

A Study of the Work Load in a Monotonous Task

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Synopsis

The work load given to workers by a monotonous task was investigated. Their load was obtained by measuring the flicker value and observing its fluctuation pattern. Each flicker fluctuation was classified into one of the three patterns. It was found that the mental load of the subject carrying out the task by himself tends to become lighter according as the speed increases, while the mental load of the subject doing the task with his companion does not show this tendency. On the other hand, the scores of the disposition tests were analyzed with regard to the flicker fluctuation pattern by using the discriminant function.

§ 1. Introduction

In the modern world, where various kinds of capital and machinery have been playing a leading role, the conveyor system has been considered to be most efficient when its speed is settled so as to economize the line control. In the very present time, however, the gap between the efficiency of machines and the human adaptability to environments has become great. Consequently, it will be best to decide the conveyor speed not only by taking into account the economization of the line control, but also, from the viewpoint of labor control, by trying to keep the worker's body and mind as sound as possible.

The present experiment was carried out in order to find the most effective conveyor speed in a very monotonous kind of work. The ideal speed was decided by examining the fluctuations of flicker value that the subject showed as the result of the various given speeds of his monotonous task. The fluctuation of flicker value is generally considered to be indicative of the worker's mental load in the monotonous task, namely, the task which does not require so much physical and mental labor.

The experiment proceeded as follows. The subject was made to do the monotonous task under three different working conditions. The flicker value of the subject under each working condition was measured in order to know how much the subject was influenced by the

task. Next, the difference of the influence, that is, work load given to the subject, was examined between when the subject did the task by himself and when he did the same task with another subject sitting next to him. In order to estimate the work load of the subject, the interrelation between his scores of disposition tests and the fluctuations of his flicker value was investigated.

§ 2. Methods

The monotonous task chosen for this experiment consisted of placing cards at indicated positions. Each card was 30mm square in size and had one of the numeral letters 1 to 5 written on it. Every card was kept in the box till it was taken out and placed on the square of the same size drawn at even intervals on a square board (500×500). This drawn square also had one of the 1 to 5 numerals written on it (Fig. 1). The subject was required to place each card on the drawn square with the same numeral letter that the card had. He was also required to arrange the cards in order beginning from the top left of the board. The period between his taking up the card and the next same act was settled even (work speed); he was informed of each time to place the card at the proper position by an intermittent pure sound (500 Hz/sec for 0.5 sec.). The moment he heard the sound of signal, the subject placed the card at the proper position, and then he was permitted to seek out the next proper card

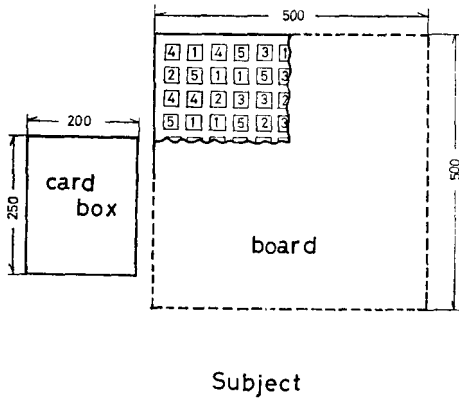


Fig. 1 Arrangement of the subject and experimental apparatus

and wait for the following signal.

The three different working conditions were that the subject should arrange 50 cards in 5 min. (C1), 90 cards (C2) and 110 cards (C3) in the same period. In the case of C1, the subject had to wait for the following signal for a considerable time. The work speed in C2 was moderate enough for the subject to do his task with ordinary efforts. In the case of C3, however, the subject had to make great efforts in order to arrange cards exactly according to the signal.

The total task period of one subject was 60 minutes, and each period consisted of 12 sessions of continuous 5 minutes each. The flicker value was measured five times after each session, and its mean value was calculated.

The subjects were male students of 20—23 of age. Each one was made to do the given task under one working condition in a day so that the result might be as exact as possible. The subject was kept by himself during his task, and he was observed with a video camera from the next room, where measurements were carried out.

