THE EFFECT OF LONG TERM FATIGUE
UPON MENTAL ACTIVITY

by

Abdel Monem Saqr

A Thesis Submitted to the Faculty of the

DEPARTMENT OF PHILOSOPHY AND PSYCHOLOGY

In Partial Fulfillment of the Requirements
For the Degree of

MASTER OF ARTS

In the Graduate College

THE UNIVERSITY OF ARIZONA

1 9 6 1

STATEMENT BY AUTHOR

This thesis has been submitted in partial fulfillment of requirements for an advanced degree at the University of Arizona and is deposited in the University Library to be made available to borrowers under rules of the Library.

Brief quotations from this thesis are allowable without special permission, provided that accurate acknowledgment of source is made. Requests for permission for extended quotation from or reproduction of this manuscript in whole or in part may be granted by the head of the major department or the Dean of the Graduate College when in their judgment the proposed use of the material is in the interests of scholarship. In all other instances, however, permission must be obtained from the author.

Signed: Abdel Monem Saqr

APPROVAL BY THESIS DIRECTOR

This thesis has been approved on the date shown below:

Dorothy I. Marquart — March 4, 1961

DOROTHY I. MARQUART — Date

Associate Professor of Psychology

Table of Contents

List of Figures

List of Tables

I. Introduction

Can subjects tabulate or do arithmetic problems for 12 consecutive hours with only 30 minutes off to eat dinner and tend to bodily needs? What type of performance curves will be obtained under these conditions? The present study was designed to answer these questions and to study the effects of long term fatigue.

A. Definitions

Effects of unfavorable work conditions have been studied widely. Among the most important of these effects are those of long continued work. Bartley and Chute (1947) distinguished among (1) physiological impairment of tissue, (2) conscious aspects of fatigue, and (3) changes in the work output of the organism.

The term fatigue has been commonly used in two senses, (1) including all of the after-effects of work, and (2) including some one of these aspects. As an example of the first type of definition, Viteles (1932) said that fatigue is characterized by three aspects of a work situation. The subject's capacity to work is decreased, his physiological state is changed, and he feels weary. Gilliland, Morgan and Stevens (1935) were using this type of definition when they said that fatigue has two components: (1) a feeling of fatigue and (2) an actual incapacity to do work. They stated that experiments have failed to demonstrate extensive neural fatigue but have demonstrated extensive muscular fatigue. Thus they seem to be considering physiological factors as the bases for both the feeling of fatigue and decreased capacity for work. Mental fatigue is considered to be really physical fatigue.

Starch, Stanton, and Koerth (1936) presented a three-part classification of fatigue. Decreased ability to do work was called _objective fatigue_, physical changes occurring as the result of extended work were called _physiological fatigue_, and the feeling of weariness or boredom was called _subjective fatigue_. Cattell (1941) also posited two basic aspects of fatigue, the physiological and the subjective.

The second type of definition in which fatigue is considered as only one type of effect of continued work can be illustrated by stating a number of definitions. Bartley and Chute (1947) suggested the use of three terms to refer to the aspects of the problem. Fatigue is used to refer to the experiential pattern in which the subject is adverse to continuing working. "This particular pattern involves feelings of limpness and bodily discomfort which, besides being undesirable in themselves, are frequently taken as tokens of inadequacy for activity. The subjective constituents of this fatigue pattern are not to be taken as epiphenomena, or as symptoms of fatigue, but as fatigue itself (Bartley and Chute, 1947, pp. 47-48)." Impairment is defined as the physiological changes which reduce the ability of the tissue to function. "Impairment is identifiable only through the methods of physiology and biochemistry. Reduction in the ability of the organism as a whole to perform is no criterion for the presence of impairment (Bartley and Chute, 1947, p. 48)." Work output includes all overt activity which is measured. Decrease in performance as the result of continued work is then considered to be included in this third group of effects.

Starch (1936) also adhered to this type of viewpoint when he defined fatigue as the physiological effect of work. He said that the physiological changes in the body that occur during fatigue involve the muscular, skeletal, respiratory and nervous systems, the digestive tract, and the endocrine and other glands. Dill (1942-1943) said that fatigue is a state in which the organism has lost its capacity to carry on. Johnson (1929) agreed with this definition.

The lack of correlation between changes in output of work and changes in the feelings, along with inconsistency in definitions, led Muscio (1921) to recommend that the concept of fatigue be banished from scientific discussion, and that mental and physiological functions be measured directly without the intermediary theory of fatigue.

The present writer believes that fatigue is real phenomenon and that refusing to use the term does not change the phenomenon to be studied. Therefore, the term will be used throughout this paper. Further, experience of fatigue cannot be measured. No one can say with certainty "I am twice as fatigued as before starting the task." Judgments are confined to "more" or "less." Physiological changes cannot be measured continuously throughout a long period. Therefore, work output has been measured in the present study. Thus, the interest of this paper is in the practical question of how well college subjects can do monotonous tasks for periods of twelve hours with only one brief break.

B. The Effect of Work Upon Output

Studies conducted in industrial situations. During the past fifty years the trend toward a reduced number of working hours per week as well as a shortened working day has been fairly constant. This trend is partly due to a recognition by management that employees do not reach their greatest efficiency when the number of working hours is excessive. Many experiments have been conducted to determine the relation between hours of work and employee production.

Miles and Angles (1925) reported that when the hours of work in a plant manufacturing boxes were reduced from 48 to 36 per week, the average hourly output increased from 793.5 to 834.0 units. Myers (1921) reported a study in which women engaged in turning fuse bodies showed an increase of 16 per cent in total production following a reduction from 66 work-hours per week to 48.6 work-hours per week. Annon, as reported in Tiffin (1958), found that an increase in working time above 60 hours per week was accompanied by increased illness, injury, and absence without permission, and by decreased hourly and weekly output.

