AN ANALYSIS OF PSYCHOMOTOR STUDIES RELATED TO MASSED AND DISTRIBUTED PRACTICE SCHEDULES IN PHYSICAL EDUCATION, PSYCHOLOGY, BUSINESS EDUCATION, AND MUSIC EDUCATION

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We hereby recommend that the dissertation prepared under our supervision by Peggy Ann Richardson entitled "An Analysis of Psychomotor Studies Related to Massed and Distributed Practice Schedules in Physical Education, Psychology, Business Education, and Music Education"

be accepted as fulfilling this part of the requirements for the Degree of Doctor of Philosophy.

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CHAPTER I

ORIENTATION TO THE STUDY

Introduction

A major objective of many research efforts is to find a basis for improvement in the methods and conditions of teaching and learning. The influence of the practice session is a concern in the classroom, in the laboratory, and on the athletic field. It is necessary to develop appropriate work and rest periods to gain efficiency in instruction and to insure maximum learning opportunities. Administrators seek answers to scheduling problems to alleviate crowded curriculums and limited facilities; teachers and coaches strive for conditions within a single period or in yearly plans which will obtain the most effective results from the learner; students also endeavor to improve and to progress, and this, too, is dependent upon the methods and conditions of practice.

In an attempt to formulate an adequate description of the learning process, exploration of the effect of time and practice in the learning of a motor skill has been undertaken. At the theoretical level, the problem is concerned with constructs of reactive and conditioned inhibition, work-decrements, growth and maturation, and differential forgetting. At the empirical level, it consists of determining functional relationships between the task and certain measures of task performance. With respect to the latter case, there has been considerable research conducted involving the manipulation of practice conditions. A majority of the investigations have shown that some form of distributed practice is generally more efficient than massed practice.

In contrast, educators, however, have used subjective values to determine the frequency of practice in the teaching of motor skills, or they have readily accepted the theoretical constructs or empirical results reported in the literature at face-value without either taking the time or possessing the interest to evaluate these findings. It is imperative, therefore, that all available information relative to practice schedules be analyzed and synthesized so that it can be utilized for teaching and learning efficiency.

Rationale for the Study

The learning of any skill is, to a certain extent, a function of the condition under which it is practiced. The variable of practice that has been investigated more extensively than any other is the distribution of a fixed amount of practice through time. However, there has been a diversity in the experimental motor skill tasks that have been studied concerning the relative efficiency of massing versus distributing practice when learning motor skills. There exists in the literature a confusion in semantics as to what represents distributed and massed practice schedules as well as a conglomerant of studies utilizing different research designs.

Deese and Hulse (1967) state that there is no problem in the investigation of perceptual-motor performance which warrants more attention than that of work produced decrements. These authors maintain that the general solution to this problem would provide educators with needed information about the distribution of practice and its consequences.

According to McGeoch and Irion (1952) the effects of the distribution of practice schedules have been studied using a wide variety of experimental materials and methods, yet the influence of these factors has seldom been systematically explored. It is entirely possible that the current theories of the distribution of practice are based upon inadequate empirical exploration. This has not been due to a lack of experimental investigation but rather because the problems are extremely complex. Deese (1958) maintains that the future course for the analysis of this problem requires a further systematic investigation of the principle variables related to massed and distributed practice schedules.

In addition to the variety of experimental designs from which generalizations have been made, there exists in the literature, relative to distributed and massed practice, a confusion in semantics as to what represents these two major conditions of practice. There is no absolute line of demarcation which separates distributed practice from massed practice. The condition of spaced practice in one experiment may pace practice at a rate considerably faster than the condition of massed practice employed in another experiment. Thus, the distributing or massing of practice appears to be a relative matter, to be determined within the condition of each experiment. Because of this fact, it is often not possible to draw generalizations beyond the condition of the particular experiment. Undoubtedly, the contradiction within the data concerning the significance of distributed practice over massed practice would multiply if the formulation of mathematically precise relationships between the effects of distribution and the condition of practice schedules were to be attempted (McGeoch and Irion, 1952).

Although massed and distributed practice schedules have been investigated for many years, fine motor skills have and continue to be the favorite tasks employed in the research designs and investigations of gross motor skills appear less frequently in the literature. Lawther (1968) questions the extent to which findings from laboratory studies testing fine motor skills should be applied to the gross and complex activities of physical education, and Mohr (1960) states that "although the sum of physical education findings agree with those in psychology, the evidence is far too scanty to uphold the assumption that distributed practice will result in more effective learning than massed practice [p. 327]."

The distinguishing factor between distributed practice and massed practice is the interval of time involved in the distributed schedules. It is interesting to note that theoretical statements have been issued by learning theorists to explain what occurs during the interval, yet many investigators have neglected to control activities during the rest periods in their research designs.

Lastly, the recommendations and guidelines for teachers of motor skills are predicated upon a skeletal number of experimental studies. From this limited number of research designs, broad generalizations concerning the superiority of distributed practice in motor learning have been perpetuated in books related to theories of learning.

The deficiency of systematic data either supporting or rejecting the superiority of distributed or massed practice for learning skills lends credence to the necessity for additional endeavors to systematize, in depth, the methods, materials, and procedures employed in research designs which permeate the literature.

Statement of the Problem

The present investigation entailed a documentary analysis and an in-depth examination of the experimental research designs related to massed and distributed practice schedules reported in the professional journals, books, abstracts, and unpublished research in Physical Education, Psychology, Business Education, and Music Education.

The investigator systematically explored the principle variables involved in massed and distributed practice schedules in reported research designs to determine the credibility of generalizations cited in books related to theories of learning and books related specifically to motor learning. The following questions directed the development of the study:

A. What constitutes massed and distributed practice? Is massed practice in one study comparable to distributed practice in another study?

B. Are designs equivalent when data are collected during one experimental session as compared with data collected over a period of a week, a month, or a year?

C. Distributed practice involves work and rest periods. Which of these two variables is of greater importance?

D. How have the optimal work loads and rest intervals been determined in the research designs? What are the optimal work loads and rest intervals?

E. What did the investigator have the subjects do during the interval of distributed practice--rest, rehearse, or perform an unrelated task?

F. Is there a point of diminishing returns in either type of practice schedule?

G. In learning, there is a correlation between motivation and level of skill. Has this factor been controlled in studies related to massed and distributed practices to support the statements that distributed practice should be used when motivation is low?

H. Is there a difference in practice schedules utilized in learning fine motor skills and gross motor skills?

I. Generalizations in the literature imply that highly skilled performers can practice for a longer period of time than performers with low skills, and older children are able to practice longer than younger ones. Which and how many studies support these guidelines?

J. Is there a difference in male and female subjects with regard to the effectiveness of massed and distributed practice schedules?

K. Does massed and/or distributed practice affect performance or learning?

L. Of the activities investigated, what aspects of the skills were chosen for the study? Is there a need for replication of these studies?

M. How many of the investigations related to gross motor skills occurred in an artificial setting?

N. Was the homogeneity of the two practice groups established prior to the experiment?

O. Did the investigators obtain a baseline performance for the task?

P. How were the data treated statistically and was the treatment adequate?

Definitions and/or Explanation of Terms

The definitions and/or explanation of words and phrases such as learning, reminiscence, massed practice, distributed practice, fine skills, gross skills, work loads, intervals, performance, generalizations, and motivation were used in this study in the same manner as that commonly accepted in dictionaries of the psychology of learning.

Limitations of the Study

The present study was subject to the following limitations:

A. The selection of research designs which utilized motor tasks in the area of Psychology.

B. The selection of research designs which utilized motor tasks in the area of Physical Education.

C. The selection of research designs which utilized machinery tasks in the area of Business Education.

D. The selection of research designs which utilized instrumental tasks in the area of Music Education.

E. The accuracy of historical and documentary resources from which the data were collected.

F. The analysis of studies which used human subjects who performed motor tasks.

G. The literature published in the United States.

H. The exclusion of studies which used atypical subjects such as those who were mentally retarded or physically handicapped.

I. The omission of studies which were designed to determine the effects of transfer principles or mental practice but which used the experimental conditions of massed and distributed practice schedules.

