Visual fatigue in congenital nystagmus caused by viewing color sequential projectors

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1. Introduction

Color breakup occurs when images produced by color-sequential projectors or displays are viewed. It has already been reported that, depending on the visual content, this phenomenon can occur frequently, causing visual fatigue. Color breakup can be seen when viewers move their eyes. So, how does this phenomenon appear to people with congenital nystagmus? And does this cause them visual fatigue or other health problems?

Nystagmus is the involuntary oscillations of the eyes. It can be observed in normal people under certain conditions. For example, optokinetic nystagmus (so-called railroad nystagmus) is induced when one attempts to fixate on objects that appear to traverse the visual field, as the eyes follow the object and then quickly jerk back to start over. In another case, if the head is turned side to side, eye movement is evoked to compensate head motion (vestibulo-ocular reflex), and when head movement is rapid or of large amplitude, nystagmus-like movement is exhibited. Nystagmus can also be caused by abnormality. Pathologic nystagmus is classified as being either congenital or acquired. Acquired nystagmus may be caused by neurological or other disorders. People with congenital nystagmus have few symptoms other than a mild deterioration in vision, and since their symptoms can be improved somewhat by treatment, they generally feel no inconvenience in their daily lives. Congenital nystagmus is thought to occur at the incidence of one per 1,000 of the population. The intensity of nystagmus changes as eye position (the direction of the eyes with reference to head direction), and they tend to gaze with eye position where the nystagmus is minimized (the neutral zone) and thus may view objects with their head turned. Congenital nystagmus increases with fixation and is partially suppressed when looking at near objects. Generally, amplitude is not more than several degrees, and frequency is 2-5 Hz. The waveforms of congenital nystagmus are complex. In one direction saccadic eye movement (a rapid jumping eye movement) is also often present.

In this study, people with congenital nystagmus viewed images produced by a variety of projector models, and they subjectively evaluated on their general health and ocular symptoms pre- and post-viewing.

2. Methods

This study involved three subjects, each having congenital nystagmus: MO (a 29-year-old male), HA (a 27-year-old female), and KN (a 31-year-old male). All three have binocular corrected vision of 0.8.

Two types of projectors were used in the tests: three-panel LCD projectors ("3-LCD projector") and RGB color-sequential projectors ("single-DLP projector").

A total of eight projectors was used for subject MO: three models of 3-LCD projector, three models of 2x-speed single-DLP projector, one 4x-speed and one 5x-speed single-DLP model. For subjects HA and KN a total of three projectors was used: one 3-LCD model, one 2x-speed single-DLP model, and one 4x-speed single-DLP model. The size of the projected image was 90 inches, and the viewing distance was 1.5 m. The subjects viewed the first 15 minutes of a movie (with subtitles) of their choice. The same movie was played on all projector models. Visual and other symptoms were evaluated using the Suzumura method (a 37-item, five-stage questionnaire), and the changes between pre- and post-viewing were examined.

3. Results

The result of measurements of eye movement indicated that MO has no clear neutral zone though he is aware of it. The waveforms are complex and undergo marked sequential changes over time. In contrast, HA has nearly pendular nystagmus with a clear neutral zone and exhibited a strong tendency to watch from the neutral zone both during routine activities and during the experiment. KN presents with minor, slow nystagmus. Large oscillations occasionally appear, triggered, for example, by looking toward the left.

The results of subjective fatigue evaluations are shown in the figures. Figure 1 shows the deterioration of MO's vision for each item, for all eight projector models. The main items of deterioration were; sense of oppression in the eyes, (5)pain in the back of the eyes, (9)difficulty in keeping the eyes open, (12)dry eyes, and (33)sleepiness.

The main items of deterioration experienced by HA were (1) visual fatigue, (5)pain in the back of the eyes, (7)pain in the center of the eyes, (8)relief from pain when the eyes are pressed. KN did not experience any significant deterioration. Figure 2 shows the sum of the symptomatic deterioration experienced by MO for all eight projector models. Figure 3 shows the sum of the symptomatic deterioration experienced by all three subjects for three models of projector.