Vernon, as reported in Burtt (1957), summarized a number of studies conducted during the First World War and concluded that maximum weekly production was obtained from a 55 to 56 hour work-week. Burtt indicated that his analysis of studies conducted during the Second World War in England resulted in values that agree practically perfectly with the value found by Vernon. Also, during the depression of the 1930's, one textile industry attempted to reduce the number of hours each employee worked rather than to reduce the labor force. This reduction in work hours increased hourly production so greatly that some employees had to be dropped from the labor rolls.

Burtt (1957) also reported a study by Wyatt who found that diurnal production curves vary with the heaviness and with the monotony of the job. He found that jobs requiring considerable physical energy showed decline in performance during the day, monotonous tasks resulted in U-shaped curves, and jobs that were neither demanding of energy nor monotonous showed constant production after initial warming up. The workers who were doing monotonous tasks performed well during the early part and the latter part of the work-day. Monotonous tasks caused considerably more variability in production from one ten-minute period during the day to another than did tasks that were not monotonous.

Davis and Josselyn (1953) studied two semi-skilled female manual workers. They found that these two workers produced less during the latter part than during the early part of the day. This decline in efficiency occurred as the result of increased stoppages or delays rather than "decrement in effective operation time." The authors concluded that the operators used the same work method at a constant level of efficiency throughout the day, when they worked. Work decrement was interpreted as an increasing reluctance to work rather than to a breakdown in method or an increase in errors.

Kosilov, as reported by Alexander Mintz (1959), disagrees with this interpretation. He found that in fatigue, the work movements tend to slow down, and the pauses between tasks tend to shorten. Thus, even before production decreases, the worker is becoming progressively less efficient. (More evidence on this question will be presented in the following section.)

Studies conducted in laboratory situations. Fatigue studies that have been conducted in laboratories have not always led to results similar to those found in industry. Thorndike (1917) had five subjects write compositions continuously for four hours. Every 20 minutes during this period the subjects evaluated their feelings on a ten-point scale. Whereas the subjects reported increasing feelings of fatigue, production remained high.

Poffenberger (1927) obtained similar results when he asked his subjects to take intelligence tests, complete sentences, judge compositions, or do addition for a five and one-half hour period. All subjects reported feelings of fatigue. Intelligence test performance improved an average of 20 per cent, addition performance declined an average of 20 per cent, and the performance on the other two tasks remained almost unchanged.

Reed (1924) had eight subjects, including himself, do addition problems for ten consecutive hours less 35 minutes for lunch. Very little fatigue was shown. However, the experiment involved the repeated solving of only 65 problems. Certainly, memory effects became important before ten hours had passed.

Other experiments have obtained indications of considerable loss of output as the result of fatigue. Arai, as reported in Bills (1937), found losses of one-half of initial production rate as the result of twelve consecutive hours of continuous mental multiplication of four-place numbers by four-place numbers.

Robinson and Bills (1926) reported that homogeneous tasks result in much more rapid decrements in performance than do varied or heterogeneous tasks. They attempted to explain this effect in terms of the neuro-physiological principle of "cumulative refractory phase", or the tendency for the "post-stimulation refractoriness of an arc to be prolonged after repeated rapid stimulations." In homogeneous work, a limited system of neural arcs is postulated as being repeatedly stimulated. The authors believe that this is probably the objective counterpart of what is subjectively known as monotony.

Robinson and Bills also presented the "principle of continuity": the more continuous the task, that is the more rapidly the successive stimulations follow one another, the greater the decrement. They said that if a task is sufficiently discontinuous, no decrement will occur.

Later Bills (1935) added a third factor to his decrement explanation. He said that if two or more responses compete with one another, the decrement is proportional to the number of competing elements. If we increase the possible number of responses, we make it more difficult for the correct response to occur. He said, also, that the more frequently a subject is required to shift his set, the greater the performance decrement. Thus, subjects who were required to do addition and subtraction problems alternately fatigued more rapidly than did those doing only one type of problem. This principle appears to the writer to be in direct contradiction to the principle of homogeneity.

Robinson and Robinson (1932) and Rounds, Schubert, and Poffenberger (1932) found that unpracticed tasks are influenced more by fatigue than are well practiced tasks. Bills (1937) explained this as due to interference patterns. He said that when new habit systems are set in operation, excitation spreads into irrelevant channels. As the habit is strengthened, these irrelevant reactions drop out. "The performance becomes more economical, and hence, less fatiguing to the whole sensory-neuro-muscular mechanism."

Bills (1931) recorded the exact time of each response in color naming, addition, naming opposites, code substitution, and other repetitive tasks. He found that the subjects did not work continuously. Short pauses occurred approximately three times per minute. These pauses increased in frequency and in duration during the work period. Decrease in work output, then, was found to be due to increased time spent pausing between problems rather than to poorer performance while working.

Bills and Shapin (1936) agreed with this conclusion. They reported that if the rate of speed at which a subject works is automatically controlled by the experimenter and the rate of speed is increased, periods of mental block increase in frequency and in duration. Errors were found to occur either immediately before or immediately after these blocks.

Warren and Clark (1937) studied the effects of going without sleep for 65 hours. Although the subjects found it difficult to stay awake, they did not drop in their performance of mental and motor tasks.

Safford (1955) studied changes as the result of 20 hours of continuous flight in choice reaction time, tweezer dexterity, and memory for digits of 37 B-47 pilots and crewmen. The men reacted more slowly after the flight than before it and failed to react to the correct stimulus more frequently than before the flight. No significant differences in tweezer dexterity nor in the repetition of digits were found. The results of this study, as well as those of the Warren and Clark study, may reflect the effect of increased motivation due to the challenging effect of presenting a brief task to a fatigued subject. Evidently a person can do brief tasks under conditions of extreme fatigue but cannot maintain the alertness needed for tasks of longer duration.

