have come into use in recent years for workplaces such as movie editing, medical imaging diagnosis and securities transaction. Multi displays have the advantage of allowing multiple open windows without overlap. No guidelines or recommendations have been defined for multi display type VDT, as such displays have not yet gained widespread public use [1,2].

The purpose of this study was to evaluate working conditions using a multi display VDT in terms of work efficiency, characteristics of head movement and EMG activities of neck muscles. Single, multi and large displays were compared to obtain ergonomic data applicable to the guidelines and recommendation for multi display VDT workstations.

Method
Fig. 1 shows the displays used in this experiment. Each subject received 3 kinds of VDT workstation devices: single; multi and large displays. The single display was a 15-inch monitor, while the multi display comprised two 15-inch displays. The large display was a 23-inch display. All displays were flat panel displays. Resolution on the single and multi displays was 1024 (H) x 768 (V) dots. Resolution on the large display was 1920 (H) x 1200 (V) dots. The personal computer used in this experiment had a G450 type video card for twin outputs (Matrox Graphics, Canada).

Subjects comprised 10 healthy volunteers (5 men, 5 women) with average age of 22.7 years range, 18-32 years). The study involved a data search and entry task using both word processing and spreadsheet software for 5 min on each workstation.

Each subject was asked to sit in a chair and engage in the VDT task. Content of the task comprised repeated searching, editing and data entry on the word processor and spreadsheet software. The subject had to memorize 6 digits from the word processor, and the figure was reversed and arranged. Next the subject input the figure to the specified place on the spreadsheet.

Head movement was detected using a C5949 position sensor (Hamamatsu Photonics, Hamamatsu), and movement was converted to rotation angle. Rotation angle was integrated for 5 min under each experimental condition. Both left and right sternocleidomastoid and trapezius muscles were selected and recorded for EMG. The EMG signal was amplified using a BA1008 bio-amplifier (TEAC, Tokyo), integrated and converted into %MVC. Analog Recorder Pro measurement software (G1 SYSTEM, Aichi) was used for head movements and EMG.

Fig. 1 Experimental conditions
A: Word Processor, B: Spread Sheet
Results

Fig. 2 shows a comparison of numbers of correct entries in the study task. Average number of correct entries for the single display was 10.7 (range, 7-16). Conversely, average number of correct entries on the multi display was 13.2 (range, 9-16). Average number of correct entries for the large display was 13.7 (range, 11-16). Significant differences were apparent between the 3 experimental conditions according to one-way ANOVA (p<0.01). The numbers of correct entries of multi and large displays showed significantly higher than the single display according to Tukey's multiple comparison (p<0.05, p<0.01, respectively). The number of correct entries was significantly lower for the single display than for the multi display (p<0.05) or large display (p<0.01).

Fig. 3 shows average and standard deviation for rotation angle among experimental conditions. The average rotation angle of single, multi, and large was 122.3.7, 22.4.2, 0, 192.1 deg respectively. Angle for the small display was extremely small compared with the multi and large displays. One-way ANOVA indicated significant differences among the 3 experimental conditions (p<0.01). According to Tukey's multiple comparison, angle of the single display was smaller than that of the multi display (p<0.05) or large display (p<0.01).

Discussion

For work efficiency, the multi and large displays were excellent compared with the single display. This was attributed to the large display areas of the multi and large display compared with the single display. Moreover, having to operate the taskbar when switching windows in the single display was also considered to exert an influence.

Head movement was reduced for the single display compared to the multi and large displays. In general, movement of the head and neck in VDT work is minimal. This can thus cause excessive load in musculoskeletal systems such as the neck and back, as static muscle work increases [3,4]. Rotation angle of the head was increased for multi and large displays, as size of the display is extended right and left compared with the single display. Using a multi or large display may decrease static muscle work of the neck. As a result, multi or large displays might be able to reduce physiological load compared to a single display. Blood flow to muscles may be elevated for multi and large displays, as muscle activity of the head and neck is increased.

Although rotation angle of the head differed significantly between each experimental condition, EMG activity did not indicate any significant difference. Physiological workload in the neck with multi and large displays are thus considered minimal. However, large displays are disadvantageous in terms of cost.

Conclusion

In conclusion, multi displays offer advantages of increased work efficiency and reduced physiological workload. These fundamental data are applicable to guidelines and recommendations for multi display type VDT workstations.

References