 66-14,254

TAUB, Daniel Victor, 1928–
ELECTRODERMAL RESPONSE AND THE
DIFFICULTY OF MENTAL LEARNING
TASKS.

The University of Oklahoma, Ph.D., 1966
Psychology, experimental

University Microfilms, Inc., Ann Arbor, Michigan

THE UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

ELECTRODERMAL RESPONSE AND THE DIFFICULTY OF MENTAL LEARNING TASKS

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

degree of

DOCTOR OF PHILOSOPHY

BY

DANIEL VICTOR TAUB

Norman, Oklahoma

1966

ELECTRODERMAL RESPONSE AND THE DIFFICULTY

OF MENTAL LEARNING TASKS

APPROVED BY

DISSERTATION COMMITTEE

ACKNOWLEDGMENT

I wish to express my appreciation to Dr. C. R. Oldroyd for his patient guidance and suggestions throughout the course of the development of this dissertation. I want to thank the members of the dissertation committee for their help in the preparation of the dissertation.

I wish to thank the various officials of the State of Arkansas, who directly and indirectly are my employers, for the support they have given me in the course of the development of this dissertation.

The subjects, all of whom served voluntarily for long periods have my thanks as do their instructors who helped arrange for their services.

Finally, to my understanding wife and children, thank you.

TABLE OF CONTENTS

LIST OF TABLES

Table		Page

LIST OF ILLUSTRATIONS

ELECTRODERMAL RESPONSE AND THE DIFFICULTY OF MENTAL LEARNING TASKS

CHAPTER I

INTRODUCTION

G. L. Freeman's _The Energetics of Human Behavior_ outlines part of his attempt to offer psychology an open system theory with which to understand the interrelations of observable behavior and the physical and biochemical states of the living organism. In place of phenomenal consciousness as a determinant of behavior he suggests the description and evaluation of the internal, the organismic changes such as might be quantified through measures of energy transformations.

For Freeman the problem of describing behavior involves description of the activities of the organism in maintaining its energy equilibra despite displacing stimuli, that is, the imbalances in energy transformations resulting from internally or externally influenced changes in energy levels. His basic thesis is "that all behavior is an attempt to preserve organismic integrity by 'homeostatic' restorations of equilibrium" (Freeman, 1948, p. 1).

The subject of the research to be reported deals with the modifications of the energetics of the human being during learning, and since Freeman's position is the explanatory system from which the research problem is obtained, a brief outline of his system is here presented.

Freeman views the total organism as an energy system or "an arrangement of work capacities, potential or aroused, which forms a unified whole" (Freeman, 1948, p. 34). Man, functioning as a whole, is seen as an open system capable of maintaining energy transformations by incorporating fuel and expending energy. From this concept we are given the definition of total behavior dynamics as "the study of an energy system undergoing change" (Freeman, 1948, p. 37). The concept that such changes occur in order to preserve or restore necessary constant states or conditions of energy exchange within a range of acceptable variations or limits within which life or continued functioning within the entirety of the body is possible, he adopts from Cannon's (1939) discussions of the subsystems of the living animal.

Freeman discusses the interdependence of the digestive-circulatory and the neuromuscular systems in terms of fuel ingestion and distribution. Internal and external changes cause transfers of fuel from one subsystem of the body to another. Trigger mechanisms exist to alleviate basic disturbances of tissues by functioning to release energy stores. The energy of the total organism is a result of metabolism, and a correlation is pointed out between higher levels of activity of subsystems or tissues and higher metabolic rates of those portions of the organism. The interrelation of subsystems implies the use of metabolic products of one or more subsystems by others.

As a concomitant of such exchange and usage, there is found an increase in neural activity, which in turn may activate additional muscular or organ systems. Thus, we find that an energy disequilibrium in a portion of the organism may have far reaching effects and that resolution of the imbalance becomes complex. To understand overt behavior, Freeman suggests studying the use and "patterning of energy transformations rather than the sum total effect occasioned by changing stimulation and needs". (1948, p. 55). This patterning is related to the homeostatic process, the energy adjustments of the organism as it reacts to stimulation.

It will be helpful to inspect the nature of the homeostatic process through a review of the homeostatic response curve. This curve is to be taken as a summative representation of the energy exchanges within the organism during a given period of observation. Identification of the parts of this measure in terms of causation will clarify Freeman's concepts:

> For the purposes of study, the typical homeostatic response curve can be treated somewhat in isolation. The human subject is brought into the laboratory and "relaxed down" until a measure of basal tissue activities "levels off" to indicate the more persistent background conditions of quiet rest. From this <u>basic energy level</u> the subject is "displaced" by an external stimulus of controlled intensity and duration. The equilibratory sequence has three phases: (1) <u>mobilization</u>, wherein bodily energies are internally aroused to meet the stimulus-induced displacement; (2) <u>discharge</u>, wherein the aroused energies are externally expressed by overt response; and (3) <u>recovery</u>, wherein the organismic energy system returns to its previous condition.
>
> Total energy transformation may be approached ex-

> perimentally in any of three ways: (a) variations in response discharge to a standard stimulus produced by manipulation of the basic energy level; (b) gross quantitative changes in arousal, discharge, and recovery indices produced by varied stimulus displacement; (c) changes in overt behavior patterning or energy distribution under varying stimulus conditions (Freeman, 1948, pp. 65, 66).

In addition it is necessary to indicate that in every reaction to stimulation both anabolic and catabolic processes occur:

> At first the anabolic processes predominate . . . later the anabolic processes begin to subside, catabolic processes begin to catch up and the measure of energy expenditure shows decrement. Now unless the excitation (anabolic process) aroused by the stimulus is taken out of the system by expressed overt reaction, it continues to rearouse--and hence to maintain--the total disequilibrium (Freeman, 1948, p. 77).

As a consideration of structuring an experimental approach to energy transformation studies, Freeman points out that any focal response is a product of the pre-stimulation background energy condition and the stimulus induced excitation. This principle must be taken into account in the design of any study of energetics. To ignore the relationship between the background energy level and the focal response discharge, or to ignore the energy adjustments to imposed stimulation, is to confuse the outcome. Freeman states, "Experimental alterations of this attained general condition have predictable effects on the quantity and quality of superposed specific S-R sequences" (1948, p. 69). He points out by way of example that eating patterns, sleep, exercise, and the interrelations of these factors materially affect responses to a constant external stimulus in experimental studies. Likewise, he cites studies indicating that induced tensions such as those obtained from continued pressure upon a hand dynamometer, general tensing of muscles, pushing upon levers, temporary raising of energy levels by the use of special incentive factors and by means of certain drugs and hormones affect performance or the dependent variable in the research, the focal response. He noted that induced changes in background tension or homeostatic level, depending upon its nature, increased or decreased performance. In some situations facilitation of focal response occurred; in others a decrement in the focal response was observed. The general inference drawn and supported by experimentation is that optimal supporting levels of background energy exist for different tasks. From his studies comes the conclusion that when overmobilization or excessive tension exists there is the likelihood that the excessive energies will flow into antagonistic response channels and thus decrease the effectiveness of the response.

The second approach to the experimental study of energy transformations deals with gross quantitative changes in arousal, discharge, and recovery indices produced by stimulation. When a stimulus is imposed upon a known energy background, changes in metabolism can be observed, and these changes follow a predictable pattern or curve. The rising portion of the curve is considered an index of energy mobilization, and its declining phase serves as an index of response or energy discharge. The relation of the two phases can be taken as an index of recovery. This general metabolic cycle can be measured with an indicator such as the palmar skin conductance changes. These are quick acting indicators of minute and of larger energy turnover differences related in their amplitude to physical exertion differences such as are involved in pushing on levers set to offer scaled increments of resistance to pressure (Freeman, 1948, pp. 71, 74). Recent experimentation (1966) by Pugh, Oldroyd, Ray, and Clark qualifies the extent to which the Galvanic Skin Response (GSR) changes reflect physical effort. Their study strongly suggests that GSRs and conductance levels are more a function of set than of muscular effort.

The two experimental approaches described above seem to have been the most frequently utilized in the area of concern of the present study, probably owing to methodological difficulties as well as the expense involved in efforts to obtain quantitative measures of the many part reactions needed to evaluate the patterning of changes in overt behavior. A third approach, though important in efficiency studies, need not be discussed here.

An understanding of Freeman's treatment of learning or modifiability in homoestatic maintenance operations is needed to understand the general theory and the research here presented. Basically, modifiability involves the process of neural backlash via proprioceptive pathways. It tends to change the internal status and prepare the organism for a new reaction upon a repetition of the old stimulus. Freeman points out that in terms of physiological definitions learning must involve a change in behavior in the direction of greater efficiency in dealing with a series of stimuli. The total reaction is regarded as converging to a homeostatic optimum which conserves neuromuscular effort; otherwise, change in behavior may be observed, but there is no learning. The acquisition of a new response is not necessarily an orderly process and is best understood when it is taken as a sequence of successive approximations. Freeman regards Pavlov's classical conditioning experiments as illustrative of the conditions that develop new adjustments. These conditions account for the original fixation of a response adjustment and are to be taken as more important to an understanding of learning than are the other two classes of conditions affecting the learning process. They are, first, the conditions present at the time a learned act is reproduced and, second, the conditions operating between learning and reproduction, commonly thought of as forgetting (Freeman, 1948, pp. 179-181).

Freeman regards four principles as being sufficient to explain the effective conditions for original fixation of material to be learned: (a) the principle of contiguity, (b) the principle of exercise, (c) the principle of effect, and (d) the principle of set-expectancy.

Briefly, the principle of contiguity is seen as being related to covert residua (backlash effects), supplying a contiguity of excitation between part-reaction sequences. This Freeman supports with examples from studies of successive comparison judgments of lifted weights, motor conditioning in dogs, tension residuals affecting output and energy expenditure, and temporal relations in recovery of GSR, and he reasons a relationship on the same grounds to explain trace, goal gradient, and backward conditioning.

The principle of exercise assumes that the increased general energy mobilization facilitates the rate of improvement in specific adaptive behavior. Cited are experiments involving induced tension, tension in specific muscular subsystems, distraction experiments (especially those involving tension shifts from nonfocal to focal muscles as the responses become more specifically directed toward the sought for overt reaction), and the demonstration that at the end of a learning series the stimulus is minimally displaced and that very close correspondence exists between patterns of energy mobilization and discharge.