Production values as measures of fatigue have the disadvantages of being affected by motivation, a variable that is probably impossible to control. Practically, however, production is more important to the country as a whole than are feelings of fatigue.

Poffenberger (1927) said that laboratory studies show decrements of performance as the result of work while typical industrial situations do not show such decrements over anything but extended periods. Poffenberger believes that the decrements obtained in laboratory studies have been found because the conditions have been deliberately arranged to produce them.

The present writer believes that the important variable is the motivation of the subject not the selection of conditions by the experimenter. Lewin (1929) found that unemployed workers could tabulate throughout an eight-hour day while college students became completely fatigued (bored) by the end of four hours.

II. Statement of Problem

The present experiment was designed to study the effects of doing tabulating and doing arithmetic problems each for 12 continuous hours. Will college students, who have a high level of motivation, be able to do these tasks for twelve hours without showing an output decrement? Much of the loss of work output found in experimental investigation performed in the laboratory probably has resulted from boredom rather than from physiological fatigue. Several of the long-term fatigue studies have involved the doing of short tasks after periods of extended work or lack of sleep. Brief tasks can probably be performed when a subject is so fatigued that he cannot maintain the alertness needed for tasks of longer duration. Also, many of the studies have been conducted in such a way that the subject always knew how much longer he was to work. Thus, a number of studies may have failed to find a work decrement because of end spurts in performance. Data is generally not presented in sufficient detail to determine the importance of this possibility. However, several investigators have reported end spurts.

The tabulation task was selected to provide as homogeneous task as possible. Robinson and Bills (1926) reported that homogeneous tasks result in more rapid decrement in performance than do heterogeneous tasks. The arithmetic task was selected to maximize decrement due to the need to change set. Bills (1935) said that the more often a subject is forced to change his set, the greater the decrement.

III. Method

<u>Apparatus and Subjects</u>. The only equipment needed for the task of tabulation was an 8½" x 11" notebook of white paper for each subject, a pencil and a stop watch.

The apparatus employed for the arithmetic task consisted of a Stoelting spring driven kymograph upon which a continuous band of paper was rolled from chart paper intended for a Stoelting cardio-pneumo-polygraph. This type of paper allowed for the continuous recording of the events occurring during the entire 12 hour period. Recording of times of response was accomplished by means of an electric driven, ink writing, time marker in series with a make-circuit reaction key and two one and one-half volt batteries. The reaction key was activated by the experimenter. The kymograph drum was adjusted to move at the rate of 1.67 inches per minute. (See Figure 1 for a drawing of the apparatus and a wiring diagram.)

The problems to be completed were written in ink upon 8½" x 11" pages fastened together in booklet form. Approximately 36 problems appeared on each page. They were equally divided between addition, subtraction, multiplication, and division. The problems were obtained from fifth and sixth grade arithmetic books. They were arranged in order by putting the problems,

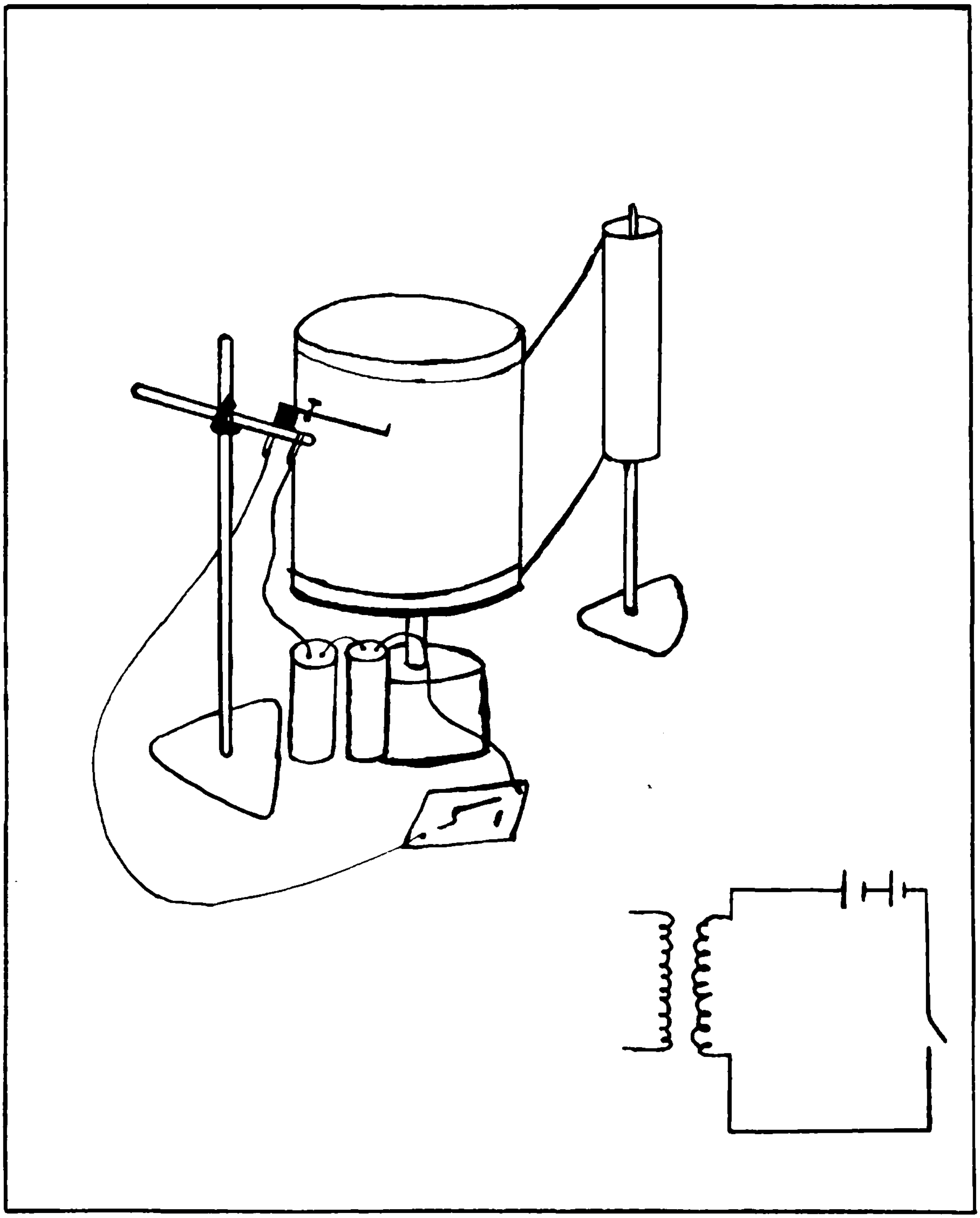


Figure 1. Drawing of apparatus and wiring diagram.

