Effect of Rest Pauses and Refreshment on Driving Efficiency*

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● REST pauses have been effectively utilized in certain industries to combat the loss in worker efficiency due to fatigue and monotony. Although there is not complete agreement as to the optimum length of time for the pause or when it should be introduced in the work period (8), few will deny its practicality.

Early research (6) has shown that long automobile drives tend to produce a loss of efficiency of certain discriminations, association processes, and motor reactions similar to those required in driving. These observations also suggest that a long automobile drive may render a driver temporarily susceptible to accidents. Much has been attributed to highway hypnosis with very few experimental facts available. One study by Lauer and McMonagle (5) touched on certain aspects of the problem.

Reports by certain insurance companies operating throughout the country indicate that a large percentage of their accidents occur during the first 3 hours of driving. Their insured are for the most part commercial drivers who start on a trip and drive for several hours. For lay drivers this would not be very convincing since it is conceivable that most of their trips are completed within a period of 3 hours.

It seemed advisable to set up an experimental situation to determine what effect, if any, the introduction of a rest pause with refreshments at regular intervals would have on the efficiency of automobile drivers.

This is the first phase of a special study on the effect of refreshment pauses on driving efficiency and will cover only the orientation and practice period of approximately 6-hour duration. Three hours were spent behind the wheel in a simulated driving situation. The remainder of the time was spent in orienting and testing the subjects on a battery of efficiency tests.

METHOD AND PROCEDURE

The method was that of a controlled experimental approach using matched groups to determine the nature of their performance in a simulated driving situation continuing for a 3-hour period. While it was impossible to match the groups exactly, they were matched as nearly as possible with respect to sex, age, and driving experience.

Thus two groups of 28 and 25 subjects respectively, used in the practice run, are included and the results from their performance will be considered in terms of (a) nature of their efficiency curves on several aspects of simulated driving as described, and (b) basic efficiency measurements made before and after the 3-hour driving period.

These two sets of measurements were made in order to determine, if possible, what psychological or physiological effects might result from a period of 3 hours performance with and without pauses such as are described.

One group of 28 subjects, used as a control, drove for three hours straight, receiving no rest pause or refreshments. Henceforth they will be designated as the no-pause group. The other 25 subjects, making up the experimental group, were served tea just prior to the driving period. After $1\frac{1}{2}$ hours of continuous driving each was given a 15-minute rest period during which time tea was again served. The drivers following this procedure will be referred to as the refreshment-pause group.

FACTORS CONSIDERED

The experimental procedure consisted of administering a series of efficiency tests to each driver before and after the simulated driving phase of the study. Included a-

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mong the tests were the following:

1. The Steadiness Test. The subject moves a stylus downward through a gradually narrowing slot between two metal strips. The distance that the subject moves the stylus downward without touching the sides determined his score for that trial. A series of ten trials, alternating hands each trial, constituted the test. The average score is used as the index of steadiness of muscle control or lack of tremor.

2. Choice Reaction Time. The subject is seated with the right foot placed on a break-type switch adjacent to a simulated brake pedal. He is instructed to hold his right foot on the switch just as though he were pressing the accelerator of an automobile.

Green, amber, and red stimulus lights are presented in random order. The subject is instructed to respond only to the red light, that is, as soon as the red light appears, to move his right foot from the switch and place it on the brake pedal as quickly as possible.

Reaction time to the red light is recorded. False reactions, such as responding to a green light, are counted by an electronic device. The test continues until the red light is presented 25 times. Several amber and green lights are given as distraction stimuli. The number of presentations is constant for each subject.

3. Coordination. This is measured with a device developed at the Driving Research Laboratory for use with Army drivers. A platform maze is controlled by means of two levers. One moves the tilting top upward or downward from front to back. The other tilts it in a similar manner from side to side. A steel ball bearing of $\frac{7}{8}$-in. diameter can be guided around the maze by manipulating the levers. At various places along the courses, holes are located through which the ball will drop if the levers are not manipulated properly to maneuver the ball around them. The object is to guide the ball bearing through the maze without its falling into one of the holes. There are 20 holes numbered 5, 10, 15, 20, etc., up to the end dock which is 100.