Freeman reformulates the principle of effect in terms of tension rather than retaining the more familiar and less exacting concepts of pleasure and pain or reward and punishment. He indicates that there are teleological implications in the original formulations by Thorndike and that research has shown that both reward and punishment reinforce learning. His formulation of the principle of effect states that "those responses which lead to tension reduction and the equilibration of a basic disturbance tend to be repeated and learned" (Freeman, 1948, p. 188). This formulation helps explain varied and continuing efforts which terminate in successful learning and the observation that the successful act is also the last act in a series of attempts at problem solving. In answer to the question of suitability of a fixated or learned act as it might involve additional tensions, Freeman says that the tension reduction does not have to imply general relaxation. It may involve only a redistribution of the tension pattern relative to the total situation in which the organism is performing. What is important is that this learned act serves as an outlet for the discharge of the excitation that initiated the organism's actions (Freeman, 1948, pp. 188, 189).

Freeman's handling of the principle of set-expectancy is in terms of the covert residuals which outlast a response, at least in terms of the overt aspects of that response. The covert residua, for example muscular tension observed as restless movements, partial postural adjustments, and attention to stimulus source, become the "set" which anticipates the next response in a learning series. This principle is an extension of the principle of effect and may serve as a necessary adjunct to contiguity. The motor residua which are found after overt focal action in response to a stimulus tend to subside rapidly and then to rise again forming the peripheral components regarded as sets for most stimulation. The ordering of such residua and overt focal responses in anticipation of further stimulus presentation is regarded as a basis of conditioning and learning.

We have now examined briefly Freeman's theoretical position as it relates to energy expenditures and the process of learning. Freeman indicates that there are optimum energy involvements for various tasks. The studies he used in the documentation of this position primarily involve the induction of muscular tension, such as might be represented by squeezing a hand dynamometer, and relating levels of this induced tension to optimum performance in learning tasks. His primary references deal with the effect of mobilization upon performance and learning. They supply an inferential basis for developing a relation between learning and energy use but do not in themselves define or demonstrate a relationship such as is implied in the effect of learning upon energy mobilization. At the theoretical level, Freeman indicates that the process of learning and the development of a learned skill is also a process of energy mobilization and the relation of such mobilization to stimulus presentation. He also argues on both a theoretical and an experimental basis that learning is accompanied by a progressive differentiation in the pattern of muscular tensions and a gradual decrease in the energy mobilization, the amount of decrease being a function of the "functional distance" of the musculature in question from the focal musculature for the task.

Learning, then, involves an increase in efficiency as a consequence of behavioral changes directed toward the reduction of neuromuscular effort in meeting the demands related to the stimuli. Ample evidence exists to demonstrate that mobilization affects learning; there is enough material to safely assume that learning affects mobilization. There does not, however, seem to be conclusive evidence to indicate a positive relationship between the difficulty of a learning task, memorization, and energy mobilization as it is affected by the process of learning.

Review of a number of typical experiments will demonstrate this lack of conclusiveness. If they are inspected closely in terms of the methodology employed, it can be understood that they involve more complex relationships than were perhaps expected since they involve changes in mobilization levels in several muscle groups which are directly involved in the learning process and the production of complex motor adjustments to demonstrate the learned response. When the subject has not learned the task to the point of errorless performance, changes in muscle groups not primarily involved in the learning task, at least in the sense of the overt response, may not be as clearly observed as in the primary muscle groups. It seems that consideration of the transition from no learning to partial learning to complete learning would involve consideration of corresponding transitions in muscular adjustment. A possibility is that such transitional effects, unallowed for in experimental designs, and the earlier mentioned redistribution of tension throughout the organism as a possible and observed alternative to reduced general energy mobilization, may largely explain inconclusive results gained in attempts to show a positive relation between difficulty of task and energy involved in learning a mental task. Likewise, the problem of the subject's "set" presents an at least potentially confounding factor.

One wonders about the feasibility of separating the energy usages so as to show the effects due to the difficulty of the task as opposed to effects related to a more general condition of increased mobilization of energy as a background upon which are imposed the changes directly related to learning. For example, in studies demanding writing or in maze tracing studies there is a methodological difficulty in measuring energy changes because the visible changes in the products, solved problems, mazes, and so forth, may occur and demonstrate satisfactory learning at the level of evident errorless performance before the organism has adequately developed patterns of total energy mobilization which permit it to function with a minimal energy expenditure. Should this be the case we should expect that in some studies involving postural changes and writing as well as problem solving there will be positive results relating difficulty of task with energy changes during learning. Other studies may not show this relationship.

An early work by Stroud (1931) is fairly typical of the reported efforts. In his study of the learning of a stylus maze pattern he measured muscle tension changes during the learning trials. His data led him to a number of conclusions. First, there seems to be no relation between tension and the difficulty of various portions of a given maze (Stroud, 1931, p. 614). However, he did find a difference between easy and difficult mazes; he observed trends which indicated increasing tension in successive trials during the learning of easy mazes as compared to a drop in tension on the more difficult mazes as learning progressed (Stroud, 1931, pp. 614, 615). The differences were in terms of mean tension on the easy as opposed to the difficult mazes. For the most part the direction of the differences recorded was consistent but not statistically significant. Stroud thought his results might have been influenced by a tendency of his subjects to spurt in their tracings when they discovered that they were on an easy maze. The observation is, however, that tension may or may not be reduced as a consequence of learning and that the results depend on the difficulty of the task. Methodologically, it is important to quantify the difficulty of the task because without such knowledge it appears that one cannot properly predict energy changes during learning. Stroud's (1931) findings would set a limitation upon the interpretation of results showing a change in energy expenditure during learning. Except for difficult mental tasks one could not predict a reduction in energy expenditure as accompanying learning. Thus, Freeman's (1948) assumed relationship between adaptive response output and supporting energy input as a function of practice would not be as simple as he implied.

Freeman (1931) studied the spread of neuromuscular activity during the learning of nonsense syllables. He found a reduction in quadriceps tension as a consequence of practice. As habituation increased he observed less spread of neuromuscular activity and greater work-output. From this work he obtained evidence of the functional relationship between supporting energy and work output as a function of practice. He would not have obtained the same relationship had he used Stroud's (1931) easy maze as his material to be learned. Possibly, the nonsense material in Freeman's study corresponded in difficulty to Stroud's difficult maze, causing the agreement in results. Stroud (1931) indicates that his subjects respond with a spurt in tension and activity when they discover that the task is an easy one.

From work of Clites (1936) comes evidence of the effect of even greater difficulty upon the course of mobilizations of energy during mental activity. In his study, which measured skin resistance during problem solving, he found that skin resistance increased as problem solutions evolved. In both the experimental and control groups, when they worked at insoluble tasks, there was no similar increase in skin resistance at a corresponding length of time of work. Here is an indication that, at least as measured by skin resistance, perceived achievement is related to energy changes with the subject. Freeman's (1931) subjects can be assumed to have had the same experience of learning or not learning as had the subjects of Clites and of Stroud.

From these studies we can draw the conclusion that mental tasks which are easily accomplished have an effect of increasing tension, while mental tasks that are more difficult and soluble have an effect of first increasing and then decreasing tension. In terms of the measured levels of tension it seems that insoluble mental tasks effect tension much as do easily solved tasks. This generalization is probably not proper or fair to Freeman's (1948) arguments because it is based upon tasks of differing nature. The reasons for the common observation probably relate to the techniques of measurement of tension. Likely there is considerable difference in the sequential changes within the subject. The reported data so far do not rule out the possibility that a redistribution of energy and a change in direction of activity would account for the similarity in the energy expenditure in dealing with easy and impossible tasks. Too, Clites used problem solving which, while a mental task, may have involved his subjects differently than did the learning tasks used by Freeman and by Stroud.

Another study dealing with the relation of muscular action to learning is that by Ghiselli (1936). He chose as the learning task the solving of serial multiple choice problems and limited the subject's response or choice time. By forcing the subject to respond in a limited time Ghiselli thought that he might be able to eliminate the cause of tension shifts during learning. In the portion of the study concerning the learning process he found that the absolute pressure (tension index) tends to remain constant during the entire learning period. This portion of his findings is at variance with the previously cited works all of which found changes in the subjects' tension as they moved toward completion of soluble problems. Ghiselli, however, did find that though the expended energy measured remained constant its application was variable. The amount of pressure applied was more variable at the beginning and less variable near the end of the learning period. It would seem that his subjects adjusted their application of energy usage rather than reducing their total energy involvement. Again, the nature of the task could account for the results. Referring once more to a concept of perceived achievement as influencing results, the variability of energy application Ghiselli observed may be a reflection of changes in "set" as the subject proceeded through the experimental sequence of exposures. Under the conditions of serial multiple choice presentation it is possible that several subjects might have begun to regard the problem as insoluble and the measured energy changes in such cases would reflect this as much as anticipated experimental factors. It might be that, though the subjects progressed through the task, they might not have had a concept of nearing completion which would be like that of solving a mathematical problem or learning a nonsense syllable list whose end points are defined upon the presentation of the list and its subsequent repetition. If this explanation is reasonable, Ghiselli's subjects may have been closer to Clites' insoluble problem situation than a learning situation such as was used by Freeman and by Stroud. It is also possible that because of the forced response time Ghiselli's subjects attained an energy mobilization level and maintained it in an effort to "beat the clock" as well as in an effort to learn. Ego-involvement rather than the course of learning may have influenced their activity levels. Ghiselli may have limited the generality of his results by his temporal demand.

In 1937 Brown reported on his study of the relation of the magnitude of GSR and rate of learning. As he stated his problem, he was interested in the relation of the GSR evoked by a specific nonsense syllable to the "ease" with which that syllable could be learned. He presented the items to be learned in a serial order, that is, in lists. As we could expect on the basis of the many studies carried out in learning theory experiments, Brown's subjects learned the first items first, then they learned the last items on the lists, and finally they learned the middle items. As for the GSR records obtained he says:

> And in these records we see greater galvanic skin changes at the beginning and end than in the middle. From these records it appears that there is some relation between g.s.r. per syllable and the order of learning that syllable in serial order memorizing (Brown, 1937, p. 268).

Brown's findings are in general agreement with those previously cited. Again we see a greater reduction in amount of change from energy levels reached during the learning, or solving, of difficult tasks than accompanies easy tasks, except for Stroud's easier task.

Davis (1938) reported his investigation of the relation of muscle action potentials to the difficulty of mathematical problems. His findings are twofold. They indicate that an increase in muscular activity accompanies the solution of the problem and that the amount of activity is related to the difficulty of the problem. He defined the difficulty of the problem in terms of the proportion of his subjects failing the problem. On this basis of difficulty he found no difference in muscle action potential relatable to solving or failing a particular problem. It seems that the more difficult the problem, the more energy required to deal with it, whether or not it is solved. Later Davis (1939) reported that, during the learning of nonsense syllables and during the solving of mental multiplication, action potential measures taken from several muscle systems indicated that there were greater potentials during these activities in the left leg and the left and right arms than during a relaxation period. He concluded that the relationship of work output to muscular action is not a simple one and its extent depends upon other factors. His 1938 work appears to be at variance with the others cited. In all, Davis seems to be indicating that there is difficulty in obtaining satisfactory relationships of energy usage and learning when the source of the data for energy usage is the energy change within limited muscle groups. Apparently one must have the appropriate muscles under observation in order to obtain useful records for this type study. Because an index of over-all energy mobilization is needed for the present study, the complex, electrodermal response may be a more suitable measure than those already cited.

