THE EFFECT OF SELF-INDUCED MUSCULAR TENSION ON MENTAL SET IN PROBLEM SOLVING BEHAVIOR

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Submitted to the Faculty of the Graduate School of
the Oklahoma Agricultural and Mechanical College
in partial fulfillment of the requirements
for the Degree of
DOCTOR OF EDUCATION
1955

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PREFACE

This investigation evolved from an initial interest in the psychological effects of muscular relaxation training. Reading activities motivated by this interest gradually shifted to research designed to investigate the effects of muscular tension on mental activity. As the writer's knowledge in this area increased, it became more and more apparent that it would be desirable to investigate the relationship, if any, between muscular tension and the operation of mental set in problem solving behavior.

Since it is the function of the teacher, counselor, and psychotherapist to create learning situations conducive to successful problem solving behavior, it becomes important that they know the effects of the variables related to the learning process. If a relationship is found between tension and the operation of mental set, then this information can be utilized to facilitate more effectively successful problem solving behavior. The purpose of this study is to provide information relative to this relationship.

The writer feels very keenly his indebtedness to the many people who helped make this work possible. The author wishes to express his appreciation to Dr. Harry K. Brobst, chairman of the committee, for his constant encouragement

and understanding; also to Dr. S. L. Reed, Dr. M. R. Chauncey, Dr. Alexis M. Anikeef, Dr. Roy Gladstone, and Dr. Roy E. Sommerfeld, the other members of the committee, for their valuable guidance and assistance during the investigation. Appreciation is expressed also to Professor Carl E. Marshall for his help in the statistical treatment of the data and to Mr. Ted Stevens and Mr. Robert Morgan for their assistance during the administration of the experiment.

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CHAPTER I

THE PROBLEM

Introduction

Problem solving behavior may be exhibited by an organism when it is confronted with an ambiguous situation which interferes in some way with the satisfaction of its needs. If the organism's response is directed toward the clarification of the ambiguous situation then the activity is properly referred to as problem solving behavior.

Successful problem solving behavior sometimes requires a reorientation to the factors involved. This reorientation is normally an integrative process in which the relevant factors are assigned new values and meanings. A problem may be unsolvable when an established habit response is employed, but the same problem will become solvable when the habitual response is replaced by a new and more adaptive response. When problem solving behavior is inhibited by the occurrence of habitual responses, then this inhibiting factor is variously referred to as "mental set," "perseveration," or "mental rigidity."[1]

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[1] J. J. Gibson, "A Critical Review of the Concept of Set in Contemporary Experimental Psychology," Psychological Bulletin, XXXVIII (November, 1941), 781-817.

A habit may be regarded as having both a positive aspect and a negative aspect. The positive aspect is manifest to the extent to which the habit is an adaptive response. The negative aspect is manifest to the extent to which the habit interfers with a more adaptive response. If a habit is regarded in this manner, then the occurrence of a habitual response under a specified condition can be evaluated in terms of its positive and negative qualities. For the purposes of this study a habitual response becomes a mental set when the negative aspect predominates.

Since it appears that mental set operates in many problem solving situations, it becomes important to know what factors influence the operation of mental set. It is the purpose of this study to investigate the effect of self-induced muscular tension on mental set in problem solving behavior.

Statement of the Problem

Broadly conceived, the problem is to discover the relationship between muscular tension and the operation of mental set in problem solving behavior. More specifically, the problem has three aspects which must be delineated clearly. One aspect is the effect of muscular tension on the initial establishment of mental set. Another aspect is the effect of muscular tension on behavior after the mental set has been established. Finally, the third aspect is the effect

of a change of muscular tension on behavior after the mental set has been established. Thus, the problem breaks down into three parts. First, does self-induced muscular tension facilitate, inhibit, or have no effect on the establishment of mental set? Second, does self-induced muscular tension facilitate, inhibit, or have no effect on the ability to overcome mental set? Third, does a change of muscular tension facilitate, inhibit, or have no effect on the ability to overcome mental set? This research effort is directed toward obtaining answers to these three questions.

Hypotheses

The experimental method may be more efficiently employed if the problem is restated in terms of the acceptance or rejection of three basic hypotheses. Formulated as null hypotheses they take the following form:

First Hypothesis--Self-induced muscular tension has no effect on the establishment of mental set.

Second Hypothesis--Self-induced muscular tension has no effect on the ability to overcome mental set.

Third Hypothesis--A change of muscular tension has no effect on the ability to overcome mental set.

Valid tests of these three hypotheses will furnish answers to the three questions contained in the thesis problem.

CHAPTER II

SURVEY OF THE LITERATURE

Although a search of the literature failed to reveal any research effort dealing directly with the thesis problem, there were a number of reported research studies which provided the groundwork for the problem. The most pertinent research studies were those which investigated the operation of mental set and those which were designed to determine the various effects of self-induced muscular tension on mental activity.

Studies Which Have Demonstrated the Effect of Mental Set in Problem Solving Behavior

Boring[1] gives a historical account of the beginnings of the concept of set. According to his account, Marbe, Ach, Watt, and others at Würzburg recognized the operation of mental set and coined terms to label the important aspects of the phenomenon. The term Aufgabe referred to the task or purpose that precedes a conscious course. The Aufgabe would

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[1] E. G. Boring, A History of Experimental Psychology (New York, 1950), pp. 404-410.

induce in the subject an Einstellung or "set." Warren[2] defines Einstellung as:

> The set which immediately predisposes an organism to one type of motor or conscious act.

Gibson[3] reports that the best known experimental example of this early period seems to be Ach's demonstration that a subject's reaction to the presentation of two numbers was dependent upon whether the task prescribed was adding, subtracting, or multiplying. The purpose of the subject, rather than the stimuli or their associative tendencies, determines the reaction.

Rees and Israel[4] made one of the earliest reported studies which dealt directly with the operation of mental set in problem solving behavior. With the use of "ambiguous" anagrams, which offered possibilities of solution in more than one way, they were able to demonstrate that sets established by the usual method of verbal instruction influenced definitely and consistently which one of the alternative solutions would be obtained. It was found also that sets may be induced through experience or training with

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[2]H. C. Warren, Dictionary of Psychology (New York, 1934), p. 371.

[3]J. J. Gibson, "A Critical Review of the Concept of Set in Contemporary Experimental Psychology," Psychological Bulletin, XXXVIII (November, 1941), 781-817.

[4]H. J. Rees and H. C. Israel, "An Investigation of the Establishment and Operation of Mental Sets," Psychological Monographs, XLVI, No. 6, (Whole No. 210), 1935, 1-27.

materials of appropriate nature that are equally as effective as those established by instructions. An additional finding of this study was that a set may operate to a high degree of effectiveness without the subject's being aware of having the set.

Siipola[5] found that under certain conditions a set may carry over and affect performance in subsequent tasks. When subjects were given verbal instructions to look for names of animals or birds in equivocal items presented on a screen, a set induced by these instructions strongly affected performance on a subsequent task which involved the completion of skeleton words.

Sells[6] found that unconscious sets had an effect upon syllogistic reasoning. In his experiments he analyzed a type of set, induced by the premises of a syllogism, which was demonstrated to determine the conclusion quite apart from logical validity. According to Sells this type of set was involuntary, unverbalized, and unreportable by introspection. A concept, identified as "atmosphere effect," was developed in this study. Sells defines this concept as:

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[5] E. M. Siipola, "A Group Study of Some Effects of Preparatory Set," Psychological Monographs, XLVI, No. 6, (Whole No. 210), 1935, 27-38.

[6] S. B. Sells, "The Atmosphere Effect: An Experimental Study of Reasoning," Archives of Psychology, XXIX, No. 200, 1936, 72.

> A temporary set of the individual, arising within a situation, to complete a task with that one of several alternative responses which is most similar to the general trend or tone of the whole situation.[7]

The most exhaustive study concerning set found in the literature was accomplished by Luchins[8] about fifteen years ago. Under the sponsorship of Max Wertheimer, Luchins constructed a series of water-jar problems and utilized these problems in a number of experiments designed to investigate the operation of mental set. Not only did the results of his experiments firmly establish the validity of the concept of mental set, but also a large amount of data was collected which yielded information concerning the actual operation of mental set. An additional contribution made by Luchins was origination of the water-jar problems. These problems gave experimenters a valuable experimental tool for investigating the operation of mental set.

Studies Which Have Investigated Factors Related to the Operation of Mental Set

Luchins[9] failed to find a clear cut relationship between I. Q. and the operation of mental set. The effects

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[7] Ibid., p. 7.

[8] A. S. Luchins, "Mechanization in Problem-Solving: The Effect of Einstellung," Psychological Monographs, LIV, No. 6, (Whole No. 248), 1942, 1-75.

