Evaluation Method of Fatigue Caused by Video Data Terminal Operations

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Abstract

Described is a new type of measuring instrument for testing the visual strain, in which a series of Landolt's rings are demonstrated on the VDT display utilizing the personal computer, and a new evaluation method of fatigue caused by video data terminal operation, which is proposed based on data of fatigue measured using this new measuring instrument. The visual strain caused by continuous VDT operations was measured using this new type of measuring instrument. The mental stress was investigated based on the results of the evaluation. Based on the two results of our experimental study, a new "Evaluation Method of Fatigue Caused by VDT Operations" is proposed.

Introduction

Fatigue of an operator during the video data terminal (VDT) operations, whose causes are complicated, is recognized as a function of visual accommodation in eyes, brain, and other body positions. Fatigue of the VDT operator can be grouped into two categories: i.e., physical and mental stresses although the mechanism of fatigue generation is generally too much complicated to be estimated[1][2]. The physical stress is considered to be investigated from the viewpoint of functional degradation in body positions due to visual strain[1]. So, the functional degradation due to visual strain can be measured using the measuring instruments for both the visual sensation (visual acuity, strabismus, and flicker) and eye movement (accommodation and convergence in the near point). On the other hand, biological changes of the subject can be measured using the sphygmomanometer and heart rate meter. Although these changes were measured, no parameters affected by visual strain during the VDT operations were found from the measurement. Even if found, there is no way for recovering the parameter functions because medical treatment will be required. The mental stress is considered to be investigated based on the results of the evaluation in the 3 category steps defined by literature.[2] Then, the relation between the visual strain and the efficiency of works during the VDT operations is considered to be investigated, and the specific indexes of the fatigue leading a rest is considered to be found from the experimental results of the fatigue.

Based on the results of the above experimental studies,[1,2] a new 'Evaluation Method of Fatigue Caused by VDT Operations"can be proposed.

Degradation of Visual Accommodation

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.[3] The focal distance can be controlled by adjusting the thickness of the crystalline lens. Clear pictures are displayed on the retina when the thickness of the crystalline lens changes corresponding to the motion of the elastic ciliary muscles

A new measuring method for testing the visual strain can be realized utilizing both the personal computer and the software to display a series of Landolt's rings on the VDT display in a predetermined sequence.[4]

Figure 1 shows the dimensions of the Landolt's rings displayed on the VDT display, and the direction of a gap in each Landolt's ring. Thickness W of the Landolt's ring measures 1/5 compared with its outer diameter D, and gap G measures 1/5 compared with its outer diameter D. Visual acuity V is defined as 1/A where A is the minimum visible angle looking from the observer's standpoint to the gap of the demonstrated Landolt's ring.

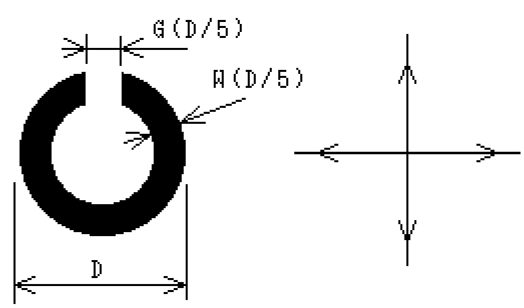

Figure 1. Landolt's rings. (a) Dimensions (b) Direction of a gap looking from the center of the each ring.

A gap in each Landolt's ring is provided in one of the four directions of Figure 1 (b). Eight kinds of visual acuities, i.e., 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8, are assumed for use in the tests. Thirty-two Landolt's rings (4 directions x 8 kinds) are provided for the visual acuity tests. Each Landolt's ring is displayed on the VDT display for a period of 0.1 second. A series of 32 Landolt's rings are successively displayed in 2 second intervals in a descending sequence of visual acuity.[1]

The background to the Landolt's rings on the computer display used for the tests was colored in white with a brightness of 29.7 cd/m^2, and the Landolt's rings were colored in gray with a brightness of 13.1 cd/m^2. The contrast was thus 0.53.