each written on a separate piece of paper, into a box and drawing them one at a time. There were a total of 1,433 problems available in each booklet. The subject either did each problem mentally or worked it on scratch paper and wrote the answer on the task booklet.

Three subjects did both parts of the experiment. These subjects were all men of graduate or senior standing at the University of Arizona. One subject was an American citizen, the other two subjects were Arabs. One of the Arab subjects was paid for his services.

Procedure. The first task: tabulation. The subject was instructed to tabulate on the white paper of the notebook and whenever he finished a page to turn to the next page. Every 15 minutes the experimenter gave the subject a signal so that he could draw a line where he was working at that time. The subject continued working in this manner for a twelve-hour period excluding 30 minutes to eat and to tend to his bodily needs. This break occurred at the conclusion of five and one-half hours of work. All subjects started work at 12:00 noon, had their breaks at 5:30 P.M., started work again at 6:00 P.M., and finished the task at 12:00 midnight. No two subjects were tested on any single day.

The second task: solving arithmetic problems. One week after doing the tabulation, the subjects were given the booklet containing the arithmetic problems and were instructed to solve the problems and put the answers in the correct space in the booklet. Each subject was tested alone. He was told that he could either solve the problems mentally or work them on scratch paper. Whenever, the subject finished a problem he held up his pencil to indicate that he had finished. The experimenter then pushed the key to record the time of each solution. The work period and the dinner break were the same as those employed during the performance of the tabulation task.

IV. Results

A. Performance Curves

Figure 2 shows the number of tabulation marks made during each fifteen minutes of the eleven and one-half hour period. As can be seen by looking at the three curves constituting the figure, subject 1 showed some irregularities with a definite low point after approximately three-fourths of the work period had passed. This period of low production followed immediately the subject's period of highest production rate. Subject 2's curve shows a period of warming-up and some irregularity primarily during the middle part of the period. And subject 3's performance rate tended to increase slightly throughout the period with relatively little irregularity.

Figure 3 shows the number of minutes required to solve each group of six problems. Subject 1 performed at an irregular rate and tended to decrease in his rate of production during the work period. Subject 2 showed a noticeable drop in production rate followed by considerable increase in rate of work. And subject 3 showed considerable loss in production while doing the first 180 problems and even greater variability in performance than the other two subjects.

