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Subjective Evaluation for Recovery from Visual Strain in Video Data Terminal Operation

— How to Recover from Visual Strain in VDT Operation —

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Abstract **: For a video data terminal (VDT) operator, visual strain was caused by continuous VDT operations was found to be recovered by watching the picture of virtual far point with the background of the complementary color when the treatment to recover from visual strain was carried out. When the VDT operator watches the picture of virtual far point with the condition of the complementary color stimuli on the CRT display in 60 or 120 minutes after the start of the VDT operation, the visual strain is recovered and the VDT operator is kept healthy.**

1. Introduction

Nowadays, as computers are widely used in many fields including educational institutions and industries, video data terminals (VDTs) are becoming of importance, and the VDT operator's visual strain is becoming the matter of public concern since visual strain is caused by accumulated forcible VDT operation. Visual strain caused by forcible VDT operation is characterized as follows:

(1) Warm color at longer wavelength increases physiological excitation of the receptors[1].
(2) VDT operations performed keeping the visual distance unchanged for many hours remarkably reduce the amplitude of visual accommodation since the ciliary muscles are hardened due to fatique[2].

At the first step of the study on the visual strain, the recovery from visual strain was evaluated by Muraoka et al., and the evaluation of the visual strain studied there was published by Muraoka et al. in 1998 at the 51st Image Processing, Image Quality, Image Capture, System Conference[3].

In accordance with the previous work by Muraoka et al., the VDT operator's visual strain can effectively be eliminated on the following manner:

(1) Adds the complementary color at shorter wavelength to the warm color at longer wavelength in order to eliminate an achromatic color tone on the retina. So, the complementary color at shorter wavelength is used to inhibit the physiological excitation of the receptors.
(2) Zooms down a picture showing natural landscape on the display, so as to display the picture of virtual far point. So, the picture of virtual far point moves until positioned to the focal distance. The VDT operator watches the picture of virtual far point, so as to relax the ciliary muscles of his/her eyes.

On the previous study, a VDT operator has to be kept healthy before the recovery treatment to visual strain starts. In order to avoid this restriction, a new mode of VDT operation can be defined with the visual strain not accumulated during the VDT operations contiguously carried out everyday. On the current study, the subjective evaluation is carried out to check whether the visual strain owing to daily VDT operations has been recovered or not.

2. Testing Processes from Loading of Visual Strain to Recovery of Visual Strain

A 17 inch CRT display was used as a VDT for a series of testing processes from the loading of visual strain to the recovery of visual strain. A loading test for visual strain was carried out when alphabetic characters were displayed on the display having a size of 600 (40V x 15H) characters. Twenty "B" characters, twenty "K" characters, and twenty "U" characters were randomly arranged in a frame on the VDT display. Other 540 characters consisting of other than "B", "K", and "U" were arranged in this frame on the VDT display. Fourteen different frames were prepared for a series of tests, where each test was carried out in 30 minutes. Five of these 14 frames were provided for other tests to apply stresses which cause fatigue to the respective VDT operators (subjects). Tests were carried out by pointing "B", "K", and "U" in a frame on the VDT utilizing a mouse on a personal computer.

When the VDT operator completes the pointing of the specified "B", "K", and "U" characters on one frame, control automatically moves to the next frame. The frame with red background color had an average brightness of 4.3 cd/m^2. White alphabetic characters were displayed on the red background color. At that time the brightness was 24.6 cd/m^2, and the contrast was 0.83. Fig. 1 shows the process of how to apply the load which causes visual strain to the respective subjects.

Then, a recovery test for eliminating visual strain was carried out by imposing the complementary color stimuli on the subject's retina and by displaying the picture of virtual far point in up to 150 minutes after visual strain was loaded as described in Fig. 1. Two different pictures were sequentially displayed for testing the recovery of visual strain on the display in one action of the treatment, and actions of the treatment were repeated every 60 or 120 minutes.