Further evidence for a relationship between tension and learning and level of performance is to be found in work such as was carried out by Courts (1939). Following concepts presented by Freeman and by Block, Courts undertook investigation of the relationship of the amount of muscle tension which was experimentally induced in his subjects to their learning task performances. The results obtained by Courts show, in general, that such a relationship does exist, but the induced tension level did not seem to have a consistent effect on the performance of good or of bad memorizers. Freeman (1948) later reported evidence for improvement in performance of "poor" subjects under induced tension. Thus, it would appear that, in keeping with the findings of Davis, muscle tensions may be meaningful in this work but, as Courts concluded from his data, local muscle tension may not be directly related to the course of learning. Again, it seems important to record energy changes within appropriate systems.

Interest in the general area of energetics continues as is evidenced by more recent literature. In her extensive review of the literature in this area, Duffy (1962) indicates that Obrist (1950) supported the hypothesis that learning is associated with attention or with a high degree of arousal of energy. Geldrich (1953) reported that as color naming work output falls off, so does the amount of energy mobilized. He concluded:

> Mental work output is a function of the momentary mobilization of energy, the momentary and previous conditions of the circulatory and neuromuscular systems, and the momentary receptivity of the subject to further stimulation (Geldrich, 1953, p. 27).

Kuppers (1954) investigated the relation of GSR to different intellectual processes. His results are described qualitatively. Reporting in summary his experimentation on his six subjects, he says:

> Intensive balanced and concentrated intellectual activity resulted in the graduated ascending pattern; the horizontally fluctuating pattern was obtained in cases of highly emotional involvement during the solution of the problems; the declining pattern was found to be an expression of the calm expectation of an anticipated solution or subject matter of a picture. The steep and uninterrupted decline characterizes an entirely relaxed state of rest. Appearing during the solution of the problem, it stands for a lack of concentration (Kuppers, 1954, p. 320).

Shaw (1956) investigated the relationship between tension and task difficulty and the ability subjects displayed in a perceptual task. He regarded perception span for digits as a simpler task than some of the earlier studies required. The subjects in his experiment were required to pull on weights and recall digits exposed at the time a predetermined degree of pull, tension, was attained. The degrees of tension were determined on the basis of the maximum pull each subject could attain prior to digit exposure. He found that optimal tension varied as a function of task difficulty. One-fourth of the subject's maximum pull facilitated perception of all the lengths of digit lists used. Greater tension was found to facilitate perception of the longer, more difficult series as compared to the shorter, easier lists. He also found that induced tension facilitated the performance of both the good and the poor performers.

Berry and Davis (1958) studied muscle action potentials as they related to the rote learning of nonsense syllables. They used one set of nonsense syllables and recorded muscle action potentials from three different muscle groups. Their findings demonstrated a relationship between localized muscular tension and learning performance. Their data led them to consider the tension changes as well as the tension displayed in their subjects after dividing the subject group into three parts, good, medium, and poor learners. They found that their best learners had a high level of muscular activity in the "head location" regardless of orders of list presentation. In these subjects they observed a decrease in tension when the subjects received a conformation of his response, that is he anticipated the nonsense list correctly. The good learners were characterized by a high activity or tension level and differential responses to conformation and correction. Their moderately successful learners had the lowest activity level with little or no change as a consequence of correct anticipation of syllables, but had a notable decrease in tension when their answers were in effect corrected. The experimenters noted that the very poor learners had a similar algebraic difference in the effects of conformation and correction, but that the components differed.

> The poor learners, like the best, have a high activity level; they also have, like the best learners, a difference between responses to confirmation and correction with a greater decrease after confirmation. They differ from the best learners, however, in presenting a very large increase in muscular activity when they receive information that the last vocal response should have been something else. (Berry & Davis 1958, p. 193).

Berry and Davis concluded that a decrease in muscle action after a correct response coupled with little or no corresponding decrease after making an error is favorable to learning.

Not all the literature presents similar results. Duffy's text cites many rather inconclusive studies. However, a pattern emerges from which she is able to develop statements similar to the concepts presented by Freeman in his 1948 text. Although her terms differ somewhat from those used by Freeman, she is discussing many of the same effects. The following two quotations from the early pages of her book indicate the commonality of the approaches taken by Freeman (1948) and by Duffy:

> Activitation . . . refers to variations in the excitation of the individual as a whole, as indicated roughly by anyone of a number of physiological measures (Duffy, 1962, p. 3).

> Activity of all types whether covert or overt requires the release of energy. Attending and thinking as well as locomotion and manipulation can be shown to involve increased release of energy, or a higher degree of activation (Duffy, 1962, p. 17).

Duffy goes on to point out that most investigators have succeeded in reporting some sort of relationship between quality of performance and the various indicators of level of activation. In this respect she conceives of three variables as determining whether a given degree of activation will affect the quality of performance. One of these is essentially the nature of the task and the conditions under which it is performed. Another variable is the locus or patterning of the energy arousal. The third variable she lists is represented by the characteristics of the subject.

Duffy's (1962) discussion of these variables cites work by Brozek and Taylor, by R. C. Davis, by Kausler and Trapp, by Telford and Swenson, as well as several other researchers mentioned in the present paper as describing the effects of the nature of the task upon activation. The summary comments that Duffy makes are to the effect that some performances, such as for tasks of a more complex nature involving selectivity in the response to cues, may be handicapped by a high level of activation, while simple tasks may be facilitated. Also, she suggests that the stage of learning of a task affects the performance requirements and hence the level of activation or energy associated with the performance of the task.

With respect to the effects of patterning of activation, Duffy concludes that organismic interaction is the rule. Within this total patterning of response there are often focal points at which greater activity may be found. Referring to an earlier review of the subject made by D. R. Meyer and to other publications, she indicates that a moderate degree of tension probably facilitates performance, but that as for facilitating learning or recall of paired adjectives or of nonsense syllables, conclusive demonstration of facilitation of learning or recall is lacking.

Duffy draws upon studies by Luria and some of her own work to support her presentation of the effects of individual differences. She suggests:

> Factors varying within the individual, as well as differences between individuals, may conceivably serve as determinants of the effect of a given level of activation upon performance. Perhaps certain features of the directional aspect of behavior interact with the arousal aspect in determining the outcome. An attitude of self-confidence in regard to a situation may, for example, reduce conflicting responses and make possible the effective organization of responses at a level of activation at which an attitude of insecurity and lack of confidence would lead to disruption. A clearly defined goal might be conducive to the organization of responses, while conflicting goals would lead to disruption. . . .
>
> It appears, then, that it is impossible to state what particular level of activation is most conducive to good performance. The answer might be considered to depend upon the requirements of the task at the moment, and certain characteristics of the individual, some of which may be temporary and others more or less permanent. If the assumptions made up to this point are tenable, it seems certain that there is an "optimal" level of activation for a given task to be performed by a given individual at a given time (Duffy, 1962, p. 193-194).

A study by Pugh, Oldroyd, Ray and Clark (1966) may be regarded as offering a basis for further study of individual differences. Their finding that "set" affects GSR and conductance levels, which Duffy clearly accepts as indicative of level of activation, points to one basis of individual differences. That different subjects may assume different sets in regard to a task can account for divergent results from time to time, from experiment to experiment, and can also form the basis of differing results for a single subject within a seemingly short period of time such as might be involved in learning a nonsense syllable list. Changes in set may accompany partial learning, and such change in set may so affect the subject as to modify his level of activation. In suggesting that the mental component of a task may be a major factor in the GSR measurements obtained in association with that task, their study effectively points to the need for the further study of the relationship of set changes and other mental modifications of the subject whose activation level is to be related to task performance.

This survey of the literature indicates the areas of concern in some thirty years of research in investigating the relation of learning and energy mobilization. Excluding the conclusions not closely related to the learning process as it is presented in connection with studies of energy mobilization and use, there are a number of statements which seem to be well accepted and some for which supportive evidence exists.

The well accepted statements are abstractions from the reported literature plus germane information from conventional texts in learning theory. There is general agreement that in the course of learning a greater energy mobilization takes place during the development of the required skill than during performance after the required skill is established. In a mental task such as the learning of nonsense syllables we can expect that the ends of the lists will be learned first and the middle of the lists last. This suggests that the middle of the list presents some special problem; perhaps that portion of the list is more difficult to learn. This difference can be taken as suggesting a need for evaluating separate portions of certain learning tasks in order to be able to demonstrate the validity of electrodermal response (EDR) measures related to learning. As a further refinement in technique we might make use of the information from empirical studies such as Hilgard (1951) and McGeoch and Irion (1952) present. These studies indicate that the association value of nonsense syllables affects the ease with which they are learned. Since Hilgard (1951) indicates that even adjacent syllables have an effect upon those under immediate consideration, it should be possible to develop nonsense lists of differing difficulty and thereby produce learning tasks of differing difficulty.

As regards measurement of energy mobilization it seems that muscle action potentials may be too limited a source of data by which to establish the precise nature of the relationship between energy mobilization and learning. This statement is made in the realization that muscle action potentials may, indeed, be the best indicators if we can provide enough recording equipment to secure the blanket-type coverage necessary, or, as an alternative to this expense, if we can make accurate prediction of pertinent muscle involvements and measure changes in all these muscle groups. In place of such specific measures, as long as we are interested in general or broad effects, the literature is supportive of the use of general indicators such as GSR or EDR. In this approach to the problem of measurement of energy mobilization we must take strict precautions to control conditions such as resting levels and the activities of the subjects. We must attempt to control set at least insofar as trying to be sure that subjects have a readiness actually to learn. The literature clearly indicates that these conditions can have critical effects upon the energy measurements obtained.

CHAPTER II

PROBLEM

The general problem is the demonstration of a positive relation between levels of difficulty of mental tasks and the degree of energy mobilization occuring during the performance of these tasks. This relationship has been demonstrated in research involving physical activity such as grasping a hand dynamometer, lifting weights and pushing on levers. It has not been clearly demonstrated in instances of mental learning tasks. There is considerable evidence showing an improvement in mental performance under heightened energy mobilization. However, much of the data involves activation of many of the neuromuscular subsystems not ordinarily greatly involved in a mental task. Because of this Freeman had to rely in part upon inference to indicate a positive relationship between thought and energy mobilization.