[9] Luchins, op. cit., pp. 18-22.

of set were found to be quite large in both the high I. Q. groups and the low I. Q. groups. There were rather definite indications, however, that the effects of mental set were greater in secondary school pupils than in college students. The type of classroom instruction to which the students had been accustomed also seemed to be related to the operation of set. Those students who were accustomed to a "democratic" type of classroom atmosphere seemed to be less susceptible to set than those who were accustomed to a more "authoritarian" type.

Guetzkow[10] found that the ACE scores of those subjects who were susceptible to set were significantly lower than those who were not susceptible to set. He also found that the women who were able to surmount set had significantly higher ACE scores than those who were not able to surmount set. This latter relationship did not hold true for the men. An additional relationship reported by Guetzkow was that those subjects who were susceptible to set performed less well on a 12-Item Reasoning Test than those subjects who were non-susceptible to set.

Fisher[11] performed an experiment in which he compared the mental rigidity manifested by conversion hysterics,

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[10]Harold Guetzkow, "An Analysis of the Operation of Set in Problem Solving Behavior," Journal of General Psychology, XLV (October, 1951), 219-244.

[11]Seymour Fisher, "Patterns in Personality Rigidity and Some of Their Determinants," Psychological Monographs, LXVI, No. 1, (Whole No. 307), 1950, 41-42.

paranoid schizophrenics, and normals. As a part of his study he investigated the relationship between rigidity and intelligence and failed to find any relation between the two variables. The results did indicate that conversion hysterics and paranoid schizophrenics were more rigid than normals.

There have been a number of recent investigations of the relationship between anxiety and mental rigidity. The results of these studies give convincing evidence that there is a positive relationship between these two variables.

Beier[12] used two equated groups of female graduate students and induced anxiety in one of the groups. Both groups were then tested for measures of rigidity and disorganization. The measuring instruments were an abstract reasoning test, a sorting test, and a mirror drawing test. From the results Beier concluded that individuals in a stage of induced anxiety show greater rigidity and disorganization in the perceptual fields.

Christie[13] conducted a similar experiment in which a set was induced through the use of Luchins' water-jar problems. After the set was induced in all subjects, the

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[12]Ernest G. Beier, "The Effect of Induced Anxiety on Some Aspects of Intellectual Functioning: A Study of the Relationship between Anxiety and Rigidity," American Psychologist, IV (July, 1949), 273-274.

[13]Richard Christie, "The Effect of Frustration Upon Rigidity in Problem Solving," American Psychologist, V (July, 1950), 296-297.

control group received a readily solvable problem and the experimental group received an insolvable problem given under conditions designed to induce frustration. An extinction problem which could not be solved by the set but was readily solvable by another solution method was then given to both groups. The performance of the two groups then was compared. It was concluded that the effects of frustration upon an established set were such that the strength of the set was increased and behavioral rigidity was manifested after such frustration.

Cowen[14] studied the relationship between psychological stress and problem-solving rigidity. The instrument used to measure rigidity was Luchins' series of water-jar problems. Three groups were used in the experiment: a non-stress or control group, a mild stress group, and a strong stress group. Cowen concluded, on the basis of the experimental results, that increasing degrees of experimentally induced psychological stress elicited increasing amounts of problem-solving rigidity.

In another study Cowen[15] used what he called a "stress" group and a "praise" group. The "stress" group was

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[14]Emory L. Cowen, "The Influence of Varying Degrees of Psychological Stress on Problem-Solving Rigidity," Journal of Abnormal and Social Psychology, XLVII (June, 1952), 512-519.

[15]Emory L. Cowen, "Stress Reduction and Problem Solving Rigidity," Journal of Consulting Psychology, XVI (1952), 425-428.

subjected to an experimentally induced stress condition while the "praise" group was praised for their previous performance. It was found that the "praise" group was significantly less rigid than the "stress" group in their behavior on water-jar problems.

Kendler, Greenberg, and Richman[16] conducted an experiment to discover whether distributed practice is superior to massed practice in the learning of a mental set. Half of the subjects were presented a series of water-jar problems under massed conditions while the remainder had a three minute interval between successive problems. The strength of the set response was measured by a test problem which could be solved with the set method or with a simpler non-set method. The results indicated that the mental set was learned to a stronger degree under conditions of massed practice.

A recent experiment by Luchins[17] investigated the relation between mental set and concreteness of thinking. Mental set was measured by responses on water-jar problems and concreteness of thinking was measured by responses to a similarities subtest of the Wechsler-Bellevue Intelligence

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[16]Howard H. Kendler, Arthur Greenberg, and Howard Richman, "The Influence of Massed and Distributed Practice on the Development of Mental Set," Journal of Experimental Psychology, XLII (January, 1952), 21-25.

[17]A. S. Luchins, "The Einstellung Test of Rigidity: Its Relation to Concreteness of Thinking," Journal of Consulting Psychology, XV (1951), 303-310.

Scale. The results showed a rather consistent but generally unreliable trend toward a positive relationship between behavioral rigidity and concreteness of thinking.

Studies Which Have Investigated the Effect of Self-Induced Muscular Tension on Mental Activity

Bills[18] was the first investigator to experimentally investigate the relation between induced tension and mental work. In each of the four experiments conducted by Bills, the performance of a group of subjects operating under a tension condition was compared with the performance of a group of subjects operating under a normal condition. Those in the "Tension" group were required to hold a specific grip pressure with each hand. Two hand dynamometers were used to measure the degree of pressure being exerted. Those in the "Normal" group operated without any induced tension. The mental activities of memorization, adding columns of digits, and letter naming were investigated. On the basis of the results, Bills concluded that induced muscular tension does increase the efficiency of mental work.

Freeman[19] found that extreme degrees of induced tension interfere with performance during a coördinated pursuit task.

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[18]Arthur G. Bills, "The Influence of Muscular Tension on the Efficiency of Mental Work," American Journal of Psychology, XXXVIII (April, 1927), 227-251.

[19]G. L. Freeman, "The Facilitative and Inhibitory Effects of Muscular Tension Upon Performance," American Journal of Psychology, XLV (January, 1933), 17-52.

Other results of his investigation showed that there were detrimental effects resulting from both hyper- and hypotension.

Jacobson's[20] work with muscular relaxation has shown that mental activity is difficult, if not impossible, under extreme relaxation. His experimental procedure involved an objective measurement of muscular tension during thought processes. The subjects were instructed to relax their muscles progressively and report their subjective thought processes. It was found that when a subject was in a state of extreme relaxation there were no conscious thought processes occurring.

Following this early experimental work, Stauffacher[21] demonstrated that there is an optimal level of tension, induced by squeezing dynamometer handles, under which serial memorization of nonsense syllables is most efficient. Tensions below and above the optimum resulted in less facilitation. Another finding of significance in this study was that the induced tension condition facilitated the performance of the poor learners but was detrimental to the performance of the good learners.

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[20]Edmund Jacobson, Progressive Relaxation (Chicago, 1937).

[21]J. C. Stauffacher, "The Effect of Induced Muscular Tension Upon Various Phases of the Learning Process," Journal of Experimental Psychology, XXI (July, 1937), 26-46.

In another study by Bills and Stauffacher[22], in which the mental work was the solution of 'Detectograms' (miniature mystery stories) and the tension was induced by hand dynamometers, it was found that good performers were made less efficient by the introduction of tension and the poor performers were facilitated in their work.

Courts[23] found that with successive degrees of dynamometer tension, induced by gripping with the right hand, memorization is progressively more efficient until the optimal tension is reached. The optimal tension was measured to be the amount of tension produced by dynamometer pressure equal to one-fourth of a pre-determined base pressure. The base pressure for each subject was the amount of pressure exerted at the end of thirty seconds of maximum effort in a preliminary trial. Higher degrees of tension resulted in successive decrements in performance. Under tension induced by pressure equal to three-fourths of the base, memorization fell below the normal level of performance. Courts found no difference in the effects of tension on good and poor memorizers.

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[22]A. G. Bills and J. C. Stauffacher, "The Influence of Voluntarily Induced Tension on Rational Problem Solving," Journal of Psychology, IV (1937), 261-271.

[23]Frederick A. Courts, "Relations Between Experimentally Induced Muscular Tension and Memorization," Journal of Experimental Psychology, XXV (September, 1939), 235-256.

Courts[24] conducted another investigation in which he sought to discover the relation between induced tension and performance on a pursuit rotor. The tension condition was induced through the use of the hand dynamometer. The results of this experiment showed that this type of learning was facilitated by induced muscular tension. It also was found that there was an optimal amount of tension for facilitating effects.

An investigation by Knott[25] yielded evidence showing that increased proprioceptive stimulation reduced the latent time of blocking of the alpha rhythm. The increased proprioceptive stimulation was accomplished by requiring the subjects to hold ten-pound weights.