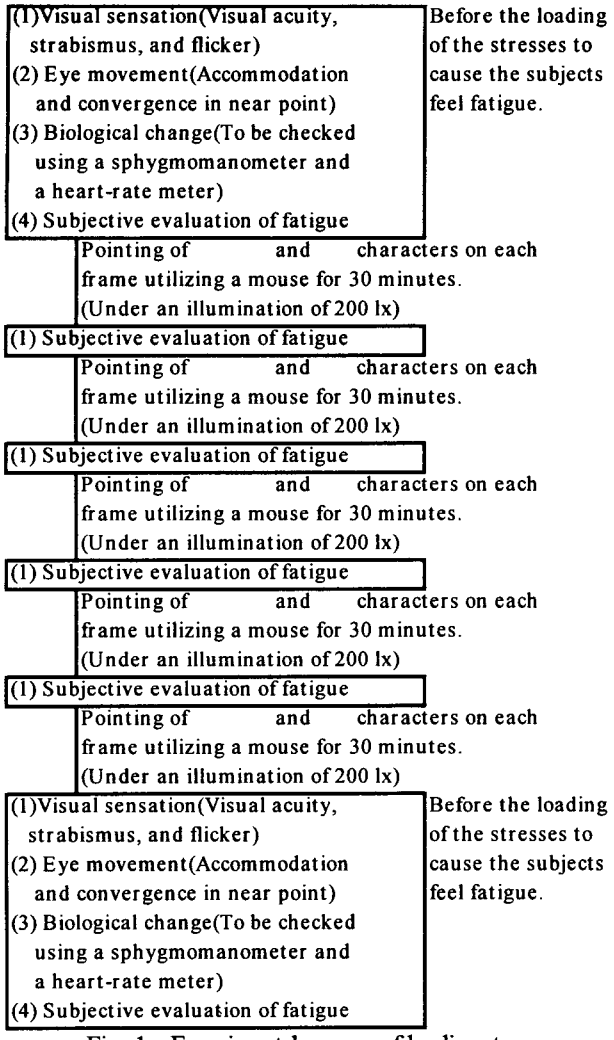


Fig. 1 Experimental process of loading stresses to cause the subjects feel fatigue.

The subjects were selected among the students with ages ranging from 21 to 26 years old, whose visual acuity was in the range of 1.0 to 1.5. The difference of visual acuity between the left and right eyes was defined to be within 0.3. They were requested to be good enough to receive a series of tests in physical conditions, and no tired conditions allowed. Ten students were selected to receive the tests. The distance between a subject and a frame displayed on the CRT of the VDT was defined as 2 times the hight (H) of the CRT display.

Degradation of visual functions due to visual strain was measured using the measuring instruments which sense both the visual sensation (visual acuity, strabismus, and flicker) and eye movement (accommodation and convergence at a near point)[4]. At that time, biological changes of the subjects were measured using both the sphygmomanometer and heart-rate meter[5]. No parameters were found to be affected by the visual strain during the VDT operation. If any, visual strain cannot be recovered automatically by self-recovering force of the human being. In this case, medical treatment will be required[6,7].

3. Efficiency of VDT Operation

The efficiency of the VDT operation was investigated in terms of visual strain. The efficiency of the VDT operation is one of the indexes for evaluating visual strain. By taking the averages and 95% confidence intervals of measured data into considerations, the measured efficiencies of the VDT operations in the loading and recovery tests for visual strain are shown in Fig. 2. The efficiency of the VDT operation in the loading test for visual strain is gradually decreased with the time of VDT operation. A picture of virtual far point was displayed while the complementary color stimuli was imposed on the retina as a background on the VDT display. Two different pictures were sequentially displayed for recovering visual strain on the display every in one action of the treatment, and actions of the treatment were repeated every 60 or 120 minutes. The color stimuli to the warm color at longer wavelength was accumulated on the subject's retina in the experiment. The accumulated color stimuli recognized as visual strain can be eliminated by displaying on the CRT the compensation color image of cool color at shorter wavelength. When visual strain is eliminated, the ciliary muscles of the subject's eyes can be relaxed, and this is accomplished by watching a picture of vurtual far point of natural landscape. When the recovery treatment of visual strain was carried out every 60 minutes, the efficiency of the VDT operation was increased 1.14 to 1.15 times of the efficiency obtained from the loading test carried out at the first time. When the recovery treatment of visual strain was carried out every 120 minutes, the efficiency of the VDT operation was decreased to 0.93. Accordingly, when the recovery treatment of visual strain was carried out every 60 minutes, the VDT operations were recognized most effective. When the recovery treatment was carried out in 120 minutes after visual strain was loaded, the efficiency of the VDT operation became a little smaller than the efficiency obtained from the loading test for visual strain which was carried out at the first time.

