REDUCING PSYCHOLOGICAL FATIGUE BY THE INTRODUCTION OF A CHANGE OF TASK

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INTRODUCTION

Definitions

Originally "fatigue" referred only to how people felt in relation to some sort of activity. Fatigue was the aversion toward activity and the feeling of inability to perform.

Fatigue was a self-recognized state of the individual involved in a certain situation. Fatigue was a directly experienced condition with an inferred connection between the way the individual felt and the amount of exertion necessary for him to perform. The study of fatigue in the laboratory brought on a connection between fatigue and work output. Fatigue became synonymous with production.

There are apparently three main views on the use of the world fatigue (Bartley, 1965). (1) The first and broadest is that the word pertains to anything anybody wants it to. (2) It is a word pertaining to biological systems only; but within such limits, it is a term applicable to all levels of description. That is, the person as a total can be tired, so can a muscle fiber, or a neuron. Fatigue is manifested by a reduction in performance of the biological system. (3) Fatigue is a term applicable only in describing people, the total organism, not subsystems or tissue within the organism.

Location of fatigue

It is possible to demonstrate the existence of changes produced at different locations of the body by isolating these parts. These isolated areas lead to a better picture of what occurs in the whole body during

physical work. It should be pointed out that this view may not give a true picture of the entire system in operation.

A piece of muscle may be removed from an animal and caused to contract by the application of an electric shock to it. Repeated stimulation causes a reduction in the amount of the contraction. Also, after repeated stimulation, the muscle will relax less after each stimulation. This is brought about by chemical changes associated with contraction. As the supply of glycogen is restored and waste products are removed, the muscular contracts return to normal (Maier, 1955). Angelo Mosso, an Italian scientist, developed an instrument known as the ergograph, which was used to measure the relationship between work and muscular fatigue in isolated parts of the body. He studied the muscles in the middle finger by strapping the arm and all other fingers to prevent movement. Only the one finger was allowed to move. This enabled him to study fatigue which was brought on quickly and thus reduced the effect of monotony, which would have been likely if a long test session was required to bring on fatigue.

The nerve can be studied by removing a piece of muscle with the nerve attached. The application of an electric shock to the nerve causes the muscle to contract. After repeated stimulation the nerve-muscle combination will not contract. If the electric shock is then applied directly to the muscle, the muscle will contract. This seems to indicate that the nerve acts as a device to protect the muscle from complete exhaustion. Other evidence of a nerve decrease in performance is the fact that a nerve consumes less oxygen after continued stimulation (Maier, 1955).

Sense organs can become less responsive after a period of continued stimulation. An example of this is the way people get used to an odor. The odor is still there but its signal to the brain is not as predominate. People also get used to continuous noises in their surroundings. This is one reason why audio warning devices used an intermittent noise to sound an alarm. This permits recovery of the audio senses and is therefore more disturbing to the listener.

Evidences of fatigue have been found in the blood stream. The blood of fatigued animals has been placed into unfatigued animals. The results were that the unfatigued animal showed the symptoms of the fatigued animal. The blood acts to remove the fatigue products from a specific area of the body and in this way exposes more of the body to the fatigue product thereby generalizing the feeling of fatigue.

The brain also plays an important part in the study of fatigue. The experience of fatigue could be caused both by the impulses from fatigued muscles and by the effect of the fatigue product in the blood that reaches the brain. People may also feel fatigued in the absence of physical effort. Many people suffer from boredom and monotony. The effects of fatigue on the brain are also governed by motivation as shown by Maier (1955) in the following:

> The end spurt which frequently occurs as one approaches a goal or the end of a day's work is an example of the effects of change in motivation. One may also speed up work to finish a task, despite the fact that muscular fatigue would call for a slowing-down. When it appears that a change is as good as a rest,

> the restfulness of the change is largely psychological. Even a change in instructions, such as requesting a person to lift the weights placed on both his hands instead of continuing to lift only the weight on the right hand, will partly restore the activity in the fatigued right hand.

It would seem unlikely that psychological and physical fatigue are separate processes; they probably interact making the study of fatigue most complex. This points up the fact that in any study of psychological fatigue, steps must be taken to remove, as much as possible, any physical fatigue.

Value of rest pauses

The introduction of rest pauses in work does not make it possible to compare work with and without rest pauses because spontaneous rest pauses inevitably occur, no matter how hard the experimenter tries to control them. The question is whether or not externally introduced rest pauses cause an increase in production.

The question could be raised as to the value of rest pauses in light physical work. In one instance (Vernon and Bedford, 1924) a ten-minute rest pause was introduced into the morning work period for girls engaged in labling. The result was a 20 per cent increase in production. Other studies showed favorable results with a five-minute rest each hour and even a two-minute rest alternated with three minutes of work. It should be pointed out that the evidence cited above was performed in the early part of this century and no tests of significance were cited. Therefore the confidence in the result of these experiments is limited.

The placement and length of rest periods could be expected to vary with the type of work, length of work-day, length of work-week, the sex of the worker, the level of motivation, and possibly the cultural background as well as individual differences.

Another point of interest in this area is the unofficial rest period. If workers do not get rest in official rest periods they can make their own by taking washroom privileges or by causing breakdowns in equipment. It is especially easy for people in office jobs to get extra rest periods. All they must do is stare at the paper on their desk and day-dream instead of reading the material. Official rest periods could reduce these unofficial breaks in work.

Varities of psychological fatigue

Psychological fatigue denotes factors in performance decrement which are more elusive. It refers to mental fatigue as well as monotony and boredom. More specific definitions of these terms (mental fatigue, monotony, and boredom) will be given later. The role of attitudes and motivation also play a large part in the study of psychological fatigue. Boredom is influenced by the way a person views his task.

Work decrement in mental operations

In tasks such as the mental multiplication of two- or three-place numbers, reciting the alphabet backwards repeatedly, and the memorizing of words or syllables produce evidence of fatigue within an hour. Controlled experiments clearly show warm-up and decrement periods in mental work as well as physical work. Maier says that too long a rest period

seems to be a disturbance in any form of mental work. He claims that the person "loses the continuity of the task or gets out of the mood for it". In general, he recommends pauses of about five minutes.

Monotony and its relation to efficiency

Monotony has been regarded as a curse of modern efficiency. It has been said that production line methods destroy pride in workmanship and cause the jobs to be more boring.

The term monotony most generally refers to a state of mind caused by repetitive work (Maier, 1965). Boredom is a more inclusive term and takes into account such items as the personality of the person, his attitude and mood as well as how he perceives the task. Boredom is a subjective reaction. Monotony and boredom can become subtopics under fatigue if it can be shown that performance of work which produces them results in a work decrement. This decrement must be the result of something other than muscular fatigue.

It has been demonstrated that monotony rather than muscular fatigue has led to loss of production (Maier, 1965). The effects of monotony are not greater in the afternoon than in the morning as would be expected if accumulated fatigue were involved. Anticipation of the end of the work day also tends to reduce the signs of monotony. In a study of five repetitive tasks performed for one month each, ten subjects were only able to agree on the boredom level of one task (Wyatt, Langdon, and Stuck, 1937). This shows the amount of individual differences involved in rating boredom.

Psychological effects of repetition

Experiments have been performed on muscles to work them to a point of exhaustion. A few experiments have been performed along this same line with mental activities. The terms satiation or habituation are used to refer to this reduction in capacity to respond to a situation or stimulus.

As reported by Maier (1965), an experiment was conducted on college students in a German university on satiation. For one activity the subjects were required to draw vertical lines on a sheet of paper in a certain pattern, such as alternating groups of lines in twos and threes. The subjects were required to fill out one sheet of paper after another. They were not allowed to stop the experiment.

Variations in the work pattern began to appear after a time. Such variations as large and small lines, heavy and light strokes, as well as tilted and curved marks were reported as common among the subjects. The method of line drawing was also changed. Some strokes were drawn upward and others were drawn downward. Some subjects began to change the work rhythm. Some subjects would fill whole papers with a few strokes. After about four hours the average subject could no longer continue. Complete satiation of the task was accomplished.

A similar study was conducted in which the subjects read a poem over and over again. Variations began to appear such as changes in the accent, punctuation, and word mispronounciation. Finally a state in which the subject was unable to talk was reached.

In both cases the subjects were moved from different stages of from

variability to reduction in quality to difficulties following instructions to a complete inability to go on with the task.

To demonstrate that the inability to perform was not due to muscular involvement, subjects who could not draw the lines were told to write their names on the page and their ability to write was restored. The subjects who could not recite the poem were able to engage in long conversations. Changes in the task without changes in the muscles involved resulted in a restoration of the use of the muscles involved.

The same experiment was conducted on a group of unemployed men who were paid a small sum per hour to serve as subjects. These men worked a full eight-hour day and at the end of their work the pages were as neat and accurate as they were at the start. The men reported they found the work pleasant. The difference in performance was found to be due to the difference in the way the subjects perceived the job. The unemployed men saw the situation as a chance to earn some money and the college students saw the task as being on a treadmill and they experienced "getting nowhere."

Psychological effects of incomplete tasks

In our present society, workers are more and more being called upon to perform incomplete tasks. A worker on an assembly line may only do a small amount of the work on the finished product. This prevents the worker from feeling a sense of completion. It has been shown that people remember incompleted tasks more readily than those which they finished entirely (Maier, 1955). Subjects performed a group of twenty tasks, such as modeling animals, stringing beads, and solving puzzles. Half of

the tasks were allowed to go to completion and the other half were interrupted and their completion was prevented. At the end of the experiment the subjects were asked to list all tasks they had done. Incomplete tasks were remembered about twice as much as completed ones. It was stated that some subjects were even tormented by the incomplete tasks.

