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On a Relation between the Flicker Value and the Learning Process

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The measurement of the flicker value is a method to estimate the degree of the fatigue. This method is investigated by several authors.[1),2)]

The control chart of the flicker value was used for one method of the labor management and found that this chart showed the learning trend. In this paper, the simulator of automobile was used to examine the relation between the variation of the flicker value and the driving environment, the learning process of the reaction and the relation between the flicker pattern and the learning process in the working hours. These were contributed to find the beginning of the stationary condition and which group was adapted to this work. Data was analyzed by statistical methods.

It was found in this study that the variation of the flicker value and the learning process of the reaction were connected with each other.

§ 1. Introduction

The effect of the work is influenced by natures of a worker and the work enviroment. The former is the ability of performance and the learning rate during the duplication of the same operation. The latter is the balance of various work conditions. So it is necessary to make the relation between them clear.

We made the control chart of the flicker value of the bus driver for the labor management and observed the variation of flicker value in the working hours. Then it was found that this measure represented not only the fatigue but also the learning trend.[1),2)]

The simulator of automobile was used to examine the variation of flicker value, learning process of the reaction time and the relation between them. Measurements were the flicker value, the reaction time of the hand or the foot and reaction frequency of the color signal. They were analyzed by t-test, the analysis of variance in one way classification and the multivariate analysis.

§ 2. Equipments

The simulator of automobile of T. K. K. Co. LTD. was remodeled for our experiment. The influence to the eye could be controlled by the projection of the driving scene. For the projection equipment was remodeled that of B. H. Co. LTD., so that we may controll the brightness on screen by varying the voltage of the source of light. The subject operated the handle looking at the mark which was controlled by the turnning gear. This experiment was practiced under the next work enviroments. That is, the room temperature was 20°C, the screen brightness 10~30 lux and the projecting area $110 \times 80 cm^2$. Before this study, we investigated the variation of the flicker value of the bus driver in the working hours. At that time, the brightness in night drive was about 10~30 lux. So using the night driving scene not only the learning process but also the influence to the eye will be investigated. The time lag of the hand and foot reaction was measured by the kinetic apptitude equipment of T. K. K. Co. LTD. which could measure the reaction time (1/1000 sec) of the hand or the foot after looking at the lightening of the lamp.

Control parts of these equipements were put in the observation room and the subject in the laboratory was watched though the magic millor. Fig. 1, 2, 3 show the disposition of the apparatus.