J. The exclusion of studies which examined the theoretical implications of massed and distributed practice schedules without experimentation.

K. The omission of studies in which the definitive difference between distributed practice and reminiscence was established although the investigation used the experimental conditions of massed and distributed practice schedules.

Summary

A major objective of many research endeavors is to find a basis for improvement in the methods and conditions of teaching and learning. In Chapter I, the investigator presented information related to the need for the systematic exploration of the principle variables involved in massed and distributed practice schedules in reported research designs to determine the credibility of generalizations cited in books related to theories of learning.

The statement of the problem, the definitions and/or explanation of the terms, and the limitations of the present study were included in this chapter.

Chapter II includes a brief historical perspective of the problems related to theoretical and experimental factors in massed and distributed practice schedules.

CHAPTER II

HISTORICAL AND THEORETICAL PERSPECTIVE

Massed and distributed practice schedules have been a critical factor of study since 1885. These practice schedules have appeared as micro-aspects of studies on learning, retention, and forgetting, and they have served as the major variable in other investigations. Within such frameworks, investigators from the field of psychology emerged as leaders in formulating theoretical models to explain what occurs during massed and distributed practices and the effect of these factors upon learning. Consequently, many subsequent investigations were undertaken to test these theoretical statements and to further explore particular variables which were attributed to specific theories. It seems, therefore, appropriate to consider a brief historical and theoretical perspective of massed and distributed practice schedules.

The advantage of distributed over massed practice was first experimentally demonstrated by Ebbinghaus in 1885. Ebbinghaus used nonsense syllables as the learning material while he served as his own subject.

> Six lists of 12 nonsense syllables each were learned at a given time with an average of 40 repetitions. Twenty-four hours later the relearning of the lists

> required an average of 41 repetitions. One list therefore required 68.3 repetitions in immediate succession for initial learning and 6.8 repetitions for relearning. When on the other hand a list of 12 syllables was learned to the point of one correct recall on each of three successive days, the total figures for the three days of distributed effort are 17.5 trials, 12.1 trials, and 8.3 trials, or a total of 37.9. Twenty-four hours later, the 12 syllables were relearned, on the average, in 6.2 trials. Thus 37.9 repetitions distributed over three days gave essentially the same retention after 24 hours as did 68.3 repetitions in immediate succession [Ebbinghaus, 1885, pp. 59-61].

These findings indicated that learning was accomplished with less work when practice was distributed than when it was concentrated.

Jost examined the same problem of spaced and concentrated practice using lists of twelve nonsense syllables in 1897. He found that concentrated efforts in the number of responses given produced poorer retention than the same number of responses distributed over a number of days (Woodworth and Schlosberg, 1964).

These early investigations of the advantages which followed the spacing of practice were mostly exploratory in nature. McGeoch and Irion (1952) state that during the thirty year period from 1885 to 1915, only twenty references either experimental or theoretical appeared in the literature concerning the distribution of practice schedules, and of that number, seven were related to psychomotor skills.

During the 1930's, 1940's, and 1950's, the character of research related to massed and distributed practices changed. A general refinement of experimental techniques was introduced to replace the vagueness of the exploratory experiments. Hypotheses were issued to guide the investigations; a major variable was manipulated while other factors were controlled to determine its specific effect; and the differences between two opposed theories was tested. In general, the immediate cause of the change was the development of specific learning theories which gave purpose and direction to subsequent research (McGeoch and Irion, 1952).

Most theories were developed either to test the decremental effects of massed practice upon the performance of an activity or the effects of the interpolation of a rest period. These early theories used the principles of perseveration, recovery from fatigue, changes in motivation, rehearsal, differential forgetting, and reactive inhibition to account for the superiority of distributed practice (Kingsley and Garry, 1962).

McGeoch and Irion suggested that these hypotheses may be classified into the three major headings of work theories, perseveration theories, and differential forgetting theories:

> 1. Work theories hold that performance of an activity tends to leave behind it some process or product in the organism which tends to prevent recurrence of the activity or which tends to lower the efficiency of its performance. The interfering process is held to dissipate during periods of inactivity while the learned habits are assumed to be permanent [McGeoch and Irion, 1952, pp. 171-172].

Three significant subcategories exist in the work theories. The first is that of the fatigue theory or the accumulation of fatigue products in the neuromuscular mechanisms which are basic to learning. This theory can be valid only if long periods of continuous practices are used and if a rest period late in practice has a more beneficial effect than an identical rest period early in learning, since there is potentially more fatigue accrued from longer practice sessions.

Reactive Inhibition theories have been precisely formulated to explain the relationship of rest to learning. The most prominent of these theories is Hull's (1943) reactive inhibition theory or drive-reduction theory in which both humans and rats were used as subjects in a variety of behavior patterns. In general, this response theory states that whenever a reaction is evoked from an organism there is created a negative drive state known as reactive inhibition (I_R) which has the capacity to inhibit the repetition of that response. This theory implies that once an individual performs a task, he is reluctant to repeat it. Reactive inhibition also is a positively accelerated, increasing function of the amount of work involved in the response. Therefore, the greater the task or the more frequently it is repeated, the greater is the reactive inhibition. According to Hull, massed practice should produce the greatest rate of increase in reactive and conditioned inhibition. This inhibition spontaneously dissipates as a simple decay function of time so that eventually a person may repeat the response after a period of time has elapsed. This process, known as spontaneous recovery, occurs automatically after rest although the response is never as strong as the original response. It is also possible for stimuli closely associated in time with the cessation of a response to become conditioned to this particular non-activity, thereby producing conditioned inhibition ($_SI_R$) or a tendency toward permanent inability to respond to a particular act. Hull's theory--reactive inhibition increases during performance and dissipates during rest--has broad applications to the conditions of massed and distributed practice schedules.

The theoretical position of Ammons (1947) and his concept of work decrement in rotary pursuit learning is similar to Hull's theory of reactive inhibition. Temporary work decrement (D_{wt}) increases during practice and dissipates with rest, while permanent work decrement (D_{wp}) is a learned reaction of not responding based upon an accumulation of temporary work decrements which remain when rest periods are insufficient. Ammons also incorporated assumptions and deductions regarding the warm-up effect and the phenomenon of reminiscence to motor learning. In summary, temporary work decrement increases as a negatively accelerated function of the rest period. In addition, warm-up or recovery of set is more rapid following a rest than without such pauses.

Another attempt to extend Hull's inhibition construct to motor learning was made by Kimble (1949a). Using inverted alphabet printing as the task, he suggested that the superiority of distributed over massed practice in motor learning results from the development during unspaced practice of an inhibitory potential (I_R), the effect of which is to reduce the work output of the organism. It was further assumed by Kimble that this total inhibitory potential was made up of two decremental components, reactive inhibition (I_R) and conditioned inhibition ($_SI_R$).

Reactive inhibition is essentially a drive state closely allied to pain avoidance or fatigue. It is a response-produced inhibition which results from actions of effort and dissipates during periods of rest. These pauses serve as reinforcements and eventually the response of resting will become conditioned to whatever stimuli are present in the learning situation. This conditioned inhibition is the learned reaction of not responding and is acquired because resting behavior is reinforced by the reduction of I_R. Since conditioned inhibition is a habit, it does not dissipate during rest. The two inhibitory components are a drive (I_R) and a habit ($_SI_R$) which are interrelated in that the drive provides the motivational basis for the development of the habit.

Also included in Kimble's theory is the assumption that the greater the motivational drive of the subject to learn the task, the greater will be the amount of inhibition which will be tolerated by the learner before rest periods are necessary. In essence, the organism is motivated to perform the task at hand until a critical level of I_R is reached.

Eysenck (1965) presented a three factor theory of reminiscence which involved the concept of conditioned inhibition, involuntary rest pauses, and consolidation. This theory is not uniquely different from that proposed by Kimble, except Eysenck relates inhibition to the amount of continued attention required by the task thereby presenting a mental work hypothesis rather than a physical one. Secondly, the impact of this theory is to be viewed in association with reminiscence rather than massed or distributed practice per se.

