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An Attempt at Preventing Asthenopia Among VDT Workers

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We report the results of 3 surveys of visual display terminal (VDT) users who took a minibreak during which they viewed a stereoscopic image of a repeating parallel pattern showing planets. The single image stereogram method employed is called Stretch Eye™, and we evaluated the effects of Stretch Eye™ on asthenopia. An accommodative relaxation of about 1 D was observed in participants while they were gazing at the image. The employees of 2 information technology companies were evaluated according to a visual analogue scale (VAS) for subjective symptoms of asthenopia and eyesight. The results showed that Stretch Eye™ was effective in easing visual fatigue due to VDT work and it improved eyesight under working conditions.

asthenopia VDT workers accommodation stereoscopic vision
single image stereogram

1. INTRODUCTION

For visual display terminal (VDT) work or data entry work, the principle stream is to read, judge data from a display, and operate a keyboard and mouse. The operators must maintain a constricted posture, and gaze at data or a text on the screen to confirm the correctness of their own work. They need close concentration. They have to move their eyes frequently as their visual tasks are detailed and complex. It has been reported that working conditions can produce musculoskeletal discomfort, symptoms of eyestrain, and other symptoms of stress such as fatigue and mood disturbances (Carayon, Smith, & Haims, 1999; Dinoff, Happ, & Crane, 1981; Hünting, Läubli, & Grandjean, 1981; Sauter, Schleifer, & Knutson, 1991). Numerous relaxation methods have been suggested for musculoskeletal and mental stresses caused by VDT work (Galinsky, Swanson, Sauter, Hurrell, & Schleifer, 2000; McLean, Tingley, Scott, & Rickards, 2001). Previous papers have reported the effects of VDT resolution on visual fatigue and visual performance (Miyao, Hacısalihzade, Allen, & Stark, 1989; Ziefle, 1998). Other studies have reported that viewing distances to screen and document at visual display unit (VDU) workplaces were comfortable in a range of more than about 50 cm (Jaschinski-Kruza, 1990, 1991). In contrast, for musculoskeletal and mental relaxation, few effective coping and relaxation methods for visual fatigue have been proposed.

When doing visual near work, a person's ciliary muscle of accommodation constantly changes the focal depth of the lens of the eye to obtain a sharp image. Thus, when the viewing distance is short, the ciliary muscle must continually contract for accommodation and convergence. In contrast, when attention is allowed to wander over distant objects, the eyes are focused on infinity and ciliary muscles remain relaxed (Kroemer & Grandjean, 1997).

Consequently, it is thought that easing the strain of the ciliary muscle due to prolonged near work may prevent accommodative asthenopia. For this, focusing and gazing on distant views should be safe and effective. However, it is often not realistic to see a distant view from an indoor office.

In this study, we used a computer relaxation program, Stretch Eye™, which was developed to prevent computer operators from suffering asthenopia. Our aim was to reveal the effect and mechanisms of a relaxation program based on subjective symptoms, visual physiology, and a follow-up study of eyesight.

2. MATERIAL AND METHODS

2.1. Stereoscopic Images

The stereoscopic image used was a repeating parallel pattern showing planets, which uses the single image stereogram method. This is a shift method in which the viewed objects diverge just at the point that makes a single shift between the right and left eyes, so that they appear to be more distant than the monitor screen (Figure 1).

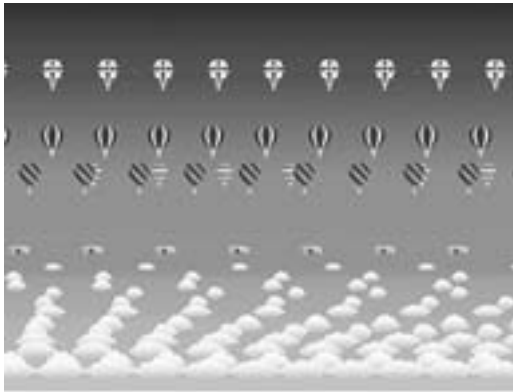


Figure 1. A sample Stretch Eye™ image. Notes. The distance between neighbouring balloons increased from 40 to 55 mm.

Computer operators can display the relaxation program easily on their monitors to see a virtually far stereoscopic view without wearing special glasses. The aim is to ease visual fatigue by viewing targets moving progressively further away on the monitor for a few minutes. Infinite remote targets appear virtually, based on the principle of single image stereograms.