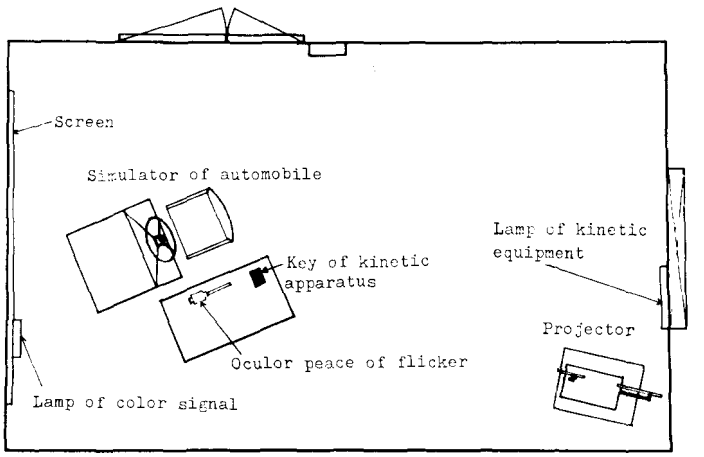

Fig. 1 Disposition in laboratory

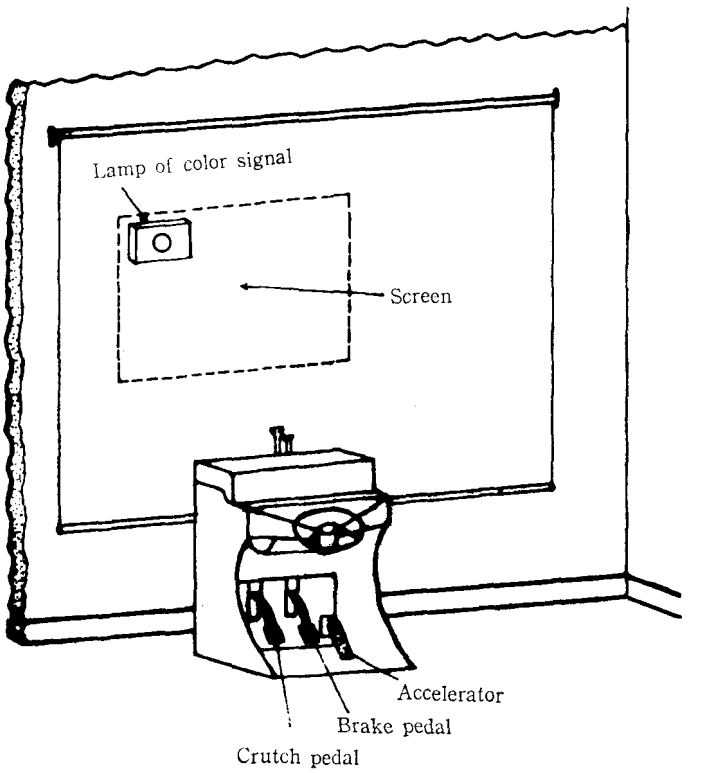

Fig. 2 Disposition in laboratory

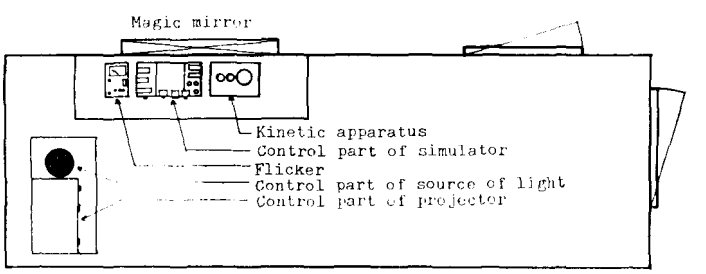

Fig. 3 Disposition in observation room

§3. Subject and Procedure

Subjects were selected from the student in the engineering department randomly. The subject was explained how to operate the apparatus before the work and then operated the simulator ten times over for five minutes. The reaction time of the hand and the foot (right) was measured before and after the work. The reaction time was measured three times and the flicker values six times at a time. Mean values of these measurements were regarded as the obervations in that time.

The operation was as follows. The subject traced the handle according with the mark which was controlled by the turnning gear and operated the accelerator, crutch and brake pedals by the foot according with the color signal. The relation between the pedalling and the color signal is shown in the next place.

Red signal: Put off the light foot from the accelerator and put it on the brake pedal.

Yellow signal: Put off the light foot from the accelerator and put the left foot on the crutch pedal.

These operatons were recoreded with the frequency of the accelerator and the color reaction when correct reactions were done within 0.5 sec. after given color stimulus.

§4. Methods of analysis

The flicker value was measured thirteen times after each same operations of five minutes. Data was treated as time series data. Then means of the flicker value are tested by the t-test with the correspondence.

The learning curve of the reaction frequency was ana-

lyzed by the equation such that $Y=A+BT^c$, where parameters 'B' and 'c' were determined by the least square method. The stationary condition was determined as follows.

Put $Y_i=A+BT_i^c$, where

T_i is the time of the observation and

Y_i is the reaction frequency at T_i.

There exsists i_0 such that for any $i \geqq i_0$

$$Y_i - Y_{i+1} < \text{constant (about 1.0)}$$

Therefore exsists T_0 such that

$$Y_0 - Y_{i0} = \text{constant and } T_0 \leqq T_{i0}.$$

We say that this point T_0 is the beginning point of the statinnary condition.

Subjects are classified into four groups, in which they have same flicker pattern in the working hours. It is tested whether the learning process of reaction frequency in each groups have the same pattern or not.

