

Ergonomic Evaluation of a Projector Using Field-Sequential Color Projection System

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1. Introduction

The field-sequential color projection system makes it possible to present color images with single panel. Although this system can miniaturize projector size and reduce cost by using a single panel, its field-sequential color projection mechanism presents a drawback in that it causes the viewer to perceive trichromatic separation at times of rapid eye movement. This trichromatic separation is called “color breakup.” This phenomenon may cause discomfort to, and even visual fatigue in, the viewer. In this study, we focused on color breakup as a characteristic problem of the field-sequential color projection system, and examined its effects as manifested through subjective asthenopic symptoms.

2. Purpose

The purpose of this study was to compare and examine the effect of color breakup on practical use, movie appreciation in a home theater setting, and presentations made in offices, all from the viewpoint of the asthenopic subjective symptom.

3. Methods

Three types of projectors were used for the experiment: a field-sequential color projector (color DLP), a field-sequential monochrome projector (monochrome DLP), and a liquid crystal projector (LCD projector). Three types of visual stimuli were used for the experiment: full color movie sequences (color movies), monochrome

movie sequences (monochrome movies), and slides in which white characters appeared on black backgrounds (slides). These stimuli lasted 15 minutes.

Movie sequences from ten popular movie titles in which color breakup was particularly severe were extracted and used as stimuli. Each sequence lasted 30 seconds; all of them were joined together in random order to create a fifteen-minute stimuli. In conditions 1, 2, and 3, the movie sequences were stripped of their color and turned into monochrome movies.

On the slides, three lines of white characters were placed at the center of each slide; all slides had black backgrounds. Viewing of the slides also continued for 15 minutes, with 90 types of slides presented at ten-second intervals. MS Gothic, in ten different font sizes legible to observers, from 0.3 to 1.2 logMAR, was used. The characters were shown at 0.1 intervals.

Those stimuli were presented to the subjects on a 100-inch screen at a viewing distance of 250 cm. The subjects sat in a chair placed in the center of the screen, and matched the height of the eyes to the center for the screen. Each projector was adjusted for illuminance at the screen center while albedo was presented across the whole screen with near uniformity. Measurement revealed illuminance as 405 lx with color DLP, 405 lx with monochrome DLP, and 410 lx with an LCD projector.

Subjective asthenopic symptoms were examined according to a 5-point self-rating method. Five characteristics of Suzumura’s subjective symptoms for discrimination

Table 1. Experimental conditions

	Monochrome movies	Color movies	Slides
Color DLP	Condition 1	Condition 4	Condition 6
Monochrome DLP	Condition 2	-	-
LCD projector	Condition 3	Condition 5	Condition 7

diagnosis of asthenopia to evaluate asthenopic complaints were used: “eye fatigue”, “eye oppression”, “eye pain”, “eye heaviness” and “sensitivity to bright light”. These symptoms were chosen as characteristic items for color breakup from the preliminary experiment.

Experimental conditions were chosen in random order, and the subjective symptoms were measured before, immediately following, and fifteen minutes after the stimulation. The subjects were thirty university and graduate students, all in good health and with normal color perception.

4. Results

Subjective symptom scores were analyzed using the ANOVA test. Interaction was found in every subjective symptom, with a significant increase after stimulation in the “Slides” condition. Figure 1 shows results for the “sensitivity to bright light” symptom, and figure 2 shows results for each symptom in the “Slides” condition.

Many subjects complained of “sensitivity to bright light” in the interview after stimulation under color and monochrome DLP conditions. In each subjective symptom for the “Slides” condition, condition 6 scored higher than condition 7.

5. Conclusions

The results of the experiment indicate that color breakup due to the field-sequential projection system may be a factor contributing to visual fatigue and viewer discomfort. These symptoms manifested themselves more

clearly in the presentation, such as during the PowerPoint viewing, than in the movie viewing.

The presentation required that the observer adjust his or her line of sight in order to read the sentence. For this reason, factors such as design and luminance differentials among presented slides had the possibility of causing color breakup, resulting in asthenopia and discomfort to the viewer. While the direction of line of sight was not restricted during movie viewing, color breakup again threatened to cause viewer discomfort. This discomfort was particularly prone to increase when viewing monochrome movies. In addition, the discomfort may increase when viewing movies with subtitles.

This problem can not be solved simply for movie viewing. For presentations, however, color breakup can be reduced through selection of appropriate slide designs. Comfortable use of the field-sequential projection system requires not only hardware-based technical solutions, such as for frame frequency, but also consideration of usage and viewing environment.