Fig. 2 depicts the efficiencies of the VDT operations, showing the recovery of visual strain obtained from both the loading test and two kinds of recovery tests. Table 1 lists variances obtained from the two-way layout data analysis, for the recovery of visual strain of Fig. 2. Differences were observed significantly among different times of treatment in the loading and recovery tests for visual strain, and the efficiency of the VDT operation was found to depend on the time of VDT operation. When the loading and recovery tests for visual strain were carried out, visual strain was changed depending on the time of VDT operation with a risk of 1%. Particularly, when the treatment of the recovery from visual strain was carried out every 60 minutes after the start of the VDT operation, the efficiency of the VDT operation was found highest.

Fig. 2 Measured values of the averages and 95% confidence intervals for the efficiency of the VDT operation in the load and recovery tests of the visual strain.

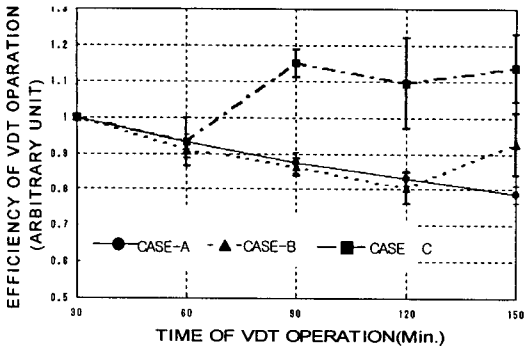
Where

CASE-A : Result obtained from the load test of visual strain.

CASE-B : Result obtained from the visual Strain which was recovered by the Treatment every 60 minutes after the start of the VDT operation.

CASE-C : Result obtained from the visual Strain which was recovered by the treatment in 120 minutes after the start of the VDT operation.

Table 1 Variances obtained from the two-way Layout data analysis when the load and recovery tests



were carried out during the VDT operation.

Variation factor	D.F.	S.S.	M.S.	F ratio
Load and recovery Tests (A)	2	0.97	0.4850	58.48**
Time of VDT Operation (B)	4	0.15	0.0364	4.39**
A×B	8	0.70	0.0874	10.54**
Experimental error	135	1.12	0.0083	
Total	149	2.93		

4. Subjective Evaluation for Results of Loading and Recovery Tests for Visual Strain

4.1 Subjective Evaluation for Results of Loading Test for Visual Strain

After each VDT operator (subject) completed the VDT operation, how strong visual strain was felt for the VDT operator was tested. The subjective evaluation was carried out utilizing the CRT display in accordance with the following 5 steps of categories.

(A)No visual strain felt.
(B) A little visual strain felt.
(C) Visual strain felt.
(D) Visual strain considerably felt.
and,
(E) Visual strain felt too much to continue the VDT operation.

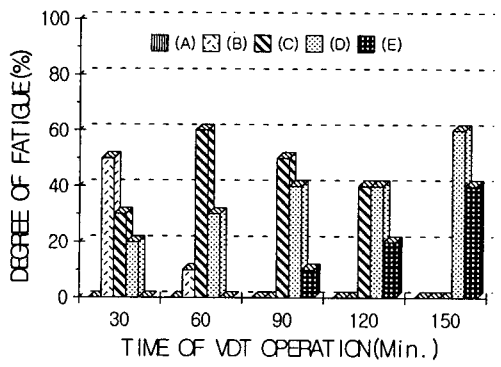


Fig. 3 Result of the subjective evaluation when The Loading test for the visual strain was carried out for the VDT operation.