Freeman[26] made a study in which optimal tension for various performances was investigated. The muscular tension was induced in the lower limbs by the maintenance of various pressures. The subjects lay on a comfortable cot and pushed with their feet against lever arrangements attached to ordinary spring balance scales. It was found that induced

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[24]Frederick A. Courts, "The Influence of Practice on the Dynamogenic Effect of Muscular Tension," Journal of Experimental Psychology, XXX (June, 1942), 504-511.

[25]John R. Knott, "Some Effects of 'Mental Set' on the Electro-physiological Processes of the Human Cerebral Cortex," Journal of Experimental Psychology, XXIX (April, 1939), 384-405.

[26]G. L. Freeman, "The Optimal Muscular Tension for Various Performances," American Journal of Psychology, LI (January, 1938), 146-150.

tension inhibited performance on mirror star-tracing and mental arithmetic. Inhibition of performance on these two activities was noted for all degrees of induced tension.

In another study by Freeman[27] it was shown that optimal facilitation is obtained from tension induced in muscle groups most closely associated with the reacting member. The performance investigated in this study was finger oscillation. Tension was induced by having the subject hold a specified pressure against a spring postal scales.

Zartman and Cason[28] investigated the influence of induced muscular tension in the leg muscles on the ability to solve forty-eight short arithmetical problems selected from a number of intelligence tests. The investigators concluded from the results of the experiment that increasing the tension of the right leg does not in itself definitely increase the efficiency of solving arithmetical problems.

Additional relationships were reported by Courts[29] in a comprehensive review of the relations between muscular tension and performance. According to Courts, experimenters

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[27]G. L. Freeman, "The Optimal Locus of 'Anticipatory Tensions' in Muscular Work," Journal of Experimental Psychology, XXI (November, 1937), 554-564.

[28]Edna N. Zartman and Hulsey Cason, "The Influence of an Increase in Muscular Tension on Mental Activity," Journal of Experimental Psychology, XVII (October, 1934), 671-679.

[29]Frederick A. Courts, "Relations Between Muscular Tension and Performance," Psychological Bulletin, XXXIX (June, 1942), 347-368.

have demonstrated that induced tension has a detrimental effect on affective judgments and on learning to toss tennis balls at a target. Courts also states that other investigators have found that induced tension had no effect on the mental activities of continuous addition, syllogistic reasoning, and selection of analogies.

Summary of the Literature

It appears as if sufficient experimental evidence has been presented in this chapter to firmly establish set as a valid phenomenon. Its effects were demonstrated by a number of investigators in various kinds of problem solving behavior. Luchins identifies this phenomenon as Einstellung, Sells labels it as "atmosphere effect," Gibson prefers to call it "set," Siipola uses "preparatory set," and Rees and Israel call it "mental set." Although there is a discrepancy in terminology used to identify the phenomenon, there appears to be agreement among the experimenters when it is defined operationally.

The results of the studies which investigated factors related to mental set showed that the operation of mental set was dependent upon a number of factors. The variables of anxiety, ACE scores, performance on a reasoning test, school grade level, and classroom atmosphere were found to be related significantly to the operation of mental set. Since these factors seem to be related to mental set, an

effort was made by the writer to control them in the present experiment.

Although a number of experimental studies have been made to investigate the effects of tension on mental activity, there is still no general statement that may be made concerning the relationship between the two variables. Investigators, utilizing a variety of techniques for inducing tension and variety of mental tasks to be executed under the additional experimentally induced tension, have reported varying results. Some experimenters have found facilitation of mental work, others have revealed inhibition, and some have observed no appreciable influence. It is the purpose of this study to investigate the effects of one kind and amount of muscular tension on the operation of mental set.

CHAPTER III

SUBJECTS, METHODS, AND MATERIALS

Subjects

Three hundred and sixty-one college students enrolled in Introductory Psychology at Oklahoma Agricultural and Mechanical College were used as subjects. The subjects were enrolled in six Introductory Psychology classes. There were approximately sixty-three per cent freshmen, twenty-three per cent sophomores, and fourteen per cent juniors and seniors. The proportion of males to females was approximately equal with fifty-one per cent of the subjects being males. The variability of age in the group was relatively small with eighty-six per cent of the subjects between the ages of eighteen and twenty-one.

Method of Inducing Muscular Tension

The self-induced muscular tension condition was created by requiring the subjects to hold the prongs of a clip type clothes pin between the front teeth and to apply enough pressure to force the prongs together. This tension condition was maintained by requiring the subject to keep the

prongs barely touching during the time allotted for solving a particular problem.

The clothes pins used as the tension instruments were the common wooden spring type. Grooves were cut approximately one-eighth of an inch from the end of each prong to provide a seat for the subject's teeth. The spring on each clothes pin was adjusted to a strength which would require five pounds of pressure to keep the prongs barely touching. An error of plus or minus one-eighth of a pound pressure was permitted.

Materials

Problems Used to Measure the Operation of Mental Set

A series of eight water jar problems was used to elicit problem solving behavior. The problems were the same problems which have been used in a number of other research efforts investigating the operation of mental set. The specific problems used in this experiment are listed in Table I.

The demonstration problem (D_1) and the set-inducing problems (S_1, S_2, S_3, S_4, and S_5) are solvable by first, filling container B full, then filling container A full once by pouring from container B, and finally filling container C full twice by pouring from container B. This operation leaves the required amount of water in container B. Algebraically this solution takes the form of B - A - 2C. All

the first set-inducing problems can be solved by applying this formula.

TABLE I

PROBLEMS USED IN THE EXPERIMENT

Problem Identification	Given the Following Containers			Obtain this Amount of Water	Solution Method
	A	B	C		
D_1	21	127	3	100	B-A-2C
S_1	43	89	7	32	B-A-2C
S_2	14	163	25	99	B-A-2C
S_3	18	43	10	5	B-A-2C
S_4	9	42	6	21	B-A-2C
S_5	20	57	3	31	B-A-2C
C_1	23	48	3	20	A-C
C_2	28	78	3	25	A-C
C_3	19	53	4	23	A+C

The critical problems (C_1, C_2, and C_3) are unsolvable by the solution method employed in solving the set-inducing problems. These problems can be solved rather easily, however, by using only containers A and C. The first and second critical problems (C_1 and C_2) can be solved simply by first, filling container A, then filling container C full once by pouring from container A. This leaves the required amount of water in container A. Algebraically this solution

takes the form A - C. The third critical problem (C_3) can be solved by filling both container A and container C full once. This solution takes the algebraic form of A + C. The basic assumption is that the process of applying the solution method of B - A - 2C to the set-inducing problems creates a mental set which inhibits the ability to solve the critical problems.

Anxiety Test

The Taylor Anxiety Scale[1] was used to measure the variable of anxiety. This test is composed of fifty questions which are answered with either a "yes" or "no" response. A scoring key, provided with the test, enables the grader to determine if the response to a particular question is indicative of anxiety. The number of anxious responses are counted and this number becomes the anxiety score.

Scholastic Aptitude Test

The test used to measure scholastic aptitude was the ACE Psychological Examination.[2] This test is composed of six sections. Three of the sections, which yield a Q-score, are designed to measure the subject's ability to think with the use of quantitative material. The remaining three

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[1]J. A. Taylor, Anxiety Scale, Unpublished Scale, Second Revision. Northwestern University, Chicago.

[2]American Council on Education, Psychological Examination for College Freshmen, (New York: Education Testing Service, 1948).

sections, which yield a L-score, are designed to measure the subject's ability to think with the use of linguistic material. A total score is obtained by adding the Q-score and the L-score. The three scores are expressions of the number of correct responses to the questions in the test.

The Data Booklet

A data booklet for the experiment was prepared for each subject. A reproduction of one of these booklets appears in Appendix A.

The booklet had a cover sheet on which spaces were provided for the student's name, sex, age, class level, section number, and group number. Age was expressed in terms of years, and grade level was expressed in terms of freshman, sophomore, junior, or senior. In addition to the cover sheet, there was a separate sheet provided for each of the eight problems to be solved. The problem number appeared at the top of each sheet.

Each student's name, group number, and seat number were placed on the cover sheet of the data booklet before the class assembled for the experiment.

CHAPTER IV

PROCEDURE

It will be recalled that in Chapter I three aspects of the thesis problem were delineated. It was shown that the three aspects of the problem could be investigated by formulating and testing three null hypotheses. The experimental design is the result of an effort to provide valid tests for these three hypotheses.

Experimental Design

The solution of the thesis problem required an experimental design which placed the variables related to the operation of mental set under control and allowed for systematic variation of the independent variable of self-induced muscular tension. Systematic variation of the independent variable of tension was made possible by selecting four groups of subjects and treating each group differently in regard to tension condition. It was assumed that control of the related variables was established by selecting these four groups at random and requiring all groups to perform under the same environmental conditions. In an effort to investigate the extent to which the related variables were

controlled in the experiment, group measures were obtained on these variables.

Each of the six Introductory Psychology classes was divided into four randomly selected groups and tested separately. This procedure provided six replications of the basic experiment.

