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Evaluation of Work Decrement Indicators

Virtus W. Suhr
Iowa State College

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By Virtus W. Suhr

The Problem

The primary purpose of the study was to determine the nature of the practice curves for various types of measurement postulated as fatigue detectors. At the same time it was thought advisable to design the experiment in such a way as to secure some information on the effect of ingestion of tea on certain psychomoter performance tasks at different practice levels as well as throughout the entire series of practices.

In other words this study was set up to select some promising techniques for measuring work decrement over a period of several hours continuous performance and to establish the degree of learning to be expected from successive practices. This was necessary to facilitate the selection of the most efficient and practical fatigue detectors available which might be used in a major study on the effect of tea pauses on continued performance of a complex nature such as driving an automobile. The data were also important for establishing correction constants for different stages of learning.

All the five measures studied here were known to have sufficient reliability to be used as detectors or indicators. The coefficients reported are of the order of .90 or above. See (1).

Two hypotheses were set up for experimental testing for each of the measures as follows:

1. There is not sufficient improvement in the function through practice to affect comparison of the third practice with the fourth practice as will be necessary in the main experimental study on tea pauses.

2. The effects of tea on alternate performances are sufficiently consistent to make a noticeable difference in scores obtained on the tests used for this study.

Method and Procedure

The method was essentially that of administering the series of tests to each of six subjects in order to obtain a learning curve according to the following schedule of practice:

First Day: Three minutes of orientation followed by—(1) Float-

ing pursuitmeter performance, two trials of one minute 20 seconds each. (2) Three-hole pursuitmeter, one trial of one minute 20 seconds. This is a test primarily of coordination. (3) Activity, two 30-second trials. (4) Steadiness, ten trials alternating hands each time. (5) Choice reaction time, 25 trials. Three aspects of choice reaction time were considered; (a) mean time, (b) average variability, and (c) false starts.

This routine was repeated for the no-tea practices on the third, fifth and seventh days for every subject in precisely the same fashion without refreshments.

The tea-practices were given as follows:

Second day: Refreshments, namely tea, with additive if desired, and a ten minute rest period following ingestion of the beverage. (1) Floating pursuitmeter, two trials of one minute 20 seconds each. (2) Three-hole pursuitmeter, one trial of one minute 20 seconds. (3) Activity, two 30 second trials. (4) Steadiness, ten trials alternating hands each time. (5) Choice reaction time, 25 trials. This sequence was repeated on the fourth and sixth days.

The tests were administered to each subject at approximately the same time every day. Tea was served on the second, fourth, and sixth days as indicated. No tea was given on the first, third, fifth and seventh days. It was thought that having both the first and last testing periods on no-tea days would tend to equalize or distribute the practice effect.

The subjects used were five men and one woman ranging in age from 17 to 21 years. All subjects had alternate practices with and without tea. Their driving experience ranged from two to seven years and from a total of 4,000 to 80,000 miles. They were selected on this basis since the main study required experience in driving. All were students at Iowa State College. They were told that the study was being made to devise techniques for measuring an individual's general level of efficiency at a particular time.

Apparatus and Procedure

The Weiss-Renshaw Pursuitmeter (3), a laboratory pursuit device that traces an irregular pattern which repeats every 7-8 minutes was used with two variations. Normally the subject follows a solid target with a rigid handle stylus. In the present study two separate phases were used. (1) The floating pursuitmeter task. This consists of having the subject hold a vertical pin in a hole about 3/8 inch in diameter so that it does not touch

the sides or edges while the pattern is being traced by the pursuit-meter. Any contacts are recorded by a polygraph on a paper tape. The number and spacing of contacts may thus be studied separately. Not only the score but variability of performance is indicated. The object of the test is to follow the moving hole without making contact with the side as described. Two one minute and 20-second trials were given at each setting. (2) The three-hole disc is set so that it moves along the pattern traced. On the disc three targets are so spaced as to form the vertices of an equilateral triangle. The subject is instructed to tap the moving contact points, always in same order of rotation, with a flexible-handle stylus as he keeps time with a metronome set for 112 beats a minute. These contacts are also recorded on the polygraph record so that the regularity of bull's-eyes can be studied.

The activity test consists of a telegraph key wired in series with a polygraph pen which records the number of contacts made in a 30-second period. A gap in the record would indicate a muscle block on the part of the subject or a missed contact usually associated with blocking. Two 30-second trials were given and the number of blockings recorded for each. It should be stated that certain persons tend to tense themselves voluntarily as was noted by Ream (2).

The steadiness test was administered by having the subject move a straight stylus downward through a gradually narrowing slotted opening between two metal strips. The distance that the subject moves the stylus downward toward the narrower end without touching the metal determines his score for that trial. A series of ten trials, alternating right and left hands for each trial, constituted the task for each sitting. The mean point of contact is used as the score.

To measure choice reaction time, red, green, and amber lights were presented serially in random order. The subject is told to respond only to the red light. The response time for the red light is measured in hundreths of a second. The "false starts" or attempts to respond to other than red are registered by a counter.

The data were recorded as obtained and then grouped according to tea and no-tea days. The mean score for all subjects on each test was computed for each practice period. An overall mean for each test was computed for tea and no-tea days. The difference between these means was used as a basis for comparison.

For the number of cases used the most important index is probably the consistency of magnitude and direction.

Results

The differences between the means for each of the factors considered are shown in Table 1. In most learning studies where several practices are required it is impractical to obtain enough cases to establish significant difference directly.

Table 1 shows the results obtained on each of the experimental tests. Those which showed consistent differences throughout are graphed in Figures 1, 2, 3 and 4.