2.2. Experiment 1. Subjective Symptoms From Hard Training With Computer Usage

Twenty participants were selected from new employees of an IT company and divided into two groups matched for gender and refractive conditions. Group A was asked to view the relaxation program image for a few minutes every hour for a week. Group B was asked to take rests only for a few minutes every hour for a week. Visual fatigue of the two groups was investigated using a visual analogue scale (VAS).

2.3. Experiment 2. Measurement of Accommodation

Using a specially made accommodo-refractometer, we measured and recorded accommodative fluctuation of a 24-year-old female participant with normal sight while she was viewing the relaxation program for 60-s periods.

Visual function was tested using a custom-made apparatus. This combined an automated infrared accommodo-refractometer (Nidek AR-1100, Japan) and an original binocular half-mirror system (Miyao et al., 1996; Miyao, Otake, & Ishihara, 1992). The display images were placed in front of the small mirror for the tests. Participants gazed at each type of image through a half (dichroic) mirror and an ordinary small mirror. The instrument objectively measured visual accommodative changes of the right eye at a 12.5-Hz sampling rate in both binocular and natural viewing conditions (Otake et al., 1993; Figure 2).

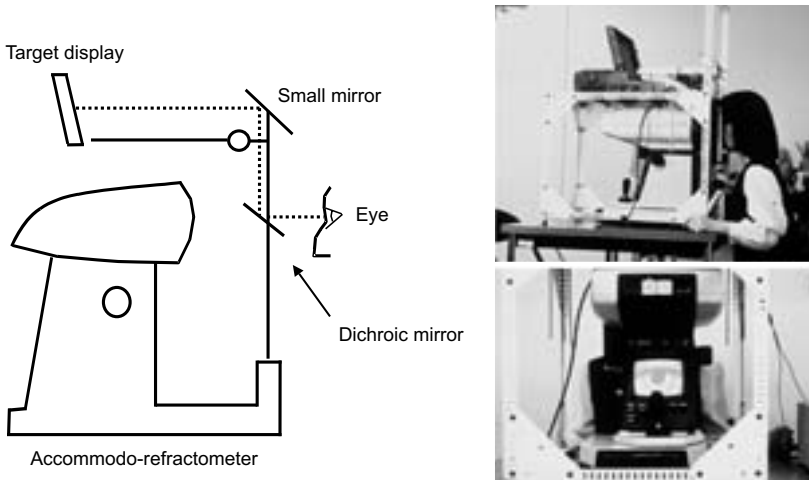


Figure 2. Experiment 2: A schematic view of the device (left), and photos of the device (right).

The distance between the participants' eyes and the target on the screen was 50 cm (2 D)¹. Using this synchronous viewing system with a crossed view caused the participants to see a presumed (virtual) near target, and with an uncrossed view to see a presumed far target. In this experiment, infinitely remote targets appear virtually based on the principle of a single image stereogram (Figure 3).

¹ diopter (D) = 1/distance (m); MA (meter angle) = 1/distance (m)

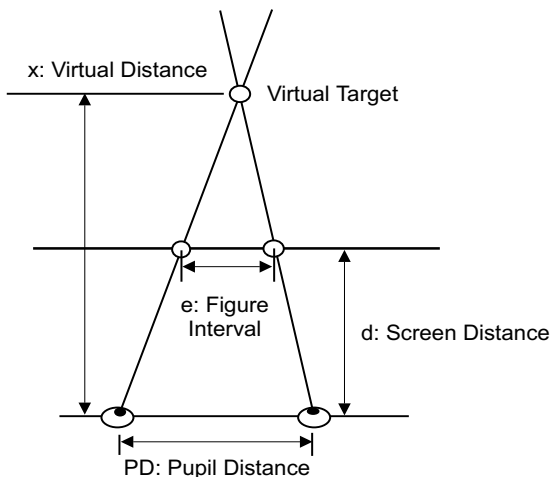


Figure 3. The principle of a single image stereogram. Notes. Virtual target was calculated as the theoretical virtual distance based on pupil distance: $x = PD \cdot d / (PD - e)$ (mm), where PD —pupil distance, x —virtual distance, d —screen distance, e —figure interval.

2.4. Experiment 3. Follow-Up Study of Eyesight for 8 Weeks

Thirty VDT workers were divided into two groups and followed for far visual acuity (5 m). Group A used Stretch EyeTM for the first 4 weeks and took rests without the relaxation program for the latter 4 weeks. The order for Group B was reversed to achieve balance in the order of the two periods. Participants' eyesight was measured every morning and late evening every Monday and Friday. For statistical analysis, we used the values in the late afternoon on the first and fifth Monday (baseline of the 4-week test) and also the values in the late afternoon on the fourth and eighth Friday. The values were naked-eye eyesight and eyesight under working conditions (naked-eye eyesight for workers who had no correction, and corrected eyesight for workers who corrected their eyesight when working with computers).