Continuous demonstration of Landolt's rings, as employed in the conventional Landolt's ring board, is not suitable for checking the temporary decrease in the amplitude of the visual accommodation due to fatigue during the VDT operation. The time of demonstration is considered to be in the order of the focusing time of human eyes for this purpose of fatigue test after the human eyes start watching an object. The time of demonstration in each Landolt's ring on the computer display is thus specified as 0.1 second.[1]

Figure 2 shows the computer display frame on which only one Landolt's ring is continuously displayed. The ambient light is set at 220 lux, provided that no external light and no external noises are allowed to be input.

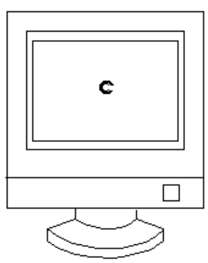

Figure 2. Display frame on which only one Landolt's ring is continuously displayed.

When the VDT display is continuously run by the VDT operator for a certain period of time, the VDT operator feels visual strain. At that time, the VDT operator outputs a series of Landolt's rings to check if the VDT operator cannot continue the VDT operations anymore due to the visual strain caused by continuous VDT operations. If the visual acuity is found to be decreased during the test for visual strain, the VDT operator stops the VDT operations immediately.

Figure 3 shows the capability of discriminating the gaps in the Landolt's rings. This mode of capability decreases with the elapsing of time during the continuous VDT operations for the TFT-LCD. When the VDT operations continue for 90 minutes, the discrimination goes to less than 90% compared with that which is measured before the start of the VDT operations.

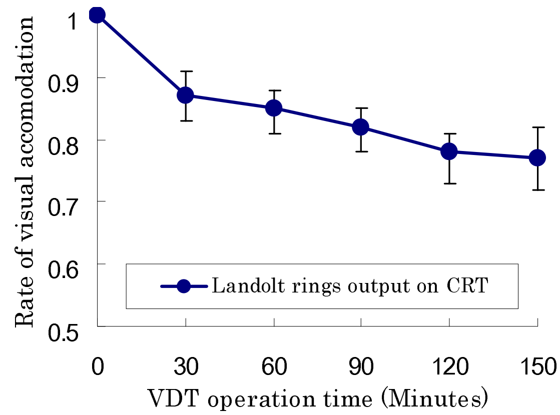

Figure 3. Averages and 95% confidence intervals of the decrease in measured visual accommodation obtained from TFT-LCD.

Figure 4 shows the capability of discriminating the gaps in the Landolt's rings. This mode of capability decreases with the elapsing of time during the continuous VDT operations for the CRT display. When the VDT operations continue for 90 minutes, the discrimination goes to less than 70% compared with that which is measured before the start of the VDT operations.

From Figures 3 and 4, we can find that visual strain is caused by continuous VDT operations for more than 90 minutes regardless of the type of the display.

Visual Strain and Efficiency of Work

If the efficiency of works during the VDT operations decrease with visual strain is to be considered in the next step of this study. If the VDT operator feels fatigue during the VDT operations, the fatigue will suppress the performance of the VDT operations, and a human body will feel fatigue. The efficiency of works obtained during the VDT operations in each display type is shown in Fig. 5. If the VDT operations are continued under the stressed conditions, fatigue will be accumulated in the human body.[5]

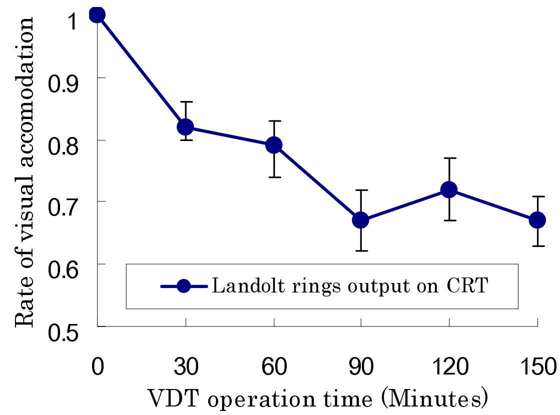

Figure 4. Averages and 95% confidence intervals of the decrease in measured visual accommodation obtained from CRT display.