There are two possible ways of dealing with the problem of incomplete tasks: to prevent interruptions and to create new task completion points. Interruptions can be prevented by specifying stopping points in the task. A person can be warned that he will be required to stop the task at a certain point thereby allowing him to choose a good stopping point for himself.

There are two ways of creating new completion points. The first way is to group small units into a bundle. This gives the person a sense of completion rather than an endless chain of work. This could be especially useful in clerical tasks in which the person is required to process a large number of the same forms. The person could process bundles of fifty or a hundred forms at a time, thereby giving some sense of completion. The second way is to divide a long job into sections. This also could apply to clerical work in which the person has several tasks to perform. An example of this would be setting goals in a job that would take a long time to complete, such as building a house. The contractor could set a goal for completion of the basement, one for the completion of the frame, and so on. This would give the workers a sense of completion.

Increasing job completion experiences

If the tendency to complete a task acts as a source of motivation,

it should be used constructively. Several examples of the benefit of reducing interruptions was shown by Maier (1955). The paint department of a plant in Detroit was having constant friction between the inspectors and the workmen. The inspectors would interrupt the painters to point out places they had missed and then require the painters to cover the mistake. As a solution to the problem, a man was sent with the inspectors to do all the touchup work. This reduced the interruptions and established harmony as well as increasing the production.

The next example dealt with repairmen in the telephone industry. These men had a tendency to return to the garage before quitting time. There were several possible reasons for this including their reluctance to start a job that they could not finish that day. As a solution the repairmen were given a few small jobs in addition to their regular larger assignments. The men were not expected to complete all the work but were given enough to keep them busy. The men did the little jobs before lunch and quitting time with no reduction in the longer jobs.

Task-completion represents a form of motivation inherent in work. It is a mistake for supervisors to interrupt their workers before task completion is reached to transfer them to some other work. It is important to create an interest in the job. Job satisfaction is more direct in motivation than such items as paid vacations, pensions, and such which must be enjoyed away from the job. The idea of task-completion should be used in conjunction with rest pauses and transfer of the worker from one job to another to reduce boredom. Task-completion points up the care that must be taken in placing rest pauses or work changing periods into the work plan.

Early studies in change of work

One of the earliest experiments on the effects on performance of changes of work was done by Chapman (1917). Chapman had read several papers on the effect of "initial spurts" on short term work. The initial spurts had a higher production rate than the rest of the work period. Chapman chose two mental tasks, one was addition and the other was a cancellation test.

Chapman set up his experiment in the manner shown in Figure 1. The subjects were high school students. Chapman tested five groups of subjects ranging in size from fourteen to twenty-nine subjects. The alternation was accomplished by having the subjects turn the pages of their test booklet every thirty seconds on command of the experimenter.

The results of this experiment were that an increase of 14% was found in the addition task due to changing tasks but the upward change in the cancellation was found to be insignificant. Chapman felt that the reason for the lack of increase in cancellation might be due to the nature of the task. The cancellation required no memory of previous cancellations to produce the next cancellation while the addition required knowledge of previous results.

To obtain more evidence, Chapman conducted another test in conjunction with the first. He alternated addition and rest periods as shown in Figure 2.

Chapman used 24 undergraduates for this test. The results of the second test showed an increase of 21% in the output of addition problems when alternate rest periods were present. Chapman attributed the lower

THIS BOOK CONTAINS NUMEROUS PAGES WITH DIAGRAMS THAT ARE CROOKED COMPARED TO THE REST OF THE INFORMATION ON THE PAGE.

THIS IS AS RECEIVED FROM CUSTOMER.

TRIAL	Half-minute Periods					
	1	2	3	4	5	6
I	A	A	A	A	A	A
II	C	C	C	C	C	C
III	A	C	A	C	A	C
IV	C	A	C	A	C	A
V	C	C	C	C	C	C
VI	A	A	A	A	A	A

"A" Addition Task

"C" Cancellation Task

Chapman's first experimental sequence.

Figure 1.

Trial	Half-minute Periods								
	1	2	3	4	5	6	7	8	9
I	A	R	A	R	A	R	A	R	A
II	A	A	A	A	A	A	A	A	A
III	A	R	A	R	A	R	A	R	A

"A" Addition Task

"R" Rest Period

Chapman's second experimental sequence.

Figure 2.

production in the continuous task to "interference" due to previous work. This is the phenomenon is now referred to as psychological fatigue and it deals with a great many interrelated conditions.

Chapman's study has several strong points including the number of subjects used, and the arrangement of the test periods. Some of the weaker points were the arbitrary scale needed to score the tasks and the short test periods, three minutes and four and a half minutes, which bear no resemblence to actual work periods found in industry. Chapman's study leaves unanswered the question of long-term effects of change of work.

The question of long-term effects of change of work was partially answered in a study by Miles and Skilbeck (1944, original 1923). The experimenters were aware of the advantages of introducing rest periods during the working day to increase output. The experiments were concerned with worker attitude about resting when they were on a piece-rate basis. It was quite likely that the real problem was one of task completion and job interruption as discussed previously.

The experimenters wished to introduce a "change period" instead of a rest period. The change of work period was occupied in the fetching of material needed for their work from the store room. Before this change all the workers obtained their material during the first fifteen minutes of the day and then as required during the remainder of the day.

The present method was studied by the experimenters and it was found that production dropped off at 11 am and 3 pm each day. It was decided to introduce a change period of fifteen minutes at 10:50 am and

at 2:30 pm. It was found that the 2:30 pm change did not produce the desired result so the change period was set at 3:20 pm. This time did not work either so a final time of 3:00 pm was used.

The results were that the production rate did not fall as much as before the change period was introduced. The afternoon change was not as effective as the morning change in reducing fatigue (decrease in production). The experimenters stated that an increase in production of 14.2 per cent was obtained. The experimenters made the following conclusions:

These experiments, considered along with the opinions of the workers, seem to indicate that where the work does not make serious demands on the operative's physical energy, and where the mental fatigue is accompanied with boredom arising from long-continued monotonous work, a change period is at least as effective as, and is even preferable to, a rest period.

A close look at this experiment reveals several limitations and apparent errors in setting up the experiment. First the experimenters failed to state the exact number of subjects or their background, age, and so on. They did say they used ten girls for a production study before the change period was introduced. There is no mention of the exact periods or number of runs covered during the experiment. No control group was mentioned which allows the possibility of increased production due to increased attention as shown by the Hawthorn experiments. The fact that the afternoon change was shifted twice and that even then the results were not as good as expected raises the question

of the possibilities of limits on the gains that can be obtained from a work change. Also the possibility that the interruptions necessary under the old method caused a decrease in performance and that the illimination of these decrements caused the upturn in production. No statistical evidence was presented to establish that there was a difference between the two methods. This experiment only points out the possibility of benefits due to a period of work change.

Poffenberger (1928) conducted an experiment on the effects of continuous mental work. He wanted to check for any relationships between changes in work output and changes in feelings.

Four forms of mental work were used. Each period lasted for five and one-half hours, or until the subject refused to work any longer. The four forms of mental tasks were:

1. Continuous addition which consisted of adding to a two-place number first 16, then 17, then 18, then 19, then 16, etc. at the end of each 30 records a new two-lace number was given.
2. The second task was sentence completion.
3. The third task was judging compositions.
4. The fourth task consisted of fourteen forms of Part I of the Thorndike Intelligence Examination for High School Graduates.

In all four tasks a ten-minute rest period was introduced. This was followed by a feeling report, a short period of work and a last feeling report.

The feelings were recorded on a scale of seven levels as follows:

1. Extremely good
2. Very good (as after a good nights rest)
3. Good
4. Medium
5. Tired
6. Very tired (as at the end of a hard day's work)
7. Extremely tired

Poffenberger took average readings of from 10 to 13 subjects for each of the mental tasks. Poffenberger stated his results as follows:

1. When the records of a number of subjects are averaged there appears to be no positive relationship between changes in output of work in a variety of activities and changes in the feelings.
2. When the individual cases are examined there is at least the suggestion that those who show the greatest falling off in output also show the greatest change in the feelings and that those who show the least falling off in output also show the least change in the feelings.

It appears that Poffenberger ran into difficulty in averaging the results of several tasks. The effect of one task could cancel out the effect of another task. The problem might also have been that the scale used to note changes in feeling was not sensitive enough to detect the changes that may have been occuring at the time. No mention is made of the amount of time the subjects had to note their feelings. This period may have acted as an additional rest pause to hide or reduce the effects of fatigue. His introduced rest period showed no significant change.

Blocking

Mental blocking refers to those periods experienced by those doing mental work when they seem unable to respond and can not, even by effort, continue until after a short time has elapsed. Bills (1931) pointed out that the phenomenon had been observed before but had not been systematically studied.

Bills (1931) used a Zimmerman adjustable speed kymograph to record the responses of his subjects. He tested five forms of mental work: (1) alternate addition and subtraction; (2) reversible perspective; (3) color naming; (4) substitution; (5) opposites. In the first two tasks ten subjects worked for seven minutes a day continuously for eight days. On the third task, the experimenter used 21 subjects for a ten minute period for two days. The fourth task had 12 subjects for 10 minute trials with two practice days and three days of regular trials. The fifth task had 12 subjects who ran three ten-minute tests, one each day for three days.

Due to the infrequency in errors detected in the five tasks, a continuous task was set up for a one hour trial. The experimenter used 12 subjects. For some unexplained reason the experimenter had half of the subjects working on the substitution task and the other half working on the color-naming task. He combined the number of blocks per minute for both tasks. Bills made the following conclusions and interpretations of the results:

1. In mental work involving considerable homogeneity and continuity, there occurs, with almost rhythmic regularity, blocking or pauses

during which no response occurs. The average frequency of these blocks was three per minute. Individuals differed in the frequency of these blocks.

