Comparison of Visual Task Performance between CRT and TFT-LCD

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Abstract

The effects of different optical characteristics between desktop CRT and TFT-LCD were compared in terms of visual performance during a 4-hr visual text and icon search tasks. The result showed that CRT is more suitable for presenting graphic information whereas TFT-LCD is suitable for presenting text information at the state of the art display technology.

1. Introduction

As TFT-LCD that was used primarily in mobile environment expanded its application area to desktop displays, many researchers interested in comparing the visual performance between CRT and TFT-LCD when using as desktop computer displays. Saito et al. [5] recorded several visual functions during different tasks carried out using different displays, such as CRT, LCD and PDP. They reported that visual accommodation was faster when using CRT than LCD or PDP. MacKenzie et al. [2] compared user performance in manipulative tasks carried out using CRT or LCD. In their experiments subjects were asked to select targets on the displays using a mouse. They found that LCD gave rise to 34% longer task times than did CRT. More recently, Menozzi et al. [3], [4] compared error rates occurred during visual search tasks using CRT and TFT-LCD. In this experiments subjects had to select target letters among distracters. They reported that TFT-LCD gave rise to 22% [4] or 34% [3] less errors than did CRT.

As shown in the above results from the literature, it is difficult to draw a conclusion on the suitability of a particular display technology to improve viewing conditions for desktop computer environment. And it is not sure that those results are still valid because there was so much progress in each display technology after the previous researches. The previous studies also concerned the suitability of the display technologies only when they were used for text information presentation. Consider that the increasing importance of graphic information in the computer tasks nowadays, suitability of the display technologies for presenting graphic information should be examined alike.

In this study, we compared visual task performance of CRT and TFT-LCD for presenting text and graphic information when they were used as desktop computer displays. The purpose of this study was not to grade the display technologies but to provide a guideline for selecting a proper display on the basis of task performance at a given condition.

2. Materials and Method

2.1 Procedure

The tasks in this study were visual searches for detecting targets among distracters presented in the window. To compare the suitability of the two display technologies for presenting text and graphic information respectively, the tasks were comprised of two distinct modes, text and icon searches. In the text search mode, the subjects were asked to select target words using a mouse at a given text in the window (see Figure 1).