References

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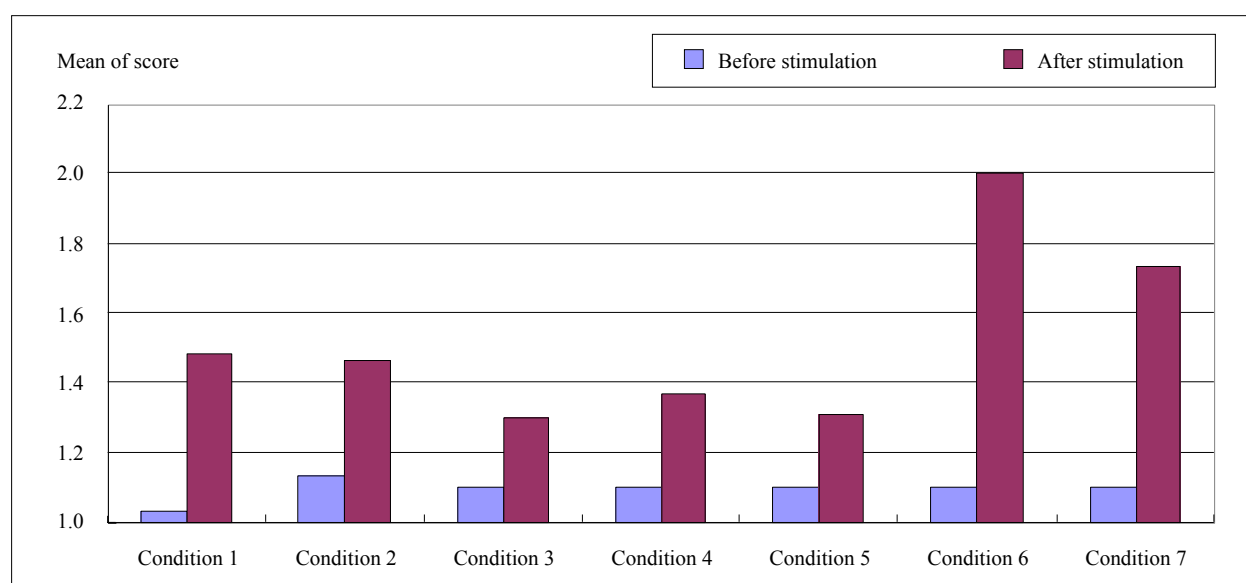


Figure 1. Result of the symptom “Sensitivity to bright light”

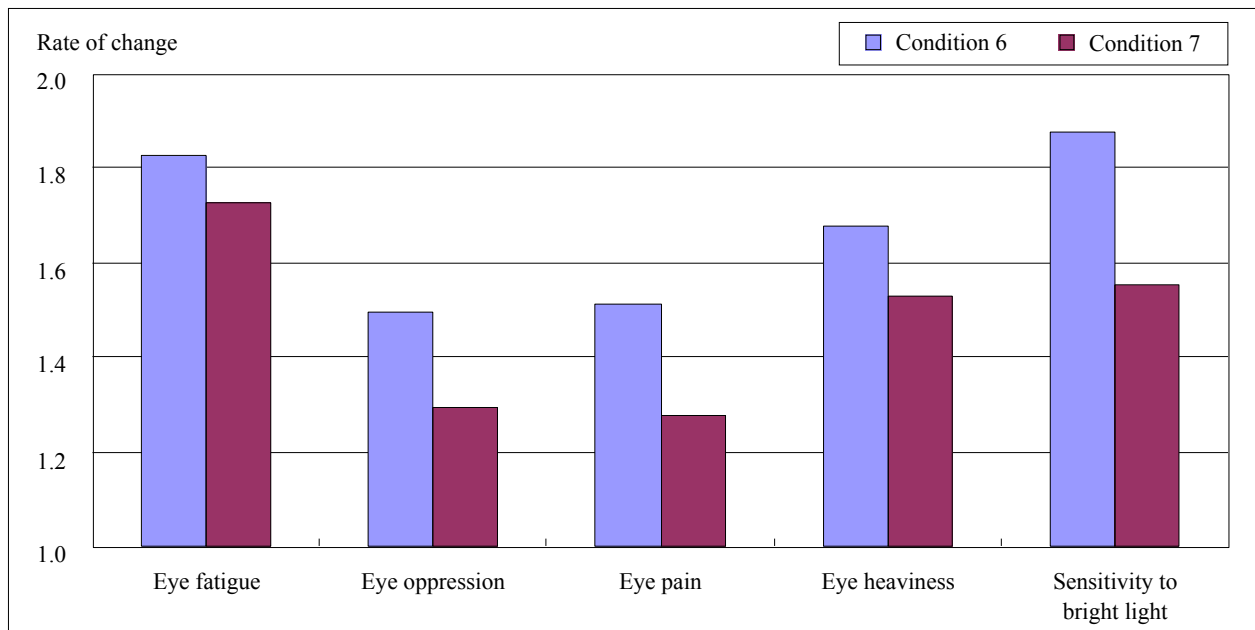


Figure 2. Result of each symptom in the “Slides” condition