2. Practice tends to reduce the frequency and size of the blocks.

3. Fatigue tends to increase the frequency and size of the blocks, producing a greater irregularity in the flow of responses without reducing the actual number of responses per minute to any extent over a period of up to one hour.

4. The responses between blocks tend to bunch toward the center of the response chart. Fatigue tends to exaggerate the bunching.

5. Individuals who respond rapidly tend to have fewer and shorter blocks than slow individuals.

6. There is a tendency for errors in reporting to be associated in conjunction with blocks.

A review of this experiment from the standpoint of reducing psychological fatigue with a change period in work reveals the following:

1. Most of this experiment was run by a few subjects for a very short period for each task.

2. Results were obtained by trends in the output figure rather than by the presently accepted tests for significance.

3. According to Bills, the phenomenon of blocking should not interfere with objective decrement readings on output due to mental fatigue because of no decrease in output, but it could effect the amount of errors due to increased fatigue.

Psychological fatigue

Bills (1943) published a book on mental work. A large portion of this work deals with the subject of psychological fatigue. Bills explains four methods of measuring psychological fatigue. The first method is the objective method and is based on the definition of fatigue being a diminishing capacity to work. This method is the measure of the decrement in output of work. The second method is the organic method and deals with such measurements as a change in metabolic rate. The third measure is the by-product method and includes signs of nervous tention, lessened emotional control, or other such changes of manner. The last method is the subjective method in which the subject records his feelings usually on a scale of values.

Bills (1943) discusses some of the characteristics of fatiguing work. These include continuity which is a continuous task with no break or pause. As has already been discussed, this can be overcome by breaking the work into increments such as discussed in connection with incomplete tasks. The second characteristic was sameness. This is the repeating of one operation or a limited number of operations over and over again. Continuity and sameness tend to work together to increase fatigue. The task of adding numbers together has a great deal of sameness. The easiest way to overcome sameness is to change to a different type of work. This is basically what Chapman (1917) as well as Miles and Skilbeck (1944) were doing. This is similar to increases shown in learning curves. Conflict is the next characteristic. Unfamiliarity is more fatiguing because of the conflict between correct and incorrect response tendencies. The

last characteristics, meaninglessness and satiation, were placed together because of their similarity. Tasks without meaning or which become monotonous tend to produce a quicker decrease in production than those tasks which have more meaning to the subject.

Bills (1943) makes the following recommendations with regard to the restful qualities of a change of task. He points out the advantages possible in a day's output if a change of work is introduced rather than a period of complete idleness. He states that if the change is very dissimilar to the original task, there should be considerable benefit; but if the changed task is too similar, then little benefit should be gained. The main benefit is felt right after the change is made. Bills recommends frequent shifts on the order of one every hour for a period of about fifteen minutes. He states this would have about the same effect as a rest period. He points out that the change period must be introduced between regular work periods and not at the end of the day to be of full value.

As mentioned earlier, one of the methods of measuring fatigue is the subjective method. Poffenberger (1928) has demonstrated one way to approach this area as has already been discussed. Giffith, Kerr, Mayo, and Topal (1950) wanted to test for a correlation between the subject's feelings of fatigue and the actual production rates. The specific hypothesis was that employees in representative types of work possessed definite attitudes as to when during the work shift they are most ready to work and when they are most tired.

The summary of results for mannual, office, and supervisory employees

measured by a Kerr "tear ballot" for an eight-hour work shift is as follows:

1. Manual, office, and supervisory personnel all reported significantly different feelings of tiredness or rest for various periods during the work shift.

2. Older workers reported significantly greater variations of feeling than did employees under age 36.

3. All three types of work produced similar curves of tired and restful feelings.

4. Maximum subjective fatigue feelings occured in the fourth and eighth hour of the eight hour shift.

5. Maximum restfulness feelings occured during the second and sixth hours of the shift. This was the second hour of each four-hour work session.

6. The possibility of different feeling times for different length of work days was pointed out.

The result of the same feeling curves for the three different types of work points out the fact that there may be little relationship between the work output and feelings of fatigue. The manual laborer had about the same feelings towards his task as the supervisor. Of interest in this area would be a study of feelings of fatigue and cultural background. Most workers are raised in a society in which one is expected to feel tired after a long day at work, no matter what the work is.

N. H. Mackworth (1950) conducted tests on vigilance tasks in conjunction with military uses such as radar operations. The particular

test of interest involved a clock watching experiment. The subject was required to signal each time the clock made a double jump. A hand traveled in a circle which was divided into one hundred parts. At certain preplaned times the hand moved a double interval. Test sessions lasted two hours. The double jump occured twelve times in twenty minutes with the clock hand moving once each second. In some of the trials the subject was interrupted by a telephone call. In conjunction with studies on work change and task interruption the following conclusions were of interest:

1. Substantially more signals were missed by the subjects after they had been working for half an hour at the task. This shows the presence of psychological fatigue.

2. The decline was prevented by an alternation of watchkeeping duties with some other work. Half an hour on and half an hour off proved to be the best combination.

3. A sudden telephone message in the middle of the test session produced a temporary improvement which lasted for half an hour.

How long should the change of work period last for a typical mental fatigue task? Previous studies already discussed used periods of from thirty seconds to fifteen minutes. A study by Mast and Heimstra (1964) gives some additional insight into the duration of the second task. In their study, Mast and Heimstra wanted to check the effect of previous work on the performance of a vigilance task. The study was conducted in the following manner.

Four groups of subjects were used. One for each of three previous

conditions and a fourth group to act as a control group. The three previous conditions were as follows: (1) Subjects worked for four hours on mental multiplication problems consisting of multiplying a four or five digit number by a one digit number; (2) Subjects operated a driving device for four hours; (3) Subjects watched a pair of red lights and reported any changes in intensity for four hours. All four groups then performed the vigilance test consisting of detecting a spot of light on a screen. The vigilance test lasted for two hours. The following results are noteworthy:

1. It was found that the subjects with psychological fatigue (condition 1) had significantly more errors than those of the control group and those of pretest condition 2 but not more than condition 3.

2. There was a vigilance decrement apparent for subjects in the psychological fatigue pretest group. Little or no decrement was noted in the other groups.

This study would indicate that in at least one instance that a two hour period of change was losing its effect to a noticeable extent. To gain a better knowledge it would have to be necessary to run a second mental work period of multiplying after the vigilance task to check for the full impact of the work change. The study also points out the lingering effects of psychological fatigue in this instance.

Zuercher (1965) conducted a study on the effects of extraneous stimulation on vigilance. The primary measure of vigilance for the task in this study was the increase in visual threshold as a function of observation time. A light would blink at about once a second at a standard

brightness. The subject was required to detect when the brightness increased. If the first increase did not elicit a response then the next signal would be increased still brighter. This was continued until a detection was made. The change of threshold over time as measured by ascending method of limits was used as the measure of performance. The tabulation of errors was used as a secondary measure.

The subjects were 18 college men. The subjects were tested on four trials of twelve minutes each. The subjects were tested under three conditions. The only difference in the conditions occured during the fourth trial period. In one condition a period of conversation was introduced in another a period of physical exercise was introduced. The final condition had no extraneous stimulus introduced. The results were that both of the extraneous stimuli, conversation and physical exercise, produced a significantly lower mean level of detection. A great variability from subject to subject and from day to day was noted in the tabulation of errors.

There extraneous stimuli could also be viewed as change periods in the task being performed. This study along with that of Mackworth (1950) demonstrate that change periods could be benefition for vigilance tasks and may also hold true for other tasks related to the brain.

An example of the value of change periods in office was described by Maier (1955). In a telephone company office six girls sat at a desk all day sorting toll tickets. Each hour a messenger would come along and pick up the tickets. In an effort to eliminate job discontent and a high turnover rate, the messenger was eliminated and the girls were

allowed to take their own tickets up the stairs to the collection point. Even though the girls would often wait for each other and go up stairs in pairs, an increase in production was the result. This increase later led to the elimination of the part time messenger altogether and the reduction of the work force by a third.

Nelson and Bartley (1968) conducted an experiment similar to that already discussed by Griffith, Kerr, Mayo, and Topal (1950). Nelson and Bartley were observing changes in feelings of periods of "most tired", "most bored", and "most rested". The subjects were 75 females ranging in age from 18 to 50 years. The subjects worked in an administrative office doing such tasks as typing and filing. They were being changed from an eight-hour day (8 am to 12 noon and 1 pm to 5 pm) to a seven-hour day (8 am to 12 noon and 1 pm to 4 pm) with no change in pay. The subjects were asked at the end of each half-day period to recall the period of "most tired", "most bored", and "most rested" if the condition applied to the period just completed. Scores were reduced to percentages for comparison. The results were comparable to the results of Griffith, Kerr, Mayo, and Topal (1950) for office workers. Nelson and Bartley used an analysis of variance to test their results. The feelings for the morning periods of the seven and eight-hour days were comparable as would be expected. The difference was felt in the period which was shortened. Apparently office workers felt "tired" more easily than "bored", suggesting that "boredom" may be more a function of the work situation than is "tiredness". The comparisons of the work by Giffith, Kerr, Mayo,

and Topal (1950) and that just discussed by Nelson and Bartley suggest that feelings of tiredness may be a general phenomena for work.

Habituation

Up to this point, the problem has been approached by observing the changes in performance of man. An idea of what seems to govern these changes in performance may be found in the area of physiological psychology. In the area of physiological psychology the term applicable to a decrease in performance is habituation. The operational definitions of central fatigue and habituation do not differ. Thompson and Spencer (1966) have made an extensive review of this area of study.