In the basic experiment conducted with each class, the subjects in the four randomly selected groups received the same instructions and solved identical problems at the same time and in the same room. Each subject was required to solve a series of eight problems. The first five problems of the series were designed to induce a mental set in regard to the method of solution and were referred to as set-inducing problems. The last three problems of the series were unsolvable by the method used in solving the set-inducing problems; however, they were easily solved by using a different and less complex method. These last three problems were referred to as critical problems. The performance of each subject was evaluated in terms of the number of critical problems solved. It was assumed that the number of critical problems solved was a measure of the operation of mental set in problem solving behavior.

Table II shows the tension condition required of the subjects in each group while solving the series of problems.

TABLE II

SELF-INDUCED TENSION CONDITION FOR EACH GROUP OF SUBJECTS

Group	Set-inducing Problems					Critical Problems		
	S_1	S_2	S_3	S_4	S_5	C_1	C_2	C_3
I	N	N	N	N	N	N	N	N
II	N	N	N	N	N	T	T	T
III	T	T	T	T	T	N	N	N
IV	T	T	T	T	T	T	T	T

"T"--Indicates that all subjects in that group solved the problem shown at the top of the column while holding self-induced tension.

"N"--Indicates that all subjects in that group solved the problem shown at the top of the column while not holding tension.

The first hypothesis stated that self-induced muscular tension has no effect on the establishment of mental set. To test this hypothesis the number of critical problems solved by those subjects who solved the set problems while holding self-induced tension (groups III and IV) was compared with the number of critical problems solved by those subjects who solved the set problems while not holding tension (groups I and II).

The second hypothesis stated that self-induced muscular tension has no effect on the ability to overcome mental set. This hypothesis was tested by comparing the number of critical problems solved by the subjects holding self-induced

tension (groups II and IV) with the number of critical problems solved by those subjects not holding the tension (groups I and III).

The third hypothesis stated that a change of muscular tension has no effect on the ability to overcome mental set. This hypothesis was tested by comparing the number of critical problems solved by those subjects who changed tension condition after solving the set-inducing problems (groups II and III) with the number of critical problems solved by those subjects who maintained the same tension condition while solving the entire series of eight problems (groups I and IV).

Orientation Period

As a result of a pilot experiment, it was decided that it would be advisable to have an orientation period for each class during the regular class period preceding the experimental class period.

The purpose of this orientation period was threefold: first, to acquaint the subjects with the tension instrument and give them practice in using the correct procedure in holding the tension; second, to eliminate those students who for any reason had difficulty in holding the required tension; and third, to motivate the students to be present during the experimental period.

A reproduction of the instructions read to each class during the orientation period appear in Appendix B. Eight students were eliminated as experimental subjects because of their difficulty in holding the required tension.

Randomization Procedure

As stated previously, the subjects were students enrolled in six Introductory Psychology classes. Each class served as an experimental unit for one replication of the experiment. This arrangement yielded six replications of the basic experiment. For identification purposes the classes will be referred to as replications R_1, R_2, R_3, R_4, R_5, and R_6.

The subjects in each replication were randomly assigned to four approximately equal groups. The groups were not equal in all classes because in some instances the total number in the replication was not divisible by four. Random assignment to each group within each replication was accomplished by using a deck of playing cards. The four suits in the deck were used to represent the four groups.

Outlined below are the steps followed in the randomization procedure:

Step 1--A roster of the students in the replication was obtained from the class instructor.

Step 2--Those students who had been withdrawn as experimental subjects during the orientation period were eliminated.

Step 3--The number of students to be used in the replication in the experiment was determined, and an equal number of playing cards was selected. The selected cards included as nearly as possible an equal number of each suit.

Step 4--The selected cards were shuffled thoroughly.

Step 5--Each student on the roster was assigned to one of the four groups on the basis of suit as the cards were dealt face up.

The identical procedure was followed in randomizing each replication.

Scoring of the Problems

Each subject's performance on the set-inducing and the critical problems was evaluated by the experimenter. If the solution method taking the albegraic form of B - A - 2C was employed on the set-inducing problems, then they were marked as being solved correctly. The first and second critical problems were considered to be correctly solved if the solution method took the algebraic form of A - C. The third critical problem was solved correctly if the solution took the form of A + C. This scoring procedure yielded two scores for each subject, a set problem score indicating the number of set-inducing problems solved and a critical problem score indicating the number of critical problems solved.

Procedure Used During the Administration of the Experiment

Seating Arrangements

A large auditorium was used for seating the subjects during the experiment. There were sufficient seats available to allow three vacant seats between subjects. The seats in the auditorium were divided into four sections. All members of a particular group were assigned seats in the same section. This seating arrangement, which placed members of the same group in the same area of the room, helped the experimenter in checking to see if all subjects were correctly following instructions regarding the tension condition demanded at a particular time.

Time Intervals Allotted

The time allotted for the solution of each of the five set-inducing problems was two minutes and thirty seconds. Solution time allowed for each of the critical problems was varied with forty-five seconds for the first critical (C_1), one minute and thirty seconds for the second critical (C_2), and two minutes and thirty seconds for the third critical (C_3). Variable time limits for the critical problems were provided for the purpose of securing a more precise measure of the operation of mental set during the initial stages of the mental orientation involved in overcoming the mental set. A rest period of two minutes duration was scheduled after each problem.

The total time used in the administration of the experiment was approximately forty-five minutes.

Instructions Read During the Administration

Carefully written instructions were prepared and read verbatim to each of the classes during the administration of the experiment. A complete reproduction of those instructions is presented in Appendix C.

Procedure Used In Obtaining Measures on Related Variables

Since the literature had indicated that the variables of anxiety, ACE score, age, sex, and grade level were related to the operation of mental set, it was considered advisable to compare the groups in terms of these variables. In an effort to provide data for these comparisons, measures on these variables were obtained. Another purpose in securing these data on related variables was to furnish additional experimental evidence regarding their effects on the operation of mental set.

Anxiety

The Taylor Anxiety Scale was administered to the subjects during a regular class period from one to four weeks after the original experiment had been completed. There was no suggestion made to the students that the anxiety test was related in any way to the original experiment. Due to

factors beyond the control of the investigator, an anxiety score was not obtained on all students who participated in the original experiment; however, measures were obtained on approximately ninety-seven per cent of the subjects.

Scholastic Aptitude

The Bureau of Test and Measurements at Oklahoma A. and M. College administers the ACE Psychological Examination to all students entering this college for the first time. The student's scores, which include a Q-Score, a L-Score, and a Total Score, are kept on file at that office. Scores were available for ninety per cent of the experimental subjects.

Age, Sex, and Grade Level

Data relative to age, sex, and grade level were obtained from the individual answer booklets used in the experiment. In an effort to simplify the handling of the data concerning grade level, each grade was assigned a number ranging from one to four. Freshmen were assigned number one, sophomores number two, juniors number three, and seniors number four. Measures on these three variables were obtained on all subjects.

Treatment of the Data

In order to facilitate handling the data, a 3 x 5 card was prepared for each subject. On each subject's card the following data were recorded:

1. Name
2. Sex
3. Age
4. Grade level
5. Group number
6. Replication number
7. Number of set-inducing problems correctly solved
8. Number of critical problems correctly solved
9. Anxiety score
10. ACE Q-Score
11. ACE L-Score
12. ACE Total Score

The information on these cards was then used to prepare IBM cards. The sums, sums of squares, and cross-products used in the statistical analysis were calculated, for the most part, on IBM equipment.

Interrelationship of Related Variables

An intercorrelation analysis, using the variables of set problem score, anxiety score, ACE Q-score, ACE L-score, and ACE total score, was performed to investigate the interrelationship of these variables. All subjects were used in this analysis.

Relationship Between the Critical Problem Score and the Other Measured Variables

In investigating the relationship between critical problem score and the other measured variables, those subjects

who solved less than four set-inducing problems were eliminated. The critical problem score was correlated with age, grade level, anxiety score, ACE Q-score ACE L-score, and ACE total score by the product-moment method.[1] Since sex was a dichotomous variable, the relationship between sex and critical problem score was investigated by the bi-serial correlation method.[2]

Comparison of the Critical Problem Scores of Non-Anxious Subjects With the Critical Problem Scores of Anxious Subjects

In an effort to secure additional evidence regarding the relationship between critical problem score and anxiety score, the data on these two variables were subjected to a different type of statistical treatment. In this analysis, those subjects who solved less than four set-inducing problems were eliminated. From the group of subjects who solved at least four set-inducing problems, two groups were selected on the basis of their anxiety scores. One group, referred to as the "non-anxious" group, was composed of subjects who had received an anxiety score of seven or less. The other group, referred to as the "anxious" group, was composed of subjects who had received an anxiety score of twenty-four or more. Within each original experimental group the number of

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[1]Henry E. Garrett, Statistics in Psychology and Education (New York, 1947), pp. 282-297.