Visual strain was made clear from the results of the loading test for visual strain caused by the VDT operators. Fig. 3 shows the results of the subjective evaluation, for the loading test for visual strain caused by the VDT operators, in accordance with 5 steps of categories. Category (D) occupied 20% to the total number of events when the treatment of the recovery from fatigue was carried out in 30 minutes after the start of the VDT operation, and it was increased to 60% in 150 minutes. Note that the treatment of the recovery from fatigue is carried out when the VDT operator (subject) watches the picture of virtual far point, provided that the background of the complementary color stimuli is imposed on the VDT display in a certain time after the start of the VDT operation. Category (E) occupied only 10% to the total number of events when the treatment of the recovery was carried out in 90 minutes after the start of the VDT operation, and hereafter it was increased to 40%. Contrarily, category (B) occupied 50% to the total number of events when the treatment of the recovery was carried out in 30 minutes after the start of the VDT operation, and it was decreased to 10% when the treatment of the recovery was carried out in 60 minutes after the start of the VDT operation. When the VDT operation continued for 60 minutes, category (C) occupied 60% at its peak and decreased to 40% when the treatment of the recovery was carried out in 120 minutes after the start of the VDT operation.

From both Figs. 2 and 3, we can conclude that VDT operators including computer programmers and the system engineers have to carry out the treatment of the recovery from fatigue, while watching the picture of virtual far point under the complementary color stimuli in 60 minutes after the start of the VDT operation. The others have to carry out the treatment of the recovery from fatigue in approximately 120 minutes after the start of the work.

4.2 Subjective Evaluation for Recovery Tests for Visual Strain

When the VDT operator as a subject felt visual strain after the VDT operation continues for 60 minutes, the treatment of the recovery from fatigue was carried out for the subject while the subject was watching the CRT display. Note that the treatment of the recovery from fatigue is carried out for the subject to watch the picture of virtual far point for recovering visual strain under the complementary color at shorter wavelength. The results of the recovery is classified in the following steps of categories.

(F) No visual strain recovered, and the fatigue felt too much to continue the VDT operation.
(G) Visual strain recovered a little, and fatigue decreased a little.
(H) Visual strain recovered comparally, and the fatigue decreased considerably.
(I)Visual strain remarkably recovered, and the fatigue felt little.
and,
(J) Visual strain recovered, and no fatigue felt.

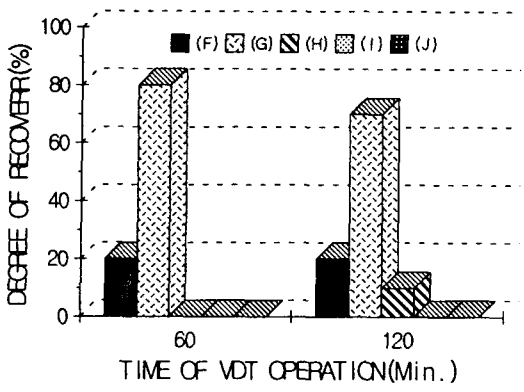


Fig. 4 Efficiency of the recovery from visual strain when the treatment of recovery from fatigue was carried out every 60 minutes during the VDT operation.

The degree of recovery for visual strain was made clear from the results of the treatment of the recovery from visual strain or fatigue after the VDT operation which continued 60 minutes. Fig. 4 shows the result of the subjective evaluation, for the treatment of the recovery from the visual strain due to VDT operating, in accordance with 5 steps of categories. When visual strain was recovered by the treatment using the picture of virtual far point under the background of the complementary colors, category (F) occupied 20% to the total number of events in 60 minutes after the start of the VDT operation, and category (G) occupied 80% of the remainder. Then, category (F) occupied 20% to the total number of events in 120 minutes after the start of the VDT operation, category (G) occupied 70%, and category (H) occupied 10%.