> 2. Perseveration theories are characterized by the assumption that some form of activity persists after practice which causes the learned response to become more firmly fixiated than it was at the termination of formal practice [McGeoch and Irion, 1952, p. 178].

Müller and Pilzecker using memory experiments with paired associates formulated a perseveration theory to account for the factor of retention and to explain what occurs during distributed practice. The theory assumed that the neural activity involved in learning continues after the cessation of formal practice. This persistence of activity enables neural patterns to become "set" or more firmly fixed. Massed practice does not give time for the setting of these neural traces or after-images to be realized (McGeoch and Irion, 1952).

The Snoddy hypothesis is another form of the perseveration theory. Snoddy (1935) described the effect of distributed practice and reminiscence in mirror-tracing in terms of interacting effects of two opposed processes of mental growth. Primary growth occurs early in practice and increases as the length of interpolated time increases. Secondary growth comes later and is enhanced by reducing the interpolated time. Both growth processes always appear in any type of practice, but they are conditioned by different states of affairs and are directly opposed to one another.

Primary growth is stable, and it does not involve loss over periods of time. It is a positive function of repetition and the passing of time. This growth is largely perceptual in nature and involves a movement from an adynamic state to a dynamic state. In contrast, secondary growth appears late in learning and is highly unstable. It is largely motor in character and represents a dynamic state. The formation of secondary growth is generally dependent upon the base of primary growth.

In summary, Snoddy stated that early growth was enhanced by distributed practices while later growth was favorably affected by continuous practices.

Another method employed by investigators to study perseveration theories is the stimulus-maturation hypothesis. Wheeler and Perkins (1940) refer to the perseverating process as a form of growth and maturation which occurs during learning as a result of induced stimulation. This maturation is a function of the time elapsed from the beginning of practice rather than the number of trials occurring within that time. Thus, the rate of improvement is enhanced by a distribution of intervals which enlarges the time factor. The distribution provides the stimulus to overcome the fatigue of practice and allows the time for mental maturation to take place.

> 3. The differential forgetting theory subscribes to the fact that during practice both correct and incorrect responses are learned. Incorrect responses may be expected to be less well fixed than the correct ones, therefore, they should be forgotten at a faster rate during rest intervals than sessions which do not offer these pauses [McGeoch and Irion, 1952, p. 183].

Easley demonstrated this principle by showing that poorly learned word-associations were forgotten at a faster rate than well learned ones. According to this assumption, the rest interval which accompanies distributed practice provides the opportunity or time for incorrect and conflicting responses to be forgotten (McGeoch and Irion, 1952).

Since Ebbinghaus' initial investigation in 1885, the work theories, the perseveration theories, and the differential forgetting theory have frequently been considered as adequate explanation for the superiority of spaced over massed practice. Each has served as the basis for experimental designs, and each has prompted additional endeavors to determine the credibility of these assumptions in both verbal and motor learning. The extent of the influence of these theories is readily seen in the large number of experimental studies which have been conducted to test the interrelationship of these variables to the conditions of massed and distributed practice schedules.

Summary

Massed and distributed practice schedules, as they relate to performance and learning, have been a critical factor of study since 1885. During this time psychologists have formulated theoretical models to explain what occurs during these practice sessions.

In Chapter II, the investigator presented a brief historical and theoretical perspective of massed and distributed practice schedules with the major hypotheses classified into three headings: work theories, persevera-tion theories, and differential forgetting theories.

Chapter III includes a detailed description of the procedures followed in the development of the study.

CHAPTER III

PROCEDURES

The procedures for the present investigation will be discussed in this chapter under the following major headings: Selection of Textbooks and Generalizations, Forms and Written Materials, Sources of Data, and Conduct of the Experiment.

The present investigation involved a documentary analysis and an in-depth examination of the experimental research designs related to massed and distributed practice schedules which have been reported in the Physical Education, Psychology, Business Education, and Music Education literature published in the United States. This process was used to determine the credibility of generalizations cited in books related to theories of learning and books related specifically to motor learning.

Selection of Textbooks and Generalizations

A preliminary investigation utilizing documentary techniques and personal inquiry was initiated to determine specific textbooks commonly used in courses related to theories of learning and/or motor learning. Seven books were selected from which generalizations related to massed and distributed practice schedules were obtained. The criteria utilized in the selection of the seven books were: (1) commonly used as textbooks for courses in the psychology of learning and/or the psychology of motor learning, (2) chronology according to recent publication dates, and (3) contained a section which emphasized massed and distributed practice schedules. Based on the aforestated criteria, three books were chosen from the field of psychology and four books were selected from the field of physical education:

1. Cratty, B. J. Movement Behavior and Motor Learning. 1967.
2. Deese, J. and Hulse, S. The Psychology of Learning. 1967.
3. Kingsley, H. and Garry, R. The Nature and Conditions of Learning. 1962.
4. Lawther, J. D. The Learning of Physical Skills. 1968.
5. McGeoch, J. and Irion, A. The Psychology of Human Learning. 1952.
6. Oxendine, J. B. Psychology of Motor Learning. 1968.
7. Singer, R. N. Motor Learning and Human Performance. 1968.

In the field of music education, the textbook entitled The Objective Psychology of Music by Robert Lundin was recommended by qualified persons as a frequently used source for methodology and research in the discipline of music.

Philosophy and Psychology of Teaching Typewriting by Russon and Wanous represented a similar selection from the field of business education. These materials did not contain additional generalizations associated with massed and distributed practice schedules which differed from those listed in the psychology and motor learning books, therefore, they were omitted as textbooks from which generalizations were chosen.

An analysis of the psychology and motor learning textbooks yielded the following generalizations related to massed and distributed practice schedules:

1. Many investigators have found that initial massing with subsequent spacing of practices produces the highest performance levels. These findings are attributed to a "warm-up" effect, "additive method" (initial massing with gradually prolonged rests), or providing a "foundation of understanding" (Cratty, 1967).

2. Early spacing with a later massing of trials proves effective. Such factors as fatigue or boredom are counteracted by distributed practice (Cratty, 1967; Singer, 1968).

3. Distributed practices are generally more efficient for learning and performance than are massed practices (Cratty, 1967; Deese & Hulse, 1967; Kingsley & Garry, 1962; Lawther, 1968; McGeoch & Irion, 1952; Oxendine, 1968; Singer, 1968).

4. Relative short practices (in time or in number of repetitions) make for more efficient learning than do longer practices (Oxendine, 1968; Lawther, 1968).

5. Proficiency which has been gained over a long period of time is retained better than that which is developed within a short period of time (Oxendine, 1968). Tests of retention indicate a lessened dissimilarity in performance between groups trained under massed and special practice conditions (Singer, 1968).

6. A higher level of motivation enables one to benefit from longer and more concentrated practices than would be possible with a lesser degree of motivation (Kingsley & Garry, 1962; Lawther, 1968; Oxendine, 1968; Singer, 1968).

7. Practice sessions should be shorter for children than for older persons (Kingsley & Garry, 1962; Lawther, 1968; Oxendine, 1968; Singer, 1968).

8. Longer practices are more beneficial to the highly skilled since they can efficiently practice that activity for longer periods of time than can persons or groups who are less competent (Kingsley & Garry, 1962; Lawther, 1968; Oxendine, 1968; Singer, 1968).

9. Relatively constant lengths for practice sessions seem to produce more learning than regular increases or decreases in sessions (Deese & Hulse, 1967; Lawther, 1968; McGeoch & Irion, 1952).

10. In motor learning, there is a point of diminishing returns or an upper limit to the advantage of spreading practice out in time (Kingsley & Garry, 1962; Singer, 1968).

11. The relative effectiveness of the distributed practice depends upon the absolute and relative lengths of

the work and rest periods (Kingsley & Garry, 1962; Deese & Hulse, 1967).

12. The effectiveness of the distribution of learning depends to a large extent upon what one does during the rest interval (Cratty, 1967; Deese & Hulse, 1967; Kingsley & Garry, 1962; Singer, 1968).

13. The optimal length and spacing of practice periods depends upon the nature of the learning task (Kingsley & Garry, 1962; Singer, 1968).