The present study attempts to relate energy mobilization to mental activity in another fashion. The intent is the collection of data showing the effects of mental activity upon energy mobilization with relatively little concomitant muscular involvement.

The first hypothesis is that more energy is mobilized during the learning of a difficult mental task than during the learning of an easy mental task.

The second hypothesis is that the greater the mobilization of energy during the course of learning, the slower the recovery or return towards the preliminary energy level of the subject. It is also expected that the rate of recovery will be more rapid immediately following the easy task than immediately following the difficult task because of greater residuals (e. g. unresolved sets, less feeling of success) following the difficult task. This would appear as an order effect.

The third hypothesis, included in case the second hypothesis is not supported, is a gross test for differences in the shape of the recovery curve. In case the recovery in general is rapid, it would be possible for subjects to reach the same recovery level within the allotted period even though they reached it at a different rate. In such a case those recovering at a faster rate would show a relatively greater proportion of recovery during the first half of the recovery period.

CHAPTER III

APPARATUS AND PROCEDURE

Basically the experiment consisted of the subjects learning nonsense syllable lists of different associative values, while continuous records were made of their electrodermal responses (EDR). These EDR records covered the period of initial relaxation as well as the learning period and the post-learning rest period for each session in which the subjects attempted to learn a list of nonsense syllables. At the same time records were made of the subjects' attempts to learn the lists. In learning the lists the anticipation method was used.

Sixty volunteers were used as subjects in this experiment. These were divided randomly into two groups of thirty. All the subjects were between seventeen and thirty years old and were college students.

After assignment to the appropriate group a schedule of appointments was arranged so that a subject would engage in all the procedures to which he was to be exposed at approximately the same time of day or night. Because of the subjects' personal needs, campus schedules, and experimental demands, it was necessary to schedule subjects within blocks of hours rather than at the same hour each day. Thus, some subjects were seen only in the early part of the morning, others were seen between 9 a.m. and noon, some came between 1 and 4 p.m., and some between 5:30 and 7 p.m., and a few served between 7 and 10 p.m. No sessions terminated later than 10:30 p.m., and none began before 7:30 a.m.

Insofar as was possible, no subjects were scheduled for learning tasks immediately before or after examinations in their college work nor soon before or after athletic endeavor. A similar restriction applied to late afternoon and evening schedules to eliminate scheduling learning tasks before important dates or trips home if these involved out of town travel. This scheduling was considered to be effective in reducing inter-session variability in EDR in that it offered some procedural control for individual metabolic patterns and for at least obvious situations which might prove arrousing.

The subjects were randomly assigned to one of two experimental groups. The thirty subjects in Group I learned a high associative value list first and at the next session learned a difficult or low associative value list. The thirty members of Group II learned the difficult list first and the easy list second.

The over-all scheduling provided for indoctrination periods prior to the first experimental session. During the indoctrination periods the subjects were familiarized with the apparatus used, a technique of relaxing, and the various sounds which might arise in the course of an experimental session. A session began with relaxation to a steady state condition of energy exchanges followed by exposure to either the easy or the difficult nonsense syllable list and then the recovery or post learning relaxation period. Sessions were scheduled in fifty minute periods, but most subjects were able to remain for two consecutive such periods, and some even made special arrangements to attend lectures in order to provide a one hundred minute block of time. The double period was requested of subjects so that ample time for the sessions would be available.

Each subject spent at least three sessions in familiarization and practice in relaxation before being exposed to the material to be learned. In his first visit he was shown the recording meter, projector, wires, electrodes, timer, battery power source, lights, and furniture necessary to the experiment. The functions of unfamiliar objects were briefly explained. The subject was seated in an easy chair, made comfortable by means of pillows if necessary, and told to relax. Each subject was told in an informal manner about locating his limbs in positions to prevent excessive pressure or constriction of blood supply. He was advised to try to duplicate feelings of tiredness or sleepiness as a means of relaxing. Most subjects seemed to understand and appreciate being told about drowsiness related to study or reading textbooks and, upon the suggestion that this state was a good start for deep relaxation, indicated that they knew what was to be sought in the way of relaxation. After this instruction, they were told that if they had to sneeze or move, they could without interfering with data gathering; however, they were also advised that this would be true only if they again became quiet and continued to relax after moving. Each subject was told that repeated deep sighs and other movements could nullify attempts at relaxation and thereby would waste time and possibly eliminate them as subjects. No subjects were eliminated for this reason though several could not or would not return after several sessions of relaxation. Travel distance from their campus probably presented problems in motivation for these subjects.

After the subject gave evidence of relaxation as seen in discontinuous EDR recordings, had demonstrated ability to remain at a "steady state" for a period of two or more minutes, and had shown that he was to quickly attain the steady state (which was one of relaxation), he was scheduled for a learning session. At the beginning of the learning session the subject was told that he would be required to learn some nonsense material later in the session, and then the following instructions were given:

> To begin with, you should relax just like you did before. After you are relaxed long enough I will start the projector. The first thing you will see on the screen will be a frame of a slide, but it will be one without anything familiar to you. It will have three letters forming a nonsense syllable. Look at it, try to learn it. After a few seconds it will be taken off the screen; then will come a period of darkness followed by another slide with another nonsense syllable. Again you are to try to learn it. This will go on until you are shown the entire list of syllables. When the list is finished I will start it over again. This second time you are supposed to tell me, if you can, what the next syllable is going to be. You are to do this in the dark period before the syllable is shown. By showing you the syllable again I will be helping you to check yourself, and I will be giving you a chance to improve your learning. The list will be shown a number of times so that you can learn it and can have a chance to correct yourself as you go. To review, I will show you the list one at a time the first time through, and then I'll tell you I'm starting again. After that, you will try to anticipate the syllable to come next, and you will spell it out to me during the dark period between syllables. Are there any questions you have about this?

At the conclusion of these instructions the subject was told to settle down and relax as in previous sessions. When the EDR tracing showed a steady state of two minutes duration, the projection appratus was turned on and the subject was told to pay attention to the screen because the learning task would soon begin.

After termination of the learning exposures the subjects were told to relax. The instructions were:

> Now, just settle down and relax like you did before. We are through with the learning job.

After termination of the exposures the subject's relaxation was recorded for a period of ten minutes.

The general apparatus consisted of a projector, a projection screen, and an electrical circuit and penwriting system by means of which EDR recordings were made. The projection device consisted of an automatic 2" x 2" slide projector. The timing sequence was set so that the nonsense syllables were projected separately and in automatic sequence. Each syllable was shown for approximately three seconds, and each syllable presentation was separated from the next by a period of darkness of about eight seconds. There was a period of about one second during which the slide was being changed. The total cycle took twelve seconds; thus, the period of exposure for the list was two minutes and for the entire five exposures approximately ten minutes. No mechanical failures occurred during experimentation.

The electrodermal responses were recorded on a G. E. recording galvanometer with a coil resistance of 86 ohms. It was wired in series with an external resistance of 500,000 ohms and in series with a parallel circuit including the subject and a variable resistance. A 1200 ohm resistor was placed across the meter terminals as a shunt to bring the meter sensitivity into an appropriate range. The circuit was calibrated by means of a comparison with known Radio Television Manufacturers Association (RTMA) resistances by the use of a RTMA substitution box.

The power source was a one and one-half volt lantern bettery, the output of which was checked daily by means of a Simpson volt-ohm-milliammeter, Model 270.

Because of the length of time of experimentation and movement

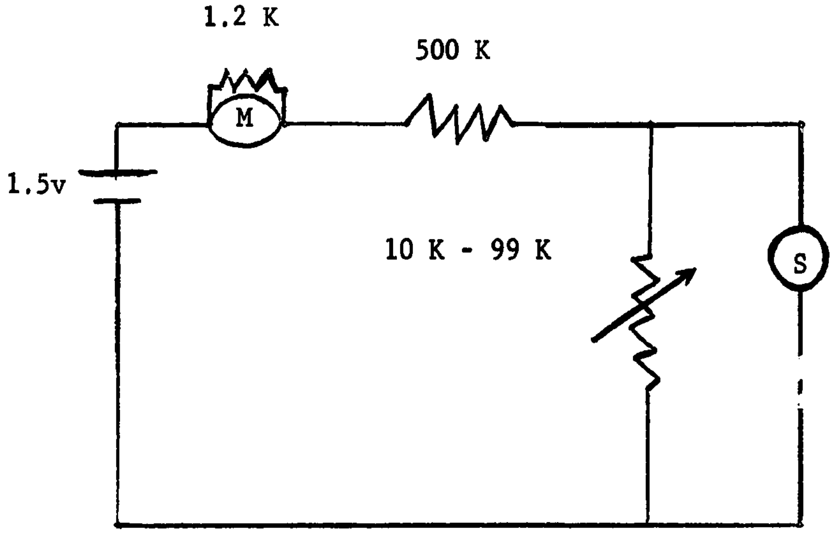


Fig. 1. Electrical Circuitry Used to Obtain and Record EDR Measures

of the apparatus from one location to another, several different batteries had been used to impose a current upon the subject, and two sets of calibrations of the meter circuit were made.

The electrodes were made of a hard felt cloth dampened with a 10 per cent zinc chloride solution. These were attached to the index and ring fingers of the subject's preferred hand. They covered the underside of the tip of the finger to about the first joint therefrom.

The nonsense syllables, taken from those reported by Hilgard, were divided into two lists of ten sequential items each. Thus the first item served as a cue for the second, the second as a cue for the third and so on. The high associative value list was made up of: BAL, FES, JIN, DUC, ROV, TEX, FAS, LIM, HUR, LOV. The low associative value list consisted of : PIV, KEB, MAF, VUT, NOJ, ZIR, KEF, WUB, JOM, DAX. These syllables were projected as a light image upon a darker, but not black, background.

CHAPTER IV

RESULTS

The terminology utilized in the presentation and discussion of the data is that which is typically used in this type of study. However, since temporal periods vary from study to study, the terms used are defined for this study. The initial resting level or steady state may be defined as a period preceding the experimental stimulus presentation portion of the experimental session. The subject is considered to have come to a steady state when, after having relaxed for several minutes, he maintains a minimum variability of EDR. For this experiment the steady state is the two minute period which defines the end phase of the pre-stimulus relaxation period. As reflected in terms of the recording meter used in the research, it is a continuous two minute period during which the subject's EDR fluctuations vary not more than the graphic distance between two adjacent printed lines of the graph paper used, G. E. Record Roll No. 9236.