Table 1

Factor	Experimental Conditions*	Means	M_1-M_2
Choice Reaction Time	1	3.080	
False Attempts	2	2.220	0.860
Choice Reaction Time	1	6.253	
Average Variability	2	5.998	0.255
Choice Reaction Time	1	33.860	
Mean Time	2	34.480	-0.620
Floating Technique	1	14.500	
First Trial	2	11.800	2.700
Floating Technique	1	14.700	
Second Trial	2	10.500	4.200
Floating Technique	1	28.800	
Total	2	22.500	6.300
Three-hole Technique	1	21.888	
	2	21.888	0.000
Activity	1	120.500	
First Trial	2	129.333	-8.833
Activity	1	119.333	
Second Trial	2	123.666	-4.333
Activity	1	235.666	
Total	2	252.833	-17.167
Steadiness	1	8.800	
	2	8.800	0.000
Muscle Block	1	3.583	
First Trial Activity	2	3.718	-0.135
Muscle Block	1	4.458	
Second Trial Activity	2	4.165	0.293
Muscle Block	1	8.040	
Total	2	7.880	0.160
Steadiness	1	2.540	
Average Variability	2	2.480	0.060

*1—No-Tea
2—Tea

Discussion

The floating pursuitmeter technique, choice reaction time—"false starts" as well as mean time—seem to consistently differen-

tiate the tea practices from the no-tea practices. The subjects made fewer contacts on the floating pursuitmeter on the days they were served tea prior to the tests. This seems to indicate that the tea has a calming effect which increases steadiness as formerly reported. The difference is shown graphically in Figure 1.

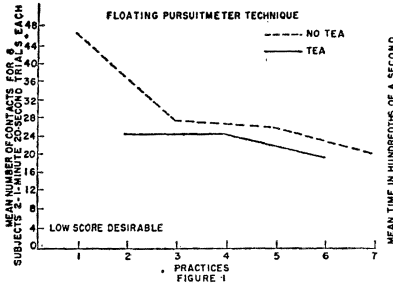

FIGURE 1

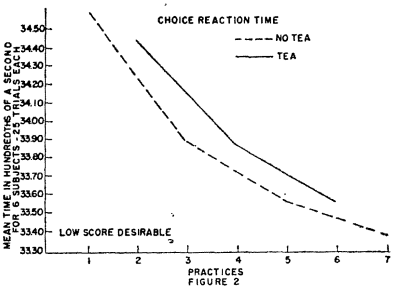

FIGURE 2

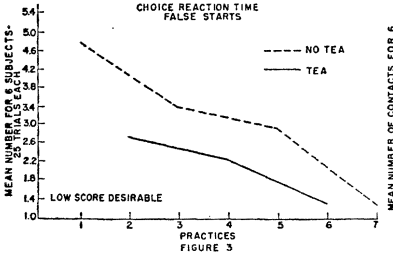

FIGURE 3

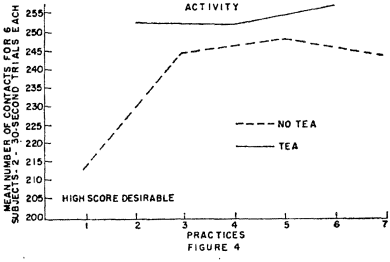

FIGURE 4

The calming effect of the ingestion of tea is further supported by the results obtained from the choice reaction time tests. Consistently the subjects took slightly longer to react on the days they had tea. This observation would indicate a lower level of tension. However, the quality of the reactions was superior as evidenced by fewer "false starts" (i.e. reaction to other than the red light) on the tea days. The results are shown graphically in Figures 2 and 3.

There was also a consistent difference in the activity test which showed higher performance on the tea days. This averaged considerably higher and would no doubt show a significant difference with more cases.

Steadiness did not show a difference in this particular study, with and without tea, but it had held up before and is somewhat related to the floating pursuit type of performance. With a few cases one extreme can very well exercise undue effect.

Average variability in steadiness did not hold up as an indicator. It may, however, be an effective work decrement indicator.

Results from the muscle blocking hypothesis were equivocal. Further work needs to be done on this aspect. Average variability in tapping seemed to decrease slightly which would support the observation that there is a relaxing effect from ingestion of tea ten minutes before the onset of performance.

It was finally decided to retain steadiness as an indicator since the number of tests possible to use was limited by the time available for them in the regular experiment. Also choice reaction was retained for the main experimental study. Other considerations deciding the acceptance of tests as fatigue detectors was the amount of improvement to be expected within the first four trials or practices.

Conclusions

Within the limits of the design, number of subjects, primary purposes of the experiment, and other conditions and limitations of this study the following tentative conclusions may be drawn.

1. In general the first hypothesis stated is affirmed in some degree for "floating pursuit", steadiness, choice reaction time and activity. It may be necessary to establish a slight correction factor for comparison of successive trials for certain variables used as indicators.

2. The second hypothesis is also affirmed consistently for certain variables but not for others. Floating pursuit performance, choice reaction time, "false starts" and activity showed consistent results.

3. Although blocking may be a good indication of fatigue it does not seem to be greatly affected by ingestion of tea as measured under the conditions of the present study.

4. While the magnitude of difference found cannot be shown to be significant with the number of subjects used, nevertheless the consistency in trends of the curves substantiates their validity.

5. Less differences are noted between practices 3 and 4 than between 1 and 2. This would favor the use of these trials as indicators with a reasonable adjustment for each type of measurement used.

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Driving Research Laboratory
Iowa State College
Ames, Iowa