

# Subjective Evaluation of Physiological Fatigue in Video Data Terminal Operation

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## Abstract

Psychological fatigue of the VDT operators is accumulated because of forcible VDT operations. The accumulation of psychological fatigue during the VDT operation is subjectively evaluated by the test in 3 categorized steps. Based on the evaluated results of psychological fatigue, the VDT operation time was decided to be 60 to 120 minutes. The indexes leading to take a rest in order to recover the fatigue of the body positions where the fatigue had been recognized was decided in terms of the change of the rate of the occurrence of the fatigue and in terms of the gradient of that rate when the plot was assumed as a linear function of the number of trials.

## Introduction

Nowadays, super-highways for exchanging information throughout the world were proposed by U.S.A., and the concept of super-highways is being realized in this multimedia era. Interests in on industries are also being changed from mechanical to intelligent electronics. Computers are central devices in this period of revolution in science and technology. Psychological fatigue of the video data terminal (VDT) operators is accumulated because of forcible VDT operations.<sup>1</sup>

The accumulation of psychological fatigue during the VDT operation can subjectively be evaluated by the test in 3 categorized steps. First, recognition of accumulated psychological fatigue due to contiguous VDT operation is considered to be effective to prevent the VDT operators from psychological disease because of chronic fatigue. Second, body positions where fatigue has been recognized are to be divided into four groups, i.e., visual accumulation, eyes, brain, and other body positions. Four indexes showing the degrees of fatigue are to be defined for each group of body positions. For taking a rest depending on the body position where fatigue has been recognized, the operator is informed of an appropriate index. Third, a new type of VDT operation can be established keeping psychological fatigue not accumulated during the VDT operation which is contiguously carried out everyday.

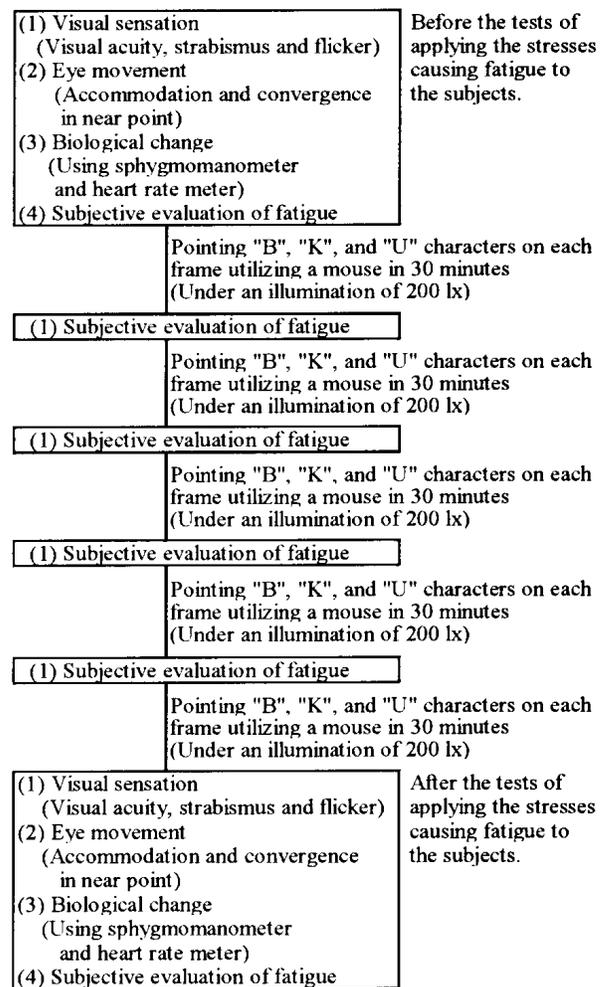


Figure 1. Experimental process of applying stresses causing fatigue to the subjects.