[2]Ibid., pp. 347-353.

"non-anxious" subjects was made equal to the number of "anxious" subjects. This equalization was accomplished by eliminating the appropriate number through random selection. This procedure selected the upper and lower fifteen per cent of the anxiety scores.

After these two groups had been selected, the significance of the difference of the means of their critical problem scores was tested with Fisher's t-test.[3]

Comparisons of the Combined Groups in Terms of Related Variables

In the tests of the three hypotheses it was necessary to combine the original groups into combined groups. These groups may be identified in the following manner:

Combined Group S--Those subjects who did not hold tension while solving the five set-inducing problems. This group included subjects in the original groups I and II.

Combined Group T--Those subjects who held tension while solving the five set-inducing problems. This group includes subjects in the original groups III and IV.

Combined Group W--Those subjects who did not hold tension while solving the three critical problems. This group included subjects in the original groups I and III.

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[3] Ibid., pp. 197-204.

Combined Group X--Those subjects who held tension while solving the three critical problems. This group includes subjects in the original groups II and IV.

Combined Group Y--Those subjects who held the same tension condition while solving both the set-inducing problems and the critical problems. This group includes subjects in the original groups I and IV.

Combined Group Z--Those subjects who changed tension condition after solving the set-inducing problems. This group includes subjects in the original groups II and III.

In an effort to investigate the extent to which the related variables were controlled in the experiment, the combined groups were compared in terms of these related variables. These comparisons were made between the same pairs of combined groups used to test the hypotheses. Combined Group S was compared with combined group T, combined group W was compared with combined group X, and combined group Y was compared with combined group Z. This analysis involved the calculation of t-values for the significance of the difference between combined group means on measured variables.

Tests of the Hypotheses

In the analysis in which the three hypotheses were tested, only those subjects who solved at least four set-inducing problems were used. It was assumed that elimination of those subjects who solved less than four set-inducing problems yielded a group of experimental subjects who had a set established.

The hypotheses were tested by using orthogonal sets of comparisons[4] in an analysis of variance. In the analysis of variance the structure of the randomized block was determined by the four tension treatments and the six replications. This design yielded a randomized block with twenty-four cells. There was a sufficient number of subjects to allow a total of three critical problem scores in each cell. In those instances in which there were more than three scores available for a particular cell, the excess was eliminated by random selection.

The first hypothesis was tested by calculating an F-value for the variance between the number of critical problems solved by those subjects who did not hold tension while solving the five set-inducing problems (combined group S) and the number of critical problems solved by those subjects who held tension while solving the five set-inducing problems (combined group T). The second hypothesis was tested

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[4]George W. Snedecor, Statistical Methods (Ames, Iowa: The Iowa State College Press, 1946), pp. 403-406.

by calculating an F-value for the variance between the number of critical problems solved by those subjects who did not hold tension while solving the three critical problems (combined group W) and the number of critical problems solved by those subjects who held tension while solving the three critical problems (combined group X).

The third hypothesis was tested by calculating an F-value for the variance between the number of critical problems solved by those subjects who maintained the same tension condition while solving both the five set-inducing problems and the three critical problems (combined group Y) and the number of critical problems solved by those subjects who changed tension condition (combined group Z).

The results of the statistical treatment are presented in Chapter V.

CHAPTER V

RESULTS

The statistical operations outlined and discussed in Chapter IV were accomplished, and the results are presented in this chapter.

Interrelationship of Measured Variables

The intercorrelation of the variables of set problem score, anxiety score, ACE Q-score, ACE L-score, and ACE total score are presented in Table III.

TABLE III

INTERCORRELATION OF MEASURED VARIABLES

	ACE L-score	Anxiety Score	Set Problem Score
ACE Q-score	.537*(N=324)	-.088 (N=314)	.222*(N=324)
ACE L-score		-.074 (N=314)	.326*(N=324)
ACE Total Score		-.094 (N=314)	.303*(N=324)
Anxiety Score			-.072 (N=350)

*Significant at the 1 per cent level of confidence

An examination of Table III reveals that, although all the correlation coefficients between anxiety score and the variables of ACE Q-score, ACE L-score, ACE total score, and set problem score are negative, none of these coefficients are statistically significant. Positive correlation coefficients, significant at the 1 per cent level, were found between set problem score and the three ACE scores. A positive correlation coefficient, significant at the 1 per cent level, was found between ACE Q-score and ACE L-score.

Relationship Between Critical Problem Score and the Other Measured Variables

Table IV presents the correlation coefficients obtained between critical problem score and the variables of age, grade level, anxiety score, ACE Q-score, ACE L-score, ACE total score, and sex.

As indicated in Table IV, the Product Moment Correlation coefficient between critical problem score and age was -.095. This correlation coefficient is not sufficiently high to warrant assuming a significant relationship between these two variables in this experiment. It should be pointed out, however, that the variability of the age of the subjects used in this experiment was relatively small; therefore, the correlation obtained should not be regarded as a valid measure of the relationship between these two factors in groups having more extreme deviations in age.

TABLE IV

CORRELATION BETWEEN CRITICAL PROBLEM SCORE AND OTHER MEASURED VARIABLES

Related Variables		Correlation With Critical Problem Score
Age	(N=225)	-.095
Grade Level	(N=225)	.104
Anxiety Score	(N=220)	-.269*
ACE Q-score	(N=205)	.230*
ACE L-score	(N=205)	.224*
ACE Total Score	(N=205)	.264*
Sex	(N=225)	.000

*Significant at the 1 per cent level of confidence

The Product Moment Correlation coefficient between critical problem score and grade level was calculated to be .104. A correlation coefficient of this value was not statistically significant; hence, no significant relationship may be inferred between these two variables in this experiment.

A statistically significant relationship was found between critical problem score and anxiety score by the Product Moment Correlation coefficient of -.269. A correlation of this magnitude is statistically significant well beyond the 1 per cent level of confidence. Since the correlation is negative, the relationship is one in which low anxiety scores tend to be associated with high critical

problem scores, and conversely, low critical problem scores tend to be associated with high anxiety scores.

A statistically significant positive relationship was found between critical problem score and the variables of ACE Q-score, ACE L-score, and ACE total score. The correlation between critical problem score and ACE Q-score was calculated to be .230. A correlation coefficient of .224 was found between critical problem score and ACE L-score. An even higher correlation coefficient of .264 was found between critical problem score and ACE total score. All three of these correlation coefficients are significant at the 1 per cent level of confidence. The relationship may be expressed as one in which high critical problem scores tend to be associated with high ACE scores, and low critical problem scores tend to be associated with low ACE scores.

The Bi-serial correlation coefficient for the variables of critical problem score and sex was calculated to be .000. This indicates no relationship between these two variables in this experiment.

Comparison of Anxious and Non-Anxious Subjects

Table V presents a summary of an analysis performed to test the significance of the difference in critical problem scores of anxious and non-anxious subjects.

TABLE V

COMPARISON OF THE NUMBER OF CRITICAL PROBLEMS SOLVED BY NON-ANXIOUS SUBJECTS WITH THE NUMBER OF CRITICAL PROBLEMS SOLVED BY ANXIOUS SUBJECTS

Statistical Measurement	Non-Anxious	Anxious	Difference
Number	32	32	0
Mean critical problem score	1.313	.563	.750
Standard error of the mean	.240	.177	.063
Standard error of the difference			.299
Critical Ratio of the means			2.508*
Standard Deviation	1.359	1.000	.359
Standard error of the Standard Deviation	.173	.127	.046
Standard error of the difference of the Standard Deviations			.215
Critical ratio of the Standard Deviations			1.669

*Significant at the two per cent level of confidence.

The non-anxious subjects obtained a mean critical problem score of 1.313 as compared with a mean score of .563 by the anxious subjects. This difference of .750 was found to be significant at the 2 per cent level of confidence. These results indicate that non-anxious subjects received significantly higher critical problem scores than did the anxious

subjects. The difference of the standard deviations of the two groups was not statistically significant. These results are in harmony with previous studies investigating the relationship between anxiety and mental set.

Comparisons of the Combined Groups in Terms of Related Variables

As shown in Table VI, comparison of the combined groups used to test the first hypothesis failed to yield any t-value which approached significance at the 5 per cent level.

TABLE VI

COMPARISON OF COMBINED GROUP S WITH COMBINED GROUP T IN TERMS OF THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS OF THE MEASURED VARIABLES

Variable	Group S	Group T	Difference Between Means	t-value
Sex (% Males)	.50	.58	.08	1.28
Mean Age (Years)	19.62	19.61	.01	.03
Mean Grade Level	1.51	1.51	.00	.00
Mean ACE Q-score	42.05	41.63	.42	.27
Mean ACE L-score	61.38	62.03	.65	.31
Mean ACE Total Score	103.42	103.66	.24	.08
Mean Anxiety Score	14.51	15.07	.56	.55

Note: None of the t-values are significant at the 5 per cent level of confidence.