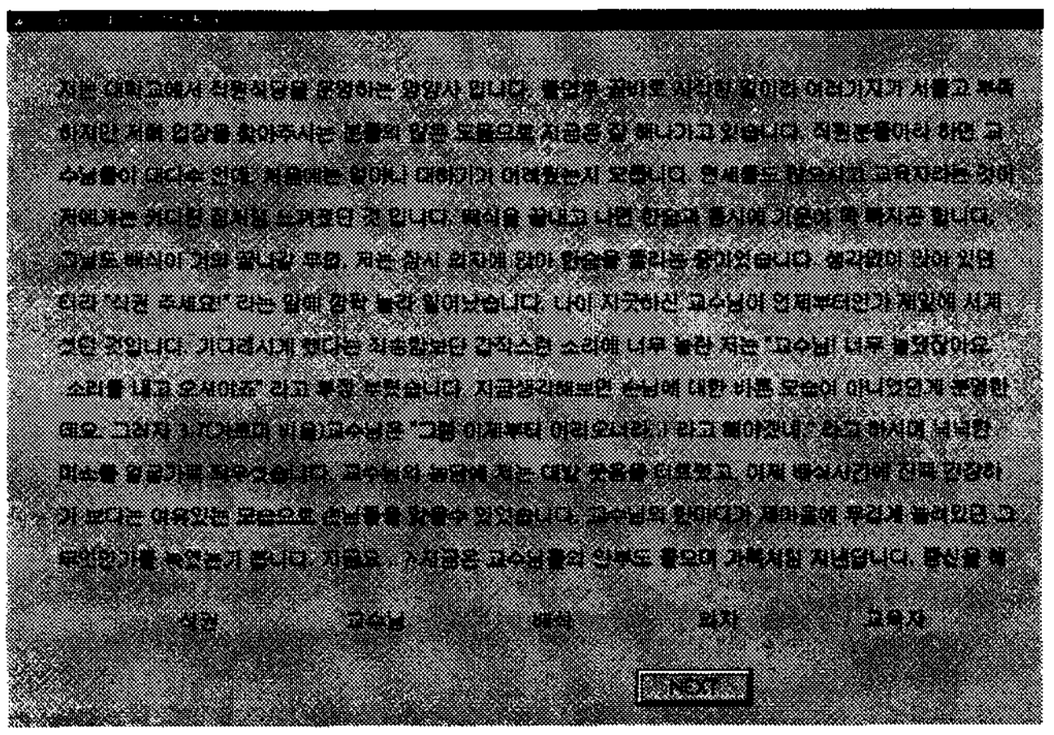

Figure 1 A sample of the text search task

In the icon search mode, the subjects had to find target icons and mark them using a mouse among distracters arranged at the window (see Figure 2). The two search modes were tested together in randomized order within a block. One block of the experiment took 250 minutes for 4 parts of search tasks of 40 minutes each and 3 parts of intermittent computer games of 30 minutes each.

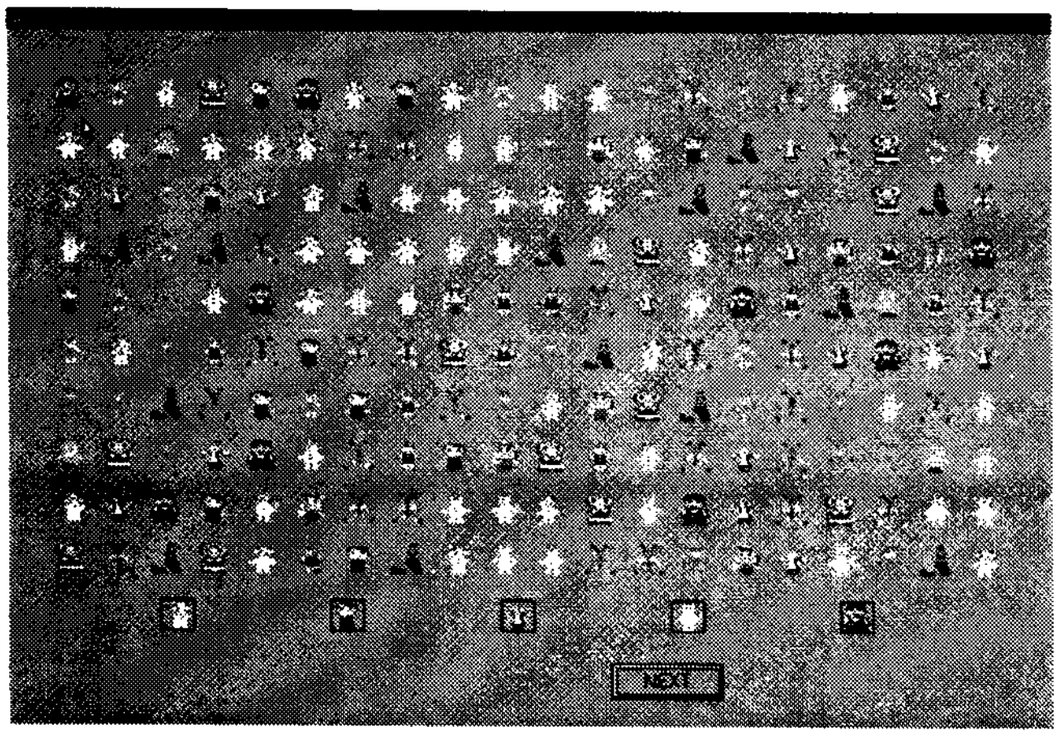

Figure 2 A sample of the icon search task

In order to account for the fact that ambient light may vary depending on location of workplace, experiments were carried out at two levels of ambient light, 300 lx and 1200 lx. Each subject completed the task at both displays and on both conditions of ambient light. The four different settings were administered in random order. Visual task performance was evaluated in terms of reaction time, hit rate and false alarm rate occurred during the search tasks.

2.2 Subjects

A total of 8 university students participated as the subjects. They were all familiar with VDU task and mouse use. The subjects were asked to accomplish the task within a minimum time avoiding errors and informed on their performance after each trial. To avoid learning effects, a training session was preceded during 16 hours for each subject before the main experiment.