The recovery from visual strain in 120 minutes after the start of the VDT operation was more remarkable than that in 60 minutes after the start of the VDT operation. Although category (H) was observed in 120 minutes after the start of the VDT operation, it was not observed in 60 minutes after the start of the VDT operation.

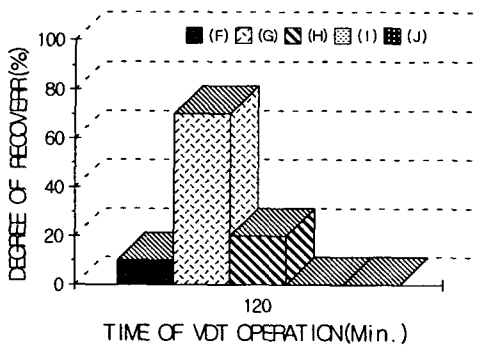


Fig. 5 Efficiency of recovery from the visual strain during the VDT operations when the treatment was carried out every 120 minutes.

The degree of recovery for visual strain was made clear from the results of the above treatment for the recovery from visual strain due to VDT operations when the treatment was carried out every 120 minutes. Fig. 5 shows the results of the subjective evaluation when visual strain was eliminated by the treatment. When visual strain was eliminated by the treatment using the picture of virtual far point under the background of the complementary colors, category (F) occupied 10% to the total number of events in 120 minutes after the start of the VDT operation, and category (G) occupied 70% of the remainder. From the above results, visual strain was a little eliminated by the treatment. When the complementary color at shorter wavelength was added to the warm color at longer wavelength on the VDT operator's (subject's) retina, provided that the VDT operator (subject) watched the picture of virtual far point, the fatigue was decreased a little.

5. Indexes for Recovery of Fatigue

Table 2 summarizes the results of the experimental studies when the treatment for the recovery from fatigue was carried out in a fixed time in the range of 60 to 120 minutes after the start of the VDT operation. When fatigue indicated by the indexes of Table 2 is felt by the VDT operator, the VDT operator has to perform the recovery treatment including the complementary color at shorter wavelength, which is added to the warm color at longer wavelength on the retina, and the picture of virtual far point, which is displayed on the CRT display.

Table 2 Indexes for effective recovery from fatigue.

Eye accommodation or body positions where fatigue has been recognized.	Index of recovery from fatigue	Rates of occurrence (%)
Recovery of eye accommodation	Far point can be seen on a picture of visual far point.	10 (Min.) 30 (Max.)
Recovery from strain in eyes	Eyes feel clear.	40 (Min.) 50 (Max.)
Recovery from strain in brain	Forehead feels clear.	30 (Min.) 40 (Max.)
Body positions other than brain and eyes	Neck and shoulder feel clear.	0 (Min.) 20 (Max.)

6. Conclusion

Visual strain caused by VDT operation is eliminated by the treatment using a picture of virtual far point with the background of the complementary color on the CRT display. Visual strain can be eliminated satisfactorily by the treatment of two kinds. Actions of the treatment for the recovery from visual strain every 60 minutes were found to be most effective. VDT operators including computer programmers and system engineers have to take actions for the recovery treatment using the picture of virtual far point with the background of the complementary color stimuli in 60 minutes after the start of the VDT operation. The others have to take actions for the recovery treatment in about 120 minutes after the start of the VDT operation.

The treatment for the recovery from visual strain after the start of the VDT operation is summarized as follows.

(1) The indexes of fatigue when the VDT operation is continued

for a certain period of time in the range of 1 to 120 minutes after the start of the VDT operation are "Eyesight flickers", "Whole head feels dull", and "Eyes feel dry".

(2) The indexes of the recovery when the visual strain is recovered by the treatment and when the fatigue is loaded for a certain period of time in the range of 1 to 120 minutes after the start of the VDT operation are "Eyes feel clear", "Forehead feels clear", "Far point is clear", and "Neck and shoulder feel clear".

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