The holes are numbered progressively so that the further the ball has advanced around the maze before it falls through a hole, the higher the score. Thus the number at the hole where the ball is lost determines the score for the trial. Each subject is given five trials and the average is used as a score. It is postulated that this device measures motor control, carefulness and perseverence, along with perceptual accuracy and attention.

4. Blood Pressure. The Tycos Self-Recording Sphygmomanometer was used for measuring blood pressure. This instrument is particularly adapted for use in this type of study since it makes a graphic recording that can be studied by more than one person and increases objectivity in the analysis of results.

5. Galvanic Skin Response, Pulse, and Respiration. A Stoelting No. 22496 Deceptograph was used for obtaining these measurements. The subject is seated

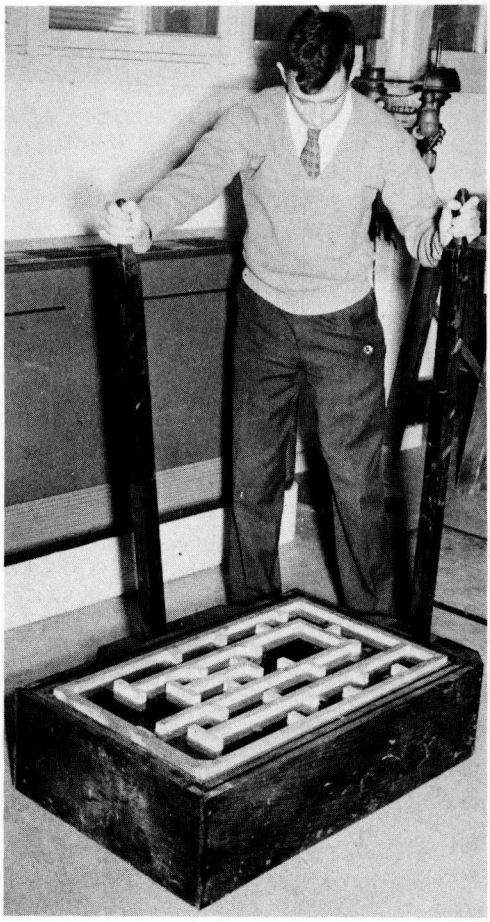

Figure 1. Coordinometer.