## Fatigue Stress Test

Both the 14.2 inch liquid crystal display with thin film transistor drives (TFT-LCD) and the 17 inch CRT display

were used as VDTs for the fatigue stress test. A fatigue stress test was carried out when 600 (40(V) x 15(H) characters) alphabetic characters were displayed on a frame of display. Twenty "B" characters, twenty "K" characters, and twenty "U" characters were randomly arranged on each frame on the VDT display screen. Other 540 characters consisting of other characters than "B", "K", and "U" were arranged on each frame on the VDT screen. Fourteen kinds of frames were displayed for a series of tests in each test set in 30 minutes. Five sets of frames were provided in other tests to apply stresses causing fatigue to the respective objects. The test was carried out by pointing the "B", "K", and "U" characters on each frame utilizing a mouse on a personal computer.

After the completion of pointing the specified "B", "K", and "U" characters on one frame, control automatically moves to the next frame. The frame having a background colored in red was a brightness of 4.3 cd/m<sup>2</sup>. Alphabetic characters displayed on the red background were colored in white, and the brightness was 24.6 cd/m<sup>2</sup>. The contrast was 0.83. Figure 1 shows the process of how to apply stresses causing fatigue to the respective subjects.<sup>2</sup>

The subjects were selected among the students with ages of 19 and 20 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 condition, but not to be felt tired. Twenty students were selected to receive the tests. The distance between a subject and a frame on the CRT of the VDT was defined as 2 times the height (H) of the frame of the VDT.

Degradation of visual functions due to physiological fatigue was measured using the measuring instruments for both visual sensation (visual acuity, strabismus, and flicker) and eye movement (accommodation and convergence in near point). At that time, biological changes of the subject were measured using the sphygmomanometer and heart rate meter. Any parameters affected by fatigue during the VDT operation were not found on the measurement. Even if found, fatigue cannot be recovered by itself and medical treatment will be required.

If one feels fatigue during the VDT operation, the fatigue suppresses the performance of the VDT operation, and then control in a human body suppresses the feeling of fatigue. If the VDT operation is continued under this stressed conditions, fatigue is accumulated in the human body.

### 3. Subjective Evaluation of Fatigue in 3 Steps of Categories<sup>3</sup>

After the completion of the VDT operation, feeling of fatigue was tested for the subjects utilizing the TFT-LCD and CRT in the following steps of categories.

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

Figure 2 shows the psychological fatigue in percentage for twenty subjects after the completion of the VDT operation. Psychological fatigue is given in 3 steps of categories.

When the TFT-LCD was used, category (1) occupied 55% to the total number of events in 30 minutes after the start of the VDT operation, and it went down to 20% in 60 minutes after the start of the VDT operation. Contrarily, category (2) occupied 45% to the total number of events in 30 minutes after the start of the VDT operation, and it went up to 80% in 60 minutes after the start of the VDT operation. When the VDT operation continued for 120 minutes, category (2) occupied 85% at its peak and decreased to 70% in 150 minutes. Category (3) was however increased by 20% in 150 minutes after the start of the VDT operation.

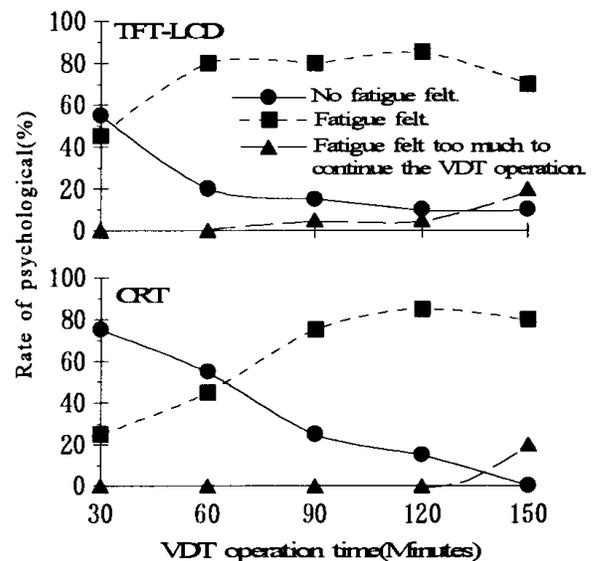


Figure 2. Psychological fatigue for twenty subjects after the completion of the VDT operation.