The mobilization period is considered to be that during which the stimuli are presented to the subject. It is during this time that the subject is supposed to try to learn the nonsense lists, the stimuli. During this time EDR changes typical of increasing energy mobilization occur. For this experiment the temporal duration of the mobilization is approximately ten minutes, the time needed to present the stimuli sequences for each session. Thus, there are records of two mobilization

CHAPTER IV

RESULTS

The terminology utilized in the presentation and discussion of the data is that which is typically used in this type of study. However, since temporal periods vary from study to study, the terms used are defined for this study. The initial resting level or steady state may be defined as a period preceding the experimental stimulus presentation portion of the experimental session. The subject is considered to have come to a steady state when, after having relaxed for several minutes, he maintains a minimum variability of EDR. For this experiment the steady state is the two minute period which defines the end phase of the pre-stimulus relaxation period. As reflected in terms of the recording meter used in the research, it is a continuous two minute period during which the subject's EDR fluctuations vary not more than the graphic distance between two adjacent printed lines of the graph paper used, G. E. Record Roll No. 9236.

The mobilization period is considered to be that during which the stimuli are presented to the subject. It is during this time that the subject is supposed to try to learn the nonsense lists, the stimuli. During this time EDR changes typical of increasing energy mobilization occur. For this experiment the temporal duration of the mobilization is approximately ten minutes, the time needed to present the stimuli sequences for each session. Thus, there are records of two mobilization periods for each subject. One is for the presentation and learning of the easy-to-learn nonsense syllable list, and the other is for the presentation of the hard-to-learn nonsense syllable list.

The recovery period is the ten minute portion of the experiment which follows the completion of the fifth presentation of the nonsense syllable list for the session. The subject is told to relax, and EDR recording is continued while the subject attempts to relax.

For each of the preceding phases there are EDR values for each subject. Since each subject is exposed to an easy-to-learn and a hard-to-learn nonsense syllable list, the data include the EDR for each of the lists, for steady state, and for recovery associated with each of the lists. The EDR for the list is also referred to as the EDR for mobilization or mobilization period. The EDR values for the mobilization periods and those for the recovery periods are shown as difference values. They are obtained by subtracting the value for the steady state from each of these. The EDR meter readings are transformed to log conductance values in order to normalize them for the statistical treatments involved in analyzing the data. This transformation preceded any other mathematical operation.

Tables 1 through 5 and their supporting tables in the appendix present portions of the data analysis pertaining to the first hypothesis. This hypothesis essentially states that more energy will be mobilized while learning a hard mental task than will be mobilized while learning an easy mental task.

Table 1 presents the means of the mistakes and the estimates of their standard deviations for the subgroups in their learning nonsense

Table 1

Means and Estimated Standard Deviations of Mistakes
Made in Learning Nonsense Lists

Order	Sequence	Difficulty Level	Mean Mistakes	Est. S. D.
I	First	Easy	17.9333	4.315
	Second	Hard	25.2333	3.720
II	First	Hard	26.3667	2.359
	Second	Easy	16.9000	2.977

Table 2

Analysis of Variance for Mistakes in Learning Nonsense Lists

Source	Degrees of Freedom	Mistakes Sum of Squares	Variance Estimate	*F*	*P*
Total	119	3502.5917			
Gross Indiv.	59	1096.0917	18.5778		
Order (O)	1	.0750	.0750	.004	> .05
Net Indiv.	58	1096.0167	18.8968		
Gross PSD	60	2406.5000			
Difficulty (D)	1	2108.4083	2108.4083	464.894	< .01
D x O	1	35.2083	35.2083	7.768	< .01
Net PSD	58	262.8834	4.5325		

lists. The mean values are plotted in Figure 2 to show the effect of order of presentation. The basic data are to be found in Tables 15 and 16 (see appendix). As seen in Table 1, the mean number of mistakes made in learning the easy lists are 17.9333 and 16.9000, while the mean number of mistakes made in learning the hard list are 25.2333 and 26.3667. The analysis of variance (Lindquist, 1940,1956) for this portion of the data is summarized in Table 2. From this analysis we have evidence that significantly more errors are made in learning the difficult nonsense list than are made in learning the easy nonsense list. The *F* ratio for the difficulty parameter is 464.894 and is far beyond the 1 per cent level of significance. This is indeed expected since the lists were drawn from previously investigated levels of difficulty and chosen on that basis to provide vastly different levels of difficulty in learning the lists. Table 2 also indicates an *F* ratio of 7.768 for the interaction of difficulty and order of presentation of the lists. This *F* ratio is significant beyond the 1 per cent level of significance. Thus, after the major effect, that of list difficulty, is removed, there still remains a significant factor, the difficulty by order interaction. The subjects profit or gain in ability to learn when they have been exposed to a nonsense list. From Table 1, fewer mistakes are made on the easy list when it is presented second as opposed to first, and fewer mistakes are made on the hard list the second time it is presented. The correlations between the EDR values and errors made in learning the nonsense lists are: r=.40 for the easy list presented first, r=.12 for the easy list presented second, r=.27 for the hard list presented second, and r=-.18 for the hard list presented first.

For the over-all sample $\underline{r}$=.38, which is significant beyond the 1 per - cent level. Counterbalancing between groups rather than counterbalancing within groups was used in the experimental design because within group counterbalancing might have provided enough practice effect to possibly diminish difficulty effects and might also have introduced adaptation effects to confound the EDR readings.

The basic EDR data for the findings summarized in Table 3 and the related analyses is to be found in Tables 17 and 18 (see appendix). Table 3 presents the subgroup means and their estimated standard deviations for the EDR values obtained during the course of the learning process during the presentation of the nonsense lists. The difference between the subgroup EDR value means wherein the easy list means are 1.3303 and 1.5987 as compared to the hard list means of 2.0606 and 2.2450 is significant beyond the 1 per cent level of significance as indicated in the analysis of variance summarized in Table 4. In this analysis, only the differences between the easy list means and the hard list means are statistically significant. Order and interaction effects do not yield significant $\underline{F}$ ratios. The analysis of covariance, Table 5, appropriate for this experimental design, indicates that during the course of learning, the difficulty of the easy as opposed to the hard nonsense list could account for the differences between the obtained EDR values for the subgroup means. The $\underline{F}$ ratio of 4.817 and that of 5.195 (depending upon the error term used) are both significant between the 1 per cent and the 5 per cent levels of significance. Neither order of presentation of the nonsense lists nor the difficulty by order interaction yield any statistically significant evidence of affecting

Table 3

Means and Estimated Standard Deviation of EDR Values
of Mobilization During Learning

Order	Sequence	Difficulty Level	Mean EDR	Est. S. D.
I	First	Easy	1.3303	.674
	Second	Hard	2.0606	.724
II	First	Hard	2.2450	.836
	Second	Easy	1.5987	.745

Table 4

Analysis of Variance for EDR Values During Mobilization

Source	Degrees of Freedom	EDR Sum of Squares	Variance Estimate	*F*	*P*
Total	119	80.5255			
Gross Indiv.	59	50.5220	.8563		
Order (O)	1	1.5374	1.5374	1.820	> .05
Net Indiv.	58	48.9846	.8446		
Gross PSD	60	30.0035			
Difficulty (D)	1	14.1331	14.1331	51.827	< .01
D x O	1	.0529	.0529	.194	> .05
Net PSD	58	15.8175	.2727		

Table 5

Analysis of Covariance for Mobilization EDR Values
and Mistakes Made in Learning Nonsense Lists

Source	Cross Products	Adjusted EDR Sum of Squares	Adjusted *df*	Adjusted Variance	*F*		*P*
D	173.1291	2.6803	1	2.6803	4.817	<	.05
E	32.9985	64.0008	115	.5565			
D+E	206.1276	66.6811	116				
O	.2316	1.5261	1	1.5261	2.742	>	.05
E	32.9985	64.0008	115	.5565			
O+E	33.2301	65.5269	116				
D x O	-1.2570	.1315	1	.1315	.2363	>	.05
E	32.9985	64.0008	115	.5565			
E+D x O	31.7415	64.1323	116				
D	173.1291	2.8724	1	2.8724	5.195	<	.05
E+D x O	31.7415	64.1323	116	.5529			
E+D x O+D	204.8706	67.0047	117				
O	.2316	1.5269	1	1.5269	2.762	>	.05
E+D x O	31.7415	64.1323	116	.5529			
E+D x O+O	31.9731	65.6592	117				

Note.-- D indicates Difficulty, O indicates Order, E indicates Error; these are used as in the analysis of variance tables.

the mobilization of energy as represented by the EDR scores obtained during the work of learning the nonsense lists. Also, the observed interaction effect, Table 5, is much simpler than if within group counterbalancing had been used.

The second hypothesis is one which pertains to the recovery period. Essentially it says that the greater the mobilization of energy during the course of learning, the less the recovery or return toward the prelearning steady state of the subject. Because recovery measures are not independent of the extent of mobilization, Freeman's (1948) formula for evaluating the extent of recovery is used in the analysis of the recovery data. The formula is: R. Q. = B - D / B - C. In this formula, R. Q. is the recovery quotient, B is the terminal mobilization value, EDR, of the work period, C is the terminal EDR value of the recovery period, and D is the EDR value of the steady state immediately preceding work.

Table 6 summarizes the basic data in Tables 19 and 20, which are in the appendix. Table 6 presents the means and their estimated standard deviation for the R. Q. scores obtained while the subjects in the different subgroups were in the recovery or rest period following the learning period. This is the ten minute period following the completion of the learning task for each of the nonsense lists. The means related to the easy list, .3906 and .3754, are contrasted to those for the hard list, .3670 and .4508. The analysis of variance for the data summarized in Table 6 is presented in Table 7. None of the $\underline{F}$ ratios are statistically significant at the 5 per cent level of significance. The analysis of covariance for the data reflected in Table 6 is presented

Table 6

Means and Estimated Standard Deviations of Recovery Quotients

Order	Sequence	Difficulty Level	Mean R. Q.	Est. S. D.
I	First	Easy	.3906	.341
	Second	Hard	.3670	.233
II	First	Hard	.4508	.222
	Second	Easy	.3754	.256

Table 7

Analysis of Variance for Recovery Quotient Values

Source	Degrees of Freedom	R. Q. Sum of Squares	Variance Estimate	F	P
Total	119	8.4050			
Gross Indiv.	59	4.3557	.0738		
Order (O)	1	.0353	.0353	.4739	> .05
Net Indiv.	58	4.3204	.0745		
Gross PSD	60	4.0493			
Difficulty (D)	1	.0201	.0201	.2947	> .05
D x O	1	.0734	.0734	1.0762	> .05
Net PSD	58	3.9558	.0682		

Table 8

Analysis of Covariance for Recovery Quotient Values and Work Mobilization EDR Values

Source	Cross Products	Adjusted R. Q. Sum of Squares	Adjusted *df*	Adjusted Variance	*F*	*P*
D	.5353	.0008	1	.0008	.011	> .05
E	1.8758	8.2219	115	.0715		
D+E	2.4111	8.2227	116			
O	.2335	.0225	1	.0225	.315	> .05
E	1.8758	8.2219	115	.0715		
O+E	2.1093	8.2444	116			
D x O	.7059	.0249	1	.0249	.348	> .05
E	1.8758	8.2219	115	.0715		
E+D x O	2.5817	8.2468	116			
D	.5353	.0037	1	.0037	.052	> .05
E+D x O	2.5817	8.2430	116	.0711		
E+D x O+D	3.1170	8.2467	117			
O	.2335	.0232	1	.0232	.326	> .05
E+D x O	2.5817	8.2430	116	.0711		
E+D x O+O	2.8152	8.2662	117			

Note.-- D indicates Difficulty, O indicates Order, E indicates Error, these are used as in the analysis of variance tables.

in summary form in Table 8. Here again we find that there are no significant $\underline{F}$ ratios. On the basis of the analyses presented, it is not possible to support the second hypothesis through the use of data collected in this experiment.