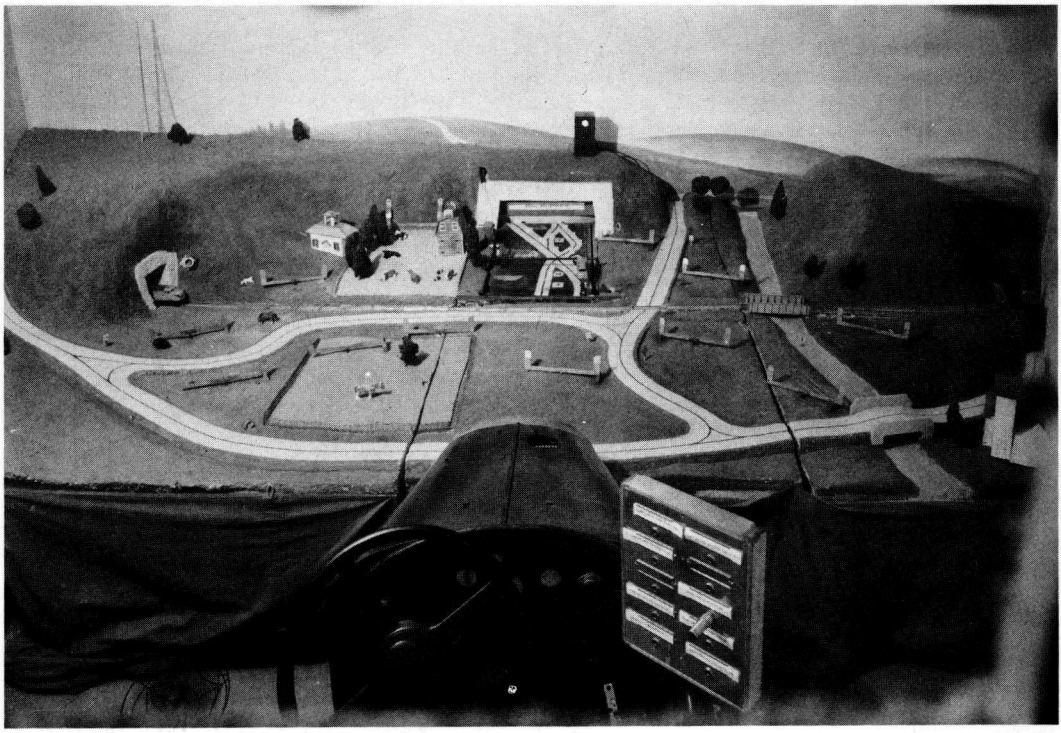

Figure 2. Drivometer.

comfortably in a lounging chair and told to relax as much as possible. A pneumatic cuff is placed around one wrist and inflated sufficiently to bring out the pulse beat.

The pneumograph, a black rubber convoluted tubing with suitable attachments, is fastened around the chest tight enough so as to stretch and contract as the subject breathes. A finger electrode is attached to the middle finger of each hand in order to obtain a measurement of skin resistance. A record of the pulse, respiration and galvanic skin responses is thus obtained for a one-minute period for each measurement—both before and after the driving period.

After the preliminary efficiency tests, each subject in the refreshment-pause group was taken into a booth built to resemble a small roadside stand where tea was served, with or without additives as desired. The subject was allowed to drink the tea at his leisure, second servings were available, if desired. The no-pause group went directly from the efficiency tests to the simulated driving phase of the study.

The driving performance was done in the laboratory. The apparatus used was the Drivometer (3, 4, 5) located in a special booth designed at Iowa State College for measuring and recording the reactions of drivers under laboratory conditions. The Drivometer is a device so constructed that the subject sits in a mock-up car using full-size automobile controls to drive a miniature car around a traveling roadway.

The special booth built around the Drivometer is designed to provide proper controls of the simulated driving conditions. The booth is air conditioned and the temperature kept at 70 deg. The relative humidity averages around 57 percent.

In order to compute a steering score, vertical protrusions are attached to the right side of the roadway in such a fashion that when the miniature car crosses one, it operates a quick-acting counter. The total number of contacts made constitutes the steering score. Thus the degree to which one keeps the car on the road is objectively recorded.

A signal box containing a red and green light similar to the conventional traffic control devices is placed above and to the right of the traveling roadway. The time required for the subject to depress the brake pedal after a red light appears in the signal

box is described as stop-light-response time.

An electric train is installed in the special booth on the mock-up landscape so that it can be made to emerge from a tunnel into the view of the driver at the will of the experimenter. The driver is instructed to depress the brake as soon as he sees the train.

As the train leaves the tunnel an electric contact starts a Standard time clock calibrated in terms of $\frac{1}{100}$ second which is stopped when the brake pedal is first depressed. The time elapsing has been designated in this study as train-reaction time.

Located above the roadway is a small aperture through which printed instructions are presented. To the right of the driver is a control box on which is printed another set of each of the instructions which appear in the aperture. The subject is instructed to stop the car as soon as he sees instructions appear in the aperture and plug in a jack below the matching instructions on the control box. Then he follows the directions as stated. The time required for the subject to note and read the instruction line, comprehend it, and plug in as instructed constitutes the error time.

At the beginning of the driving phase, a control test run covering the series of seven instructions is made. During this time the red light and the train are each presented on five different occasions. The time required for the driver to perform the exercises as outlined in the instructions is measured by a second Standard time clock and recorded as the total-trip time. This series of evaluations will be referred to as a test-run. The before and after test-runs yielded the following data: (1) steering score, (2) stop-light-response time, (3) train-reaction time, (4) error time, and (5) total-trip time.

THE WORK PERIODS

The subjects were told to drive the Drivometer just as they would on the open highway as soon as the instructions ceased to appear in the aperture at the end of the test-run. The stop-light and train are consistently presented five times each ½ hour. These ½-hour intervals of simulated driving are called work periods.

After 1½ hours of continuous driving, the subjects in the refreshment-pause group are given a 15-min rest period and again served tea as previously described. The no-pause group drive for 3 hours straight.