A review of the parametric characteristics of habituation compared with the observed results of human performance on mental tasks is quite interesting. The parameters are as follows:

1. Given that a particular stimulus elicits a response, repeated application of the stimulus results in decreased response (habituation). The decrease is usually a negative exponential function of the number of stimuli present.

2. If the stimulus is withheld, the response tends to recover over time (spontaneous recovery).

3. If repeated series of habituation training and spontaneous recovery are given, habituation becomes successively more rapid.

4. Other things being equal, the more rapid the frequency of stimulation, the more rapid and/or more pronounced is habituation.

5. The weaker the stimulus, the more rapid and/or more pronounced is habituation. Strong stimuli may yield no significant habituation.

6. Habituation of response to a given stimulus exhibits stimulus generalization to other stimuli.

7. Presentation of another (usually strong) stimulus results in recovery of the habituated response (dishabituation).

8. Upon repeated application of the dishabituatory stimulus, the amount of dishabituation produced habituates.

The first parameter is applicable to the decrease in performance noted for a certain task. The work to be done is the stimulus and the output is the response. Actually the stimulus for the work situation could include a number of other items such as money, and other factors already discussed. The second parameter is demonstrated by the recovery noted after a rest pause is introduced in the work period. The third parameter gives insight into decreases in performance even with rest periods after a long duration of alternating. It suggests that rest pauses should be more frequent later on in the work period. The fourth parameter points up the idea used by experimenters in psychological fatigue. They use continuous mental tasks to gain the effects of psychological fatigue as quickly as possible so that they can check the effects of psychological fatigue. It has also been demonstrated that the more frequent the stimulation the faster that fatigue is shown to be present by a decrease in output. The fifth parameter on stimulus weakness is related to the area already discussed in that tasks of little meaning to the workers produce fatigue faster. The sixth parameter points out the fact that fatigue can spread to different areas of the body and that psychological and physical fatigue can effect each other. This could

also partly explain the carry over effect of the psychological fatigue that was noted in the experiment, conducted by Mast and Heimstra (1964). The seventh parameter is the basis for this thesis. That is, that a change in the work task instead of a rest pause can cause a significant increase in production and thus a reduction in mental fatigue. This has already been demonstrated to some degree by Chapman (1917) and Miles and Skilbeck (1944). The last principle, number eight, suggests that the amount of gain possible due to work change is limited.

Bhatia and Murrell (1969) conducted a study on the value of rest pauses in an actual manufacturing plant. The effect of ten and fifteen minute rest pauses was studied with regard to production rate and earnings was well as operatives' attitude to the job. The job was the manufacture of account books.

It was noted that the actual plant studied had several handicaps including the fact that although the work was repetitive, it was small-batch and therefore the output measurement depended on the accuracy of the "rates" allowed for each batch. The number of operatives involved was twelve women. The experimenters were unable to make measurements of working and resting time in advance of the experiment.

In one condition six ten-minute rest periods were introduced, four in the morning and two in the afternoon. In the other condition four fifteen-minute breaks were taken, three in the morning and one in the afternoon. Interviews were conducted with the operations before the start of the experiment, after the end of the ten-minute rest tests, and at the end of the fifteen-minute rest periods. The purpose of the interviews

was to obtain the feelings of the operatives toward the job. It should be pointed out that during the rest periods the operatives left the work area and were served tea in a refreshment area.

The results were that although a hour of time was given away to the workers a slight increase in production was noted. All subjects agreed that the ten minute rest periods were more effective.

THE PROBLEM

Many jobs have been made monotonous by the introduction of industrial efficiency methods such as time and motion study. Time and motion study has its value but the person using it should also take into account certain psychological factors, many of which were discussed in the introduction. Sometimes the very factors that induce efficiency unintentionally have brought on other forms of inefficiency and job dissatisfaction. In a recent issue of Industrial Engineering, Boepple and Kelly (1971) stated that the combined white-collar and the service sector of the economy (jobs with a high degree of mental content) today make up about 60 percent of the employed population with an estimated figure of 70 percent by 1980. Therefore the area of mental work is becoming one of increasing importance.

More effort will have to be placed on the area of mental work and therefore on the area of psychological fatigue. Most of the work in this area has been in psychology. Industrial engineers need to look at this area of study with new interest.

The problem that was studied in this thesis deals with an investigation into the possibilities of reducing psychological fatigue by introducing a change of work period into the task. The specific hypothesis is that the rate of production for a specific task with a change period introduced in the test session will be significantly greater than the production rate for the same task without the change period.

The previously discussed work of Chapman (1917) and Miles and Skilbeck (1944) would support this hypothesis. The parameters on

habituation that are noted for stimulus-response situations would indicate that the hypothesis is correct provided that the change stimulus is strong enough and that habituation is, indeed, occuring.

In designing this experiment it was necessary to chose between a laboratory-type of experiment and one conducted in an actual work situation in some plant or office. The application of the findings of this experiment were hoped to be useful in actual work situations for jobs requiring repetitive mental work and this would seem to be the best situation to study. The main problem is in finding a good actual situation. In an actual situation many problems arise including many that cannot be foreseen. Bhatia and Murrell (1969) discovered some of these problems in their study on rest pauses using an actual work situation in a factory. After being turned down by the factories that they thought were best suited for their study, they finally found a factory that would let them run their experiment. This factory did not have the ideal continuous flow task that they had desired due to the fact that the work was small-batch and therefore the measured output depended on the accuracy of the "rates" allowed for each batch. The work group was small in that it consisted of twelve women. The experimenters were not allowed to take working and resting measurements in advance of the experiment. During the actual experiment it was found that the work was not always continuous due to batches not being available at all times. It was also noted that the subjects were required to take their annual two-week vacation at some period during the experiment. Other problems that could arise during an on-the-job type of study are worker absences and the

possible fear of workers of being made to produce more for no more money after the experiment is finished. It was decided in this experiment to use a laboratory type of study condition with an effort to simulate a work situation and an effort to control as many variables as possible and thereby to compensate for the fact that an actual work situation was not studied.

METHOD

Task

There were two treatments studied in this experiment. In one treatment a group of ten subjects added columns of four four-digit numbers. The addition problems were grouped with 20 problems to a page. Each subject was given a test booklet containing 36 addition pages, an instruction sheet, and an example page. In the second treatment a different group of ten subjects were given the same addition problems with the exception that the addition problems were divided into three groups of twelve pages each. At the end of each 50 minute period a change of task was introduced by having the subjects work on pages of ranking problems. The ranking test booklets contained three columns of twenty three-digit numbers. Each column of numbers had a blank provided at the right of the number. In this blank the subjects ranked the numbers from one to twenty with the lowest number receiving a ranking of one. The ranking test booklets contained four pages and the subjects worked on this task for a ten minute period before being told to return to the original task of addition. In both treatments the subjects were told that accuracy was the important factor in scoring the results. Examples of the test pages are shown in Figures 3 and 4. In both test treatments the test period lasted for two hours and 50 minutes. Each subject in a group was given the same test booklet. Mathematical tasks such as those used by Chapman (1917), Poffenberger (1928), and Mast and Heimstra (1964) have been used in studies on psychological fatigue.

8807	8638	1640	4735
2735	5993	1862	9247
4870	5103	7311	1703
1831	8283	5749	5341
8294	3407	3040	2798
2577	0454	1663	1517
3885	2199	9677	3944
2441	6917	3893	6048
1860	3886	3162	6768
7119	5686	7891	4756
9459	1866	0393	6075
5774	3632	7442	5532
1859	7646	0906	6656
8314	9434	4223	8976
7698	4583	1615	3283
9022	6095	2145	3793
3997	1891	2158	2065
7408	2829	5561	0992
7622	2988	4465	5687
2657	0611	9134	6696

Adding task.

Figure 3.

603 _____	349 _____	476 _____
033 _____	491 _____	425 _____
603 _____	748 _____	463 _____
850 _____	812 _____	257 _____
388 _____	512 _____	023 _____
518 _____	282 _____	982 _____
162 _____	146 _____	430 _____
524 _____	218 _____	912 _____
287 _____	780 _____	254 _____
165 _____	915 _____	444 _____
333 _____	227 _____	197 _____
052 _____	552 _____	590 _____
126 _____	132 _____	923 _____
995 _____	608 _____	878 _____
916 _____	825 _____	469 _____
827 _____	349 _____	993 _____
237 _____	355 _____	660 _____
843 _____	378 _____	168 _____
002 _____	281 _____	341 _____
936 _____	712 _____	060 _____

Ranking task.

Figure 4.

Design of research

The tasks were chosen with several areas in mind. It was hoped to use tasks that would require little or no learning beyond the level that the subjects already possessed. This was to minimize the effect of learning on the production performances that were to be studied. In a pilot study that was conducted for this experiment using three subjects, no learning was apparent. The second area was to find tasks that were continuous and had little or no interest to the subjects in order to produce monotony associated with psychological fatigue. It was decided to offer no special pay for performance since this has not been the general practice with most mental type jobs such as those found in government as well as those in private business.