Figure 4 shows the number of problems completed during

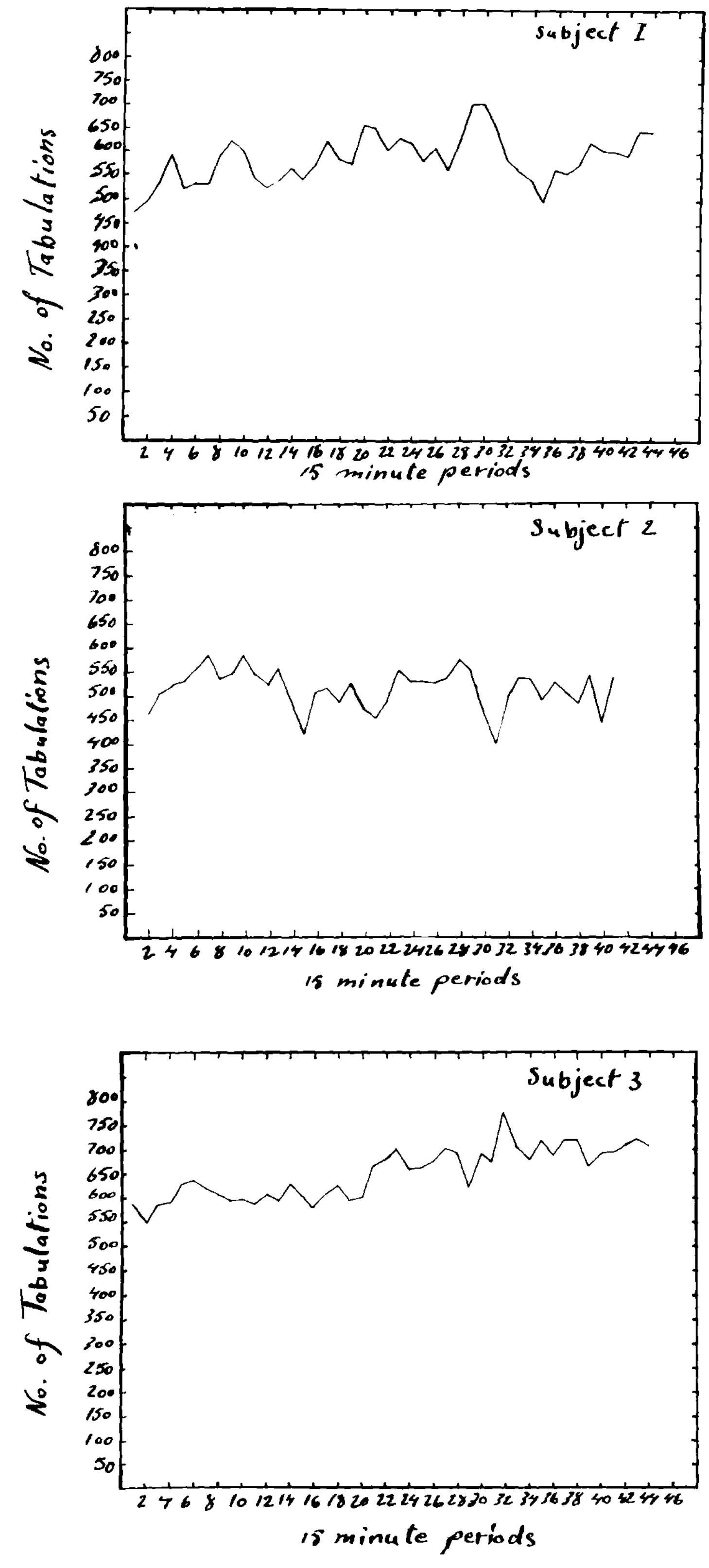


Figure 2. The number of tabulation marks made per 15 minute period.

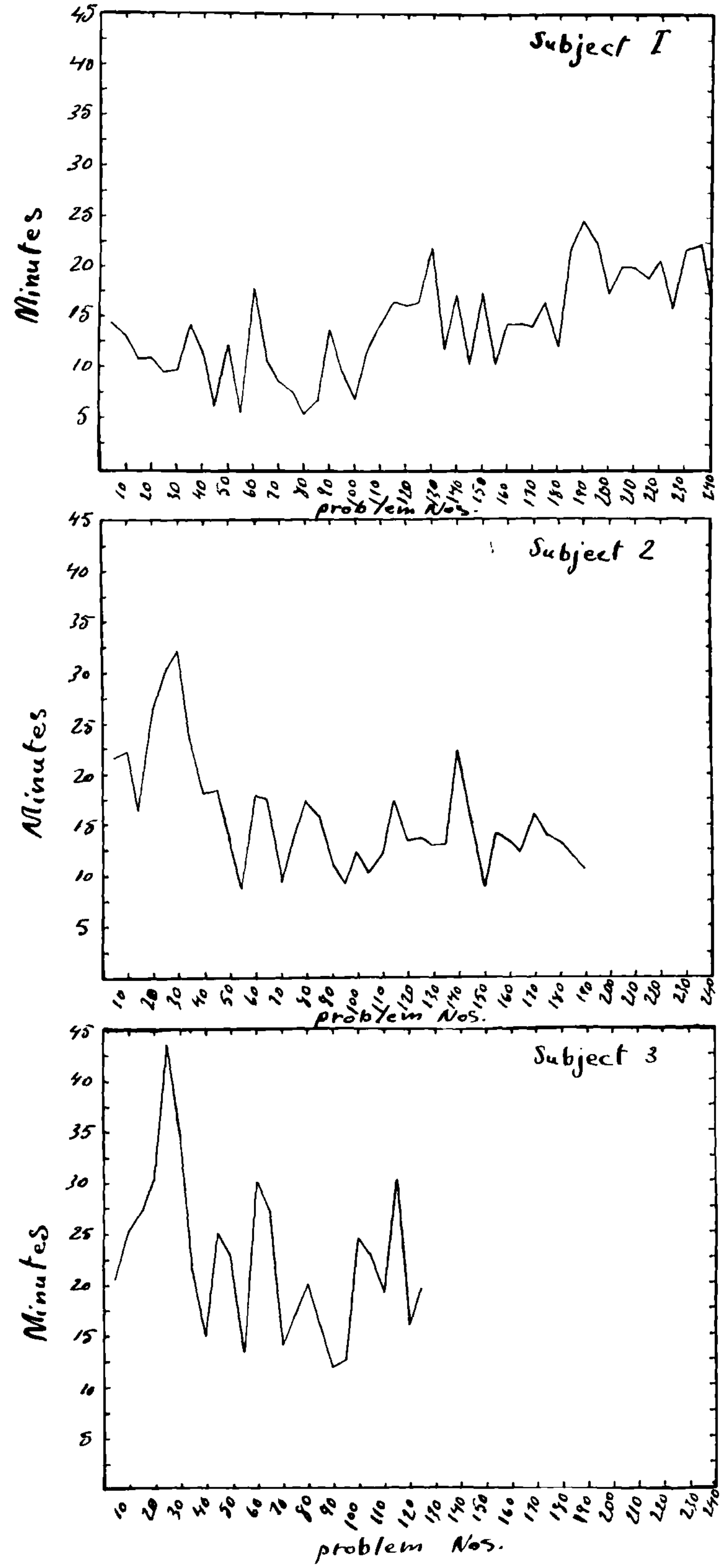


Figure 3. Amount of time required to do each group of 30 problems.