3. RESULTS

3.1. Eye Fatigue During Hard Training With Computer Work

Subjective fatigue symptoms during hard training with computer work were investigated using a visual analogue scale (VAS). The VAS scores were scaled from 0 (*no visual fatigue*) to 100 (*severe fatigue*). We compared the

values of the subjective symptoms. The mean value ($\pm SD$) was 59.4 ± 7.7 among the group who took breaks only and did not view the relaxation program, against 37.5 ± 8.3 among the group who viewed the relaxation program. In other words, participants who used the stereoscopic view relaxation program in their minibreak had improved VAS scores by a large 21.9 points. This indicates relief of the subjective symptoms.

Thus, according to statistical analysis, the relaxation program significantly eased eye fatigue ($p < .001$, t test).

3.2. Measurement of Accommodation

We measured and recorded accommodative fluctuation of a 24-year-old female participant with normal sight while she was viewing the relaxation program for 60-s periods. She gazed at the open-field stereoscopic target, Stretch Eye™, under binocular and natural viewing conditions. We measured and recorded the change in accommodation of her right eye continuously and accurately.

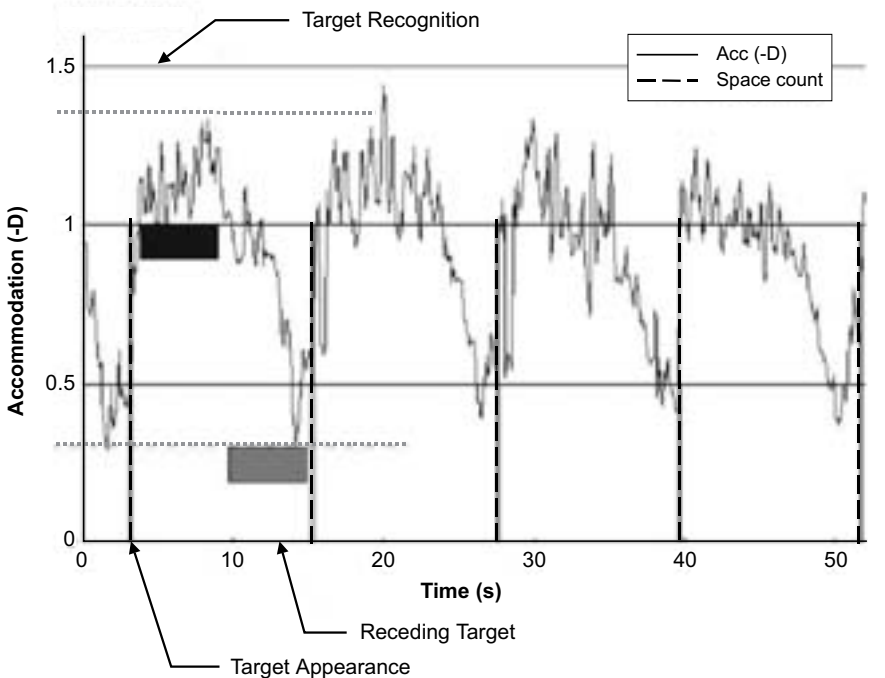


Figure 4. Accommodative fluctuation of the left eye. Notes. x axis shows time: 0–50 s, y axis shows diopter: 0–1.5 D.

The display was set at a distance 50 cm from the participant’s eyes. The viewing object (a planet) appeared at a distance 50 cm from the display. The planet then moved away slowly and disappeared at a distance about 3 m from the eye. Figure 4 shows the objective changes in accommodation.

To illustrate numerically, when the participant recognized the target that appeared at a near point, her eyes were accommodated about 1.3 D. With this level of accommodation, the ciliary muscle was stressed. When the participant’s eyes viewed the progressively receding target, they were accommodated about 0.3 D at the presumed furthest points, a level at which the ciliary muscle was relaxed. The accommodative power differed by 1.0 D from the near to far point. Thus, the ciliary muscle was repeatedly strained and relaxed while the participant viewed the moving target.

3.3. Follow-Up Study of Eyesight for 8 Weeks

The eyesight of 30 VDT workers was measured on the late afternoon before and after the 4-week sessions. There were two sessions, one with and one without the relaxation program. Eyesight was measured at 5 p.m., on the first Monday evening and the fourth Friday evening, but data of the period with and without the relaxation program could be obtained for only 28 and 17 participants, respectively, due to business demands of the others.