This indicates no significant difference between these groups in regard to the measured variables related to the critical problems score. T-values of the same level of significance were obtained in the comparisons of the combined groups used to test the second and third hypotheses. These two latter comparisons are presented in Table VII and Table VIII.

TABLE VII

COMPARISON OF COMBINED GROUP W WITH COMBINED GROUP X IN TERMS OF THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS OF THE MEASURED VARIABLES

Variable	Group W	Group X	Difference Between Means	t-value
Sex (% Males)	.53	.57	.03	.38
Mean Age (Years)	19.72	19.51	.21	.62
Mean Grade Level	1.49	1.54	.05	.45
Mean ACE Q-score	40.99	42.79	1.80	1.13
Mean ACE L-score	63.22	60.00	3.22	1.54
Mean ACE Total Score	104.21	102.79	1.42	.45
Mean Anxiety Score	15.36	14.18	1.18	.70

Note: None of the t-values are significant at the 5 per cent level of confidence.

TABLE VIII

COMPARISON OF COMBINED GROUP Y WITH COMBINED GROUP Z IN TERMS OF THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN MEANS OF THE MEASURED VARIABLES

Variable	Group Y	Group Z	Difference Between Means	t-value
Sex (% Males)	.52	.57	.05	.81
Mean Age (Years)	19.61	19.62	.01	.03
Mean Grade Level	1.54	1.48	.06	.55
Mean ACE Q-score	41.90	41.78	.12	.08
Mean ACE L-score	60.53	62.87	2.34	1.11
Mean ACE Total Score	102.44	104.66	2.22	.70
Mean Anxiety Score	14.66	14.94	.28	.28

Note: None of the t-values are significant at the 5 per cent level of confidence.

These results would make it reasonable to assume that any difference found in critical problem scores between these compared combined groups was due to the independent variable of tension rather than the other related variables.

Tests of the Three Hypotheses

Three null hypotheses were formulated before the experiment was performed. These hypotheses were stated in Chapter I in the following form:

First Hypothesis--Self-induced muscular tension has no effect on the establishment of mental set.

Second Hypothesis--Self-induced muscular tension has no effect on the ability to overcome mental set.

Third Hypothesis--A change of muscular tension has no effect on the ability to overcome mental set.

The hypotheses were tested by means of orthogonal sets of comparisons in an analysis of variance. The results of this analysis are summarized in Table IX.

The "treatments" in Table IX refer to the tension condition required of each group while solving the series of eight problems. The first set of comparisons, "Tension vs. No Tension While Solving the Set-Inducing Problems," provided a test for the first hypothesis. The second set of comparisons, "Tension vs. No Tension While Solving the Critical Problems," furnished a test for the second hypothesis. The third hypothesis was tested with the third set of comparisons, "Change of Tension Condition vs. No Change of Tension Condition."

The variance of critical problem score attributed to treatments yielded an F-value of 2.36. This value was not statistically significant.

TABLE IX

ANALYSIS OF VARIANCE USING ORTHOGONAL SETS OF COMPARISONS TO TEST THE THREE HYPOTHESES

Source	Degrees of Freedom	Sum of Squares	Mean Square	F
Total	71	115.11	1.62	
Treatments	3	12.78	4.26	2.36
Tension vs. No Tension While Solving the Set-Inducing Problems	1	0.50	0.50	0.29
Tension vs. No Tension While Solving the Critical Problems	1	1.38	1.38	0.77
Change of Tension Condition vs. No Change of Tension Condition	1	10.89	10.89	6.02*
Replications	5	4.44	.89	
Experimental Error	15	27.22	1.81	
Sampling Error	48	70.67	1.47	

*Significant at the 3 per cent level of confidence

The first set of comparisons, testing the first hypothesis, yielded an F-value of 0.29, and the second set, testing the second hypothesis, yielded an F-value of 0.77. Since neither of these values are statistically significant, both the first and the second hypotheses were retained.

The variance in critical problem score attributed to "Change of Tension Condition vs. No Change of Tension Condition" yielded an F-value of 6.02. This value is significant at the 3 per cent level of confidence. On the

basis of this significant F-value, the third hypothesis was rejected as being untenable.

Table X presents the number of critical problems solved by the subjects in each of the combined groups as calculated from the data used in the analysis of variance.

TABLE X

NUMBER OF CRITICAL PROBLEMS SOLVED BY EACH OF THE COMBINED GROUPS AS CALCULATED FROM THE DATA USED IN THE ANALYSIS OF VARIANCE

	Number of Critical Problems Solved	Difference
Combined Group S	37	
Combined Group T	43	6
Combined Group W	45	
Combined Group X	35	10
Combined Group Y	26	
Combined Group Z	54	28

An inspection of the number of critical problems solved by the subjects in each of the combined groups, as shown in Table X, reveals that subjects in Group Y (composed of those subjects who held a constant tension condition) solved twenty-six critical problems; whereas subjects in Group Z (composed of those subjects who changed tension condition) solved fifty-four critical problems. Since the subjects in Group Z solved more critical problems than did the subjects in Group Y, and the difference was shown to be statistically significant by analysis of variance, it was concluded that

the number of critical problems solved was significantly increased by a change of tension condition.

CHAPTER VI

SUMMARY AND CONCLUSIONS

General Summary of the Investigation

This study was designed to investigate the relationship between self-induced muscular tension and the operation of mental set in problem solving behavior. The problem was attacked by formulating three null hypotheses and conducting an experiment which provided tests for these hypotheses. The null hypotheses were stated in the following manner:

First Hypothesis--Self-induced muscular tension has no effect upon the establishment of mental set.

Second Hypothesis--Self-induced muscular tension has no effect upon the ability to overcome mental set.

Third Hypothesis--The change of tension condition has no effect on the ability to overcome mental set.

The 365 college students used in the investigation were members of six Introductory Psychology classes. Each class was divided into four randomly selected groups and tested separately. This procedure provided six replications of the

basic experiment. All subjects were required to solve a series of "water jar problems" designed to measure the operation of mental set. The series of problems was composed of five "set-inducing" problems and three "critical" problems. In the basic experiment each of the four randomly selected groups was treated differently in regard to the independent variable of self-induced tension. Subjects in Group I did not hold tension at any time while solving the series of eight problems. Subjects in Group II held tension while solving the three critical problems, but did not hold tension while solving the five set-inducing problems. Subjects in Group III held tension while solving the five set-inducing problems, but did not hold tension while solving the three critical problems. Subjects in Group IV held tension while solving all eight problems. The self-induced muscular tension condition was induced by requiring the subjects to hold the prongs of a clip type clothes pin between the front teeth and to apply enough pressure to force the prongs together.

The first hypothesis was tested by comparing the number of critical problems solved by the subjects who solved the set problems while holding self-induced tension (groups III and IV) with the number of critical problems solved by those subjects who solved the set problems while not holding tension (groups I and II). The second hypothesis was tested by comparing the number of critical problems solved by the

subjects holding self-induced tension (groups II and IV) with the number of critical problems solved by those subjects not holding the tension (groups I and III). The third hypothesis was tested by comparing the number of critical problems solved by the subjects who changed tension condition after solving the set problems (groups II and III) with the number of critical problems solved by those subjects who maintained the same tension condition while solving the entire series of eight problems (groups I and IV).

Data regarding the variables suspected of being related to the operation of mental set also were obtained on the experimental subjects. These data not only made it possible to investigate the relationship between these variables and the operation of mental set, but also provided measures which indicated the extent to which the related variables were controlled in the combined groups used to test the hypotheses.

Summary of the Results

1. A correlation analysis failed to yield coefficients which approached the 5 per cent level of confidence between critical problem score and the variables of age, grade level, and sex.
2. Positive correlation coefficients, significant at the 1 per cent level of confidence, were found between critical problem score and the three ACE scores. The

coefficients were .230, .224, and .264, respectively, for Q-score, L-score, and Total score.

3. A negative correlation coefficient of -.269, significant at the 1 per cent level of confidence, was found between critical problem score and anxiety score.
4. An intercorrelation analysis yielded uniformly negative correlation coefficients between anxiety score and the variables of ACE Q-score, ACE L-score, ACE Total score, and set problem score; however, none of these coefficients approached the 5 per cent level of confidence.
5. A significant relationship was indicated between set problem score and the variables of ACE Q-score, ACE L-score, and ACE Total score by positive correlation coefficients significant at the 1 per cent level of confidence. These coefficients were .222 for Q-score, .326 for L-score, and .303 for Total score.
6. A significant positive correlation coefficient of .537 was found between ACE Q-score and ACE L-score.
7. Non-anxious subjects solved significantly more critical problems than did anxious subjects. The critical ratio of the means was calculated to be 2.508. This value is significant at the 2 per cent level of confidence.
8. The variance between the number of critical problems solved by those subjects who held tension while solving the set-inducing problems, and the number of critical problems solved by those subjects who did not hold

tension while solving the set-inducing problems yielded an F-value of .29 which was not statistically significant; hence, the first null hypothesis, which stated that self-induced muscular tension has no effect on the establishment of mental set, was retained.