$x_i=(x_{i1}, \cdots\cdots, x_{ik})'$, $y_i=(y_{i1}, \cdots\cdots, y_{ik})'$

$(i=1, 2, \cdots, N_1)$ $(i=1, 2, \cdots, N_2)$

x_i and y_i: the colum vector of k-dimension in group A and B.

$\bar{x}=(\bar{x}_{\cdot 1}, \cdots\cdots, \bar{x}_{\cdot k})$, $\bar{y}=(\bar{y}_{\cdot 1}, \cdots\cdots, \bar{y}_{\cdot k})$

$\bar{x}$ and $\bar{y}$: sample mean

$\zeta_A=(\zeta_{1A}, \cdots\cdots, \zeta_{kA})$, $\zeta_B=(\zeta_{1B}, \cdots\cdots, \zeta_{kB})$

ζ_A and ζ_B: population mean

Ho: $\zeta_A=\zeta_B$ (population means are equal): Hypothesis

Then $$F_0=\frac{(N_1+N_2-k-1)N_1\cdot N_2}{k\cdot(N_1+N_2)}\cdot (\bar{x}-\bar{y})'\cdot S^{-1}\cdot(\bar{x}-\bar{y})$$

was calculated and if

$F_0 > F_\alpha(k, N_1+N_2-k-1)$ then $\zeta_A \neq \zeta_B$ significant at α percent level

$F_0 \leqq F_\alpha(k, N_1+N_2-k-1)$ then $\zeta_A=\zeta_B$

Where $S^{-1}=(\sum_k(x_{ki}-\bar{x}_{\cdot i})(x_{kj}-\bar{x}_{\cdot j}) + \sum_n(y_{ni}-\bar{y}_{\cdot i})(y_{nj}-\bar{y}_{\cdot j}))^{-1}$

§ 5. Results

(1) The variation of the flicker value in the working hours.

Means of the flicker value in the working hours are shown in Fig. 4. From this, the

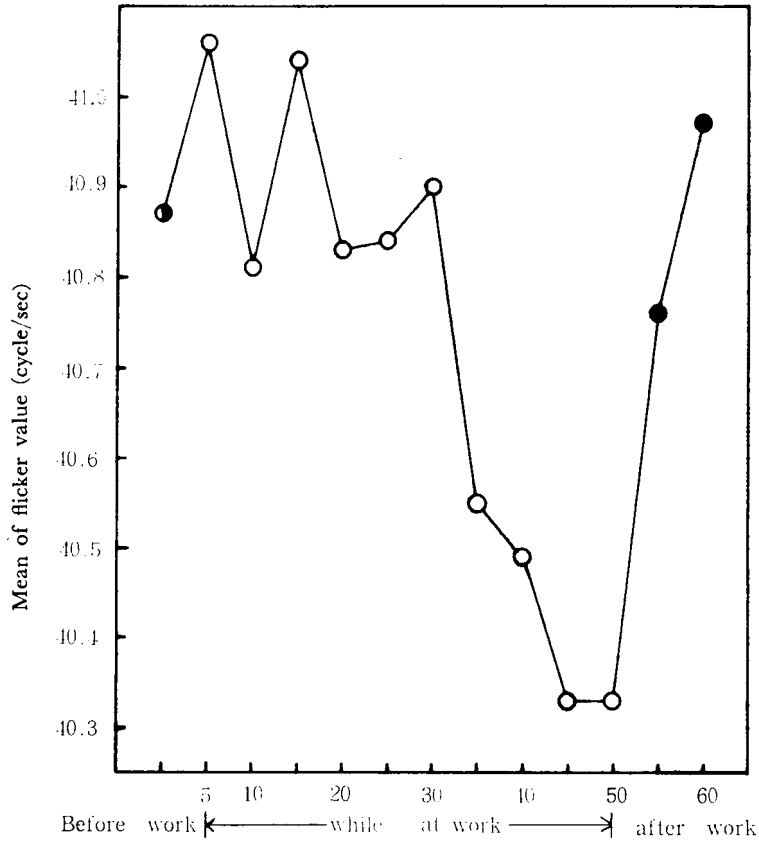

Fig. 4 Variation of flicker value

mean value increased slightly at the beginning of the work and was nearly equal to the first which was meassured before work. It decreased at the terminal of the work and recovered in ten minutes up to the value of the first.