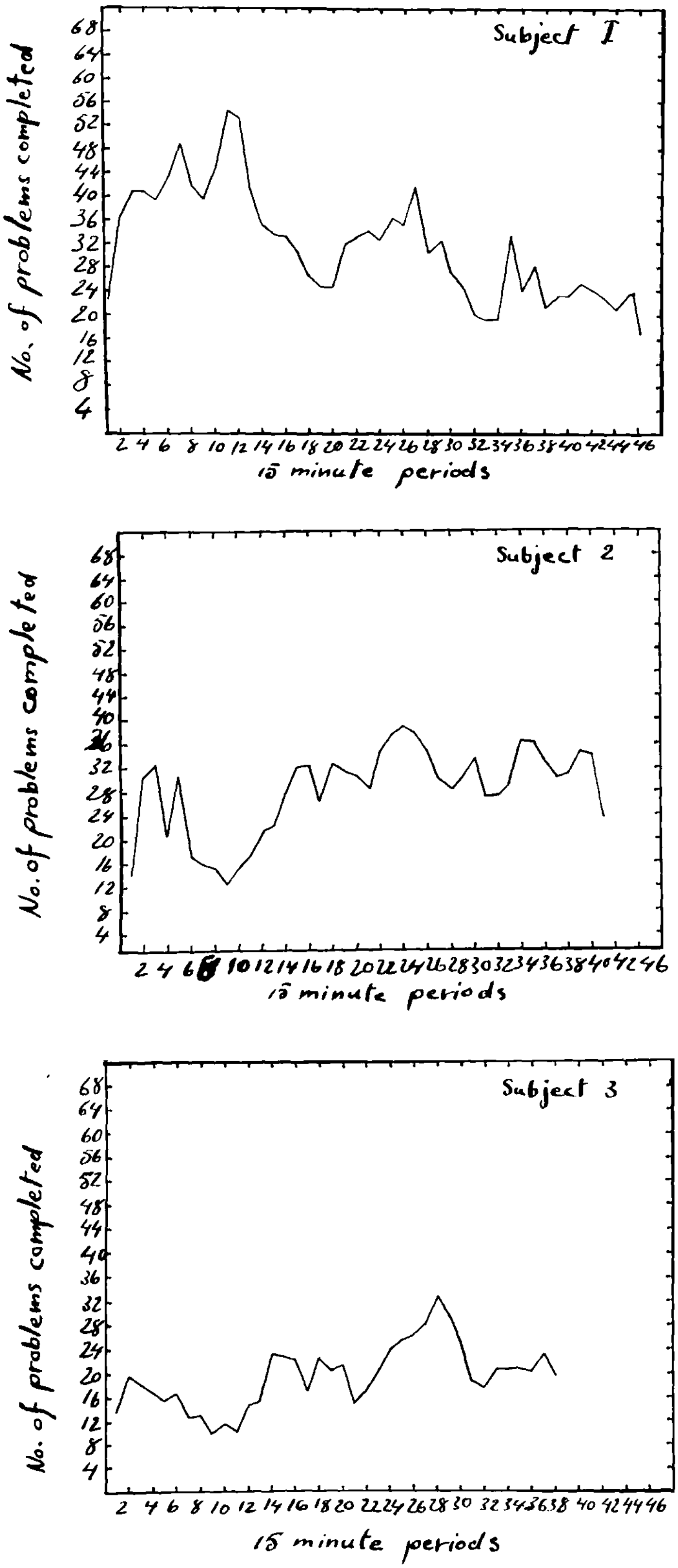


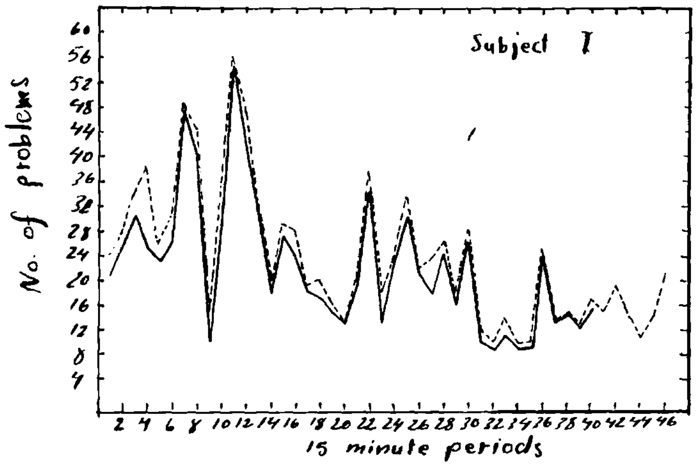
Figure 4. The number of problems completed per 15 minute period. Curves have been smoothed.

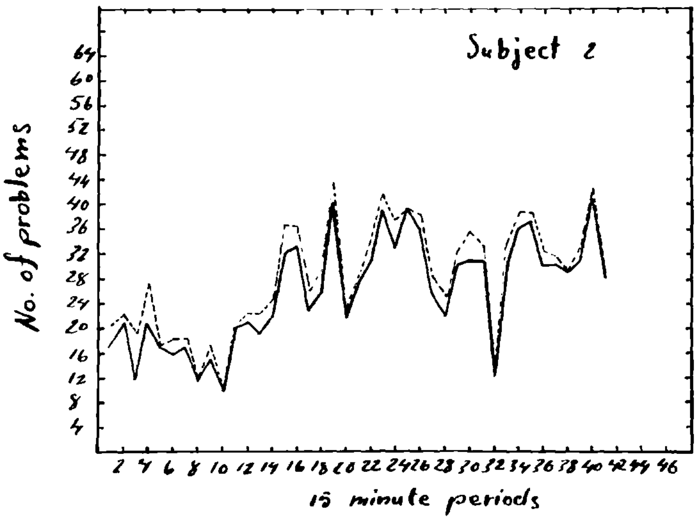
each 15 minutes of work. Smoothing was done by averaging the number done during each 15 minutes with the numbers done during the previous and following 15 minute periods. This method of treatment forces low production values for the first and last periods. Thus, these two values should be ignored in analyzing the curves. Subject 1 showed, by this method of analysis, a warm-up period followed by a decreasing rate of performance. Subject 2 showed an early decline followed by an increase in performance. Subject 3 also showed an early decline in performance. He showed a peak in performance approximately three-fourths of the way through the period.

Figure 5 compares the number of problems done during each 15 minute period with the number correct during each period. Subject 1 tended to be less accurate during the first part of the work period than later. His accuracy tended to be lower during periods of rapid and of slow performance than during the periods in which his performance was approximately average. Subject 2 tended to be least accurate during periods of high performance level. Subject 3 tended to be accurate and to work slowly. This subject reported an attempt to be very accurate.