The third hypothesis pertains to the recovery period and assumes a difference in the course of recovery from mobilization between the easy and the hard lists. One test of this hypothesis involves analyses of variance and covariance for the recovery quotients representing the first half of the recovery period. To further test the hypothesis, similar analyses were carried out on the recovery quotients for the second half of the recovery period. The analyses followed the pattern used to analyze the data pertaining to the second hypothesis. The implied assumption was that there would be a statistically significant difference between corresponding segments of the recovery curves for the easy list when compared to the hard list. The division of the recovery curve into halves was based upon Freeman's (1948) suggestion that five minute periods could be sufficiently long to include major decreases in energy turnover after the end of stimulus exposure. Inasmuch as the recorded recovery period was of ten minutes duration, the five minute or half period appeared to be an appropriate temporal unit by which to define the segments of the recovery data for the analyses to be performed.

Table 9 summarizes the basic data in Tables 21 and 22 (see appendix). Table 9 presents the subgroup means and the related standard deviation of the recovery quotients for the first half of the recovery period. The obtained means of .2881 and .2909 for the easy list presentations are to be contrasted with those obtained from the hard lists,

Table 9

Means and Estimated Standard Deviations of Recovery Quotients for the First Half of the Recovery Period

Order	Sequence	Difficulty Level	Mean R. Q.	Est. S. D.
I	First	Easy	.2881	.297
	Second	Hard	.2564	.259
II	First	Hard	.3386	.196
	Second	Easy	.2909	.232

Table 10

Analysis of Variance of the Recovery Quotients for the First Half of the Recovery Period

Source	Degrees of Freedom	R. Q. Sum of Squares	Variance Estimate	F	P
Total	119	302.8341			
Gross Indiv.	59	24.8724	.4216		
Order (O)	1	.0542	.0542	.127	$>$ .05
Net Indiv.	58	24.8179	.4279		
Gross PSD	60	277.9517			
Difficulty (D)	1	.0019	.0019	.0003	$>$ .05
D x O	1	.0472	.0472	.010	$>$ .05
Net PSD	58	277.9026	4.7914		

.2564 and .3386. Even without considering the estimated standard deviations, the means suggest considerable overlap between the four subgroups of data. When the estimated standard deviations are taken into account, the overlap of the distributions of the subgroups is manifest, and a lack of significant F ratios in the analyses of variance and covariance may be anticipated. Table 10 presents the summary of the analysis of variance of this data analysis. None of the F ratios are significant at the 5 per cent level of significance. In Table 11 the summary of the analysis of covariance of the same recovery quotient data and the work mobilization EDR values are presented. Again, the obtained F ratios are not significant at the 5 per cent level of significance. In both analyses the obtained F ratios are far short of the 5 per cent level of significance even for an infinite number of degrees of freedom. It would seem that the experimental procedures, as their effects are evaluated, do not significantly affect the recovery measures for at least the first half of the recovery period.

A second aspect of the data pertaining to the third hypothesis is summarized in Table 12. This table presents the means and the related estimated standard deviations for the recovery quotients obtained from the data for the second half of the recovery quotients for each of the four subgroups. The means of .1335 and .0883 for the easy lists are to be compared to the means of .1423 and .1259 for the hard lists. As with the first half of the recovery period data (presented in Table 9), considerable overlap of means is observed. Again significant F ratios are not to be expected, especially in view of the estimated standard deviations which materially approach the size of the means themselves.

Table 11

Analysis of Covariance for the Recovery Quotients of the First Half of the Recovery Period and the Work Mobilization Values

Source	Cross Products	Adjusted R. Q. Sum of Squares	Adjusted *df*	Adjusted Variance	*F*	*P*
D	.1697	.0078	1	.0078	.003	> .05
E	-.9221	302.7177	115	2.6323		
D+E	-.7524	302.7255	116			
O	.3041	.0615	1	.0615	.023	> .05
E	-.9221	302.7177	115	2.6323		
O+E	-.6180	302.7792	116			
D x O	.4084	.0562	1	.0562	.021	> .05
E	-.9221	302.7177	115	2.6323		
E+D x O	-.5137	302.7739	116			
D	.1697	.0045	1	.0045	.002	> .05
E+D x O	-.5137	302.7739	116	2.6101		
E+D x O+D	-.3440	302.7784	117			
O	.3041	.0576	1	.0576	.022	> .05
E+D x O	-.5137	302.7739	116	2.6101		
E+D x O+O	-.2096	302.8315	117			

Note.-- D indicates Difficulty, O indicates Order, E indicates Error; these are used as in the analysis of variance tables.

Table 12

Means and Estimated Standard Deviations of Recovery Quotients for the Second Half of the Recovery Period

Order	Sequence	Difficulty Level	Mean R. Q.	Est. S. D.
I	First	Easy	.1355	.131
	Second	Hard	.1423	.122
II	First	Hard	.1259	.1005
	Second	Easy	.0883	.0895

Table 13

Analysis of Variance of the Recovery Quotients for the Second Half of the Recovery Period

Source	Degrees of Freedom	R. Q. Sum of Squares	Variance Estimate	*F*	*P*
Total	119	54.7274			
Gross Indiv.	59	8.8323	.1497		
Order (O)	1	.4906	.4906	3.412	$> .05$
Net Indiv.	58	8.3417	.1438		
Gross PSD	60	45.8951			
Difficulty (D)	1	.4751	.4751	.607	$> .05$
D x O	1	.0308	.0308	.039	$> .05$
Net PSD	58	45.3892	.7826		

Table 14

Analysis of Covariance for the Recovery Quotients of the Second Half of the Recovery Period and the Work Mobilization Values

Source	Cross Products	Adjusted R. Q. Sum of Squares	Adjusted *df*	Adjusted Variance	*F*	*P*
D	.4602	.4865	1	.4865	1.042	$>$ .05
E	2.0267	52.6675	115	.4667		
D+E	2.4869	54.1540	116			
O	-.2141	.5045	1	.5045	1.081	$>$ .05
E	2.0267	53.6675	115	.4667		
O+E	1.8126	54.1720	116			
D x O	.2249	.0160	1	.0160	.034	$>$ .05
E	2.0267	53.6675	115	.4667		
E+D x O	2.2516	53.6835	116			
D	.4602	.4602	1	.4602	.995	$>$ .05
E+D x O	2.2516	53.6835	116	.4627		
E+D x O+D	2.7118	54.1437	117			
O	-.2141	.5063	1	.5063	1.094	$>$ .05
E+D x O	2.2516	53.6835	116	.4627		
E+D x O+O	2.0375	54.1898	117			

Note. -- D indicates Difficulty, O indicates Order, E indicates Error; these are used as in the analysis of variance tables.

The basic data are to be found in Tables 23 and 24 within the appendix. Table 13 presents the analysis of variance for this data. None of the F ratios are significant at the 5 per cent level of significance. The F ratio for order is significant at between the 5 per cent and the 10 per cent levels of significance. Table 14 presents the analysis of covariance for the same data and the work mobilization EDR values. Again, the F ratios are not significant at the 5 per cent level of significance. The significance of the order effect is reduced and no longer is seen as approaching the 5 per cent level. It would seem that tasks difficulty as its effects are evaluated, does not significantly affect the recovery measures for at least the second half of the recovery period.

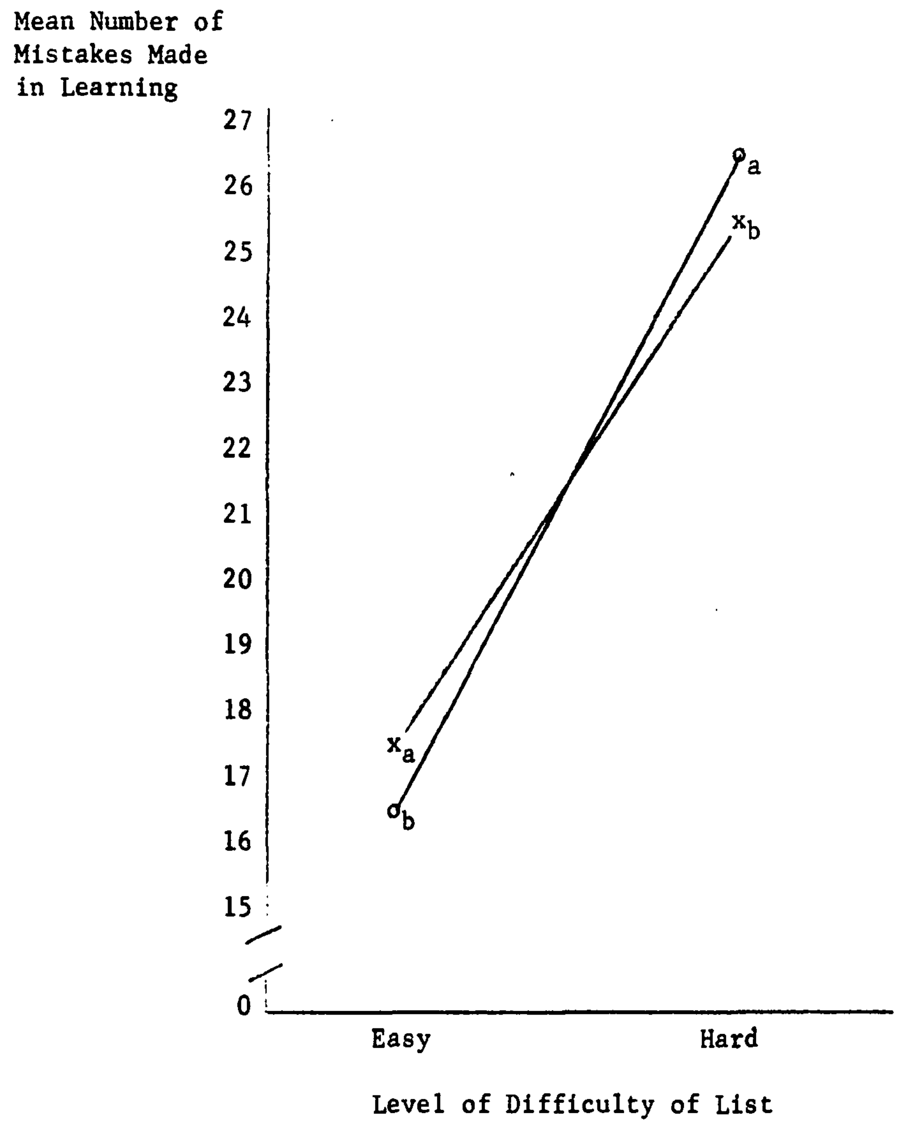
The analyses summarized in Tables 9 through 14 do not necessarily relate to those of Tables 6, 7, and 8. It was not demonstrated empirically, but it was a logical possibility that the recovery periods might have differed in their segments to a significant degree and yet in toto not yield recovery quotient values which were statistically of significant difference.