9. The variance between the number of critical problems solved by those subjects who held tension while solving the critical problems and the number of critical problems solved by those subjects who did not hold tension while solving the critical problems yielded an F-value of .77 which was not statistically significant; therefore, the second hypothesis, which stated that self-induced muscular tension has no effect on the ability to overcome mental set, was retained.

10. The third hypothesis, which stated that the change of tension condition has no effect on the ability to overcome mental set, was rejected on the basis of an F-value of 6.02 which is significant at the 3 per cent level of confidence. This F-value was calculated from the variance between the number of critical problems solved by those subjects who changed tension condition and the number of critical problems solved by those subjects who maintained a constant tension condition. These results showed that those subjects who changed tension condition solved significantly more critical problems than did

those subjects who maintained a constant tension condition.

Interpretations and Conclusions

1. There was no evidence gained from this investigation which indicated a significant relationship between the ability to overcome mental set and the variables of age and grade level. Since there was relatively little variability in the variables of age and grade level, the estimate of no relationship obtained from this study should not be assumed in groups which are more heterogeneous in regard to these two variables.
2. There appears to be sufficient evidence available to warrant the conclusion that the males and females used in this experiment did not differ significantly in regard to their ability to overcome mental set.
3. The ability to overcome mental set was positively related to the ability to perform on the ACE Psychological Examination. This relationship indicates that a high ability to overcome mental set was associated with a high ability to perform on the ACE Psychological Examination.
4. Anxiety, as measured by the test used in this investigation, was significantly related to the ability to overcome mental set. This relationship was such that increasing amounts of anxiety were associated with a decreasing ability to overcome mental set.

5. Degree of anxiety was not significantly related to ability to perform on the ACE Psychological Examination or the ability to solve the set-inducing problems.
6. The ability to solve the set-inducing problems was positively related to the ability to perform on the ACE Psychological Examination.
7. The extent and kind of self-induced muscular tension used in this experiment had no effect on the establishment of mental set or on the ability to overcome mental set after it was established.
8. A change of tension condition after the mental set was established had the effect of facilitating the ability to overcome mental set.

Implications of the Study

The results of this study have a rather specific implication for experimenters investigating the effects of muscular tension on learning and some general implications for those individuals who have the responsibility of creating the most favorable learning situation.

Since this study demonstrated that change of tension condition had a significant effect upon mental set, it becomes necessary for investigators conducting a learning experiment involving a change in tension condition to design the study so as to control or evaluate the effects of this factor. In many previous studies of this nature the factor

of change has been neglected. It is possible that some of the conflicting results obtained from previous experiments designed to investigate the effects of tension can be reconciled by taking this factor of change of tension condition into consideration.

Since it was found that increasing amounts of anxiety were associated with an increasing inability to overcome mental set, it would seem advisable to make efforts to reduce anxiety in learning situations which demand insightful reactions.

The facilitating effect of change of tension condition on ability to overcome mental set would suggest that types of learning which involve a large element of understanding may be facilitated by variation of muscular tension patterns. This variability in tension could be accomplished in a variety of ways.

In the clinical situation variability of muscular tension which would facilitate insightful reactions could be accomplished by the appropriate use of suitable stimulant or depressant drugs, the creation of a permissive atmosphere, or through training in voluntary muscular relaxation. In the classroom situation change of muscular tension pattern could be accomplished by training in voluntary muscular relaxation, introduction of novel or laughter producing material, or creation of permissive atmosphere.

Suggestions for Future Investigations

A number of questions regarding the relationship between muscular tension and the operation of mental set remain unanswered. It is suggested that the following studies would be helpful in further clarifying the relationship:

1. A study designed to investigate the effects of various degrees of change of tension on the operation of mental set.
2. A research project investigating the effects of constant and variable tension in various muscle groups on the operation of mental set.
3. A study designed to investigate the operation of mental set under variable and constant environmental conditions.

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APPENDIX A

DATA BOOKLET

NAME_____ Group Number_____

SEX_____ Section Number_____

AGE_____

CLASS_____
(Fresh., Soph., etc.)

Group Number_____

Problem Number 1

Use the space below for your computations:

Solution:

Group Number_____

Problem Number 2

Use the space below for your computations:

Solution:

Group Number_____

Problem Number 3

Use the space below for your computations:

Solution:

Group Number_____

Problem Number 4

Use the space below for your computations:

Solution:

Group Number_____

Problem Number 5

Use the space below for your computations:

Solution:

Group Number_____

Problem Number 6

Use the space below for your computations:

Solution:

Group Number_____

Problem Number 7

Use the space below for your computations:

Solution:

Group Number_____

Problem Number 8

Use the space below for your computations:

Solution:

APPENDIX B

INSTRUCTIONS READ TO EACH CLASS DURING
THE ORIENTATION PERIOD

We intend to use members of this class as subjects for a psychological experiment to be conducted during the regular class period next Wednesday. Your participation in this experiment is a part of your course work in Introductory Psychology.

During a portion of the experiment some of you will be required to hold a clothes pin in the open position with your teeth. One of the purposes of this orientation period is to familiarize you with the technique to be used in holding this clothes pin in your mouth.

Everyone should be equipped with a clothes pin wrapped in a kleenex. If there is anyone who does not have one, please raise your hand.

Remove the kleenex from the clothes pin at this time.

You will notice that there are grooves made near the end of the clothes pin to provide a seat for your teeth while you are holding it in the open position.

Place the clothes pin in your mouth at this time and put your teeth in the grooves provided.

Now close your jaws slowly until the prongs touch. The desired pressure is just enough to keep the clothes pin in the open position. Hold just enough pressure to keep the prongs touching and no more. You can judge the pressure that is necessary by placing your tongue on the tips of the prongs and releasing pressure until you feel the prongs spreading apart. This is the pressure we want--just enough to keep the prongs touching.

(Lapse time two minutes and thirty seconds)

Release the pressure and remove the clothes pin from your mouth.

Are there any questions at this point?

One of the things in which we are interested at this time is finding out if there is anyone that has difficulty in holding the required pressure. If there is anyone who

has excessive overbite or has a dental bridge that makes it difficult for him to hold this pressure, then please see me after class is dismissed.

When you report to class next Wednesday, please come to the auditorium up on the third floor of this building. Do not come to this room, but go directly to the auditorium upstairs.

Each of you will be assigned a seat number which will be listed by your name on a seating chart posted by the door as you enter the auditorium. Go directly to your assigned seat where you will find material to be used in the experiment.

The experimental design demands that every member of the class participate in the experiment. In the event there is anyone who cannot possibly be here Wednesday please contact either your instructor or myself. If you know of any member of the class who is absent today, please let him know that he should be here Wednesday if at all possible.

Are there any questions?

Drop your clothes pin in the box on the table as you leave.

You are dismissed.

APPENDIX C

INSTRUCTIONS READ DURING THE ADMINISTRATION OF THE EXPERIMENT

The purpose of this experiment is to discover how well you can think. Other studies with this test indicate that a student's performance on this test is closely associated with his I. Q.

Each student's performance on the test will be evaluated, and the results will be made available to you. Your performance on the test will depend, in a large measure, on your ability to follow the directions that are about to be given.

Each of you should have a data booklet with your name on it. If there is anyone who does not have a booklet, please raise your hand.

Fill in the data called for directly below your name on the cover sheet of your data booklet. Do this now.

The class has been divided into four groups. Each student has been assigned to one of these four groups. The group to which you are assigned is indicated in the upper right hand corner of the cover sheet.

Members of the class assigned to groups two, three, and four have been furnished with a clothes pin which is wrapped in a kleenex. Those assigned to group one will not use a clothes pin during the test. Those assigned to groups two, three, and four will be required to place the clothes pin between the teeth and close the jaws until the prongs touch, thus holding the clamp in the open position during the time allotted for the working of a particular problem.

Those who have a clothes pin will remove the kleenex at this time.

Before placing the clothes pin in your mouth, I would like to reassure you that the clothes pin you are using has been sterilized thoroughly.

Now place the prongs of the clothes pin between your teeth, putting your teeth in the grooves provided. When I say the word BEGIN, close your jaws slowly until the prongs touch and the clothes pin is in the full open position.

Hold this tension until I say the word STOP. We want just enough tension to keep the prongs touching. Do not hold any more pressure than is necessary to keep the prongs touching.

Ready, BEGIN. Remember to hold just enough tension to keep the prongs touching.

(Lapse time--10 seconds)

STOP

Remove the clothes pin from your mouth.