A matched-subjects type of experiment was used for this study. A group of twenty subjects was given a 40 minute pre-test on the type of addition problems used in the regular study. This was done to match the subjects according to addition speed and to detect anyone who might have a performance rate greatly above or below the rest of the subjects. From the scores obtained in the pre-test, the subjects were ranked according to the number of problems done correctly. Figure 5 shows how this was accomplished. Once the two groups were formed, a coin-toss determined which group rotated tasks and which did not. Errors in the pre-test were intended to eliminate any subjects who did not seem to be trying to really work the problems. No subject was eliminated because of the pre-test. A wide range of scores was found but no subject's score was judged to be above or below the rest of the group. Subjects

Subject	Number Correct on Pre-Test	Group 1	Group 2
1	153	X	
2	150		X
3	146		X
4	141	X	
5	139	X	
6	132		X
7	119		X
8	117	X	
9	114	X	
10	113		X
11	111		X
12	108	X	
13	104		X
14	101	X	
15	98	X	
16	98		X
17	87	X	
18	71		X
19	69		X
20	43	X	

Group 1		Group 2	
No. Attempted	No. Errors	No. Attempted	No. Errors
1248	147	1261	148

Group matching.

Figure 5.

were given the regular test 48 hours later. In both the 40 minute pre-test and the two hour and 50 minute regular test, assistants were used to record the progress of each subject at the end of each five-minute period. This information was used to detect performance trends during the longer test periods.

All subjects were given written copies of the instructions to insure that they all received the same instructions (see Appendix I). All subjects were given reproduced copies of the test to insure equal legibility. All subjects within a group had the test conducted in the same room with equal illumination, noise and temperature levels. These same conditions were kept as nearly equal as possible between groups as well. Each group was tested at the same time but in different rooms. This was done to reduce the possibility of subjects being influenced by others who had already taken the test. The only exception was one subject who could not attend the regular test period and was tested later, this subject's score placed his ranking the same as it was in the pre-test. The experimenter and the assistants were in the test rooms during the entire test to observe for any actions that might occur unexpectedly and effect the results of the experiment. The assistants were three students who were friends of the experimenter and were paid on the same basis as the subjects. The assistants were checked on their procedures during the pre-test.

Test booklets were used to insure exact uniformity of the task for all subjects. In the pilot study it was found that the average time per page of addition problems was about seven minutes. The average

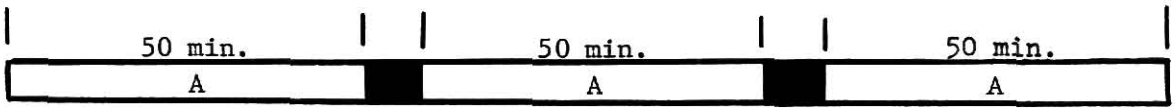
and the variance found in the pilot study were used in calculating the number of pages in the test booklets necessary to insure that no subject ran out of material before the test period finished. The pilot study indicated that a decrease in performance had started toward the end of a 40 minute test period. It was therefore assumed that a three hour test period would be sufficient in length to produce the effects of monotony that were to be studied in their relationship to a change of task. Numbers used in the booklets were selected randomly from a table of random numbers.

Subjects

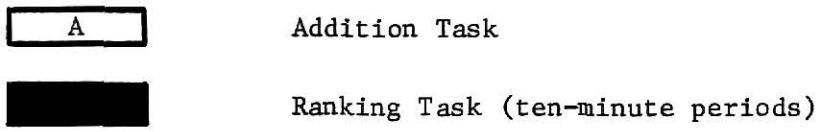
The subjects were all male students at Kansas State University. The subjects were selected by placing a sign-up sheet on the bulletin board of a college fraternity house. The sheet told the pay scale for the experiment ($1.60 per hour) and the number of hours required. The selection of subjects from one group made the task of scheduling the test sessions easier. The age of the subjects ranged from 17 to 24 years. All male subjects were used in an effort to reduce any differences due to the sex of the subject. All females could just as well have been used as was done in the study by Bhatia and Murrell (1969). No foreign students were used because of differences noted in the pilot study between the performance of foreign and native American students. In his study on vigilance, Zuercher (1965) also noted a difference between foreign and American student performance which he said was due to a misunderstanding of the instructions by the foreign student.

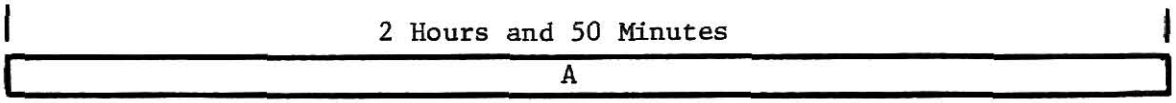
Experimental procedure

The groups were tested in the sequence shown on Figure 6. Each test



Group 1 Change of Task Period





Group 2 No Change of Task Period

Test sequence.

Figure 6.

session lasted for two hours and 50 minutes with the assistants noting the subjects progress every five minutes. One group worked addition problems continuously for two hours and 50 minutes while the other group had two ten-minute change-of-task periods introduced every 50 minutes. Before the beginning of the first trial each subject filled out a personal information sheet such as the one shown in Figure 7. Before the start of each trial the experimenter read the instructions to the subjects at the same time the subjects were in possession of a written copy of the instruction sheet. After this was completed and any questions on the instructions were answered, the subjects looked at the sample problems. The subjects in each group began the experiment on the command of the experimenter and worked continually until told to stop.

Correlation

A **Spearman** rank correlation test was computed between the individual scores in the pre-test that was used to divide the subjects into two groups and the individual scores obtained on the final test. This test of correlation showed a significant correlation ($a = .05$) between the test scores for the number of problems correctly worked. The correlation coefficient was found to be +.49.

Subject Name (Print) _____

Age _____

Student _____ Non-student _____

Year in school if student _____

Major area of study if student _____

Approximate size of hometown _____

Location of hometown _____

Information sheet.

Figure 7.

RESULTS

Group comparison

In any experiment such as this one in which different groups are doing different tasks, there is a possible difficulty in the comparison of the results. This was overcome in this experiment by the design of the experiment. With the design used in this experiment it was possible to compare the results by comparison of five-minute intervals with the periods of time in which the two groups were doing different tasks being disregarded. This was similar to the method used by Chapman (1917) in his experiment on the same subject. Poffenberger (1928) had a similar problem in that he tried to equate different tasks and came up with no differences. One alternative would be to use percentages to compare the two groups but due to the complications involved in equating five-minute intervals, it was decided to omit the two ten-minute periods in which the two groups were working on different tasks.

Statistical tests

Appendix II shows the data obtained for each five-minute interval. The number of problems attempted and the number of errors per individual per five-minute interval are indicated for both groups. The results were compared by means of an analysis of variance on the IBM 360 computer using AARDVARK programming. Significant differences were further checked with t-tests and Tukey's test for significant differences with an alpha level of five percent. The means and analysis of variance are shown in Tables 1 to 4. The results of the t-test are shown in Figures 8 to 10. Tukey tests are shown in Tables 5 to 7. An analysis was computed for

the number of errors, number of problems attempted, and number of correct problems done comparing mean values for five-minute intervals.

Number of errors

The analysis of variance showed a difference between groups and between periods. The group that did not change had an average of 2.03 errors per five-minute interval as compared to 1.71 for the group that had the change of task periods. One-tailed t-tests between periods of the two groups revealed significant differences between groups for the first two periods with the groups equal in the last period as shown in Figure 8. Tukey's test reveals a significant difference between periods two and three (1.59 for period two versus 2.17 for period three) indicates that an increase in errors may be associated with psychological fatigue. There was no significant difference among the error rates for five-minute intervals. The interactions showed no differences.

Number of problems attempted

There were significant differences among the number of problems attempted by the subjects per five-minute interval for the two groups. Table 3 shows the results of the F-tests. This shows differences between groups, periods, and intervals. One-tailed t-tests show a difference between groups for the last period as shown in Figure 8. The Tukey test shown the second and third 50-minute periods were significantly lower in the number of problems attempted than the first period. The first five-minute interval had a significantly higher rate of problems attempted than the rest of the intervals. The interactions showed no differences.

Table 1

Mean Values

Entry	Number Errors	Number Attempted	Number Correct
Group 1 (Task Change)	1.7166	16.7266	14.9699
2 (No Change)	2.0299	15.0966	13.0833
Period 1	1.8449	17.2149	15.3799
2	1.5999	15.2949	13.6449
3	2.1749	15.2249	13.0549
Interval 1	2.1999	19.1333	16.9333
2	1.5999	15.5333	13.9499
3	1.8999	15.3333	13.4666
4	1.5499	15.4333	13.8833
5	2.0166	15.5333	13.5166
6	1.8999	16.0166	14.1166
7	1.8999	15.4666	13.3666
8	1.9833	16.3666	14.4166
9	1.7499	15.1666	13.4166
10	1.9333	15.1333	13.1999

Table 2

F-Test on Number of Errors

Due To	Sum of Squares	D.F.	Mean Square	F	Alpha Hat
Groups (G)	14.72	1	14.72	4.997	0.0256
Periods (P)	33.30	2	16.65	5.650	0.0037
Intervals (I)	20.37	9	2.26	0.768	0.6461
GP	1.74	2	0.87	0.296	0.7441
GI	17.01	9	1.89	0.641	0.7620
PI	46.00	18	2.56	0.867	0.6194
GPI	23.82	18	1.32	0.449	0.9764
Error	1591.36	540	2.94		
Total	1748.32	599			