14. In gross motor activities, the number of repetitions (shots, throws, and dives) should be considered as the unit of practice rather than the time spent at the work session (Oxendine, 1968).

In general, it may be stated that when the work involved in a task is great, when the skill is complex and not meaningful, when frequency of required effort is high, the practice should be spaced. In contrast, massed practice periods are more productive when the task is meaningful, when insight is possible, when material is learned to a high degree of proficiency, when peak performance is required in a well learned task, or when prolonged warm-ups are necessary.

Forms and Written Materials

It was necessary to develop a format for recording and systematizing the data. Two forms were constructed which provided for an in-depth examination of each experimental design as well as the principle variables involved in massed and distributed schedules which might affect the conditions of practice. Form A (Appendix) was sub-divided into six parts. Five of these parts provided for a representative summary of each study and included bibliographic material, the purpose(s) and/or hypotheses, the task employed, the treatment of the data, and the conclusions of the study. The sixth component afforded an opportunity for the present investigator to critically examine the materials and methods employed by the researcher, to analyze the design, and to assess the constructs, procedures, and variables which were employed in the investigation.

Form B was developed to facilitate a numerical count of the specific variables utilized within the practice schedule of each experimental design. Copies of Form B are contained in Chapter IV. This form included 14 factors which the investigator considered to be of primary importance in an adequate research design: (1) selection of subjects, (2) the tasks or skills employed, (3) the experimental environment, (4) the type of schedule, (5) the length of the interval, (6) activity of the subjects during the interval, (7) a theoretical explanation for the interval, (8) length of the experimental session, (9) motivation of the subjects, (10) the length of the practice period or the time element for each session, (11) homogeneity of the groups, (12) recording of baseline performance, (13) relationship of hypotheses to either performance, retention, or both, and (14) experimental results relative to the superiority of massed and distributed practice.

These 14 variables were subdivided into additional categories. Selection of the subjects was distinguished by either age, sex, or the population from which they were drawn. The tasks or the motor skills employed also have an effect on any experimental design, therefore, this category provided an opportunity to record the level of proficiency of the subjects in the task, the type of task relative to fine and gross skills, and the type of movement(s) in the task described as either serial or discrete.

It was important to note the setting or the experimental environment in which the investigations were conducted since artificial and natural conditions present concepts which may be incongruous. Artificial settings provide for carefully controlled conditions while natural situations increase the realistic probabilities of performance at the expense of some decrease in the control of variables.

The concept of distributed practice is based upon some change that takes place during the interval; consequently, it was necessary to account for the time of the interval, what the subjects did during the interval, and an explanation or construct for the inclusion of the interval. In contrast, the work load for each task exemplified by either a time factor or the number of trials might affect learning and performance and must be included in the records.

These variables are further influenced by the length of the experimental sessions, by the homogeneity of the groups, and by the assessment of a baseline performance.

The workability of the formats for recording data was determined by an in-depth analysis of five studies. For this preliminary investigation, two designs were chosen from physical education and three studies were used from psychology. One study represented different schedules for practice; two studies utilized a constant work pattern but varied the rest interval; and another design varied the practice session and held the rest interval constant. The fifth study tested for the influence of massed and distributed practices in which the variable of motivation also was controlled.

The preliminary investigation included designs which used both male and female subjects from college and high school populations. All subjects were engaged in a novel task utilizing the fine skills of mirror tracing, billiards, and the pursuit rotor in both artificial and natural settings.

As a result of this in-depth analysis of five studies, minor revisions were adopted for several topical headings to give clarity and meaning to the variables as differentiated on Form A and Form B.

Sources of Data

The data utilized in the present inquiry included books, periodicals, bulletins, theses, dissertations, reports, microcards, and microfilms related to massed and distributed practice schedules. The reader is reminded that to meet the demands of this study, the disposition of the data was restricted to studies which used human subjects who performed motor tasks and to the literature published in the United States.

Several methods were employed to locate data pertinent to the study. The investigator consulted with qualified persons in physical education, psychology, business education, and music education at the Texas Woman's University, Denton, Texas, and North Texas State University, Denton, Texas, during the spring of 1970 to seek aid in the proper selection of experimental literature related to massed and distributed practice schedules.

To supplement the consultations, a letter was written to the Houston Academy of Medicine Library, Houston, Texas, for a "Medlars" search request pertaining to the topic of practice schedules. This service renders a preliminary search of all experimental studies listed in Index Medicus for the past ten years. It is directed by a Medlars Search Analyst and prepared on an I. B. M. "read-out." A second letter was written to the Curator of Music, Library and Museum of the Performing Arts, Lincoln Center, New York, New York, to secure materials in the field of Music Education.

These data represented by experimental designs were listed also in major educational and research indices. The Cummulated Index Medicus which originated in 1960 annually reviews approximately 2400 periodicals. Prior to this time, this information was synthesized in the Quarterly Cummulated Index Medicus published from 1927 through 1959. The topic of massed and distributed practice schedules was listed under the headings of learning, motor skills, practice, and teaching.

The Education Index which incorporates references from 213 journals and magazines began in 1929. Pertinent sources of data in this reference were recorded under the topic of practice.

Two major reference books were used to obtain data in Music Education. The Music Index which originated in 1949 consolidates resources from 204 magazines and journals. Experiments concerned with massed and distributed practice schedules were registered under the categories of study and teaching. A compilation entitled Evaluation and Synthesis of Research Studies Related to Music Education by Schneider and Cady proved invaluable to the present investigation. This book covered research in Music Education from 1930 to 1962 and included reports, theses, dissertations, and published books and articles. A grand total of 11,810 titles of probable research were listed in this book. Of that number, 1818 studies were reviewed and abstracted upon a priority system. All dissertations and 212 theses, as well as published documents were included in the final 1818 studies reviewed. The largest number of investigations were concerned with the music teacher, the music student, and the teaching-learning process. The latter category represented potential data for the present investigation.

An additional 20 articles in Music Education were reviewed in which the principle of spaced practice was advocated over massed practice. None of these sources contained references which were different from those found in the psychological literature.

Master's Theses in Health, Physical Education, and Recreation edited by T. K. Cureton yielded a list of 3,725 studies. Unpublished theses concerned with massed and distributed practice schedules were recorded under the topics of methods of teaching, practice, or schedules.

Completed Research in Health, Physical Education, and Recreation included abstracts of master's and doctor's theses from 73 institutions offering graduate programs in this discipline. It also included an index and a bibliography of published research cited in 198 periodicals. The topic of massed and distributed practice was listed under the headings of practice and distributed practice.

The Business Education Index which was first published in 1940 reviews 73 periodicals and yearbooks in Business Education. Data specific to the conditions of massed and distributed schedules were categorized under the subheadings of education and/or teaching.

Three additional indices proved to be beneficial in locating pertinent data in Business Education. A _Bibliography of Research Studies in Stenographic-Secretarial Training and Work Reported Prior to 1959_ compiled by Harves Rahe reviewed 30 periodicals, books, and monographs. Experimental studies were recorded under the topic of psychological bases for teaching. Another source entitled _Ten Years of Shorthand References_ (1927-1937) by Clyde Rowe summarized investigations from 30 journals. Practice and type of schedules were categorized under the divisions of methods, psychology, and research. The _Typewriting Research Index_ edited by Harves Rahe covered research studies in typewriting from 1904 to 1963. Books, journals, theses, dissertations, and papers specific to massed and distributed practice schedules were listed under the topics of scheduling of classes, psychology of skill building, length of class periods, and rest periods.

Twenty-three articles in Business Education were reviewed in which the principle of spaced practice was advocated over massed practice. From these sources, two experimental designs were incorporated in the working bibliography.

At the conclusion of this major overview of these various indices which included published and unpublished research in physical education, psychology, business education, and music education, the present investigator examined 24 periodicals and magazines beginning with the publication of Volume I to the volume published in 1970 (Appendix).

Conduct of the Experiment

The documentary analysis of studies began in April, 1970. An attempt was made to include all studies bearing upon the problem of massed and distributed practice schedules which covered a period of time from 1885 (Ebbinghaus' pioneer study) through February, 1971. In all but one case, the original book, article, report, dissertation, or thesis cited was read, abstracted, and analyzed in detail. Each study served as an additional source for securing data by following the network of references from article to article.