MO complained that fatigue caused by color breakup on the 2x-speed single-DLP projector made it difficult to watch the video for even 15 minutes. Originally, MO, who regularly uses a projector for study sessions, had felt that some machines produced a strange noise in the picture on occasion. MO reports that he had not considered that this noise could be due to his own eye movements and instead thought there was something wrong with the projector. He became concerned, however, after asking others whether they saw the same thing and being told no. Instead of color breakup, HA sensed flicker, with brightness level changes several times per second, and likewise complained of

intense fatigue when viewing images projected by single-DLP projectors. In contrast, the effects of the 2x-speed single-DLP projector on KN were minimal, and he did not complain of any serious problems. However, after viewing the video on the 4x-speed single-DLP projector, he did report fatigue from both flickering and color breakup.

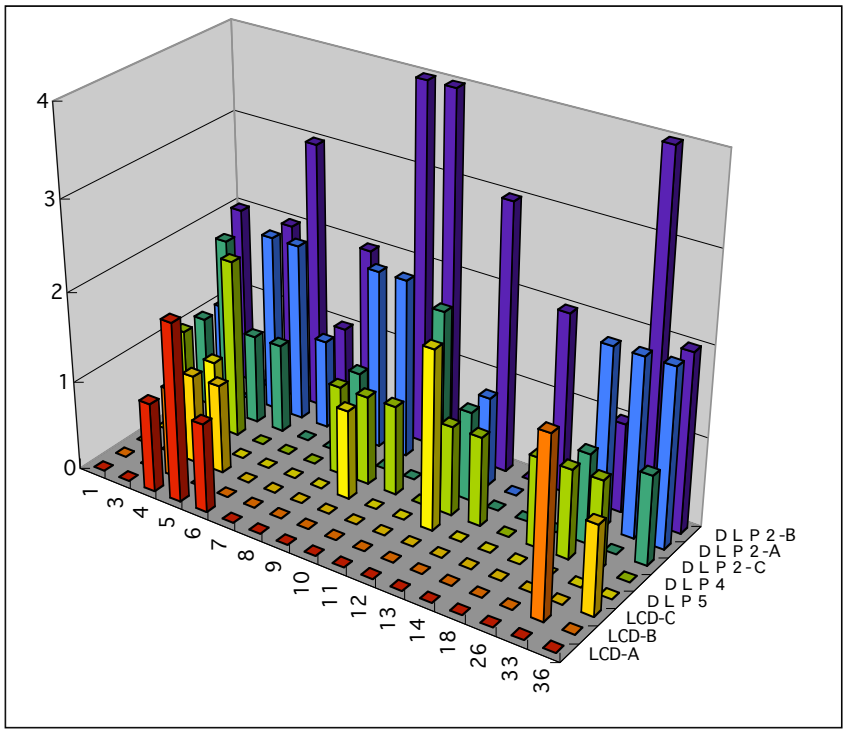

Figure 1. Symptomatic deterioration, by item, experienced by MO for eight projector models