Table 3

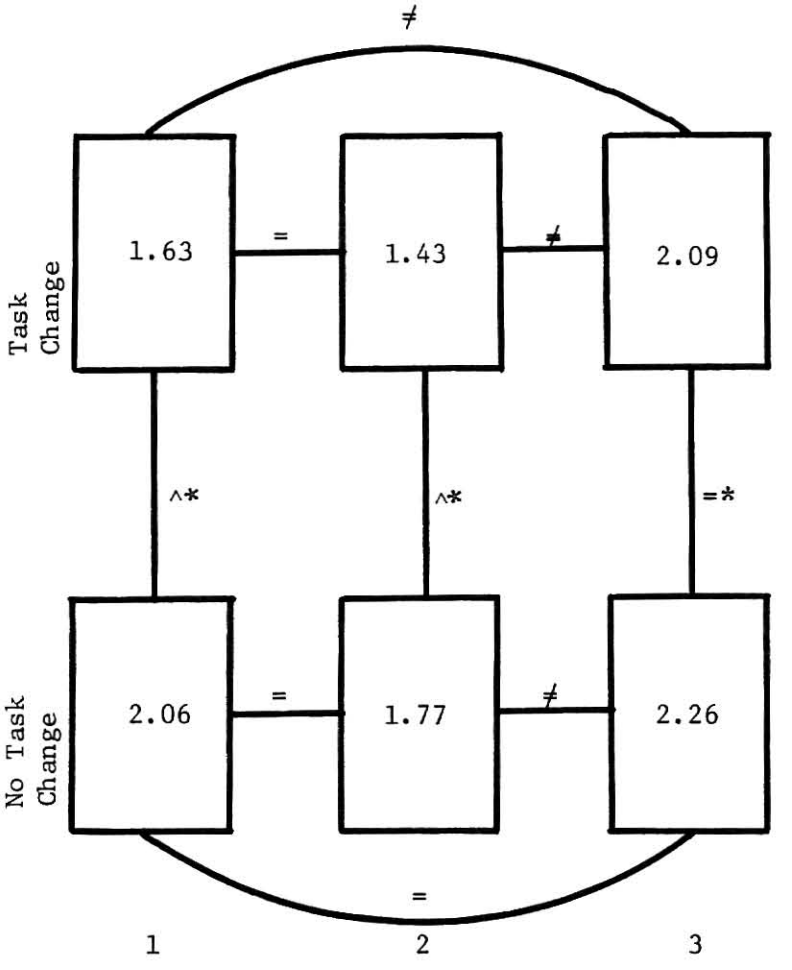
F-Test on Number of Problems Attempted

Due To	Sum of Squares	D.F.	Mean Square	F	Alpha Hat
Groups (G)	398.53	1	398.53	11.676	0.00068
Periods (P)	510.09	2	255.04	7.472	0.00063
Interval (I)	768.33	9	85.37	2.501	0.00828
GP	33.24	2	16.62	0.487	0.61481
GI	512.94	9	56.99	1.670	0.09318
PI	433.14	18	24.06	0.705	0.80748
GPI	394.72	18	21.93	0.642	0.86666
Error	18432.30	540	34.13		
Total	21483.30	599			

Table 4

F-Test on Number of Problems Worked Correctly

Due To	Sum of Squares	D.F.	Mean Square	F	Alpha Hat
Groups (G)	533.93	1	533.93	17.119	0.00004
Periods (P)	584.26	2	292.13	9.366	0.00010
Intervals (I)	642.01	9	71.33	2.287	0.01597
GP	21.64	2	10.82	0.347	0.70704
GI	430.04	9	47.78	1.532	0.13328
PI	381.30	18	21.18	0.679	0.83315
GPI	344.99	18	19.17	0.614	0.88959
Error	16842.44	540	31.19		
Total	19780.62	599			

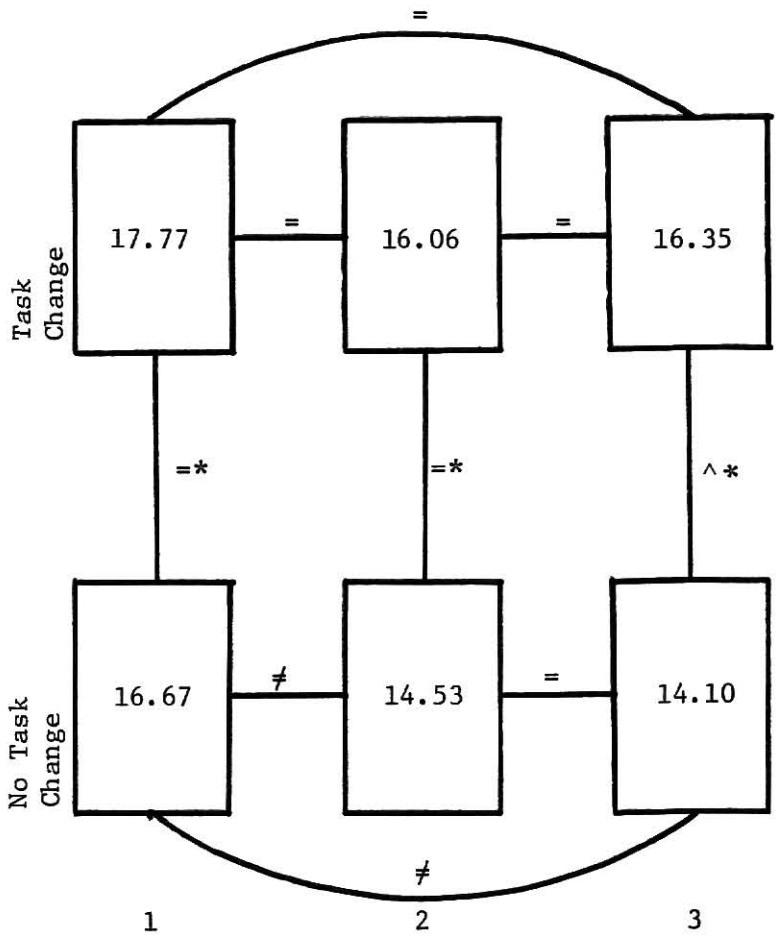


50 - Minute Period

*One-tailed tests Alpha level = .05

Number of errors.

Figure 8.



50 - Minute Period

= No Significant Difference

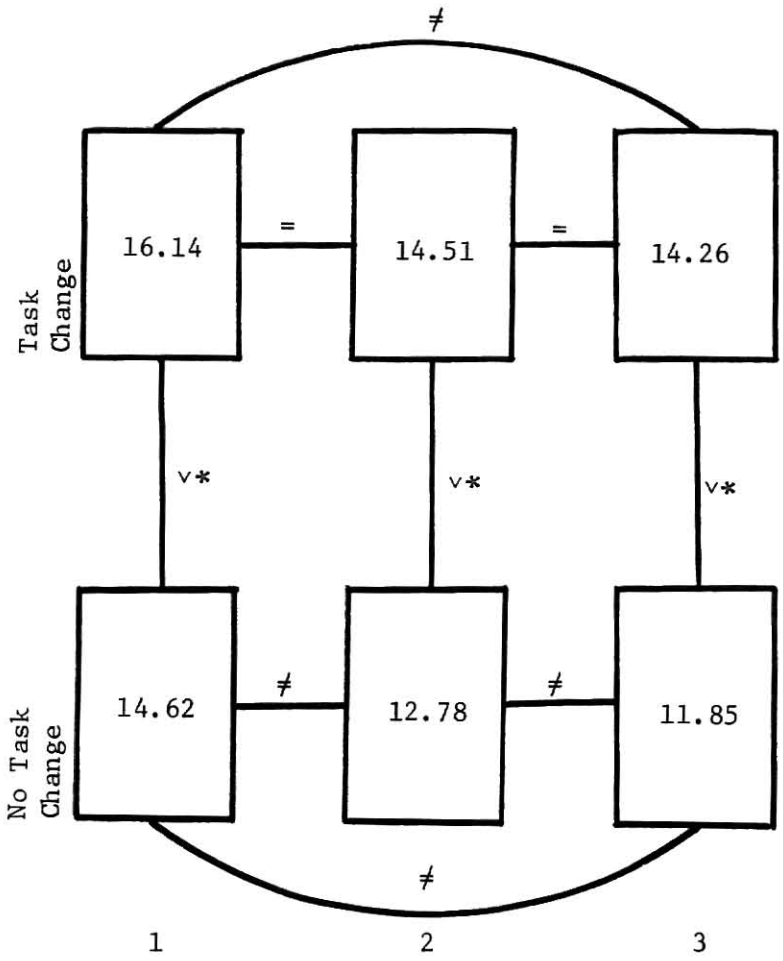
≠ Significant Difference

* One-tailed test

Alpha level = .05

Number of problems attempted.

Figure 9.



50 - Minute Periods

* One-tailed test. Alpha level = .05

Number of correct problems.

Figure 10.

Table 5

Tukey Test --Errors

Entry	Means		Non-Significant Groupings Connected By Column of Asterisks
G(2)	2.029	*	Number of Means = 2
G(1)	1.716	*	Significant Range = 0.3608
P(3)	2.174	*	Number of Means = 2 to 3
P(1)	1.844	**	Significant Range = 0.4989
P(2)	1.599	*	

Alpha Level = 0.05

For All Tests

Table 6

Tukey Test --Number Attempted

Entry	Means	Non-Significant Groupings Connected By Column of Asterisks	
G(1)	16.726		Number of Means = 2
G(2)	15.096		Significant Range = 1.2278
P(1)	17.214		Number of Means = 2 to 3
P(2)	15.294	*	Significant Range = 1.6979
P(3)	15.224	*	
I(1)	19.133	*	Number of Means = 2 to 10
I(8)	16.366	**	Significant Range = 3.8919
I(6)	16.016	**	
I(2)	15.533	**	
I(5)	15.533	**	
I(7)	15.466	**	
I(4)	15.433	**	
I(3)	15.333	**	
I(9)	15.166	*	
I(10)	15.133	*	

Alpha Level = 0.05

For All Tests

Table 7

Tukey Test --Number of Problems Worked Correctly

Entry	Means		Non-Significant Groupings Connected By Column of Asterisks
G(1)	14.969		Number of Means = 2
G(2)	13.083		Significant Range = 1.1737
P(1)	15.379		Number of Means = 2 to 3
P(2)	13.644	*	Significant Range = 1.6231
P(3)	13.054	*	
I(1)	16.933	*	Number of Means = 2 to 10
I(8)	14.416	**	Significant Range = 3.7203
I(6)	14.116	**	
I(2)	13.949	**	
I(4)	13.883	**	
I(5)	13.516	**	
I(3)	13.466	**	
I(9)	13.416	**	
I(7)	13.366	**	
I(10)	13.199	*	

Alpha Level = 0.05

For All Tests

Number of correct problems

There was a significant difference between the rate of problems correctly worked between groups as well as among the periods and intervals. There was a significant difference between the rate of problems correctly worked between the two groups (14.96 for task-change versus 13.08 for no change). The two-tailed t-tests show that the group with a change of task did not significantly decline from period to period while the group that did not change had significant changes between periods as shown in Figure 10. The Tukey test for the periods shows a significant difference between the second and third periods as compared with the first period. The Tukey comparison also noted the same difference between the first interval and the rest of the intervals.