B. Statistical Analyses of the Tabulation Data

Comparisons of tabulation rates during the first ten fifteen minute periods and the last ten fifteen minute periods





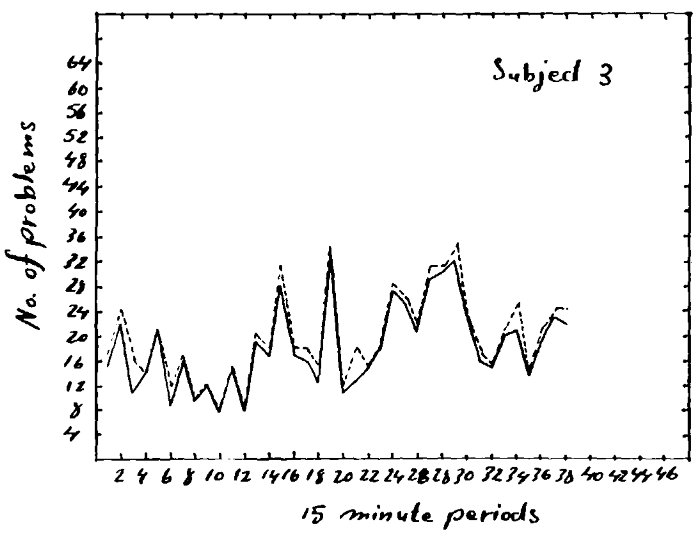


Figure 5. The number of arithmetic problems completed per 15 minute period and the number of problems done correctly during each 15 minute period.

were made using the "t" test of significance. As can be seen in Table 1, the only significant shift between performance during the first 150 minutes and the last 150 minutes was in the performance of subject 3. This subject performed significantly faster during the last part than during the first part of the task period.

F-ratios reveal greater variability in Subject 2's data for the first ten fifteen minute periods than for the last ten fifteen minute periods ($F = 3.530$ with 9 by 9 degrees of freedom, level of significance 5 per cent). The variability for the other two subjects did not differ significantly.

Table 2 shows the average neatness score values for the first and last 20 periods of 15 minutes each. Scores of 4 were given for each 15 minutes of production which was considered very well done. Well done work was scored as 3, average work as 2, poor work as 1, and very poor work as 0. Subjects 2 and 3 did less neat work during the last than during the first group of 20 periods.

The rank order correlation between the number of tabulation marks per 15 minute period and the goodness of the constructions of the tabulations was significant for subject 3. His work became less neat the faster he worked (rho = -.812). This is the only subject who significantly changed his performance level to correspond with his rate of work.

Table 1

Average Numbers of Tabulation Marks Made Per Fifteen Minutes During the First and Last 150 Minutes, t Values for Differences, and Level of Significance of Differences.

Subject	Average Number of Tabulations Per 15 Minutes		t Score of the Difference	Degrees of Freedom	Per Cent Level of Significance of the Difference
	First 150 Minutes	Last 150 Minutes			
1	550.1	591.4	1.973	18	6.7
2	525.0	508.9	.788	18	44.3
3	598.6	704.1	10.154	18	1.0

Table 2

Average Neatness Scores for Tabulations Completed During the First and the Last 20 Periods of 15 Minutes Each, t Values for Differences, and Levels of Significance of Differences

Subject	Average Neatness Scores		t Score of the Difference	Degrees of Freedom	Per Cent Level of Significance of the Difference
	Average for First 20 Periods	Average for Last 20 Periods			
1	1.25	1.60	1.434	38	15.8
2	2.45	1.65	2.980	38	1.0
3	2.65	1.55	6.351	38	1.0

C. Statistical Analyses of the Arithmetic Data

As can be seen in Table 3, subject 1 slowed significantly in his solving of arithmetic problems from the first to the last of the work period. The rate of work of the other two subjects did not change significantly.

F-ratios for the time required to solve groups of 6 of the first 60 problems compared with the length of time required to solve groups of 6 of the last 60 problems completed failed to reveal any changes in variability.

However, subjects 2 and 3 solved significantly more problems correctly per 15 minute period during the last 150 minutes of the work period than during the first 150 minutes of the work period. See Table 4.

Subject 1 was more variable in the number of problems solved correctly during the first 10 periods of 15 minutes ($F = 5.644$ with 9 by 9 degrees of freedom, level of significance 1 per cent).

Table 3

Average Numbers of Minutes Required to Solve Groups of 6 Problems During the Period Required to Solve the First 60 Problems and the Last 60 Problems, t Values for Differences, and Levels of Significance of Differences

Subject	Average Number of Minutes to Solve Groups of 6 Problems		t Score of the Difference	Degrees of Freedom	Per Cent Level of Significance of the Difference
	First 60 Problems	Last 60 Problems			
1	2.76	3.81	2.912	18	1.0
2	4.47	2.56	1.919	18	6.9
3	4.58	3.93	.901	18	31.0

Table 4

Average Number of Problems Solved Correctly Per 15 Minutes During the First 150 Minutes and the Last 150 Minutes of the Work Period, t Values for Differences, and Levels of Significance of Differences.

Subject	Average Number of Problems Correct Per 15 Minute Period		t Score of the Difference	Degrees of Freedom	Per Cent Level of Significance of the Difference
	First 150 Minutes	Last 150 Minutes			
1	35.6	20.6	1.373	18	18.9
2	15.8	30.5	7.097	18	1.0
3	13.8	23.8	3.801	18	1.0

V. Discussion and Conclusions

The results of the present study reveal that certain college students can do boring tasks or tasks that demand continual changes in set for a period of $11\frac{1}{2}$ hours with only minor losses in production. As was noted in the introduction to this paper, Robinson and Bills (1926) and Bills (1935) postulated that boring tasks and tasks that demand changes in set both result in greater loss in production than do other tasks.