2.3 Instrument

17" flat CRT and 15" TFT-LCD were used in this study. The dot pitch of the displays was 0.24㎜. The resolution of the displays was 1024× 768 pixels. The luminance was set at 100 cd/m² at the center of white background. To resolve the difference in actual screen size between the displays, the size of the task windows and objects were adjusted identically.

2.4 Data Analysis

Analysis of variance (ANOVA) was used to analyze the effect of task conditions on the reaction time, hit rate and false alarm rate. To exclude the subjective difference from the analysis, a within-subject design[1] was used to analyze the data.

3. Results

Table 1 summarizes mean differences and their statistical significant levels of the performance measures between the experimental conditions.

Table 1 Summarized results from the ANOVA

Index	Factors		TEXT	ICON
Reaction Time	Display	Mean	CRT < LCD	CRT < LCD
		p-value	0.230	0.000**
	Ambient Light	Mean	Low < High	Low < High
		p-value	0.670	0.101
Hit Rate	Display	Mean	CRT < LCD	CRT > LCD
		p-value.	0.440	0.026*
	Ambient Light	Mean	Low > High	Low < High
		p-value	0.408	0.051
False Alarm Rate	Display	Mean	CRT > LCD	CRT < LCD
		p-value	0.432	0.116
	Ambient Light	Mean	Low > High	Low > High
		p-value	0.447	0.118

3.1 Reaction Time

In comparison of the displays, CRT showed faster reaction times than TFT-LCD for both of text and icon search tasks. The difference in reaction time between the displays was statistically significant for icon search task, but not for text search task.

In comparison of the ambient light conditions, the reaction time was shorter at 300 lx than 1200 lx for both displays, but the mean differences were not statistically significant.

Figure 1 illustrates the differences in mean reaction times under the experimental conditions tested in this study.

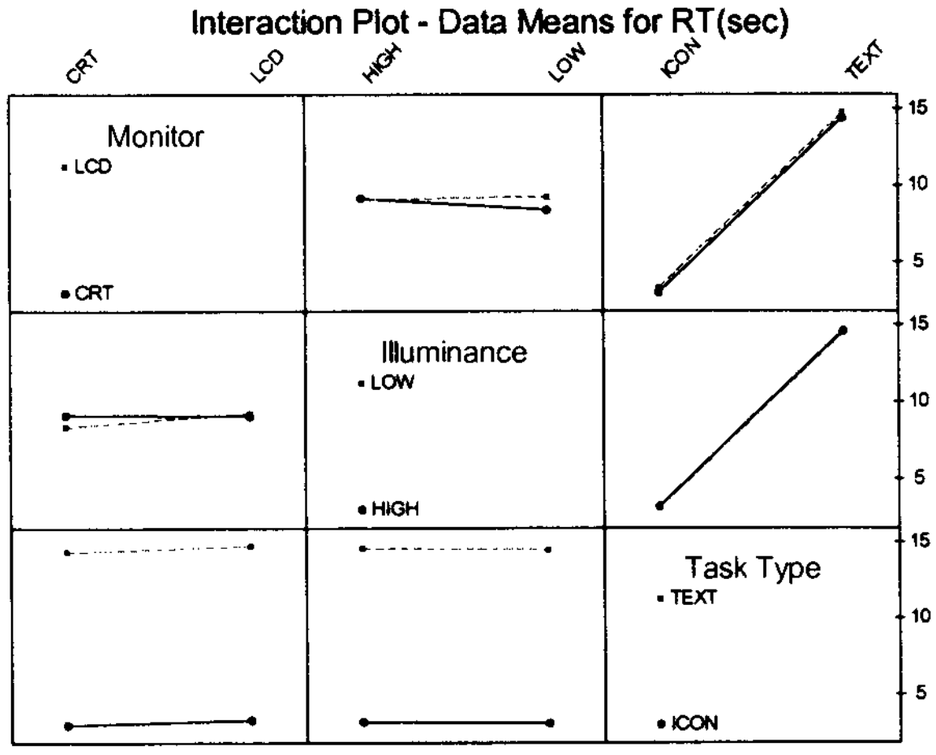

Figure 1 Interaction effects of task conditions on the reaction time

3.2 Hit Rate

The overall hit rate of the icon search task was higher than that of the text search task. For text search task, TFT-LCD showed a higher hit rate than CRT, but the mean difference was not statistically significant. On the contrary, CRT showed a higher hit rate than TFT-LCD for icon search task, and the mean difference was statistically significant. This result indicates that there is an apparent interaction effect between the types of task and display.