To insure accuracy in the investigator's summary of each study, a photocopy was made of the introduction and the review of literature from the first 50 experimental designs. This information was intended to serve as a cross reference for the final analysis and evaluation of the studies. The investigator discontinued this procedure when she discovered that the benefits accrued were not commensurate with the cost involved.

The data were collected alphabetically according to the surname of the author and organized chronologically by the publication date of the book or article.

A total of 433 studies was examined. Two hundred and sixty-two were omitted from further analysis because they did not meet the established criteria for inclusion in this investigation. Prominent factors which led to the deletion of the studies were the use of nonhuman subjects, the extensive number of designs which incorporated mental or verbal tasks, and the misleading titles used by investigators to describe their studies. Titles often bore no relationship to the contents of the report.

The remaining 171 psychomotor studies were subjected to a documentary analysis and an in-depth examination to determine the credibility of generalizations cited in books related to theories of learning and books related specifically to motor learning.

Summary

In Chapter III, the investigator presented a detailed discussion of the procedures followed in the development of this inquiry under the following major headings: Selection of Textbooks and Generalizations, Forms and Written Materials, Sources of Data, and Conduct of the Experiment.

Chapter IV contains an analysis and interpretation of the data collected during the present investigation.

CHAPTER IV

ANALYSIS AND INTERPRETATION OF THE DATA--PART ONE

The analysis and interpretation of the data collected during this study are presented in this chapter. The various factors which have been shown in the experimental literature to affect the conditions of spaced and unspaced learning will be enumerated, and each will be presented in relation to the questions which guided the development of this inquiry.

Fourteen factors from each experimental design were tabulated in Table 1 upon the basis of relationships which exist within the two major conditions of practice. In this table, the studies are listed in chronological order. Certain aspects of some investigations could not be forced into tabular form, therefore they are analyzed and reported in the body of the review with a further consideration of the studies found in the table. A few studies (14, 21, 30, 40) did not include the information necessary for tabulation, while others (34-35, 133-143, 124-129, 54-58) are reported although they are duplications of the same investigations cited in different publications. In 13 studies (1, 9, 12, 14, 24, 28, 34, 35, 55, 61, 93, 124, 129), only the aspect related to massed and distributed practice schedules was

BLE I

motor Studies Pertaining to

;	DURING INTERVAL				HESES	SUPERIORITY OF PRACTICE	
.ed)	Rest	Rehearse	Unrelated Task	No In- structio	ention	Massed	Distributed
			School work	*			*
				X			*
				X		*	
				X			*
				X			*
ed	X				X ›nth liffer-	X-Early learning No difference	X-Late learning
				No dis- cussion or Practice		No difference--	early learning * Late
				X	X ›nth ›red ributed	No difference	
				X		X Part method and late learning	X Whole method and late learning
				X			*

Continued

	DURING INTERVAL				THESES	SUPERIORITY OF PRACTICE	
ed)	Rest	Rehearse	Unrelated Task	No In-struction	tention	Massed	Distributed
				X		No difference--	*Early learning -late learning
				X	D: E:	*	
				X		No difference	
				X	P: ac Se fa	*Late learning	*Early learning
				X		No difference	
				X		No difference--	-No. of trials * 4 Day Interval
d				X	: months ored tributed		*
/ n/				X	Pe Se		*
			Record feelings Smoked Talked				*
				X			*

E I: Continued

ALS (…uted)	DURING INTERVAL: Rest	Rehearse	Unrelated Task	No Instructi…	HYPOTHESES: Retention	SUPERIORITY OF PRACTICE: Massed	Distributed
				X			*
			Write mode of attack			No difference	
rs. rs.				X	X 4 weeks-T 2 weeks-cross Favored Distribution	I. * Puzzle II. * Early learning T & cross	II. * Late learning T & cross
				X		No difference	
s. sec. al; ated ntert. erp.				X		*Late learning	*Early learning
				X		*Early learning by errors No difference No difference	*Late learning by time early by time late by errors
min.			Read magazine				*
				X		*Late learning	*Early learning
ial ed				X	X 1 week Favored distribution		*
20 ..				X			Effect of rest 5-20 min. best

Continued

	DURING INTERVAL				OTHESES	SUPERIORITY OF PRACTICE	
ed)	Rest	Rehearse	Unrelated Task	No In- struction	etention	Massed	Distributed
)				X		*Early learning	*Late learning
1. 1.				X		No difference--	*Early learning late learning
				X		*Late learning	*Early learning
ed			Talked Mirror maze Spool packing				Effect of rest * Sex differences
ed			Talked Mirror maze Spool packing				Effect of rest * Sex differences
				X			No effect from daily practice
				X	R	Effect of	practice *Short--2 min.
			Music activity		T p. X weeks vored stribution	No diff	erence
				X			*
				X			*Performance-- 20 min. *Learning-- 2 days

I: Continued

S	DURING INTERVAL				THESES	SUPERIORITY OF PRACTICE	
ted)	Rest	Rehearse	Unrelated Task	No In- struction	etention	Massed	Distributed
			Read magazine			*Late learning	*Early learning
			Talked			No difference learning	*Performance
ıl ıted			Read			No difference learning	*Performance
			Asked not to think of pat- terns			I. * II. *	
ıl rs. ıted				X			*
ıted				X	I (	*Late learning	*Early learning
·				X	S I		*
				X		No difference--early learning	*Late learning
· ;.	X		Group 8 made tallies & crossbars No practice		D		*
ı.			Talked Read magazine		T d	Tested for effect of work-rest 8 min. work and 5 min. rest optimum	

I: Continued

LS uted)	DURING INTERVAL Rest	Rehearse	Unrelated Task	No In- structic	YPOTHESES Retention	SUPERIORITY OF PRACTICE Massed	Distributed
				X		No difference	
				X			*
			Lived in lab dorm			No difference	
)			Read Talked Smoked				* 10 min. optimum
				X			*
in. ial hrs. ted inter- 3 min. ted	X		Talked				*
				X			*
)0,			Read Talked Smoked				* 10 min. optimum
				X		*Early learning	*Late learning
				X			*

I: Continued

S	DURING INTERVAL				'POTHESES	SUPERIORITY OF PRACTICE	
ted)	Rest	Rehearse	Unrelated Task	No Instruction	Retention	Massed	Distributed
				X		*By time factor	*By practice factor
			Talked			No difference	*Performance learning
				X		No difference	
sec.				X		No difference	*Performance learning
			Read			No difference	
			Talked				*
	X					No difference	*Performance learning
ntrol 0,				X			*
				X		Work and rest Late in learning	*
al ted				X		No difference	*Performance learning

I: Continued

LS	DURING INTERVAL				HYPOTHESES	SUPERIORITY OF PRACTICE	
uted)	Rest	Rehearse	Unrelated Task	No In- structi	Retention	Massed	Distributed
				X			* Work more important than rest
				X	X 1 year Favored additive	*Early learning	*Late learning
				X		*Early learning	*Late learning
				X		No difference	
,			Talked Read Played cards				Effect of rest 50 sec. best
sec., al ated ial16			Read Magazine				*
				X		X Early learning	X Late learning
ial				X		No difference	*Performance learning
				X			*
al ated				X			*

I: Continued

S	DURING INTERVAL				OTHESES	SUPERIORITY OF PRACTICE	
ted)	Rest	Rehearse	Unrelated Task	No In-struction	etention	Massed	Distributed
al 6				X		*Early learning No difference at end	*Late learning
				X		No difference	
	X		Talked				*
				X			*
l ted			Talked Read			No difference learning	*Performance
ter	X						*
l ted	X					No difference learning	*Performance
., n. l l			Read			No difference learning	*Performance
			Talked			No difference learning	*Performance
al ted				X		No difference learning	*Performance