CHAPTER V

DISCUSSION

With regard to the first hypothesis, the statistical analysis of the energy mobilization data supports the contention that despite the presence of other variables the subjects mobilized more energy, as measured by EDR, during the ten minute learning effort associated with the hard-to-learn nonsense syllable list than they mobilized in the ten minute learning effort associated with the easy-to-learn nonsense syllable list. In both tasks the subjects ostensibly were required to do the same thing, serially anticipate nonsense syllables. The only difference between the two tasks was the associative value of the syllables of the two lists and order of presentations. That the associative value affected the ease of learning was reported by McGeoch (1930), verified since, and is supported by the present study. The F ratio reported in Table 5 is significant far beyond the 1 per cent level, supporting this contention. No order effect of statistical significance at the 5 per cent level was found. However, a residual in terms of a difficulty by order effect had a significant F ratio at the 1 per cent level of confidence. It clarifies the meaning of the subgroup means presented in Table 4.

Stated simply, apparently it has been demonstrated that a more difficult mental task arouses more energy mobilization than does an easier mental task.



Group I x——x

Group II o——o

List Learned First a

List Learned Second b

Figure 2. The relationship between order of learning and mean number of errors made during learning.

There is an over-all correlation between the FDR displayed in association with learning and the number of errors made in learning. This correlation, significance beyond the 1 per cent level, indicates that an increased EDR and a greater number of errors during learning occur together and that a smaller number of errors accompanies a lower task related EDR.

The second hypothesis of this study is concerned with the differences the task effects produce in the recovery or return toward the prelearning energy level between the different experimental groups. The analysis of the recovery quotients did not indicate any differential effects. None of the obtained $\underline{F}$ ratios approached a 5 per cent level of statistical significance. Reviewing the conditions of the experiment, it appears possible that the subjects followed the experimental instructions carefully. The recovery portions of the total EDR curve seem to have essentially the same slopes. Any differences in terms of degree of recovery which are perceived in the visual inspection of the raw data tapes is probably related to the extent of mobilization during learning. When the effects of the mobilization during learning as the start points from which recovery begins are removed through the use of Freeman's recovery quotient technique, the visually perceived differences between groups are found to be artifacts of the mobilization related to the learning task. The observed practice effects are shown in Figure 2.

While this study was not designed to take set effects into account, it may later be of interest to conduct research in which varying the instructions to the subjects as regards the recovery period becomes variable. The study of Pugh, Oldroyd, Ray, and Clark (1966) demonstrated the effects of set upon performance as reflected in EDR measures. Their study showed that EDR was dependent upon the set the subject assumed rather than the physical efforts he expended. It is conceivable that the instructions given the subjects in the present study gave them a set relationship, a state which they had practiced and learned to adopt. If so, the recovery data may represent this set effect.

On the other hand, set may not be of significance. The obtained data may be the results of physiological changes involved in returning the subject to a steady state and the set producing instructions might only change with slope of the recovery curve, either speeding or inhibiting recovery, but not differentially affecting the experimental group. That other instructions, provided they did not continue the energy mobilization of the learning period, would produce a difference in the slope of the recovery curve between the two learning conditions of difficulty does not seem probable in light of the exceedingly small differences observed in the present data.

Again, if differences between groups are found under another sort of instructions for the recovery period, individual differences may be important factors. The present study yielded relatively large estimates of standard deviation, relative to the obtained means, and this despite the training in relaxation the subjects were given. Under other instructions some subjects might engage in other activities, even continuing to try to learn or improve their mastery of the nonsense lists without seeing them, and different slopes for recovery curves might be obtained. This would further reduce the possibility of keeping the variance within limits which would permit demonstration of differences between the experimental groups.

There are then several possible conditions which might affect the recovery curves which are not considered in this study. The primary interest was to observe the effects of mental tasks of different difficulty upon the recovery curves reflecting a post work return to a steady state.

The third hypothesis which called for a comparing of corresponding segments of the recovery curves of the experimental subgroups was tested. Here, too, no significant $\underline{F}$ ratios were obtained at the 5 per cent, or better, level of significance. Thus, the first half of the recovery curve is substantially the same for all four subgroups of the data. Also, the second half of the recovery curve is substantially the same for all four subgroups of the data.

Based upon the analysis of this data, it seems that when the extent of work associated mobilization is eliminated as an influencing factor, the subjects display very similar patterns of relaxation. The possibilities presented in the discussion of the second hypothesis may pertain here. However, it would seem that the subjects in this experiment showed a set to relax, and the EDR values obtained reflect a physiological process common to all the subjects.

Though only the first of the three experimental hypotheses was supported by the data, the demonstration of that first hypothesis may be regarded as adding to Freeman's concepts of energetics. The literature already published does not offer experimental evidence of differential energy mobilization related to mental task difficulty, The relationship has been inferred, and the support for the inference has been drawn from a variety of studies involving physical activity in addition to learning or problem solving. Because of the element of set, as indicated by Pugh _et al_, and possibly because of backlash physiological effects as discussed by Freeman, the earlier studies were not clear cut in their results nor in agreement. The present study was designed to minimize the complexity of the experimental situation as perceived by the subject and thus to minimize, hopefully, the opportunities for backlash effects and orientation to task effects. The results may have been obtained because of the reduction of the operation of these extraneous variables.

The results are taken as supporting the first hypothesis and not supporting the remaining two hypotheses.

CHAPTER VI

SUMMARY

The present study was based on G. L. Freeman's theory of energetics as it dealt with energy mobilization. He attempted to create a systematic explanation of human behavior on the basis of energy exchanges within the human being. The research presented in this dissertation was done in an attempt to supply information supportive of a basic assumption within Freeman's approach. Specifically, the study dealt with the relation of the difficulty of learning verbal tasks and the energy mobilization associated with the process of learning these tasks. Prior to this study there was evidence in the literature to indicate the facilitation of learning when learning occurred under conditions involving imposed tensions in addition to those presumably related to the process of learning. In those cases the literature appears conclusive in indicating the facilitation of learning under differing degrees of energy involvment. The literature offers less conclusive evidence in the direction of demonstrating that different levels of energy mobilization accompany easy as opposed to difficult mental tasks when no additional physical activity is imposed upon the subject. This study was undertaken for the purpose of establishing experimental evidence supporting the implicit assumption made by Freeman which related the level of energy mobilization accompanying the performance of a mental learning task to the difficulty of that task.

Sixty college students were ultimately used as subjects in this research. They were randomly divided into two groups. They were given opportunities to practice fairly deep relaxation and finally instructed to learn nonsense syllable lists that were shown to them. Two different lists were used. One was developed of syllables having a high associative value and was relatively easy to learn. The other was developed of syllables having a low associative value and was relatively hard to learn. The subject's degree of learning was tested by means of the serial-anticipation method on each of four presentations of the list involved after an initial presentation of the list. Errors in anticipation became an indicator of lack of success in learning the tasks. All subjects were shown both lists. Half the subjects were required to attempt to learn the easy list first then the hard list one day later. The other half of the subjects were exposed to a reverse order of presentation of the lists, that is, the easy list was the second to be learned. During the sessions in which the subjects were to learn the nonsense lists, they were placed in an EDR measuring circuit as they had been in the preceding sessions when they practices relaxing. During the learning sessions continuous EDR recordings were taken from the fingertips of the subject's preferred hand. In addition to this EDR recording, an accounting of the subject's errors in serial anticipation of list items was made. The EDR and learning error data were statistically analyzed to determine whether there was a difference in the mobilization of energy related to the learning of the two lists, whether there was a difference in the recovery from the mobilization associated with the easy list as opposed to the recovery from the mobilization associated with the hard list, and to determine whether the segments of the recovery curves associated with the easy list were different from the corresponding segments of the recovery curve associated with the difficult list.

The hypothesis which dealt with the mobilization differences due to task difficulty was supported statistically. The results indicated that more energy was mobilized in associations with the learning of a difficult task than was mobilized during the learning of an easy task. The other two hypotheses were not supported.

The study offers support of Freeman's assumption that human beings differentially mobilize for mental tasks on the basis of task difficulty. While this had been previously demonstrated in terms of energy mobilization in connection with physical tasks, there was a lack of evidence for statistically significant experimental support of the assumption for mental learning tasks. In addition to the theoretical and empirical contribution this study suggests the need for different methodological approaches and consideration of variables which might confound experimental study in the general problem area.

REFERENCES

Berry, R. N., & Davis, R. C. Muscle responses and their relation to rote learning. _J. exp. Psychol._, 1958, 55, 188-194.

Brown, C. H. Relation of magnitude of galvanic skin responses and resistance levels to the rate of learning. _J. exp. Psychol._, 1937, 20, 262-278.

Cannon, W. B. _The wisdom of the body._ New York: W. W. Norton & Co., Inc., 1939.

Clites, H. S. Certain somatic activities in relation to successful and unsuccessful problem solving. II. _J. exp. Psychol._, 1936, 19, 106-115.

Courts, F. A. Relations between experimentally induced muscular tension and memorization. _J. exp. Psychol._, 1939, 25, 236-256.

Darrow, C. W. The equation of the galvanic skin reflex curve. _J. gen. Psychol._, 1937, 16, 285-309.

Davis, R. C. The relation of muscle action potentials to difficulty and frustration. _J. exp. Psychol._, 1938, 23, 141-158.