Subjective Evaluation of Fatigue

The results of evaluation obtained in accordance with the above 3 category steps refers to the body position where the fatigue is caused by the VDT operations, and the relation between them will be investigated. The specific indexes of the fatigue, leading to take a rest, will be proposed based on the results of evaluation of fatigue.[2]

Subjective Evaluation of Fatigue in accordance with 3 Category Steps

After the VDT operations, fatigue was tested for the subjects utilizing the TFT-LCD and CRT in accordance with the following 3 category steps.[4,6]

(1)No fatigue felt.
(2)Fatigue felt.
(3)Fatigue felt too much to continue the VDT operations.

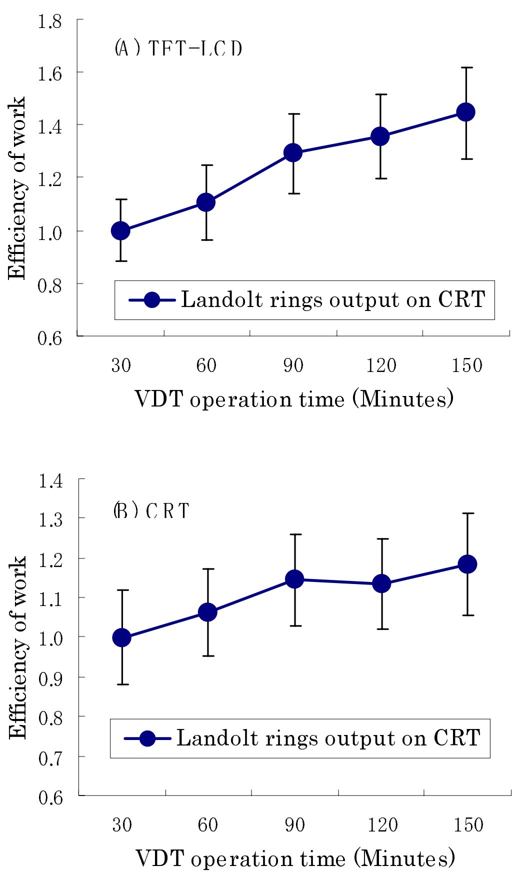

Figure 5. Efficiency of works obtained during the VDT operations.

Figure 6 shows fatigue in percentage for twenty subjects after the completion of the VDT operations. Fatigue is given in 3 category steps. Fatigue in each category step was changed with time depending on the display type, and the mode of change of fatigue with time is characterized by the display type. For instance, category (2) has its peak in the time range of 60 to 120 minutes for the TFT-LCD, and in the time range of 90 to 150 minutes for the CRT.

Based on the results of the measurement of psychological fatigue in terms of the time of VDT operations when the TFT-LCD and CRT were respectively used, the time of continuous VDT operations was determined to be 60 to 120 minutes. For both types of VDT operations, physical conditions of the subjects might be affected by the time at which fatigue begin felt. So, the time span between rests before and after the successive VDT operations needs to be defined as 60 to 120 minutes even though this time span is longer than the expected one. If a VDT operator takes a rest after the VDT operations continued for 60 to 120 minutes, the VDT operator can do work without fatigue accumulated to the next day.

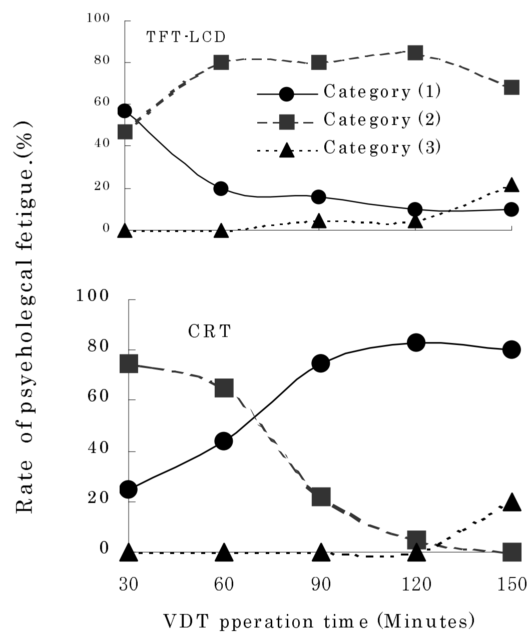

Figure 6. Fatigue for twenty subjects after completion of the VDT operations.