Ten minutes prior to the end of the last work period, a second test-run is given. As soon as the simulated driving phase is completed, the efficiency tests are administered again in the same sequence as followed before, thus completing the experimental cycle in this, the first phase of the study. The subjects are paid standard wages by the hour for the time taken by the experiment—about 6 hours for the practice run.

TREATMENT OF RESULTS

The mean scores on the factors measured during the test-run and also the mean scores on the factors measured by the efficiency tests were computed for the two groups,

TABLE 1

TEST-RUN - REFRESHMENT-PAUSE GROUP
(Made to establish the presence of practice effects and/or decrement)

Factor	Mean Before	Mean After	$M_b - M_a$	t-Value
Total-trip time	4.716	4.212	.504 A[b]	1.115
Error time	1.153	.838	.315 A	2.067[a]
Stop-light-response time—mean	2.122	2.145	-.023 B	.032
Stop-light-response time—a. v.	2.060	2.632	-.572 B	.401
Steering	99.760	103.800	-4.040 A	.348
Train-reaction time—mean	.924	.936	-.012 B	.063
Train-reaction time—a. v.	.788	.640	.148 A	.851

[a] Significant at the five percent level.
[b] A = increment or improvement, B = decrement or loss.

both before and after the driving period. The differences between the before and after group mean scores were computed for each variable measured for both the refreshment-pause and the no-pause group. A t-test with pooled variance was made to determine whether the differences found were statistically significant.

No attempt was made to determine the significance of group differences in this phase

TABLE 2

TEST-RUN - NO-PAUSE GROUP
(Made to establish the presence of practice effects and/or decrement)

Factor	Mean Before	Mean After	M_b-M_a	t-Value
Total-trip time	4.726	4.207	.519 A[c]	1.312
Error time	1.081	.878	.203 A	1.436
Stop-light-response time—mean	3.128	1.319	1.809 A	2.131[a]
Stop-light-response time—a. v.	3.938	.706	3.232 A	2.763[b]
Steering	83.214	87.036	-3.822 A	.420
Train-reaction time—mean	1.139	1.024	.115 A	.699
Train-reaction time—a. v.	.820	.619	.201 A	1.021

[a] Significant at the five percent level.
[b] Significant at the one percent level.
[c] A = increment or improvement, B = decrement or loss.

TABLE 3

EFFICIENCY TESTS - REFRESHMENT-PAUSE GROUP
(Before and after practice run)

Factor	Mean Before	Mean After	M_b-M_a	t-Value
Blood pressure				
Systolic	127.360	125.280	2.080 A[c]	.263
Diastolic	66.120	66.800	-.680 B	.324
Steadiness	8.128	8.820	-.692 A	1.144
Choice reaction time				
False attempts	2.560	2.040	.520 A	.524
Mean	38.297	37.670	.627 A	.358
A. V.	7.313	6.262	1.051 A	1.731
Coordination	43.400	46.280	-2.880 A	.356
Pulse				
Rate	78.160	70.920	7.240 B	2.865[b]
Regularity	1.007	1.015	-.008 B	.707
Oscillation	1.200	1.120	.080 B	.395
Bridge measurement	102150.400	99016.800	3133.600 B	.063
Respiration				
Frequency	15.120	15.240	-.120 B	.084
I/E ratio	.767	.733	.034 B	.412
I/E variability	.287	.157	.130 A	2.029[a]

[a] Significant at the five percent level.
[b] Significant at the one percent level.
[c] A = increment or improvement, B = decrement or loss.

TABLE 4

EFFICIENCY TESTS - NO-PAUSE GROUP
(Before and after practice run)

Factor	Mean Before	Mean After	M_b-M_a	t-Value
Blood pressure				
Systolic	132.000	120.071	11.929 A[b]	1.835
Diastolic	67.893	66.143	1.750 A	.764
Steadiness	8.028	7.982	.046 B	.110
Choice reaction time				
False attempts	1.678	.786	.892 A	2.730[a]
Mean	38.840	39.924	-1.084 B	.675
A.V.	7.876	7.417	.459 A	.534
Coordination	43.464	46.750	-3.286 A	.427
Pulse				
Rate	75.750	71.178	4.572 B	1.786
Regularity	1.002	1.006	-.004 B	.100
Oscillation	.928	.964	-.036 A	.161
Bridge measurement	101580.357	112371.071	-10790.714 A	.089
Respiration				
Frequency	15.178	15.214	-.036 B	.031
I/E ratio	.775	.772	.003 B	.071
I/E variability	.335	.401	-.066 B	.584

[a] Significant at the one percent level.
[b] A = increment or improvement, B = decrement or loss.

of the study. They are being considered in the main experimental run during which each subject spent six hours behind the wheel. The objective in this phase of the study was to determine the nature and extent of practice effects and/or decrements on the various measures used.