Davis, R. C. Patterns of muscular activity during mental work and their constancy. _J. exp. Psychol._, 1939, 24, 451-465.

Duffy, E. _Activation and behavior._ New York: John Wiley & Sons, Inc., 1962.

Freeman, G. L. The spread of neuro-muscular activity during mental work. _J. exp. Psychol._, 1931, 5, 479-494.

Freeman, G. L. _The energetics of human behavior._ Ithaca, New York: University Press, 1948.

Freeman, G. L., & Katzoff, E. T. Methodological evaluation of the galvanic skin response with special reference to the formula for R. Q. (Recovery Quotient). _J. exp. Psychol._, 1942, 30, 161-174.

Geldreich, E. W. Some psychological concomitants of mental work. _Psychol. Monogr._, 1953, 67(8), No. 358.

Ghiselli, E. Changes in neuro-muscular tension accompanying the performance of a learning problem involving constant choice time. _J. exp. Psychol._, 1936, 19, 91-98.

Hilgard, E. R. Methods and procedures in the study of learning. In Stevens, S. S. (Ed.), Handbook of experimental psychology., 517-567. New York: John Wiley & Sons, Inc., 1951.

Kuppers, W. Geistige Tatigkeit und galvanisches Phanomen. Z. Exper. Angewan. Psychol., 1954, 2, 291-320.

Lindquist, E. F. Statistical analysis in educational research. Boston: Houghton Mifflin Co., 1940.

Lindquist, E. F. Design and analysis of experiments in psychology and education. Boston: Houghton Mifflin Co., 1956.

McGeoch, J. A. The influence of associative value upon the difficulty of nonsense-syllable lists. J. genet. Psychol., 1930, 37, 420-430.

McGeoch, J. A., & Irion, A. L. The psychology of human learning. New York: Longmans, Green and Co., 1952.

Pugh, L. A., Oldroyd, C. R., Ray, T. S., & Clark, M. L. Muscular effort and electrodermal responses. J. exp. Psychol. 1966, 71, 241-248.

Shaw, W. A. Facilitating effects of induced tension upon the perception span for digits. J. exp. Psychol., 1956, 51, 113-119.

Stroud, J. B. The role of muscular tensions in stylus maze learning. J. exp. Psychol., 1931, 14, 606-631.

APPENDIX

Table 15

Group I Mistakes Made in Learning Nonsense Lists

Subject	Easy List Number of Mistakes	Hard List Number of Mistakes
1	15	23
2	12	20
3	15	24
4	29	35
5	13	22
6	22	29
7	14	22
8	27	29
9	16	21
10	20	27
11	20	29
12	21	27
13	18	27
14	21	27
15	13	27
16	19	25
17	15	24
18	13	21
19	24	29
20	18	23
21	22	30
22	14	25
23	19	27
24	19	29
25	16	21
26	19	22
27	21	29
28	12	21
29	14	21
30	17	21

Table 16

Group II Mistakes Made in Learning Nonsense Lists

Subject	Easy List Number of Mistakes	Hard List Number of Mistakes
31	17	27
32	16	22
33	17	25
34	18	28
35	17	25
36	14	30
37	21	28
38	18	26
39	13	24
40	17	29
41	25	27
42	20	24
43	21	30
44	15	30
45	13	22
46	13	28
47	16	26
48	14	23
49	11	28
50	19	25
51	19	26
52	13	27
53	18	30
54	14	23
55	18	24
56	19	25
57	18	27
58	17	28
59	18	27
60	18	27

Table 17

EDR Values for Group I Subjects During the Mobilization Period

Subject	Easy List EDR Values	Hard List EDR Values
1	.9696	2.0637
2	.8102	1.0239
3	1.1856	2.2706
4	1.4865	1.4843
5	.5353	1.6266
6	1.0937	2.3548
7	1.8478	3.2591
8	2.0343	2.3135
9	1.0386	1.4341
10	2.5475	1.1933
11	.4195	1.4507
12	1.5815	1.5925
13	.5462	1.3240
14	1.6633	1.9149
15	.2304	1.3403
16	2.1385	2.4989
17	.5522	1.0765
18	.6076	1.6179
19	1.9620	2.5732
20	1.6934	2.0135
21	1.5889	3.0721
22	1.7807	4.1973
23	1.6194	2.4136
24	1.0338	2.9170
25	2.0134	2.6894
26	2.0471	2.3035
27	.6251	1.5798
28	.4379	1.5915
29	1.1434	2.1366
30	2.6772	2.4899

Table 18

EDR Values for Group II Subjects During the Mobilization Period

Subject	Easy List EDR Values	Hard List EDR Values
31	2.0495	3.0447
32	1.3734	1.6577
33	1.4532	2.1837
34	1.4544	2.0050
35	1.2054	1.4730
36	.3935	1.3397
37	2.3800	2.1139
38	.4691	1.0559
39	1.2570	2.3619
40	.4835	1.2002
41	.9767	1.3448
42	1.3315	1.9234
43	2.5906	1.5930
44	1.6771	2.1736
45	1.4193	2.1470
46	2.7174	2.6993
47	1.9264	1.5958
48	1.8887	2.0570
49	.6433	1.5310
50	2.0193	2.8628
51	2.6433	2.8597
52	1.8871	4.3166
53	.4381	2.2755
54	2.4076	3.8846
55	2.9452	3.3133
56	2.2189	2.2290
57	1.5853	1.6215
58	.4962	3.0773
59	1.4635	1.6218
60	2.1664	3.7867

Table 19

Group I Recovery Quotients for the
Entire Recovery Period

Subject	Easy List R. Q.	Hard List R. Q.
1	.0000	.2197
2	.2498	.0000
3	.2809	.5075
4	.2106	.3763
5	1.0000	.3713
6	.7927	.6291
7	.0000	.3009
8	.2419	.3268
9	.4927	.7667
10	.5522	.3505
11	.0000	.2708
12	.6008	.2257
13	.0000	.1726
14	.8884	.2561
15	.3333	.0000
16	.4892	.5283
17	1.0000	.2392
18	.3333	.4661
19	.5985	.4941
20	.3261	.5667
21	.9249	.5922
22	.2449	.1373
23	1.0000	.1964
24	.0000	.0000
25	.3637	.7339
26	.0745	.4338
27	.0000	.1954
28	.0000	.8950
29	.0887	.1239
30	.6311	.6337

Table 20

Group II Recovery Quotients for the
Entire Recovery Period

Subject	Easy List R. Q.	Hard List R. Q.
31	.2609	.5789
32	.1763	.3472
33	.0000	.4259
34	.3749	.5236
35	.0000	.8603
36	.6640	.2975
37	.2430	.7057
38	.2856	.0590
39	.6938	.0000
40	.0000	.4429
41	.2952	.2390
42	.5241	.2048
43	.4625	.2621
44	.4715	.4705
45	.7399	.7368
46	.5486	.3666
47	.2689	.4335
48	.4917	.2414
49	.6037	.6612
50	.1814	.5240
51	.2197	.4502
52	.2077	.2259
53	.6597	.5080
54	.0000	.7607
55	.5597	.4933
56	.7739	.8665
57	.0000	.5159
58	.3329	.7403
59	.3268	.2749
60	.8964	.3061

Table 21

Group I Recovery Quotients for the First
Half of the Recovery Period

Subject	Easy List R. Q.	Hard List R. Q.
1	.0000	.2657
2	.2498	.0000
3	.0563	.2806
4	.0000	.0938
5	.8007	1.2102
6	.7927	.3276
7	.0187	.0000
8	.0519	.2721
9	.4927	.5338
10	.2537	.0557
11	.0000	.0901
12	.3008	.1807
13	.2493	.0000
14	.5323	.1072
15	.3333	.0000
16	.2797	.4314
17	1.0000	.2392
18	.0000	.0583
19	.3695	.3246
20	.0654	.4916
21	.6457	.5360
22	.0715	.0823
23	.6561	.0986
24	.7497	.0000
25	.1654	.4364
26	.0745	.2945
27	.0000	.2604
28	.0000	.5512
29	.0000	.0000
30	.4323	.4691

Table 22

Group II Recovery Quotients for the First
Half of the Recovery Period

Subject	East List R. Q.	Hard List R. Q.
31	.0870	.3720
32	.0000	.2606
33	.0000	.3166
34	.1963	.0990
35	.4089	.7199
36	.6640	.2975
37	.1822	.5022
38	.2856	.4703
39	.4734	.0000
40	.0000	.4429
41	.2952	.2390
42	.5241	.0000
43	.3344	.1311
44	.5887	.4180
45	.6598	.6248
46	.5482	.2211
47	.1774	.4335
48	.3214	.1464
49	.0604	.4263
50	.0000	.2389
51	.2529	.4502
52	.0695	.1294
53	.3960	.2752
54	.0000	.5584
55	.3331	.3379
56	.6835	.7332
57	.0000	.3543
58	.3329	.6064
59	.1634	.1040
60	.6890	.2480

Table 23

Group I Recovery Quotients for the Second Half of the Recovery Period

Subject	Easy List R. Q.	Hard List R. Q
1	.0000	.0000
2	.0000	.0000
3	.2246	.2269
4	.2106	.2825
5	.1993	.0000
6	.0000	.3015
7	.0000	.3009
8	.1900	.0547
9	.0000	.2329
10	.2685	.2948
11	.0000	.1807
12	.3000	.0450
13	.0000	.1726
14	.3561	.1489
15	.0000	.0000
16	.2095	.0969
17	.0000	.0000
18	.3333	.4078
19	.2290	.1695
20	.2607	.0751
21	.2792	.0562
22	.1734	.0550
23	.3439	.0978
24	.0000	.0000
25	.1983	.2975
26	.0000	.1393
27	.0000	.0000
28	.0000	.3438
29	.0887	.1239
30	.1988	.1646

Table 24

Group II Recovery Quotients for the Second
Half of the Recovery Period

Subject	Easy List R. Q.	Hard List R. Q.
31	.1739	.2069
32	.1763	.0866
33	.0000	.1093
34	.1786	.4246
35	.0000	1404
36	.0000	.0000
37	.0608	.2035
38	0000	.0000
39	.2204	.0000
40	.0000	.0000
41	.0000	.0000
42	.0000	.0000
43	.1282	.1310
44	.0000	.0525
45	.0801	.1120
46	.1004	.1455
47	.0894	.0000
48	.1703	0950
49	.0000	.2349
50	.1814	.2851
51	.0000	.0000
52	.1382	.0965
53	.2637	.0965
54	.0000	.2023
55	.2266	.1554
56	.0904	.1333
57	.3543	.0000
58	.6064	.1339
59	.1040	.1634
60	.2480	.0581