The test itself consists of a series of eight problems. Here is an example of the type of problem you will be required to solve.

(The problem is written on the blackboard in this fashion)

Given the following containers			Obtain
A	B	C	
21	127	3	100

You are given three containers. Container A which holds 21 gallons, container B which holds 127 gallons, and container C which holds 3 gallons. The problem is to obtain 100 gallons of water through the use of any of these containers.

One possible solution is to fill the 127 gallon container, then pour the 3 gallon container full 9 times, thus leaving 100 gallons in the 127 gallon container. You would record this solution below the word "solution" on your answer sheet in this manner:

(This solution placed on the board)

$$127 - 9 \times 3 = 100$$

Another possible solution to this problem would be to first fill the 127 gallon container, then fill the 21 gallon container full once, and fill the 3 gallon container full twice by pouring from the 127 gallon container. This would leave the required amount of water in the 127 gallon container. You would record this solution below the word "solution" on your answer sheet in this manner:

(This solution placed on the board after erasing the previous solution)

$$127 - 21 - 2 \times 3 = 100$$

Either of these solutions is correct but only <u>one</u> is desired.

Everyone will work the same problem at the same time. Two groups will be required to hold the clothes pin in the open position with their teeth during the entire time allotted for the solution of a particular problem. It is essential that there be absolutely no talking either during the test itself or during the rest periods.

Open your booklet to the first page. You will see your group number in the upper right hand corner. For those in groups three and four, you will see the words "HOLD TENSION." This means that you are to hold the clothes pin in your mouth during the entire time allotted for solving problem one. Those in groups one and two will notice that there is nothing written below your group number. This means that you are not required to hold the clothes pin in your mouth during the solving of problem one and that you are to keep your jaw muscles as relaxed as possible.

Everyone make sure that you have the right page by checking to see that the problem number is number one.

Note the phrase "Use the space below for your computations." You are to use this space as it has been used in the demonstration problem to make any computations that are necessary.

Record your solution below the word "solution" as it was done in the demonstration problem.

Immediately after recording your solution turn your booklet over face down. If you are holding tension, continue to hold tension until the signal STOP is given. At the signal STOP, those who have not already recorded their solution and turned their booklet over will stop working and turn their booklet over immediately. Those who are holding tension will release pressure on the clothes pin and remove it from their mouths at the signal STOP.

We are now ready for the first problem.

First write the letters A, B, and C and the word "obtain" on your sheet as it is written on the board.

Everyone will copy the quantities and put them under the appropriate letter as I read them aloud. The same numbers will be placed on the board to serve as a check to make sure you have copied them correctly.

Start working the problem immediately after it has been read to you.

Members of groups three and four will place the clothes pins in their mouths at this time.

At the signal BEGIN those in groups three and four will press the prongs of the clothes pin together and hold enough pressure to keep them touching until the signal STOP is given. At the signal BEGIN those in groups one and two will relax their jaw muscles and keep them relaxed until the signal STOP is given.

Ready, BEGIN.

(The problem is read aloud)

A	B	C	Obtain
43	89	7	32

(Lapse time--two minutes and thirty seconds)

STOP. Everyone should have his booklet turned face down.

I would like to repeat the instructions in order that we all know the procedure to be followed.

1. Remember, no talking at any time.

2. At the signal BEGIN those holding the clothes pins in their mouths will press the prongs together and hold just enough tension to keep the prongs touching.

3. Those not holding the clothes pins in their mouths will let their jaw muscles relax.

4. Those holding the clothes pins in their mouths will continue to hold the necessary pressure during the entire time allotted for the problem. Even if you finish the problem before the time limit is up, continue to hold the tension until the signal STOP is given.

5. Turn your booklet face down just as soon as you have recorded the solution.

6. At the signal STOP those holding the clothes pins will release and remove the clothes pins from their mouths, and anyone who has not finished the problem will stop immediately and turn his booklet face down.

We are now ready for problem number two.

Turn your booklet over and turn to the next page. Check to make sure it is problem number two at the top of the page. Write the letters A, B, and C and the word "obtain" as you did on the previous problem. Groups three and four will again hold tension during the solving of this problem. Groups one and two will keep their jaw muscles relaxed.

Members of groups three and four place the clothes pins in your mouths.

Ready, BEGIN.

(This problem is read aloud)

A	B	C	Obtain
14	163	25	99

(Lapse time--two minutes and thirty seconds)

STOP. Remove the clothes pins from your mouths. Everyone should have his booklet turned face down.

We will begin the third problem in two minutes. During this short rest period everyone let your jaw muscles relax.

(Lapse time--two minutes)

We are now ready for problem number three.

Turn your booklet over and turn to the next page. Check to make sure that problem number three appears at the top of the page. Write the letters A, B, and C and the word "obtain" the same as you did on the previous problems. Groups three and four will again hold tension during the solving of this problem. Groups one and two will keep their jaw muscles relaxed.

Members of groups three and four place the clothes pins in your mouths.

Ready, BEGIN.

(This problem is read aloud and placed on the board)

A	B	C	Obtain
18	43	10	5

(Lapse time--two minutes and thirty seconds)

STOP.

We will have another two minute rest period before going on to the next problem.

(Lapse time--two minutes)

We are now ready for problem number four.

Turn your booklet over and turn to the next page. Check to make sure that problem number four appears at the top of the page. Write the letters A, B, and C and the word "obtain" as you did in the previous problems. Groups three and four will again hold tension during the solving of this problem. Groups one and two will keep their jaw muscles relaxed.

Members of groups three and four place the clothes pins in your mouths.

Ready, BEGIN.

(This problem is read aloud and placed on the board)

A	B	C	Obtain
9	42	6	21

(Lapse time--two minutes and thirty seconds)

STOP.

We will start the fifth problem in two minutes.

(Lapse time--two minutes)

We are now ready for problem number five.

Turn your booklet over and turn to the next page. Check to make sure that problem number five appears at the top of the page. Write the letters A, B, and C and the word "obtain" the same as you did on the previous problems. Groups three and four will again hold tension during the solving of this problem. Groups one and two will keep their jaw muscles relaxed.

Members of groups three and four place the clothes pins in your mouths.

Ready, BEGIN.

(This problem is read aloud and placed on the board)

A	B	C	Obtain
20	57	3	31

(Lapse time--two minutes and thirty seconds)

STOP.

We will start the sixth problem in two minutes.

(Lapse time--two minutes)

We are now ready to begin problem number six.

Turn your booklet over and turn to the next page. Check to make sure that problem number six appears at the top of the page. Write the letters A, B, and C and the word "obtain" as you have done on the other problems.

During the solving of this problem, groups two and four will hold the clothes pins in their mouths. Groups one and three will keep their jaw muscles relaxed. Remember groups two and four will hold the tension, and groups one and three will keep their jaw muscles relaxed at the signal "BEGIN."

Members of groups two and four place the clothes pins in your mouths.

Ready, BEGIN.

(This problem is read aloud and placed on the board)

A	B	C	Obtain
23	48	3	20

(Lapse time--thirty seconds)

STOP.

We will proceed with problem number seven in two minutes.

(Lapse time--two minutes)

We are now ready to begin problem number seven.

Turn your booklet over and turn to the next page. Check to make sure that problem number seven appears at the top of the page. During the solving of this problem, groups two and four will again hold tension. Groups one and three will keep their jaw muscles as relaxed as possible.

(This problem is read aloud and placed on the board)

A	B	C	Obtain
28	78	3	25

(Lapse time--one minute and thirty seconds)

STOP.

We will begin the final problem in two minutes.

(Lapse time--two minutes)

We are now ready to begin problem number eight.

Turn your booklet over and turn to the next page. Check to make sure that problem number eight appears at the top of the page. Write the letters A, B, and C and the word "obtain" as you have done on the other problems.

During the solving of this problem groups two and four will again hold tension. Groups one and three will keep their jaw muscles relaxed.

Members of groups two and four place the clothes pins in your mouths.

Ready, BEGIN.

(This problem is read aloud and placed on the board)

A	B	C	Obtain
19	53	4	23

(Lapse time--two minutes and thirty seconds)

This completes the test. If you have seen a series of problems of this nature, and know what these problems are measuring, then put on the back of your booklet what it is we are measuring in this experiment.

You may leave your test booklet and clothes pin on your seat. You are dismissed.

VITA

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candidate for the degree of
Doctor of Education

Thesis: THE EFFECT OF SELF-INDUCED MUSCULAR TENSION ON MENTAL SET IN PROBLEM SOLVING BEHAVIOR

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THESIS TITLE: THE EFFECT OF SELF-INDUCED MUSCULAR TENSION ON MENTAL SET IN PROBLEM SOLVING BEHAVIOR

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The content and form have been checked and approved by the author and thesis adviser. The Graduate School Office assumes no responsibility for errors either in form or content. The copies are sent to the bindery just as they are approved by the author and faculty adviser.

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