The factors measured during the work periods were analyzed graphically so that not only the differences but also any changes in direction of performance could be revealed.

The mean scores, differences between the means, the t-values for the factors measured during the test run are shown in Table 1 for the refreshment-pause group and in Table 2 for the no-pause group.

The error time was significantly less on the second test run for the refreshment-pause group. Since this was the first time any of the subjects had driven the Drivometer, it is probably due to practice effect and learning rather than to an increase in efficiency. The purpose of this phase of the study was to practice all subjects.

The significantly faster stop-light-response time on the second test-run for the no-pause group as compared to the very low t-value indicating no change for the refreshment-pause group seems to substantiate previous findings (7) suggestive of a calming effect from the ingestion of tea. This may be an indication that tea has a beneficial effect on driving performance. The National Safety Council has cited data indicating that reaction time is related to accident rate with the quick reactors having the higher rate.

The highly significant decrease in choice-reaction time false attempts by the no-pause group is contrary to previous findings and against expectations. No satisfactory explanation can be offered for this observation.

The highly significant decrease in pulse rate as well as the significant decrease in breathing variability by the refreshment-pause group seems to indicate a lower level of tension which would possibly have a favorable effect on driving by lessening fatigue.

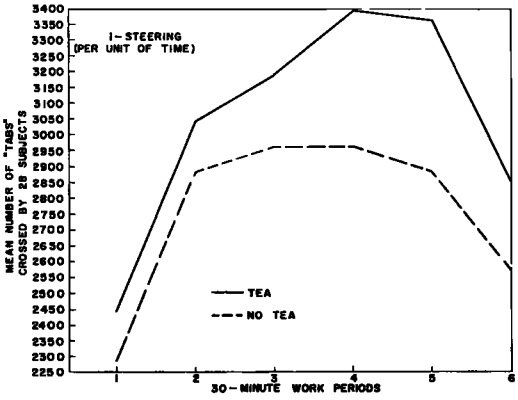

Figure 3. Steering (per unit of time).

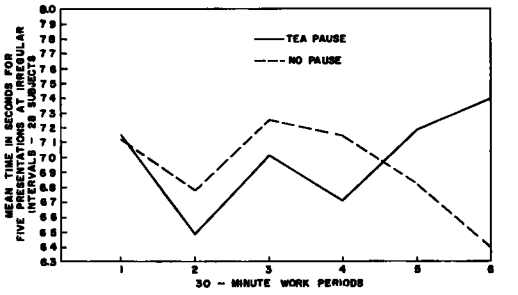

Figure 4. Train reaction time (mean).

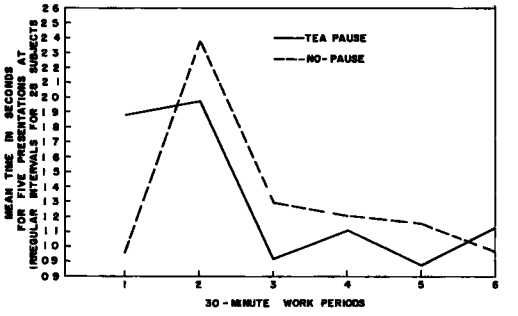

Figure 6. Stop light response time (mean).

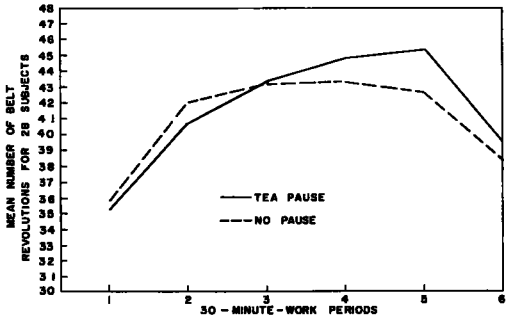

Figure 8. Belt revolutions (per unit of time).