When the CRT was used, category (1) occupied 75% to the total number of events in 30 minutes after the start of the VDT operation, and it was decreased to 25% in 90 minutes after the start of the VDT operation. Although category (2) occupied 25% to the total number of events in 30 minutes after the start of the VDT operation, and it was increased to 75% in 90 minutes, and it went up to 85% at its peak in 120 minutes. Category (2) was however decreased to 80% in 150 minutes. Contrarily, category (3) was increased to 20% in 150 minutes.

Fatigue in each step of categories was changed with time for each display type, and the type of change of fatigue with time characterizes the display type. For instance, category (2) has its peak in the range of 60 to 120 minutes for the TFT-LCD, and in the 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 operation when the TFT-LCD and CRT were respectively used, the

time of a continuous VDT operation was determined to be 60 to 120 minutes. Both the type of the VDT operation, and the physical conditions of the subject might affect the time that the fatigue is felt. So, a time span between rests before and after the successive VDT operations is defined to be 60 to 120 minutes even though this time is larger than the expected time.

If the VDT operator takes a rest after the VDT operation for 60 to 120 minutes, the VDT operator can do work without accumulation of fatigue to the next day.

#### 4. Fatigue and Rest

The body positions where fatigue is felt to such an extent that a rest is needed, are classified into following categories so that the degrees of fatigue can be measured by indexes.

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

Four indexes are defined in each of these four categories. Each of twenty subjects selects the most suitable one out of these 4 indexes. Since each VDT operation time is defined to be 60 to 120 minutes, both the type of fatigue and the body position where the fatigue has been recognized are considered hereafter. The rules for selecting indexes are as follows:

The degree of fatigue of a special type is changed to a great extent when the index before the VDT operation is compared with that after the VDT operation.

The rate of occurrence in a special type of fatigue is increased as the VDT operation time increases.

The rate of occurrence in a special type of fatigue seems to be in proposition to the VDT operation time.

Based on the above rules, the indexes required for determining the VDT operation time are selected for each body position where fatigue has been recognized.

#### Degradation of Visual Accommodation

Figure 3 shows the degradation of visual accommodation in terms of the VDT operation time. In Figure 3, items (A) through (D) indicate that images become obscure, the eyesight flickers, images are seen doubled, and the eyesight becomes opaque, respectively.

When the TFT-LCD was used, items (B) and (D) were remarkably increased with the elapsing of the VDT operation time until the operation stopped at a time of 120 minutes. Item (B) was more remarkable than item (D). The index for determining the degradation of visual accommodation was determined to be item (B). Item (B) was increased linearly with the VDT operation time until the operation stopped at a time of 120 minutes, and thereafter it was unchanged.

When the CRT was used, items (B) and (D) were continuously increased with the VDT operation time until the operation stopped at a time of 120 minutes, and thereafter it was unchanged, and either item (B) or item (D) could be used as an index for determining the degradation of

visual accommodation. The change of item (D) was however greater than that of item (B).

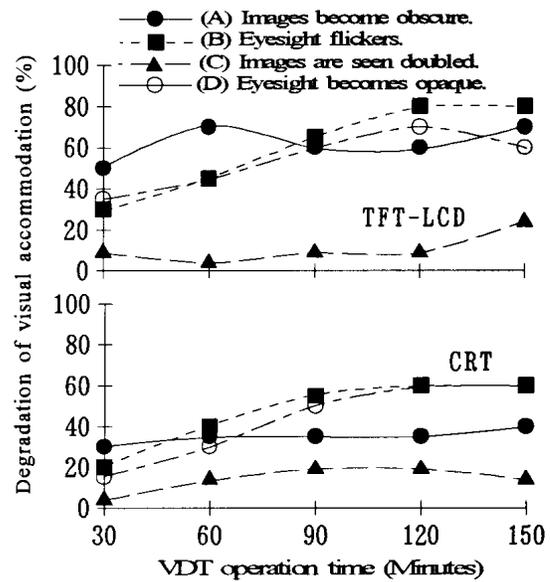


Figure 3. Relations between the degradation of visual accommodation and the VDT operation time.