Fatigue and Rest

We need to consider the body positions where fatigue is felt to such an extent that a rest is needed, and these are classified into the following 4 categories in accordance with the degrees of fatigue measured referring to the indexes which will be defined hereafter.

(1)Visual accommodation.
(2)Visual strain.
(3)Fatigue of brain.
(4)Fatigue of any other body positions than eyes and brain.

The four indexes are defined in each of these four categories. Each of twenty subjects selects the most suitable one out of these 4 indexes. The rules for selecting the indexes are as follows[2]: However, since each time span is defined as 60 to 120 minutes for the continuous VDT operations, both the fatigue and body positions where the fatigue have been recognized are to be considered hereafter.

(1)The fatigue of special type is increased to a great extent when the index before the VDT operations are performed is compared with that after the VDT operations are done.
(2)The occurrence of fatigue of special type is increased as the VDT operations continue for a long time.
(3)The occurrence of fatigue of special type seems to be in proposition to the time during which the VDT operations continue.

Based on the above rules, the index required for determining the time during which the VDT operations continue is to be selected in accordance with the body position where fatigue has been recognized.

Table 1 summarizes the results of the experimental studies when the tests were continuously carried out until the continuous VDT operations were stopped at the first time in a time of 60 to 120 minutes after the start of the VDT operations.[1,2] On Table 1, the specific index leading to take a rest is described in terms of the body position where fatigue has been recognized. Fatigue is considered as an averaged strain of the body since the strains are recognized all over the respective body positions. The maximum and minimum rates of occurrence of the respective indexes have been given so that the fatigue leading to take a rest can be evaluated by the amplitude of the strains which have occurred in the respective body positions.

Table 1. Occurrence of fatigue and indexes indicating fatigue leading to take a rest.

Eye accommodation or body positions where fatigue has been recognized.	Index of fatigue.	Occurrence of specific index indicating fatigue.	
		TFT-LCD (%)	CRT (%)
Degradation of eye accommodation	Eyes feel flickering.	30 (Min.) 80 (Max.)	20 (Min.) 60 (Max.)
Strain of eyes	Eyes feel pain.	45 (Min.) 65 (Max.)	35 (Min.) 65 (Max.)
Strain of brain	Brain feel dull.	20 (Min.) 75 (Max.)	15 (Min.) 50 (Max.)
Body positions other than brain and eyes	Body feel dull.	15 (Min.) 50 (Max.)	15 (Min.) 40 (Max.)