DISCUSSION

General results

The task itself had the necessary characteristics that were desired. No learning was detected for either group in the results. Many of the subjects expressed feelings of "boredom and monotony" due to the task. The significant differences detected in the periods and between the intervals indicate that fatigue was present. By definition this fatigue was a decrease in performance over time. If this fatigue had not been present then it would have been impossible to measure the effect of a change of task on it.

This experiment had several improvements over others in the same area of study such as Chapman (1917) and Miles and Skilbeck (1944). The use of a control group and statistical tests of difference were among the improvements. Studies by Griffith, Kerr, Mayo, and Topal (1950) and by Nelson and Bartley (1968) suggest that the effect of the lunch break can eliminate many of the fatiguing effects of the morning period of work. This would divide the average work-day into two four-hour periods. The two hour and 50 minute test period of this experiment closely approximates this four hour work period. Although this study has shown positive results in the area of a higher rate of correct problems and a higher number of problems attempted as well as a fewer number of errors will it work for other tasks? It is impossible to say for sure but the addition tasks bear some resemblance to other mental tasks. Boepple and Kelly (1971) in their article on analysis

of mental tasks show similar areas applicable to all mental tasks such as information storage and retrieval.

Number of errors

The analysis of variance shows a significant difference between the number of errors per five minute interval for the change-of-task group (2.029) and the group with no change (1.716). The fact that the second period (1.599) was different than the third period (2.175) suggests that the psychological fatigue caused an increase in this rate but that the difference in stimulus due to change of task was not strong enough to overcome the fatigue and that habituation of the response continued to occur as in the terminology of Thompson and Spencer (1966).

Number attempted

The difference between the number of problems attempted for the change-of-task group (16.726) was significantly different from that of the control group (15.096). The second and third periods (15.294 and 15.224) were different than the first period (17.214) signifying that fatigue was present after the first period. The decrease in performance was not continued between the second and third periods therefore the change of task may have reduced the fatiguing effect to some extent. The first interval was significantly different than the other intervals indicating that the change did produce a positive change in the rate of problems attempted but that the effect did not last significantly over the first five minute interval. The results of the t-test indicate that the reason for the difference between groups may be due to the fact that the change-of-task group had a steady rate while the control group had

a decreasing rate of problems attempted, see Figure 8. From the information in the article by Thompson and Spencer (1966) it seems that the difference in stimulus in switching from addition to ranking was a great enough change to slow habituation and therefore the fatigue associated with it. The comparison of habituation and fatigue was mentioned by Thompson and Spencer (1966).

Number of correct problems

By definition the number of correct problems is related to the number of problems attempted and the number of errors made. The results of the number of problems done correctly follows closely those of the errors and problems attempted. The difference between the rate for the control group (13.083) is significant in comparison with that of the change-of-task group (14.969). Differences were significant among periods with particular differences between the second and third periods (13.644 and 13.054) and the first period (15.379). This difference once again indicates the presence of fatigue in the test. The difference between the first interval and the rest of the intervals is repeated as it was with the number of problems attempted. The difference in groups indicates that there is an advantage in changing tasks characterized by an increased production rate, see Figure 10. The decreasing values in the second and third periods indicate that fatigue was still present. The difference in the first interval suggests that the positive effect of changing the task was short in duration and also that more frequent changes could increase the difference in output rates even more than was found in this experiment.

Differences

Differences detected in the intervals were not significant yet they were of a greater percentage difference than those reported by Chapman (1917) and Miles and Skilbeck (1944). This demonstrates the importance of conducting statistical tests of significance rather than citing percentages which could be misleading.

Future research

Areas of possible future research include studies on the best frequency of the change of task. For this experiment the results indicated that it may be better to rotate more frequently for a higher rate of problems. It might be better to rotate every half hour or every hour or perhaps every two hours. The possibility that certain characteristics of the task may determine the best frequency for rotating tasks. It may be that tasks dealing with numbers need a different frequency that a task dealing with recall of non-mathematical information or a vigilance task. In his study of vigilance Mackworth (1950) reported a positive effect by introducing a phone call to break the test period. He reported that the increase in vigilance lasted for about a half an hour while the positive effects noted in this experiment appeared to be shorter. A study of the behavior of different tasks to a change of task would be most helpful in this field of study. A study on the degree of difference between tasks and how this difference relates to the frequency and length of change periods for the largest increases in areas such as production would be of the greatest value. It would be possible to tell the degree of difference between adding and ranking numbers in the instance

of this study. There is also the area of studying imposed versus chosen periods of rotation. Many managerial jobs or other office work involve a person being given several different tasks to perform. This person can chose his own rate of changing from one task to another. A comparison of a self-chosen system versus an imposed rotation system could lead to some of the answers to frequency of change and the duration of change necessary for the best results. The sex or the age of the people involved could be an important factor in task rotation. The duration of the work period could be a factor as well as the nature of the task. The results of a change of work may have the same results on mental and non-mental tasks. All of the previous areas of study could add more knowledge in the study on the effects of changing tasks.

Practical implications

This is the first experiment this experimenter has discovered that proves the benefits of changing task that does not have the limitation of no tests of significence, no control group, or a short period of study. The ideas of job enlargement and job enrichment are currently popular in industrial engineering studies. This experiment points to the significant advantages that may be possible using these methods. Job enrichment consists primarily of adding new tasks to a persons job. If the effects of changing tasks hold true for other tasks then it would be possible to use fewer rest periods to obtain the same output in addition to having the benefit of the work done during the change period from the other task. Thompson and Spencer (1966) indicate that the effect of changing will decrease after a certain number of applications and therefore the

idea of changing tasks must be continual. Different tasks will have to be introduced at various times to continue to get positive results.

CONCLUSIONS

1. In the area of the error rate the change-of-task group was different than the control group. The change-of-task group had a lower error rate. The difference in periods indicated that fatigue was present after the change of task. The difference between adding and ranking problems may not have been enough to slow the effect of fatigue in this area.

2. The change-of-task group was able to maintain a steady rate of problems attempted while the control group showed a decrease in their rate. This shows that the habituation of the change-of-task group was slower than that for the control group. The change of task reduced the effects of psychological fatigue.

3. The outcome of the rate of correct problems was the same as that for the number of problems attempted. The decrease in the periods indicates that fatigue is still present. The difference in the first interval and the rest of the intervals indicates that the main effect of a change of task for this experiment did not last beyond the first five-minute interval. More frequent changes could produce larger differences between groups.

4. There are many areas of possible future research in this field of study. The measurement of similarities and differences between tasks as well as the different frequencies and lengths of the periods of change represent some of these areas. The difference between self-chosen and imposed rotation patterns is another area. Age differences could be an important factor.

5. The first implication of this study is that it confirms the value of previously accepted ideas such as job enrichment as well as checking the results of previous experiments that had no tests for significance as well as some errors in the design of their studies. This study indicates that positive results, increased production rates, can be obtained by the introduction of a change of task. The idea of introducing change must be a continuous one as the effects of the change are limited by the nature of psychological fatigue particularly in the area of habituation as was discussed by Thompson and Spencer (1966).

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APPENDIX I

INSTRUCTION SHEETS

1. Pre-test
2. Addition Task
3. Ranking Task

INSTRUCTION SHEET

1. You are about to begin a test that will run approximately 60 minutes.
2. The test you are to perform consists of adding four four-digit numbers to each other.
3. You will start with the upper-left group of numbers and proceed across to the right side of the row of numbers. The last group of numbers that you add will be the one in the lower right corner.
4. Accuracy is the important factor in scoring this test. You should concentrate on getting the correct answer to each problem.
5. You will mark the test with the pencil which was provided to you. You may erase any answer that you wish to change and correct it.
6. Once you are told to begin, you will work the entire test until you have either finished all the pages in order or until you are told to stop.
7. The next page contains a sample problem, study it and ask any questions you may have on the procedure. Do not go beyond the sample page until you are told to start the test.

INSTRUCTION SHEET

1. You are about to begin another test similar to the one you have already.
2. The test you are to perform consists of adding four four-digit numbers to each other.
3. You will start with the upper-left group of numbers and proceed across to the right side of the row of numbers. The last group of numbers that you add will be the one in the lower right corner.
4. Accuracy is the important factor in scoring the test. You should concentrate on getting the correct answer to each problem.
5. You will mark the test with the pencil which was provided to you. You may erase any answer that you wish to change and correct it.
6. Once you are told to begin, you will work the entire test until you have either finished the test or until you are told to stop.
7. The next page contains a sample problem, study it and ask any questions you may have on the procedure. Do not go beyond the sample page until you are told to start the test.