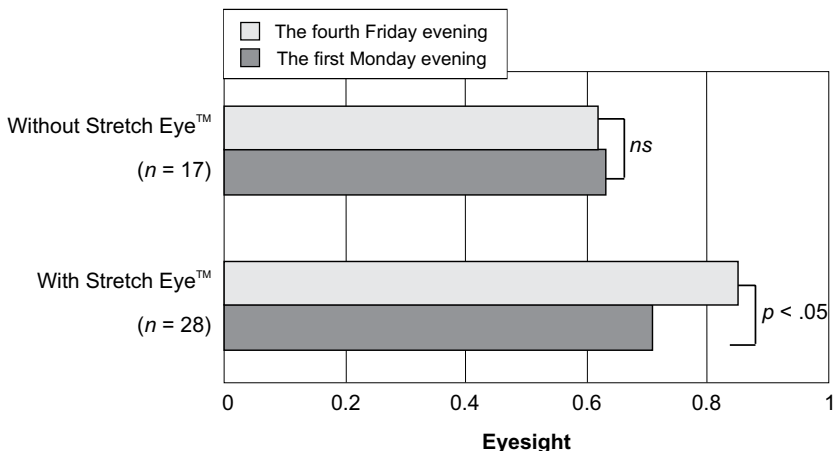


Figure 5. Eyesight under working conditions improved after using the relaxation program for 4 weeks (comparison of geometric mean values).

Figure 5 shows eyesight following periods with and without Stretch Eye™. After the period with the relaxation program, far visual acuity (5 m)

under working conditions was significantly improved compared with the values on the first Monday evening ($p < .05$, Wilcoxon's matched pairs sign rank test), whereas no significant change was observed following the period without Stretch Eye™.

4. DISCUSSION

Asthenopia is a syndrome mainly consisting of subjective fatigue complaints. Objectively, however, accommodative functions become weak. In a previous study on visual fatigue among VDT workers, Jaschinski-Kruza (1988) reported that when the VDU was near, visual strain in near-dark-focus participants (2 D) was lower than in far-dark-focus participants (1 D). Tyrrell and Leibowitz (1990) reported that persons with far dark vergence postures experience more visual fatigue after prolonged near work than do persons with near dark vergence postures, presumably because of a greater vergence effort. Thus the ciliary muscle incurred continued strain due to extreme accommodation.

From the aforementioned point of view, the relaxation program was tested with regard to three aspects: subjective eye fatigue, vision in a stereoscopic view, and changes in visual acuity following 4 weeks each with and without Stretch Eye™. Among VDT workers, the relaxation program significantly eased eye fatigue and improved eyesight under working conditions.

Iwasaki, Tawara, and Miyake (2002) suggested that outward-shift stimuli for accommodation were effective in relieving eyestrain following the deterioration of ocular functions, except when the far point was shifted inward. They did not carry out measurements of accommodation with outward-shift stimuli. This report coincides with our results that participants who used the relaxation program of stereoscopic view in their minibreak experienced significant relief of subjective fatigue symptoms compared with participants who did not use this relaxation program.

Miyao et al. (1996) revealed that some people exhibit large changes in accommodation while performing a stereographic task. In the present study, a participant's accommodation was measured in experiment 2. The changes were distributed from 0.3 to 1.3 D when the target moved from a near to a far point. Thus, the participant was confirmed to have accommodative focuses with visual distances of approximately 3 m when she gazed virtually at the stereoscopic distant images. Therefore, it is assumed that ciliary muscles of the participants who viewed the relaxation program changed repeatedly between the stressed and relaxed stages. In other words, the ciliary muscle was suggested to be stretched effectively.

Henning, Jacques, Kissel, Sullivan, and Alteras-Webb (1997) reported that short rest breaks that included physical activity were more effective than passive rest breaks.

In this study, it was also shown that visual fatigue was eased more among the group using the relaxation program than among the non-use group.

From these results, it is suggested that prolonged near work with computers caused eyesight to shift toward a myopic state, and that the relaxation program might improve eyesight under working conditions.

5. CONCLUSIONS

The relaxation program, Stretch Eye™, was tested with regard to three criteria: subjective eye fatigue, vision in a stereoscopic view, and changes in visual acuity following 4 weeks each with and without Stretch Eye™. Among VDT workers, the relaxation program significantly eased eye fatigue and improved eyesight under working conditions.

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