From the results of the experimental studies described above, item (B) was chosen as an index of visual accommodation for both the TFT-LCD and CRT. Index (B) was linearly increased with the VDT operation time until the operation stopped at a time of 120 minutes.

#### 4.2 Visual Strain

Figure 4 shows the visual strain in terms of the VDT operation time. In Figure 4, items (A) through (D) indicate that eyelids feel hot, the eye edges feel incongruity, the eyes feel dry, and the eyes feel pain, respectively.

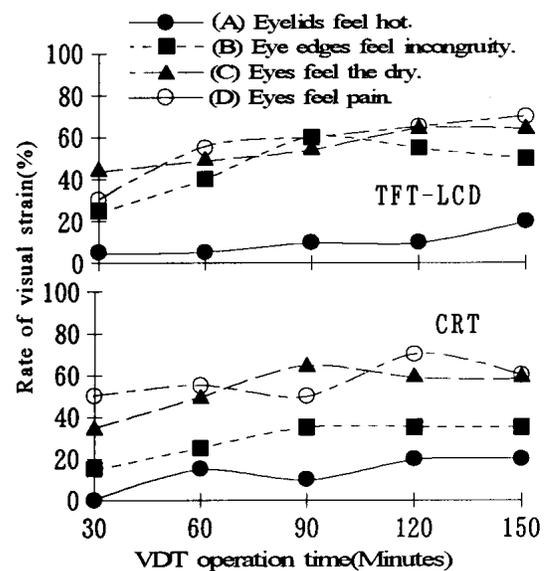


Figure 4. Visual strain in terms of the VDT operation time.

When the TFT-LCD was used, item(B) had a peak for the trial at the third time. Items (A), (C), and (D) were, however, monotonically increased with the VDT operation time. An item (D) was greater than those of items (A) and (C). Approximately 55% of the subjects were suffered from the pain of the eyes due to item (D) when the VDT operation was completed in 60 minutes from the start of the operation.

When the CRT was used, item(B) and (C) was increased with the VDT operation time until the operation stopped at a time of 90 minutes. Item (C) was however a little greater than item (B).

From the results of the experimental studies described above, item (C) was chosen as an index of visual strain for both the TFT-LCD and CRT. Index (C) was linearly increased with the VDT operation time until the operation stopped at a time of 120 minutes.

### Fatigue of Brain

Figure 5 shows the fatigue of the brain in terms of the VDT operation time. In Figure 5, items (A) through (D) indicate that the forehead feels dull, the rearhead feels dull, the head feels pain when shaken, and the whole head feels dull, respectively.

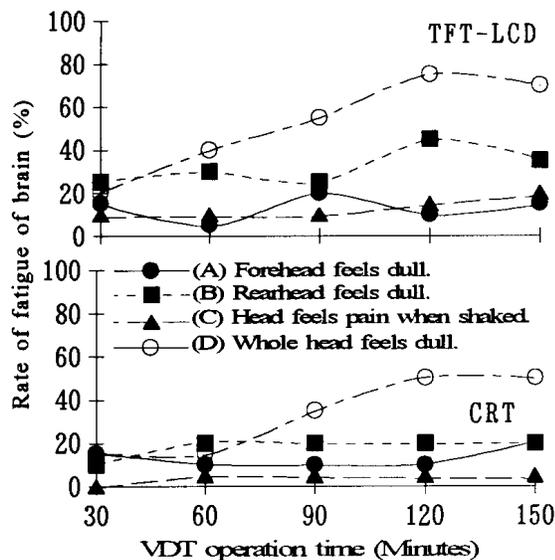


Figure 5. Fatigue of the brain in terms of the VDT operation time.

When the TFT-LCD was used, item(D) was greater than other items, and it was linearly increased with the VDT operation time until the operation stopped at a time of 120 minutes. No other items exhibited the accumulation of the fatigue in terms of the VDT operation time.

When the CRT was used, item(D) was greater than other items.