In comparison of the ambient light conditions, CRT showed a higher hit rate at 300 lx, whereas TFT-LCD showed a higher hit rate at 1200 lx compared to each other. But the mean difference was not statistically significant for both displays.

Figure 2 illustrates the differences in the mean hit rate under the experimental conditions tested in this study.

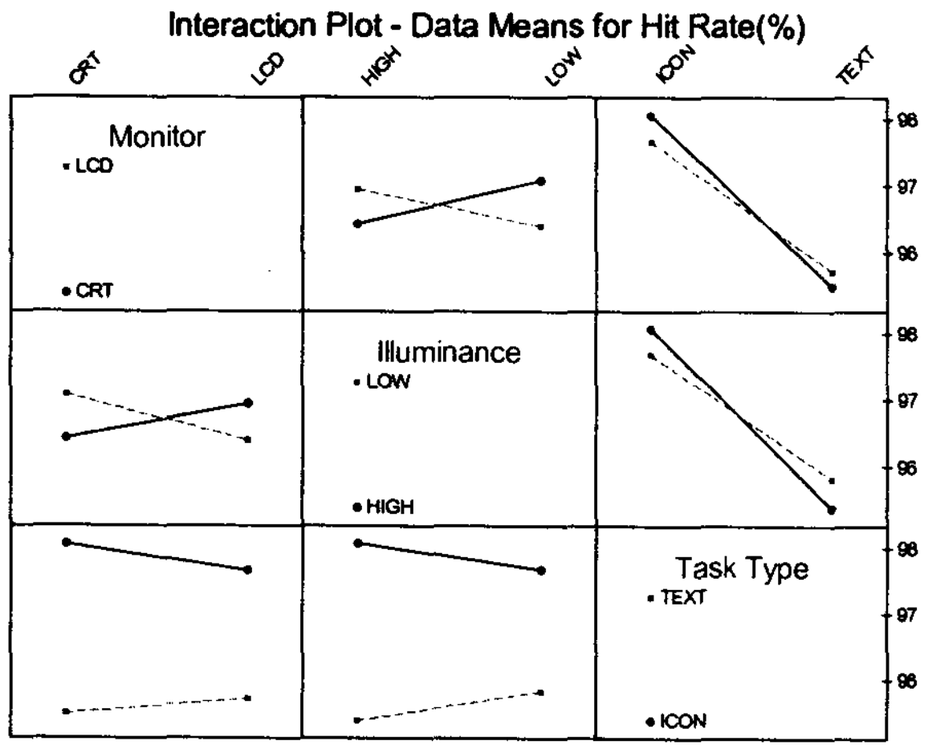

Figure 2 Interaction effects of task conditions on the hit rate

3.3 False Alarm Rate

Despite the faster reaction time and higher hit rate compared to the text search task, the false alarm rate of the icon search task was much higher than that of the text search task. In comparison of the displays, TFT-LCD showed a lower false alarm rate than CRT for the text search task, but the reverse was true for the icon search task. This result reinforced the existence of interaction effect between the types of tasks and displays. The mean differences between the displays were not statistically significant for both task conditions, however.

In comparison of the ambient light conditions, the false alarm rate was lower at 1200 lx than 300 lx for both types of tasks. TFT-LCD showed a more sensitive response to the change of ambient light condition than CRT, but the mean difference of the false alarm rate between the light conditions were not statistically significant for both displays.

Figure 3 illustrates the differences in the mean false alarm rate under the experimental conditions tested in this study.