I: Continued

ALS	DURING INTERVAL				IYPOTHESES	SUPERIORITY OF PRACTICE	
e buted)	Rest	Rehearse	Unrelated Task	No Instruct	Retention	Massed	Distributed
			Read				*
·ial ılated				X		Late learning	Early learning
'ter 5th trial ter 20th trial ated				X		No difference— * Last 40 trials	1st 40 trials * 2nd 40 trials
:ec. ›0, or ·c. ›0, or c.				X	X 10 weeks No Difference		*
her al			Warm-up with tallies and crossbars				*
			Read Talked			Rest beneficial	
or ther 28				X			*
to ll,				X		No difference	*Performance learning
ial			Viewed slides			No difference	
,		X				No difference	

I: Continued

.S	DURING INTERVAL				'POTHESES	SUPERIORITY OF PRACTICE	
ted)	Rest	Rehearse	Unrelated Task	No Instruction	Retention	Massed	Distributed
, or				X		No difference learning	*Performance
l :ter :ial				X		No difference learning	*Performance
sec. - :ed			Instructions for next 4 trials			*By response No difference learning	*By time *Performance
: hr. ed	X		Read				*
), :.				X		*Late learning	*Early learning
l.				X			*
				X		No difference	
				X		No difference	
ed				X		*Late learning	*Early learning
				X		*Archery	*Badminton

Continued

l)	DURING INTERVAL					:HESES	SUPERIORITY OF PRACTICE	
	Rest	Rehearse	Unrelated Task	No Instruction		:ention	Massed	Distributed
			Talked		Tem men Ski		Effect of sex and age differences	
	X		Button pressing for 12 trials 2 groups		Rea			*
	X		Read Talked		Rea Con		No difference learning	* Performance
	X		Read		Mat Tem wor		No difference learning	* Performance
			Mark out letters		Rea Lac		Women better than men	*
,0 1			Read Talked		Lac Rea Wor		No difference learning	*Performance
	X		Read Talked		Set Rea	week dif- rence	No difference learning	*Performance
',	X				Rea Con	weeks vored stributed		*
				X		months dif- rence		*
				X			No difference	

I: Continued

S ted)	DURING INTERVAL Rest	Rehearse	Unrelated Task	No Instruction	YPOTHESES Retention	SUPERIORITY OF PRACTICE Massed	Distributed
				X			
				X			
				X		No difference	
				X		*Late learning--volleyball No difference late learning for badminton No difference early learning for volleyball	*Early learning-badminton
ed				X		No difference learning	*Performance
				X		No difference	
	X						
:ed				X	X 2 weeks No difference	No difference	
				X		*Late learning--volleyball No difference late learning for badminton No difference early learning for volleyball	*Early learning--badminton
				X			

I: Continued

LS	DURING INTERVAL				YPOTHESES	SUPERIORITY OF PRACTICE	
uted)	Rest	Rehearse	Unrelated Task	No In struc	Retention	Massed	Distributed
0, or	X		Read Talked				*
				X		No difference	
				X			*Performance *Learning
				X	X 3 weeks No difference	*Early learning	*Late learning
d fter trial				X			*
				X		*Skill--Sw. *Bowling	*Endurance--Sw.
ited				X			*
				X	X 3 weeks No difference	No difference laboratory skill	*Activity skill
				X	X Test distributed groups	No difference	
				X		No difference	

1: Continued

	DURING INTERVAL				HYPOTHESES	SUPERIORITY OF PRACTICE	
ed)	Rest	Rehearse	Unrelated Task	No Instruct	Retention	Massed	Distributed
				X	X 3 weeks No difference	*Early learning No difference	late learning
	3. X		1. tied knots 2. symbol cancellation				X Tested for effects of rest interval activity--none
				X		No difference	*Performance learning
sec. .ed	X		Read Talked				*
				X		No difference	
				X		Effect of work-rest 2-1 ratio	
				X		No difference	
				X		No difference	
				X		*	
				X		No difference	

E I: Continued

.S	DURING INTERVAL				HYPOTHESES	SUPERIORITY OF PRACTICE	
ted)	Rest	Rehearse	Unrelated Task	No stri	Retention	Massed	Distributed
					X 4 weeks No difference		*
ol						No difference learning	*Performance
.					X 1 week Favored massed		*
ith			X Drives			No difference	
l ed						No difference	
.ed			X Chipping			No difference	
				X			*
				X	X 9 weeks No difference	No difference	
				X		No difference postrest	*Prerest
ec. ed				X		No difference learning	*Performance

S	DURING INTERVAL				POTHESES	SUPERIORITY OF PRACTICE	
ted)	Rest	Rehearse	Unrelated Task	No In- structio	Retention	Massed	Distributed
	X					No difference	*Early learning late learning
				X		*	*
				X		No difference	
:ed			Talked				*
l. l. l.				X		*b. Stabilometer learning No difference	a.&b. * Performance learning--ladder climb
				X		*Stylus maze Did not compute	ball bounce
l ted			Serve and volley for D group	X		No difference--	forehand drive *Backhand drive
l ted al				X		No difference	*Performance learning
ial min 100 ial ter- coups				X		No difference	*Performance learning
l ted				X		No difference	*Performance learning

l: Continued

.S	DURING INTERVAL				POTHESES	SUPERIORITY OF PRACTICE	
ted)	Rest	Rehearse	Unrelated Task	No Instruct	Retention	Massed	Distributed
l ted l				X		No differen	*Performance ce learning

discussed in the present inquiry, rather than the more comprehensive investigation which was presented in the original paper.

Time Periods and Experimentation

Ebbinghaus, using a verbal learning task, first experimentally demonstrated the influence of massed and distributed practice schedules in 1885. It was not until 1905--20 years later--that experimental studies concerned with these practice conditions utilized motor tasks to determine if results would be the same for both verbal and motor learning.

An exploration of the importance of distribution (a general term which includes absolute massing as well as different degrees of spacing) to learning is readily seen by the number of investigations that have been devoted to the subject. When the 171 studies analyzed in this study are subdivided into experimentation over ten-year periods, some insight is gained concerning the primacy of the issue. These data are reflected in Table 2 as it relates to motor learning.

TABL E 2

Number of Investigations During Ten-Year Periods
N=171

Years	Number of Investigations
1905-1915	7
1916-1925	6
1926-1935	12
1936-1945	23
1946-1955	65
1956-1965	40
1966-	18

The first 30 years represents a total of 25 investigations in motor learning. Interest and unanswered concerns provided for an increase in experimentation during the 1930's, reaching a peak during the 1946-1955 decade. A small decline follows, although the number is greater than any other period excluding the previous one. Eighteen studies were conducted from 1966 to 1970. It appears that questions and issues remained unresolved and that the influence of massed and distributed practice schedules on performance and learning continues as an important domain for investigation. The emphasis in research prior to 1956 was concerned, almost without exception, with the effects of distribution of practice upon motor performance, with such performance phenomena as scores at a designated stage of practice, reminiscence, or warm-up rather than motor learning. In contrast, the experimental evidence from the late 1950's and 1960's indicates that these studies were designed to compare the effects of massed practice versus distributed practice on motor learning.

In addition to the total number of investigations completed, it is interesting to note the number of contributors to this area. One hundred and fifty-four investigators have developed experimental designs to test the effects of massed and distributed practice conditions. Ammons, who conducted 10 different studies, and Kimble, who directed 8 investigations, have been the most systematic contributors. Adams, the Bilodeaus, Buxton, Cook, Hilgard, Reynolds, Snoddy, Travis, and Tsao also have devoted much of their effort to the problem of decrements in learning performance.

Selection of Subjects

The influence of age and/or sex of the subjects on the effectiveness of practice conditions varies both in type and extent of the experiment. The majority of the findings have been based upon experiments in which the subjects have been of college age. Of the 171 studies, 65%, or 123 designs, had college students as subjects. Categorically, the number of investigations which used samples from a population other than the college group are: (a) preschool--1, (b) elementary--8, (c) junior high--8, (d) high school--14, (e) and others, such as the Air Force, adults, auto workers, and Nuns--23. Thirteen studies did not indicate the selected sample. The number of subjects involved in each investigation must be considered for several studies have used too few subjects to provide data that is applicable beyond the selected experiment.