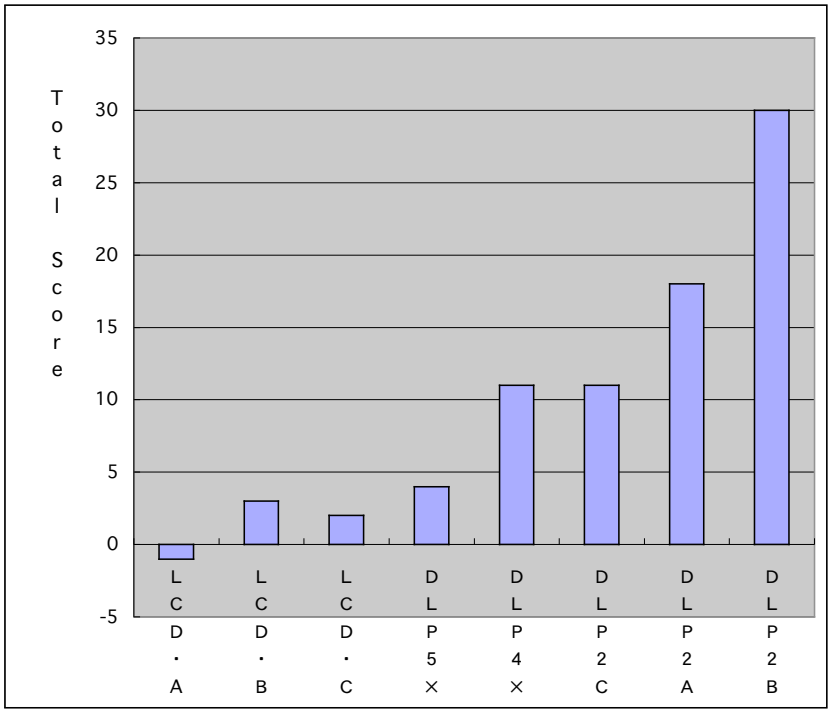

Figure 2. Symptomatic deterioration experienced by MO for eight projector models (total score)

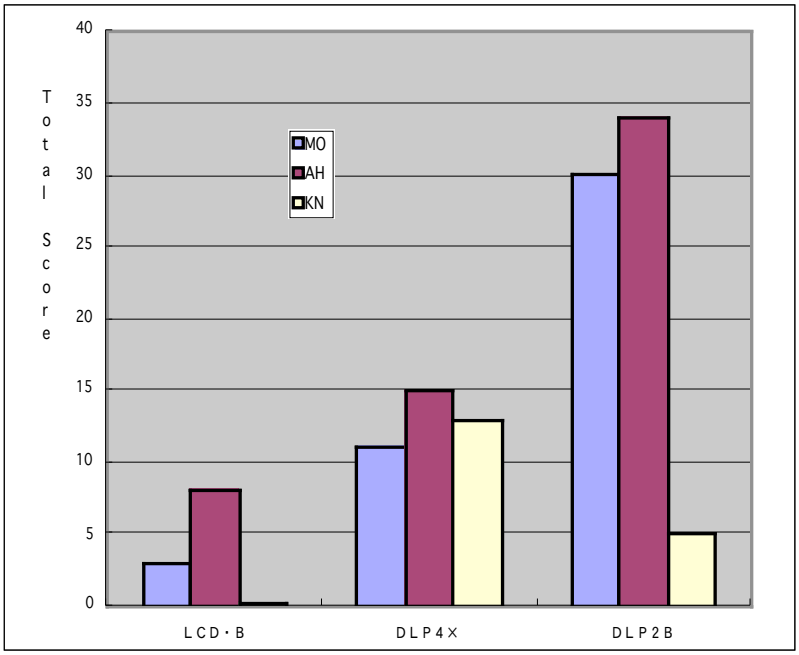

Figure 3. Symptomatic deterioration experienced by all three subjects for three projector models (total score)

4. Discussion and conclusion

As indicated in Figure 3, two of the subjects exhibited similar symptoms. The least amount of deterioration in subjective symptoms was seen with the liquid crystal projectors, while the greatest deterioration was experienced with the 2x-speed single-DLP projector. The 4x-speed single-DLP projector triggered intermediate deterioration. The third subject experienced little deterioration in subjective symptoms on viewing the video projected by the 2x-speed single-DLP, perhaps because the subject's nystagmus was mild, but for all other projector models, the subject experienced symptomatic deterioration similar to that of the others.

When eye movements caused by nystagmus are rapid, subjects sense color breakup; when these eye movements are slow, subjects sense flickering that is thought to coincide with the nystagmus frequency. These are what cause fatigue. Flicker is almost nonexistent with liquid crystal projectors, and the reason it occurs on color-sequential systems is unclear.

From the above discussion, when people with congenital nystagmus view a display presented by a color-sequential method, they may experience intense fatigue in a short period. Care must be exercised when using such systems. Hence, it would be best to avoid using low-speed single DLP projector in the classroom and for other audiences made up of the general public.