There was not the significent difference in the population mean which was measured five minutes apart except for 15~20 minutes. The difference between 15 and 20 minutes was not so large but the variance is too small. Hence t-test was significent.

There was the significant difference between 40~50 minutes and 20~30 minutes or 55~60 minutes. But there was not the significant difference between the first and 45~50 minutes, because the variance was large. The mean of the first was nearly equal to that of 20~30 minutes and of 55~60 minutes.

From this analysis, it was found that the flicker value became stably after about 25 minutes from the start of the work, but suddenly decreased and recovered up to the first in ten minutes after the work.

These phenomena showed the exsistence of the fatigue and the learning process of the reaction. The fatigue will begin after about 45 minutes from the start of this work.

(2) The learning process of the reaction frequency

In this experiment, the simulator of automobile was used. Then the reaction frequency was that of the accelerator and of the color signal. The color stimulus (red. yellow) was given 45 times in each time, therefore the number of the accelerator and the color reaction will converge to this point. The learning curve in each reaction was as follows.

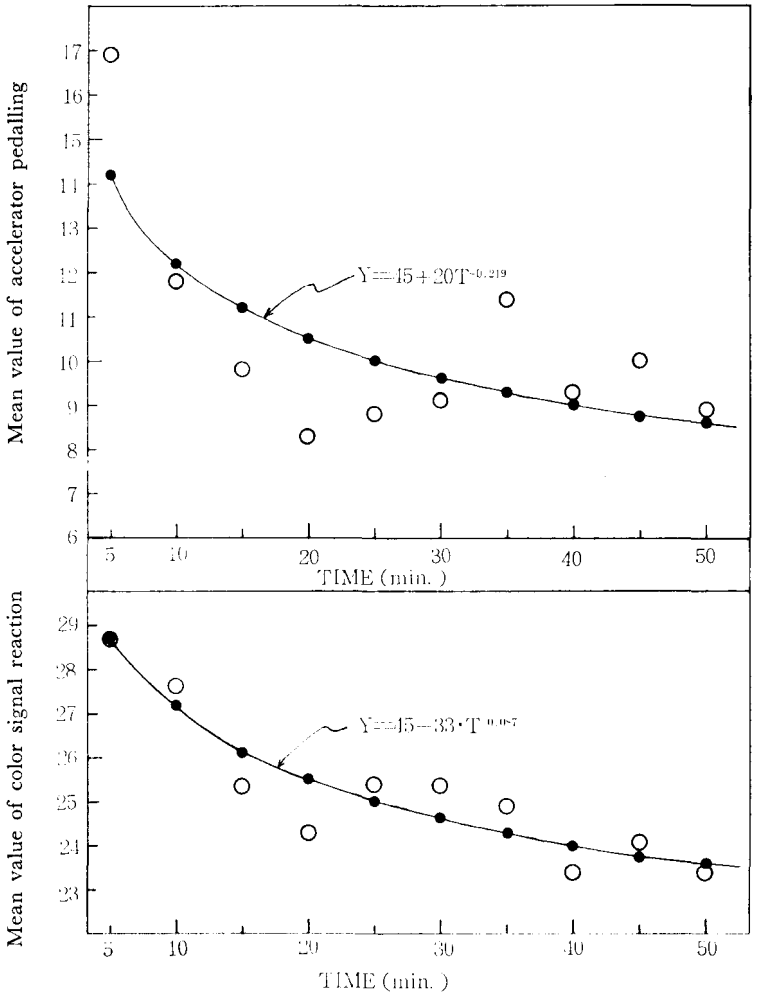

Fig. 5 Learning curve for the accelerator pedalling and color signal reaction

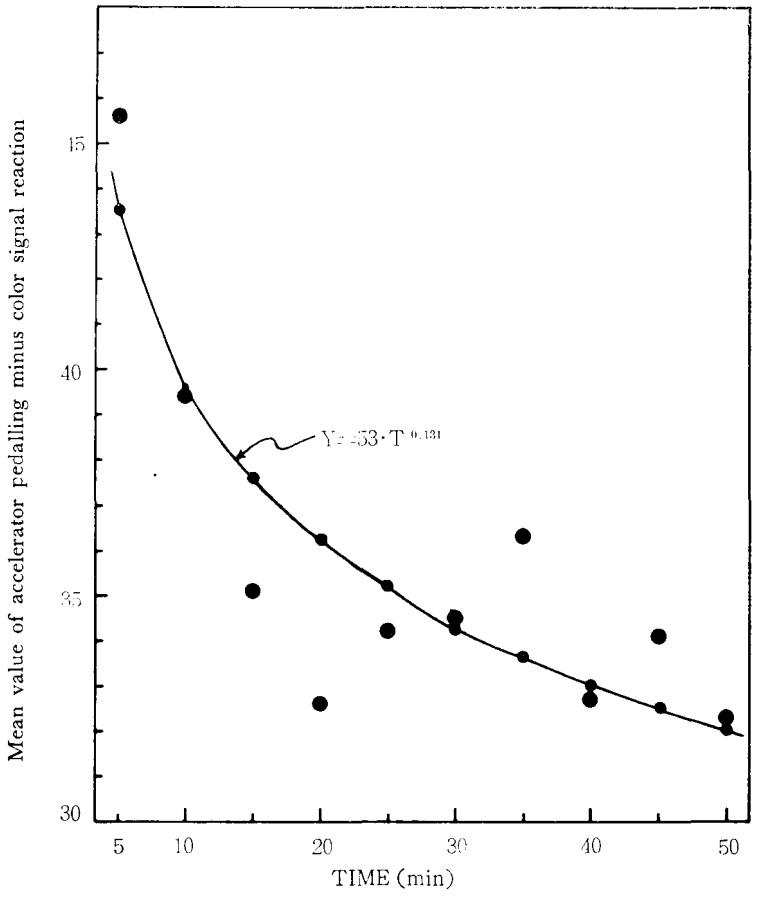

Fig. 6 Learning curve for the accelerator pedalling minus color signal reaction

$Y = 45+20 \cdot T^{-0.219}$: the learning curve of the reaction of the accelerator

$Y = 45-33 \cdot T^{-0.087}$: the learning curve of the reaction of the color gignal