Age of the Subjects

Several studies have specifically examined the influence of age to the condition of practice. Knapp, Dixon, and Lazier (1958) compared high school freshmen and college seniors and found no difference between the time required to learn to juggle when both massed and distributed schedules were used by both groups. Totten (1953) used a control group ranging in age from 14½ through 19½ years and an experimental group ranging in age from 13 through 17 years to compare typing results. She found that the two groups did not differ significantly on measures of rate and error when the factor of age was held constant.

Ammons, Alprin, and Ammons (1955) using the pursuit rotor and subjects from grades three through twelve found a progressive increase in skill accompanying an increase in age. In contrast, Moncrieff, Morford, and Howell (1962) compared 5-6-7 year-olds with 8-9-10 year-olds on six swimming skills. These investigators found no difference in performance achievement of the two age groups.

Abbey's investigation (1962) points to the need for longitudinal studies to determine the effect of age on performance. The Toronto Complex Coordinator was used with three different age groups--3-6 years, 6-8 years, and 7-10 years--and the results indicated that older subjects showed higher levels of performance. It is evident that experimental results do not offer evidence to substantiate the claim that adult subjects are able to practice longer than younger ones. Of primary interest is the fact that a limited number of studies, five, have been devoted to this topic when both age and practice conditions have been considered. It appears that the generalization related to age has its basis only in studies that use learning curves for different age groups rather than the two variables of age and practice.

<u>Sex of the Subjects</u>

The sex of the subject is a factor which has received experimental consideration. Seventy studies analyzed in the present investigation used only male subjects, while 34 investigations employed only female subjects; 39 designs used both sexes; and 26 studies did not indicate the sex of the subjects. Of the 36 investigations which used both sexes as subjects, five (111, 113, 115, 125, 131) assigned an equal number of men and women to each group while 12 others (14, 15, 34, 35, 47, 66, 110, 133, 139, 140, 144, 151) assigned specific conditions within the sex.

Thirteen studies have considered the distinctive influence of sex upon the performance scores as a function of distribution. Snoddy (1926), using a mirror tracing task, found college women superior to men in the early stages of learning but no significant differences between the sexes in the late stages of learning. Goodenough and Brian (1929) used preschool subjects and suggested that boys were better than girls when the results of a ring-toss were compared.

Buxton and Henry (1939), as well as Buxton and Grant (1939), looked at the performance of men and women on the pursuit meter. These studies yielded data which showed that males exceeded females on initial and final performance ability. The investigators concluded that women were more subject to fatigability on the pursuit meter than men. Within the experiment, women had a greater improvement when the interpolated period involved rest than when another activity was involved.

With similar apparatus, Spence, Buxton, and Melton (1945) found significant differences between men and women on the pursuit rotor with performance scores favoring the men. Ammons, Alprin, and Ammons (1955) also used the pursuit rotor to compare scores for boys and girls. Their results indicated that boys were always superior to girls, but these differences were greater from grades nine to twelve. Irion (1949) found systematic sex differences on the pursuit rotor with men scoring higher than women.

Young (1954) compared men and women in performance in archery and badminton. She concluded that the results were not affected by sex although women showed greater gains than men.

Archer and Bourne's investigation (1965), which involved alphabet printing, showed women superior to men in this task.

Moncrieff, Morford, and Howell (1962) discerned no significant difference in performance in swimming when boys and girls ranging in age from five to ten years were used as subjects. A similar study by Keough (1962), which compared the fitness of third and fifth grade boys and girls in a daily or two-day-a-week program, indicated little difference between the gains of the two groups.

The Multiple Serial Discriminator was selected by Patel and Grant (1964) to determine if sex differences existed. No overall difference in performance was obtained although women were superior to men in the early periods while opposite results were achieved in the late periods of practice.

Oxendine (1965) compared the performance scores of men and women in a mirror-tracing skill and found no difference between the sexes.

From this analysis, it can be determined that the five studies which used a form of the pursuit rotor indicate definite sex differences favoring male subjects. When the two tasks of mirror-tracing and serial discrimination were used, women were superior in the early periods of learning while men were better in the latter periods of learning. Data from the inverted alphabet printing indicate superior performance by women. An additional study involving mirror-tracing produced no significant differences between the sexes. Lastly, three studies with young children as subjects performing gross activities yielded dissimilar results. One found boys superior to girls and two reported no difference in the performance of boys and girls.

The evidence is inconclusive when performance scores as a function of distribution are tested to determine the influence of sex. It appears that a consensus of support favoring the superiority of male over female subjects occurs only when the task involves performance on the pursuit rotor. This factor presents two concepts which should be considered when one chooses subjects to participate in an investigation to determine the effects of massed and distributed practice schedules. If the subjects represent only one sex, then the conclusions must be restricted to that sex; if both sexes serve as subjects, an equal number from each must be assigned to both conditions for the results to be applicable as a generalization.

Two issues remain unresolved. First, there is a need for additional research to determine the influence of sex upon performance scores when practice conditions are used as independent variables. Secondly, it appears that twice as many studies have employed male subjects as female subjects when according to census statistics women actually constitute a greater proportion of the general population.

Skill Level of Subjects

The initial proficiency of subjects performing a designated task may affect the results obtained under different practice conditions. Of the 171 studies analyzed, only seven investigators secured subjects who were not novice in the skill to be performed.

Oliphant (1939) investigated the influence of daily practice sessions for varsity basketball players. The results indicated no advantage of short, daily practice for this group. In contrast, Webster's study (1940), which was descriptive in nature and involved the use of a question-naire, found that intermediate and champion bowlers indi-cated a preference for short and frequent practice periods, or, more specifically, three times per week for 30 minutes were advocated.

Rubin-Rabson (1940) had nine experienced piano players practice selected pieces of music under both distributed and massed conditions. There was no difference in final results regardless of the condition used.

Crawford et al. (1947) observed Air Force members in aerial gunnery techniques on four to eight flying missions. Hits were more accurate when 2,000 rounds were distributed over several missions rather than one day. These investi-gations also compared nine high-scoring and nine low-scoring pilots with scores based upon accuracy of their first 10 missions. The advantage of the superior group on perform-ance was maintained for 45 missions.

There was no difference in 2, 3, or 4 days of practice with 30 minutes each period when intermediate swimmers were compared by Scott (1954). The same results were obtained by Brassie (1965) when he compared the free throw shooting of skilled basketball players under massed and distributed schedules.

Each of these studies, with the exception of those by Crawford and Webster, point to the fact that highly skilled performers can effectively practice under either type of condition without incurring decrements in performance of learning. This statement is made with some reservation because of the limited number of investigations to substantiate it.

An additional aspect emerges when the level of proficiency for subjects is discussed. The possibility exists that a subject may become proficient at a skill during certain stages of learning, especially in fine motor skills. One hundred and sixty-four studies used subjects who had no experience with the task.

From this number, 30 concluded that distribution was more effective during the initial stages of learning and massing more efficient in the final stages, or vice versa. These statements suggest that high degrees of proficiency have been obtained somewhere in the learning period by the subjects.

It should be pointed out that this generalization is based upon an investigator's arbitrary standard of when a person became proficient in the task. Examples of this arbitration are exhibited by Pyle (1914) who considered the first 5 of 60 practices as early learning; Lashley (1915) concluded that few habits in archery were acquired after 100 shots in an experiment that involved 400 rounds, or, more specifically, one-fourth of the practice period was utilized to gain proficiency in the skill; Snoddy (1926) stated that five circuits in mirror-tracing constituted the adaption or early stage of learning while the 6th to 60th circuits favored facilitation or late stages of learning when improvement is a function of repetition; Spence, Buxton, and Melton (1945b) considered five minutes of an eight minute task on the Complex Coordination Task as early learning, alloting more time for the development of the skill than for the refinement of it; Harmon and Miller (1950) stated that from three to five practice periods out of nine were satisfactory for establishing beginning skills; Carron and Leavitt (1968) found greater individual differences and intra-individual variability within the first four trials of a 20 trial sequence on the pursuit rotor and stabilometer. Other studies (9, 11, 23, 25, 28, 31, 32, 41, 46, 59, 72, 73, 81, 92, 93, 106, 109, 124, 134, 141) follow similar patterns in arbitrarily assigning the point at which the subjects were proficient in their performance. To compound the problem, 11 studies favor massing during the beginning stages of learning while 16 indicate a superiority for distribution at the initial stage. Consequently, when the bulk of experimental designs are considered, there is little support for the belief that highly skilled subjects can profit more from massed practice sessions.