In order to estimate the work load of each subject by using the discriminant function, *Taken* disposition test and *Yatabe-Guilford* (Y-G) test were made on every subject, because disposition is considered to have something to do with the work load.

§ 3. Results

The fluctuations of flicker value during the task were classified into the following three patterns (P1, P2, P3) in order to know the degree of the work load by grasping the fluctuation as time series.^{1), 2)}

- P 1: The flicker value always became higher than the initial one, that is, the flicker value before the task. This signifies that the mental load to the subjects was small.
- P 2: The flicker value became higher or lower than the initial value. This implies that the mental load was moderate.
- P 3: The flicker value became lower and lower after the beginning of the task. This shows that the mental load was considerably large.

Fig. 2 shows each typical pattern of these three kinds.

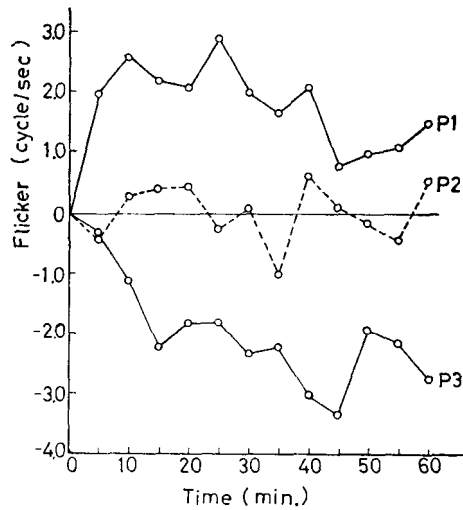


Fig. 2 Typical patterns of flicker fluctuation

(I) Working by oneself

The results of the task done separately by each subject under three different working conditions were classified as shown in Table 1. The results in the case C 1 (slow pace) mostly

Table 1 Distribution of the subjects in flicker patterns. The numbers in parentheses show values revised so as to make each total number 32.

Work speed \ Pattern	Pattern			Total number of subjects
	P 1	P 2	P 3	
C 1	0 (0)	8 (9)	19 (23)	27 (32)
C 2	10	12	10	32
C 3	13 (14)	13 (14)	4 (4)	30 (32)

come under P 3 (falling pattern) and not at all under P 1 (rising pattern). This may seem contradictory, but is considered to be quite natural. It is true that the physical load was least under C 1, but the subject was compelled to wait for a considerable while between the acts of arranging cards. This waiting is considered to have made the subject feel much the monotony of his task, and as the result his mental load became great. Consequently, his flicker value went down.

In the case of C 2 (moderate pace), the results come under three patterns almost equally. This shows that the subjects' mental load was different from one another's, although the amount of each one's physical labor was the same. One of the reasons for such a result may be that all the subjects were students who had never done such a monotonous task of arranging cards at a given interval and were apt to respond variously to their working environments. Therefore, this difference may have been caused by the difference in disposition of the subjects.

The results in the case of C 3 (fast pace) are contrary to those in the case of C 1, that is, there are few that come under P 3 (falling), and many come under P 1 (rising). This shows that the subjects' flicker value was high, in other words, they did not feel so much the monotony of their task in spite of the great amount of their physical labor and the greatest efforts they had made.

From these results it was found that the mental load tends to be lighter according as the working speed increases. It may be concluded that the mental load of the worker has a close relation with the speed at which he carries out his monotonous task.

(2) Doing the task with another subject

When two subjects did the same task of arranging cards, sitting side by side and talking freely with each other, the results were as follows. These are shown in Table 2.

In the case where they worked with a slow pace (C 1), there were more subjects who showed the rising pattern (P 1) than when they worked separately. In the case of C 3, on the contrary, the number of the subjects showing the falling pattern (P 3) increased, compared with that in the case of working by oneself. In other words, regardless of the difference in

Table 2 Distribution of the subjects in flicker patterns. The numbers in parentheses show values revised so as to make each total number 40.