No subject decreased significantly in his production of tabulation marks during the $11\frac{1}{2}$ hour interval. Subject 3 increased significantly in his production. Subjects 2 and 3 both became less neat in their performances and subject 2 was more variable in his rate of work during the latter part than during the early part of the work period. Thus, two subjects showed some decrease in output as the result of the long work period. However, since subject 3 increased in his rate of work, the decline in neatness may have been a simple correlate of speed rather than the result of fatigue. Subject 3 increased from an average production of 598.6 tabulation marks per 15 minute period during the first 150 minutes of the session to 704.1 tabulation marks per 15 minute period during the last 150 minutes of the session. This gain is certainly far different than the loss reported by Lewin (1929) who found that his college-student subjects considered themselves so tired that they could not continue to tabulate after only four hours of continuous work.

Subjects 2 and 3 decreased in their neatness of work. However, the losses were minor. On a four-point scale, subject 2 lost only .80 points, subject 3 lost only 1.10 points. Again, these subjects' performances were far from the poor performance after relatively brief periods of work reported by Lewin. In only one subject, subject 3, was the rate of tabulation signficantly related to the neatness of work.

Only one subject, subject 1, showed a significant production loss as the result of doing arithmetic problems for 11½ hours. Since this task demanded the doing of four different types of problems, rapid changes in set were necessary. This subject required an average of 2.76 minutes to do each group of 6 of the first 60 problems and of 3.81 minutes to do each group of 6 of the last 60 problems.

The other two subjects, subjects 2 and 3, did not decrease in their rate of work during the 11½ hour work period. They actually solved more problems correctly during the last 150 minutes of the session than during the first 150 minutes of the session. Subject 2 completed correctly an average of 15.8 problems per 15 minutes during the first 150 minutes of the work session and of 30.5 problems per 15 minutes during the last 150 minutes of the session. The two corresponding values for Subject 3 were 13.8 and 23.8.

As can be seen by the values presented, subject 1, the subject who showed a production loss, was the fastest worker on the arithmetic task. There is no way of knowing from the data available whether rate of work explains the difference in effects upon the three subjects.

The results, however, indicate that the 11½ hour work period exerted very little adverse effect upon the performance level of the three subjects studied. Tabulation performance was probably adversely affected in only one subject, subject 2. Subject 3 did less neat work during the last of the work period than during the first of the work period. However, his rate of performance increased, and his performance rate was found to be inversely related to his neatness of work. Arithmetic performance slowed in only one subject, subject 1. This subject was the fastest working subject of the group. The other two subjects did not decrease in their rate of performance and actually did more problems correctly per unit time during the latter part than during the early part of the work session.

Thus work decrement found in the typical laboratory experiment as the result of relatively short periods of work is probably to be attributed to boredom rather than to physiological fatigue.

VI. Summary

Three college student, male subjects were asked to tabulate or do arithmetic problems for 12 hours with a 30 minute meal break. Tabulation was done one week and arithmetic problems the following week. Each subject worked separately.

Two subjects became less neat in their tabulation performance during the 11½ hour period. One of these subjects, however, showed a compensatory increase in rate of work. Therefore, only one subject showed a definite decrement in work output as the result of the long work period.

Only one subject showed a loss in arithmetic production rate during the work period. The other two subjects actually did more problems correctly during the last 150 minutes than during the first 150 minutes.

In subjects who were highly motivated, work decrement as the result of 11½ hours of work was found to be very small. Therefore, it was concluded that laboratory studies which have shown decreased production after brief periods of work have probably measured the effects of boredom rather than those of physiological fatigue.

References

Bartley, S. H., and Chute, Eloise. Fatigue and impairment in man. New York: McGraw-Hill, 1947.

Bills, A. G. Fatigue in mental work. Physiol. Rev., 1937, 17, 436-453.

Burtt, H. E. Applied psychology. New York: Prentice-Hall, 2nd ed., 1957.

Cattell, R. B. General psychology. Cambridge, Mass.: Sci-Art Publishers, 1941.

Davis, L. E., and Josselyn, P. D. How fatigue affects productivity: a study of manual work patterns. Personnel, 1953, 30, 54-59.

Dill, R. B. Physiology of fatigue. J. Lab. and Clin. Med., 1942-43, 28, 596-601.

Gillilan, A. R., Morgan, J. J. B., and Stevens, S. N. General psychology. Boston: D. C. Heath and Company, 1935.

Johnson, H. M. The real meaning of fatigue. Harpers, 1929 158, 183-193.

Lewin, K. Investigations on the psychology of action and affection. Psychol. Abstracts, 1927, No. 1477. (Original article published in Psychol. Forsch., 1926, 10, 142-254.)

Miles, G. H., and Angeles, A. The influence of short time fatigue on speed of production II. J. Nat'l. Insti. Indust. Psychol., 1925, 2, 300-302.

Mintz, A. Further developments in psychology in the U.S.S.R. Ann. Rev. Psychol., 1959, 10, 455-487.

Muscio, B. Is a fatigue test possible? Brit. J. Psychol., 1921, 12, 31-46.

Myers, C. S. Mind and work. London: Pulman Company, 1921.

Poffenberger, A. T. The effects of continuous mental work. Amer. J. Psychol., 1927, 39, 283-296.

Reed, H. B. Fatigue and work curves from a 10-hour day in addition. J. Educ. Psychol., 1924, 15, 389-392.

Safford, L. A. Some psychological effects of prolonged flight in airplanes. Unpublished master's thesis, University of Arizona, Tucson, Arizona, 1955.

Starch, D., Stanton, H. M., and Koerth, W. Controlling human behavior. New York: MacMillan, 1936.

Thorndike, E. L. The curve of work and the curve of satisfyingness. J. Appl. Psychol., 1917, 1, 265-267.

Tiffin, J., and McCormick, E. J. Industrial psychology. New York: Prentice-Hall, 4th ed., 1958.

Viteles, M. S. Industrial psychology. New York: W. W. Norton, 1932.

Warren, N., and Clark, B. Blocking in mental and motor tasks during a 65-hour vigil. J. Exp. Psychol., 1937, 21, 97-105.