From the results of the experimental studies described above, item (C) was chosen as an index of the fatigue of the brain for both the TFT-LCD and CRT.

### 4.4 Fatigue of Body Positions Other than Brain and Eyes

Figure 6 shows the fatigue of the body positions other than the brain and eyes in terms of the VDT operation time. In Figure 6, items (A) through (D) indicate that the shoulder feels stretched, the waist feels pain, the neck feels stretched, and the body feels dull, respectively.

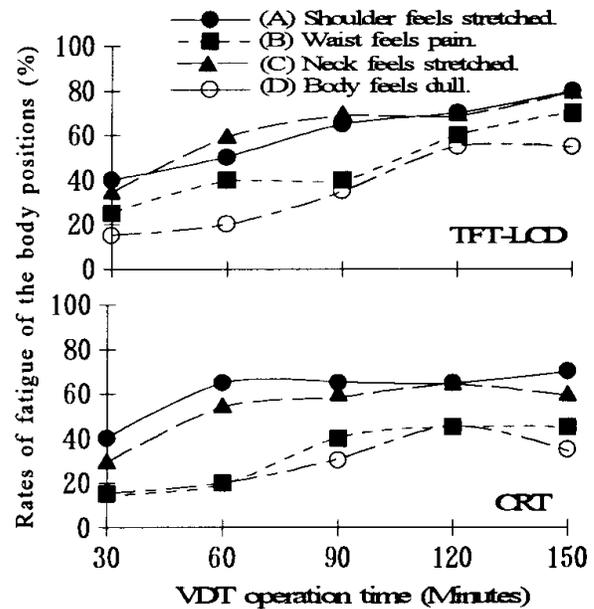


Figure 6. Fatigue of the body positions other than the brain and eyes in terms of the VDT operation time.

When the TFT-LCD was used, all items were increased with the VDT operation time, and item(D) was linearly increased.

When the CRT was used, the change of item(D) was largest among those of items (A) through (D).

From the results of the experimental studies described above, item (D) was chosen as an item of the fatigue of the body positions other than the brain and eyes for both the TFT-LCD and CRT.

### 4.5 Indexes Leading to Take Rest

Table 1 summarizes the results of the experimental studies when the tests were continuously carried out until the first trial of the VDT operation was stopped at a time in the range of 60 to 120 minutes after the start of the VDT operation. On Table 1, the specific indexes leading to take a rest are described in terms of the body positions where the fatigue has been recognized. The fatigue is considered as averaged strains of the body, which 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.

The effective use of the indexes on Table 1 enables as to intensively continue intelligent works every day without exceeding the normal mode of fatigue which can be

recovered next day. This means that a rest should be taken after the VDT operation in 60 to 120 minutes.

**Table 1. Rates of Occurrence of the Specific Indexes of the Fatigue Leading to Take a Rest**

Eye accommodation or body positions where fatigue has been recognized.	Index of fatigue	Rates of occurrence of specific index	
		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.)

## 5. Conclusion

The VDT operation should be carried out without exceeding the normal mode of fatigue which can be recovered next day while the fatigue felt due to the VDT operation is being recovered by the rests taken among the trials of the tests. The VDT operation time after which a rest is taken, and the indexes to test the fatigue of the respective body positions in order to decide the continuous VDT time are described as follows:

When the fatigue was felt, the rate of the occurrence of the fatigue had its peak at a time in the range of 1 to 120 minutes after the start of the tests if the TFT-LCD was used. On the contrary, this rate had its peak at a time in the range of 90 to 150 minutes after the start of the tests if the CRT

was used. The VDT operation time was decided to be 60 to 120 minutes. The reason is that the fatigue can be recovered by a rest taken among the trials of the tests if the VDT operation is continued without exceeding the normal mode of fatigue which can be recovered next day.

When the VDT operation was carried out for 60 to 120 minutes, the indexes leading to take a rest in order to recover the fatigue of the body positions where the fatigue had been recognized was decided in terms of the change of the rate of the occurrence of the fatigue and in terms of the gradient of that rate when the plot was assumed as a linear function of the number of trials.

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