Work speed \ Pattern	Pattern			Total number of subjects
	P 1	P 2	P 3	
C 1	8	18	14	40
C 3	12 (12)	13 (14)	13 (14)	38 (40)

the working condition, almost the same number of subjects showed each one pattern of the three, namely, P 1, P 2, or P 3. This implies the subject's mental load was affected by the presence of his companion, especially under the slow working condition (C 1). This will be easily understood, because it is quite natural that the subject should feel less tired of his monotonous task while working with his companion than when he does it by himself.

It may be concluded that the work load given to the subject by the task has a considerable relation with the environments in which he does his task and that the work load is individually different.

(3) Estimation of the flicker fluctuation pattern by means of the discriminant function

In the first part of this section, the subjects' flicker fluctuations were classified into three patterns, namely, P 1, P 2, and P 3. However, with the purpose of estimating the flicker fluctuation pattern without carrying out the above-mentioned experiment, the following analysis was attempted. The scores of disposition tests obtained by each subject were analyzed by using the linear discriminant function, and all the subjects were discriminated and divided into each two pair groups, namely, P 1 and P 2, P 2 and P 3, and P 3 and P 1. The error probability (α) of this discrimination is shown in Table 3 (Taken) and Table 4 (Y-G).

Table 3 Error probability of pattern classification (Taken)

Group \ Work speed	Work speed		
	C 1	C 2	C 3
P 1 — P 2	—	31	34%
P 2 — P 3	27	40	—
P 3 — P 1	—	38	—

Table 4 Error probability of pattern classification (Y-G)

Work speed Group	C 1	C 2	C 3
P 1 — P 2	—	11	15%
P 2 — P 3	20	12	—
P 3 — P 1	—	24	—

The discriminant function of each of the two tests, *Taken* and *Yatabe-Guilford*, is as follows:

$$Y = A_1X_1 + A_2X_2 + \dots + A_5X_5$$

(X_i : Scores of *Taken* disposition test consisting of five items)

$$Z = B_1Y_1 + B_2Y_2 + \dots + B_{12}Y_{12}$$

(Y_i : Scores of Y-G disposition test consisting of twelve items)

For example, the discriminant function between P 1 group and P 2 group in the case of C 2 is as follows:

$$\begin{aligned} Z = & 0.019y_1 - 0.414y_2 - 0.101y_3 + 0.363y_4 \\ & - 0.168y_5 + 0.269y_6 + 0.255y_7 - 0.481y_8 \\ & - 0.108y_9 + 0.374y_{10} - 0.001y_{11} - 0.477y_{12} \end{aligned}$$

The mean of Z of P 1 group is -4.17 and that of P 2 is -10.24 , and the discriminant point is -7.21 . When the value of Z , which was determined by substituting Y_i with scores of the disposition test, is larger than the discriminant point, the subject's pattern is judged to be P 1. When Z is smaller than the discriminant point, the pattern is considered to be P 2. And the error probability in this case is 11%.

The error probability in such a pattern classification according to the scores of the Y-G test is smaller than 25%. As there were no

patterns of P 1 type in the case of C 1 and few in the case of C 2, the discriminant function in these cases were not calculated.

When the *Taken* test was employed, each error probability was larger than 25%, and consequently this kind of test is considered to be inferior to the Y-G test.

§ 4. Conclusion

The degree of the work load given to subjects by a monotonous task was studied by measuring their flicker values. Furthermore, their scores of disposition tests were analyzed by using discriminant functions with regard to their flicker fluctuation patterns.

The conclusions obtained from these results are as follows:

1. The degree of the mental load of a worker carrying out a monotonous task depends upon the working speed or upon environmental conditions: When the worker does the task by himself, his mental load tends to become lighter according as the working speed increases, but when he does the task with his companion, the mental load tends to be light especially at a slow working speed.

2. It is possible to classify the workers' flicker fluctuation patterns by analyzing their scores of the Y-G disposition test with the linear discriminant function.

References

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