Now there is one to one correspondence in the accelerator and the color reaction, so that the difference of these two reactions will converge to zero. Hereafter, the learning curve of the difference was used to investigate the learning rate. The learning curve of all subject was as follows.

$Y = 53 \cdot T^{-0.131}$

From this equation, the beginning point of the staionary condition was about 26 minutes. Fig. 5, 6 show the mean frequency of the color reaction and its learning curve.

§ 6. Discussion

We obtained the following results on the variation of the flicker value, on the learning process of the reaction and the relation of each other in the working hours.

(1) It was found by t-test that the flicker value became stably about ten minutes from the start of the work and became the lowest in 40~50 minutes and recovered in ten minutes up to the mean which was measured before work. The fatigue will begin after about 45 minutes from the start of the work.

(2) The range of the flicker value was the lowest in the first observation and increased in the working hours. But there was the significant difference between 15 minutes and 20 minutes.

(3) The learning curve of the accelerator minus color reaction in the working hours was $Y = 53 \cdot T^{-0.131}$.

The learning rate was high at the strat of the work and became stably about 25 minutes. Then the stationary condition of the learning will begin about 26 minutes from the start of the work.

(4) Subjects were classified into four groups according with the flicker pattern in the work-

ing hours.

It was found that the learning process was differnt in each groups. From this, it was decided whether the subject was adapted to this work or not.

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