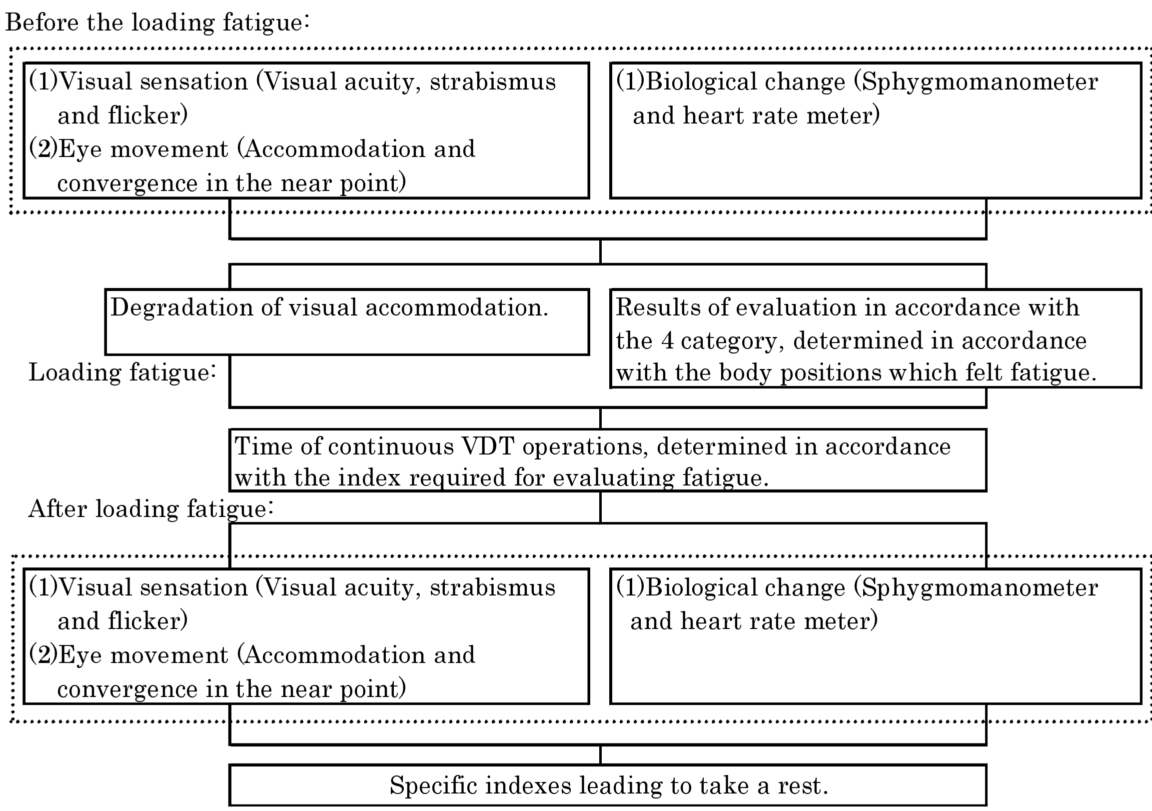

Figure 7. Evaluation method of fatigue caused by VDT operations.

The effective use of the indexes on Table 1 enables us to intensively continue intelligent works every day without excessive fatigue so that fatigue can be recovered on the next day. This means that a rest should be taken after the continuous VDT operations in 60 to 120 minutes.

Evaluation Method of Fatigue Caused by VDT Operations

The evaluation method of fatigue caused by the VDT operations is as follows:

(1) Measures degradation of the functional activity due to fatigue using the measurement instruments for both the visual sensation (visual acuity, strabismus and flicker) and eye movement (accommodation and convergence in the near point).
Measures biological changes of the subject using both the sphygmomanometer and heart rate meter.
(2) Evaluates visual strain from the degradation of visual accommodation caused by the VDT operations. Note that the degradation of visual accommodation caused by the VDT operations can be measured by using the Landolt's rings for testing the visual acuity displayed on a frame of the CRT display.
(3) Evaluates fatigue from the results of evaluation in accordance with the above 3 category steps. Note that the time of the continuous VDT operations is 60 to 120 minutes, according to the results of evaluation in accordance with the above 3 category steps.
(4) Selects the specific index of fatigue leading to take a rest for each body position where fatigue has been recognized.

The above methods are summarized in Figure 7.

Conclusion

Fatigue caused by the VDT operations can be evaluated by measuring the degradation of visual accommodation in accordance with the 3 category steps defined for the subjective evaluation of fatigue. If the specific indexes of the fatigue can be obtained from the results of evaluation, the VDT operator has to take a rest. If no parameters affected by fatigue during the VDT operations are found during the measurement of fatigue, the VDT operations can be carried out everyday keeping the body healthy. Then, the new mode of VDT operations has been established using the evaluation method of fatigue caused by the VDT operations.

Acknowledgment

The authors wish to thank both Mrs. Yamane and Washio at the Research Institute of Liquid Crystal Laboratories, Sharp Corporation for their assistance in experimental study, and also the personnel in charge at Sharp Corporation for providing the LCD's used for the VDT operation tests.

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Biography

Tetsuya Muraoka received his B.S. degree in Engineering from Kinki University in 1973, a M.S. degree in Engineering from Toyo University in 1978 and a Ph.D. in Engineering from Shizuoka University in 1991. He is a Professor at Gunma Polytechnic College in Japan. His major is Psychophysics. He is a member of the SID and the IEEE.