INSTRUCTION SHEET

1. This task consists of ranking a column of 20 random numbers.
2. The lowest number will have a ranking of 1 and the highest will have a ranking of 20.
3. In the event a number appears more than once in a column, the first number to appear in the column will receive the lowest ranking, the second to appear the next ranking and so on.
4. The important factor in grading this test is accuracy. For each number in a column a rank should appear. The rankings should contain the numbers 1 to 20.
5. You will begin each page of this task with the left column, then the middle, and the right column last.
6. You will mark the test with the pencil which was given to you. If you make a mistake, erase the incorrect ranking and change it.
7. Once you are told to begin, you will work the entire test until you are told to stop or until you have finished.
8. The next page contains a sample problem, study it and ask any questions you may have on the procedure. Do not go beyond the sample page until you are told to start the test.

APPENDIX II

INTERVAL READINGS BY SUBJECTS

1. Group 1 First 50-Minute Period
2. Group 1 Second 50-Minute Period
3. Group 1 Third 50-Minute Period
4. Group 2 First 50-Minute Period
5. Group 2 Second 50-Minute Period
6. Group 2 Third 50-Minute Period

Group 1 First 50-Minute Period

No. Attempted / No. Errors

Subject No.	Time (Minutes)									
	05	10	15	20	25	30	35	40	45	50
1	21/3	15/2	17/1	16/1	16/2	16/2	13/0	16/3	14/0	12/1
2	13/1	10/0	13/0	10/0	10/1	11/1	14/0	9/1	5/0	13/1
3	21/1	14/0	15/0	17/0	17/0	17/1	20/1	15/0	17/0	14/0
4	30/2	25/2	26/1	21/1	28/0	32/2	22/5	26/2	23/3	20/1
5	15/1	11/1	13/1	10/1	13/0	13/0	12/2	13/0	17/1	14/2
6	35/4	15/0	24/2	25/2	26/1	24/4	26/3	22/1	27/4	22/2
7	26/5	19/2	21/3	19/0	22/2	25/3	24/2	19/2	25/1	20/1
8	20/3	15/3	15/4	15/4	16/2	18/1	17/3	15/2	10/3	17/6
9	19/1	13/2	15/2	17/0	16/3	15/1	19/1	14/0	13/2	17/0
10	26/2	16/1	18/5	17/0	19/3	19/2	25/2	15/3	18/2	17/4

Group 1 Second 50-Minute Period

No. Attempted / No. Errors

Subject No.	Time (Minutes) 05	10	15	20	25	30	35	40	45	50
1	24/3	14/1	10/1	14/0	13/1	9/1	10/0	8/0	12/0	12/0
2	14/0	10/1	12/0	10/2	15/1	8/0	6/0	12/1	10/1	8/0
3	20/2	13/0	16/1	15/0	15/1	11/0	13/0	14/0	16/0	11/0
4	36/2	19/0	22/2	26/0	27/1	19/1	21/2	27/5	28/3	16/5
5	8/1	13/3	14/2	14/0	11/1	13/1	9/0	9/1	10/1	11/2
6	33/5	19/3	24/4	22/1	26/3	21/0	21/2	20/1	23/4	21/2
7	32/5	19/1	23/0	19/3	26/4	18/2	18/0	18/3	20/1	17/2
8	21/3	11/0	12/4	10/4	12/0	10/3	9/0	12/2	17/2	6/1
9	22/3	16/1	14/0	13/0	16/0	11/1	15/0	10/2	17/1	8/0
10	28/0	17/2	16/2	16/1	17/1	14/3	18/3	15/3	25/4	10/1

Group 1 Third 50-Minute Period

No. Attempted / No. Errors

Subject No.	Time (Minutes)									
	05	10	15	20	25	30	35	40	45	50
1	17/0	14/2	14/1	10/0	10/0	10/1	11/1	14/3	11/1	14/0
2	10/1	12/2	9/1	10/0	9/1	9/0	7/0	12/0	9/1	7/1
3	17/1	13/2	18/0	17/0	14/3	14/3	14/0	16/0	14/0	12/0
4	30/3	21/3	23/5	24/2	22/4	22/2	22/3	25/2	23/3	23/5
5	15/1	12/1	9/1	16/1	12/0	10/1	16/1	22/3	9/0	18/3
6	27/7	20/5	22/4	24/6	20/14	21/6	16/4	21/4	24/5	21/5
7	24/2	17/1	20/0	20/2	20/0	20/4	17/0	27/2	21/2	18/3
8	16/1	13/3	13/0	12/4	10/2	10/2	10/2	14/0	10/2	9/1
9	19/4	13/1	15/1	14/1	14/1	14/0	12/0	18/2	14/0	13/0
10	26/1	19/1	21/9	24/4	18/4	23/7	16/2	23/2	22/1	18/6

Group 2 First 60-Minute Period

No. Attempted / No. Errors

Subject No.	Time (Minutes) 05	10	15	20	25	30	35	40	45	50
11	27/2	24/2	24/2	24/6	24/3	28/1	26/5	26/5	24/6	25/2
12	19/1	16/0	16/0	18/0	17/3	20/1	21/1	21/4	16/0	22/2
13	17/4	12/0	12/3	13/1	12/2	12/3	13/3	10/2	12/3	10/2
14	23/1	22/0	20/2	22/0	20/0	26/1	21/1	25/1	20/2	24/2
15	8/2	5/1	5/1	2/1	5/1	4/0	8/2	6/2	3/1	5/0
16	16/1	11/2	11/0	11/1	11/0	15/0	14/2	16/1	13/0	13/2
17	19/6	14/3	16/2	22/4	17/2	22/3	18/4	18/2	13/0	20/4
18	21/1	16/1	18/3	14/1	13/4	16/4	16/3	19/6	12/4	15/3
19	20/4	17/5	16/5	13/4	12/1	11/2	13/5	13/3	9/2	19/6
20	28/2	19/1	21/1	24/1	17/2	26/0	20/1	20/2	23/0	20/0

Group 2 Second 50-Minute Period

No. Attempted / No. Errors

Subject No.	Time (Minutes)									
	05	10	15	20	25	30	35	40	45	50
11	24/6	24/1	20/2	21/4	22/7	26/1	26/2	23/3	20/2	23/5
12	21/3	19/2	16/1	18/1	17/0	20/0	17/1	21/1	16/0	18/2
13	11/1	9/1	8/3	10/2	13/1	12/3	13/3	19/2	8/2	13/2
14	21/0	20/1	16/4	20/1	21/1	21/1	18/1	18/1	18/1	24/0
15	8/1	4/0	5/1	1/0	3/2	4/0	4/1	3/0	10/1	3/0
16	11/0	12/2	11/1	15/0	11/1	12/1	12/2	14/1	9/2	13/2
17	16/2	13/1	11/1	10/0	11/2	12/4	16/0	18/3	7/2	15/1
18	9/3	13/2	13/4	13/1	16/5	11/3	11/4	12/4	6/3	9/5
19	13/3	15/3	9/1	9/2	12/3	9/1	12/2	13/1	9/2	11/2
20	14/0	22/1	18/0	26/2	21/2	24/0	17/2	22/7	23/0	22/0

Group 2 Third 50-Minute Period

No. Attempted / No. Errors

Subject No.	Time (Minutes)									
	05	10	15	20	25	30	35	40	45	50
11	24/3	25/4	22/3	19/4	21/5	24/9	20/2	22/0	18/4	19/4
12	21/2	20/1	19/0	15/0	16/0	20/1	21/3	22/2	19/2	20/1
13	9/2	10/2	10/3	10/3	10/6	12/2	10/2	10/3	11/2	9/2
14	24/1	26/0	21/5	18/1	20/3	26/2	21/4	23/2	23/3	14/2
15	6/1	8/1	7/0	4/0	3/0	3/1	6/1	3/0	6/0	10/4
16	12/1	14/3	13/1	11/1	11/0	10/2	10/1	13/3	11/2	11/1
17	13/2	10/1	12/1	9/2	11/2	15/0	11/3	17/3	6/0	11/1
18	5/2	9/3	9/1	6/3	6/2	11/5	7/4	7/5	4/2	6/2
19	15/4	15/5	12/4	10/2	8/3	18/8	15/6	13/3	8/2	8/0
20	20/2	18/2	18/2	21/2	20/2	24/3	20/0	20/1	23/5	23/3

REDUCING PSYCHOLOGICAL FATIGUE BY THE INTRODUCTION OF A CHANGE OF TASK

by

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Many jobs have been made monotonous by the introduction of industrial efficiency methods such as time and motion study. As more of the working force becomes engaged in mental rather than physical work, the area of psychological fatigue increases in importance. The decrease in performance that is characteristic of psychological fatigue has been dealt with in the past by the introduction of rest periods to permit the individuals to recover their ability to perform. The value of rest periods has been demonstrated in a number of cases. Another approach to psychological fatigue is the introduction of a different stimulus to permit recovery. This has been done by introducing a change of task into the work schedule. Previous tests of the effect of a change of task, while showing a positive effect, have lacked necessary controls and in many cases, tests of statistical significance.

This study was a matched-subjects type of experiment. The subjects were matched on the performance in a pre-test and then divided into two groups of ten men each. One was a control group doing continuous addition problems and the other group had two ten-minute change of task periods introduced during a two hour and 50 minute test period. Readings were taken on the progress of each subject in each group every five minutes during the entire test. The results showed a significantly higher rate of problems attempted and problems done correctly for the change-of-task group over the group with no change. There was no statistical significance found for the rate of errors between the two groups. The study indicates that the introduction of a change of task can produce beneficial results in certain instances.