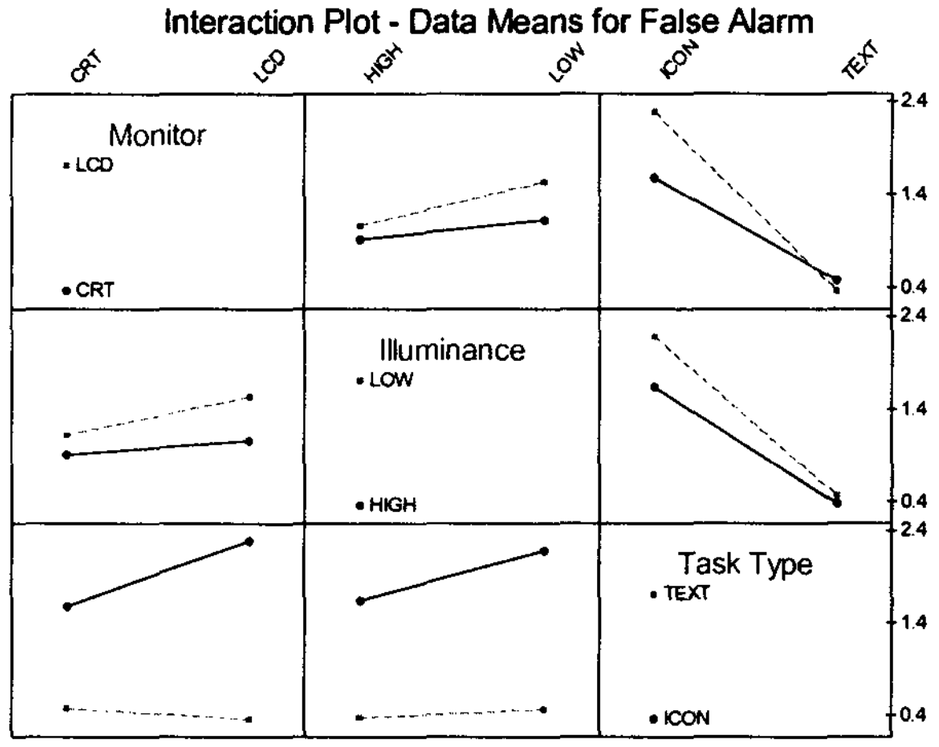

Figure 3 Interaction effects of task conditions on the false alarm rate

4. Discussion

Though the differences in task performance between CRT and TFT-LCD were not strongly supported by the statistical analyses, the overall results suggested that there are interaction effects between the types of displays and the task conditions.

TFT-LCD showed a better performance for text search tasks, whereas CRT did for icon search tasks with respect to each other display. This result was interpreted that TFT-LCD is more suitable than CRT for presenting text information, and the reason was supposed to its good resolution and linearity. And CRT is more suitable than TFT-LCD for presenting graphic information, owing to its good color reproducibility and viewing angle.

The increase in ambient light showed both negative and positive effects on the task performance. The negative effect was increase in the reaction time and the positive effect was increase in the hit rate with decrease in the false alarm rate. The increase of ambient light level may increase the task difficulty and that was supposed to the cause of increase in the reaction time. The cause of the positive effect was supposed to increased attention level of the subject to

cope with the increased task difficulty. The ambient light conditions also interacting with the types of displays. CRT showed a higher hit rate at dimmer whereas TFT-LCD did at brighter ambient light condition.

5. Conclusion

From the results of this study and previous studies, it can be concluded that the goodness or suitability of one display to another is hard to objectify in a simple way unless their optical characteristics are similar. That means, even if preferences of the users are excluded, experiments for comparing the performance of different types of displays can draw inconsistent results depending on the experimental conditions such as the measures adopted, tasks to be done, and the state of the displays themselves. Moreover, the rapid progress of display technologies is being considered, it has not so much meanings to grade different types of displays on the basis of simple criterion. It is more useful way of comparing or evaluating the state of the art display technologies to find out which one is more good to fit the characteristics of a given task condition.

In the current state of the display technologies, a user's guide to select a proper display for a given task can be suggested as follows:

1) When the given task should be done in a text mode and the legibility is of prime concerns, TFT-LCD would be better than CRT
2) When the given task should be done in a graphic mode and the reproducibility of color is of prime concerns, CRT would be better than TFT-LCD.
3) When the given task should be done with TFT-LCD in a graphic mode, a higher ambient light would be better for reducing the errors.

6. Acknowledgements

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7. References

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