The results recorded for the factors considered during the work period are presented graphically.

The graphs indicate the trend of the work curves throughout the 3-hour period. The tabulations were made at 30-min intervals hence the graph shows a progressive account of performance. Appropriate methods of evaluation of these trends are being considered, both parametric and nonparametric (1).

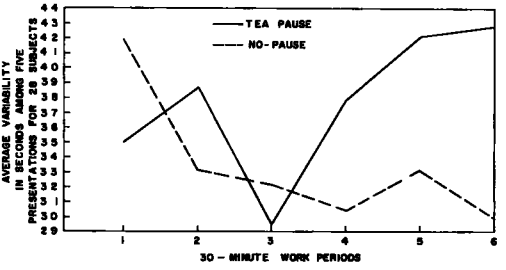

Figure 5. Train reaction time (a.v.).

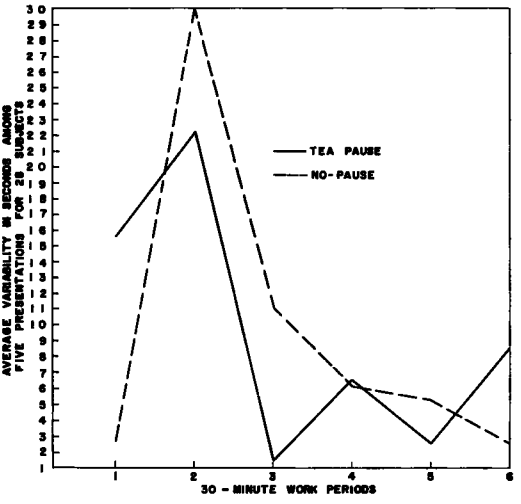

Figure 7. Stop light response time (a.v.).

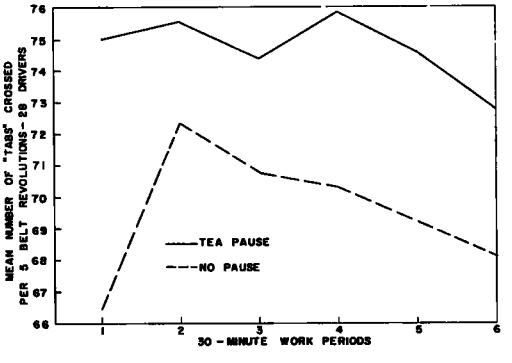

Figure 9. Steering efficiency (per 5 revolutions).

SUMMARY AND CONCLUSIONS

Two groups of 28 and 25 subjects, respectively, were given a practice run of three hours simulated driving on the Drivometer which was installed in a special air-conditioned booth. A series of efficiency tests were administered both before and after the simulated driving period.

One group of drivers, the refreshment-pause group, was served tea just before the driving phase of the study and again during a 15-min rest period after 1½ hours performance. The other group received no rest pause or refreshments. Data were recorded on both groups every ½ hour during the simulated driving period for the factors that could be subjected to continuous evaluation.

The variables that lent themselves to statistical evaluation were so analyzed. The other factors were analyzed graphically to determine the nature, extent, and direction of trends in performance.

A point regarding significance should be mentioned. Without a large number of cases, small differences which are found between two sets of means may not show significance by use of the t-test or comparable tests of significance. When curves consistently indicate a small difference at a number of different points, ordinary two-group comparison methods do not seem to apply. Further study is being made of evaluation methods suitable to the data.

In interpreting the results it must be remembered that the data were gathered during the orientation and practice period preliminary to the main experimental run which involved two groups of 28 subjects each taken through a 9-hour experiment. This study will be reported later. However, the findings seem to support the tentative conclusion that the general effect of the tea and the pause combined has a quieting effect which is reflected in (a) the tendency to work a little harder, (b) sustained alertness, and (c) greater efficiency at the problem at hand. From several phases of the study there is some evidence of a quieting effect and reduction of tension for the refreshment-pause group. Further interpretations are being withheld pending the completion of analysis of the experimental run.

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