Nature of the Task

The nature of the tasks employed in the 171 studies were analyzed under the following headings: fine and gross shills, complexity of the task, and methods for recording scores.

Fine and Gross Skills

Fifty-one tasks were used in the 171 studies to determine the influence of massed and distributed practice schedules. When results are combined on the basis of the number of times the task was used, almost two thirds, or 127 of the studies, employed fine motor tasks as experimental variables, in contrast to 59 gross motor skills.

Table 3 provides a summary of the specific tasks which were utilized, and the number of investigations that incorporated the task.

An analysis of these data supports the contention that the pursuit rotor, in one of its many forms, is the most frequently used tool to determine the effects of massed and distributed practice schedules. Over 25% of the experiments used this apparatus as a testing device. It is interesting to note that no investigator found massed practice superior to distributed practice when the task involved the pursuit rotor; six studies (31, 32, 41, 92, 109, 161) reported an advantage for one condition early and another condition late or vice versa; the remaining 44 studies favored distribution

TABLE 3

Type and Number* of Investigations Using Fine and Gross Tasks

Fine Skills	Number	Gross Skills	Number
Aerial Gunnery	1	Archery	4
Ball Chute	1	Badminton	3
Billiards	6	Balance Board	1
Card Sorting	1	Ball Bounce	1
Chain Assembly	1	Ball Throwing	1
Cranking	3	Basketball	7
Foottracking	1	Bowling	3
Handwriting	3	Driving a Car	1
Inverted Alphabet	12	Fitness Tests	2
Mazes	8	Folk Dance	1
Minnesota Manipulation Test	2	Golf	3
Mirror Tracing	13	Gymnastics	1
Path Tracing	1	Handball	1
Peg Turn	1	Javelin	1
Piano	1	Juggling	3
Pursuit Rotor	55	Ladder Climb	3
Puzzles	3	Ring Toss	1
Rudder Control	1	Shuffleboard	1
SAM Complex Coordinator	5	Softball Throw	1
Serial Discriminator	1	Stabilometer	6
Toronto Complex Coordinator	1	Swimming	3
Transcribe Alphabet	2	Tap Dance	1
Typing	3	Tennis	3
Vector Reaction Time Test	1	Track and Field	3
		Treadmill	1
		Volleyball	4
		Walking Maze	1
Total 24	127	27	59

*The discrepancy in the total number of investigations (127+59=186) occurs because some studies employed more than one type of task.

of practice either for both performance and learning (28 studies) or for performance with no difference in learning (16 studies). It seems quite plausible that Meyers' (1967) statement that the pursuit rotor is not a typical motor task may be correct. She charges that "it is notorious for its sensitivity to the influence of massing and distributing practice and for the relatively large amounts of reminiscence as well as the warm-up phenomenon [p. 73]." This problem is further illustrated when the two studies by Spence, Buxton, and Melton (1945a and b) are compared. Practice conditions were similar; continuous practice for eight minutes was combined with three conditions of rest. One experiment used the pursuit rotor and reported the superiority of distributed practice over that of massing. The SAM Complex Coordination Task was used in the second design. No differences were observed for the first five minutes of practice and distribution was important only during the last three minutes of the practice period.

This pattern which favors distributed over massed practice continues when another frequently used fine motor skill--inverted alphabet printing--is employed. Twelve studies (49, 67, 68, 69, 70, 86, 95, 99, 103, 115, 123, 131) were conducted with this task. Two studies (99 and 123) revealed no difference between the conditions; results of the remaining 10 investigations ascribed an advantage to distributed practice although three (67, 70, 103) designs credited this superiority to performance, with no difference between the conditions when motor learning was considered.

Mirror-tracing (stabilimeter) was another fine motor skill often used to determine the influence of distribution of practice. The results for this task are not as consistent as for the former two tasks. Four of the 13 studies found no difference; two favored distribution; four suggested the advantage of massed practice late in learning and distribution early in learning, while two others indicated that a massed schedule was better early in learning and a distributed schedule was superior late in learning; one study found massed practice helpful when scores were taken in terms of time and distribution beneficial when scores were indicative of the number of responses made (14, 18, 25, 33, 46, 61, 74, 81, 82, 128, 134, 138, 151).

These three tasks constitute over one-half of the investigations concerned with fine motor skill learning. It appears that distributed practice is superior to massed practice when fine motor skills are employed, especially if the scores represent performance rather than learning.

This pattern is not substantiated when gross motor skills are used as the task variable. Basketball (13, 21, 36, 141, 145, 148, 153), the stabilometer (152, 159, 161, 165, 168, 171), volleyball (125, 129, 145, 158), and archery (7, 24, 110, 120) were repeatedly chosen as tasks to ascertain the better practice schedule. In basketball skills, the results from four studies indicated no difference between the conditions; two favored distribution; and one found massing in early learning and distribution in late learning to be helpful. Six investigations using the stabilometer had results which showed significantly better performance with distributed practice but reported no difference in learning between the practice groups; one found learning to be better under massed conditions and performance superior under distributed conditions; and one favored distribution for early learning but no difference in late learning. In volleyball studies, two investigators reported no difference between practice groups and two suggested achievement in volleyball was best obtained when early practices were distributed and late practices were massed. Archery provides similar data. One study favored massing, two found no difference between conditions, and one indicated no difference early in learning although distribution was better late in learning. The trend of the findings for these four activities is parallel to that obtained when studies using the other 24 skills are examined.

It is evident that the findings from laboratory studies testing fine motor skills cannot reliably be applied to learning or performing gross and complex motor activities.

Complexity of the Task

The complexity of the task has been listed as one criterion that determines the effectiveness of either massed or distributed practice schedules. Eighteen studies have investigated this facet of learning in relationship to conditions of practice. The investigations can be subdivided into six areas: maze and puzzle learning, weight loads or resistance, category responses, work surface height, relationship of fine and gross skills, and relationship of two gross skills.

Cook and Hilgard (1949) studied massing and distributing practice using a finger maze. They found that easy skills are mastered more efficiently with massed practice, while difficult skills should be spaced for best results.

Pechstein (1917 and 1921) investigated the effect of distribution of practice in the learning of mazes with twelve cul de sacs. In both experiments, the results indicated an advantage for massed practice when the task was short and easy, when elements needed to be connected or consolidated, but that distributed practice was essential when a task may have many errors, for the elimination stage, and when the whole method is used in conjunction with the practice condition.

T. W. Cook studied conditions of practice using a U-type finger maze (1937) and T and Cross puzzles (1934). He concluded that massed practice was beneficial when the task involved trial and error, when it was short, when problem solving, insight, and configuration were involved, and when the experimental procedures involved a response element. Distribution was helpful when long mazes were used, when it was necessary to fixate the pattern, and when the experimental procedure involved a total-time element.

Gavurin (1965) used a T puzzle with a massed group performing for 50 consecutive minutes. Two distributed groups had 25 two minute trials with 15 seconds and five minutes rest. The massed group was superior to the distributed groups. The investigator concluded that massed practice facilitated the problem-solving technique.

Bilodeau (1952a) used 64 practice conditions on a ball chute test. Subjects lifted weighted balls of 21, 42, 84, and 168 grams in practice conditions of 2, 4, 8, and 16 minutes with rest after 1, 2, 4, or 8 minutes. Physical output was inversely related to the length of the practice period.

Bilodeau (1952b) had subjects perform a cranking task with resistant loads of 1, 2, 3, and 4 degrees of braking force controlled by a tachometer generator. Bilodeau (1954) used the same cranking task but force was increased with an increasing rate of rotation. Results from both experiments indicated that rate of cranking decreased as a function of practice time. In contrast, Bilodeau and Bilodeau (1954) used load resistances of 1, 2, 3, and 4 degrees of braking force on a manual cranking task. They found performance and recovery independent of work loadings.

Patel and Grant's investigation (1964) compared forced resistance of 200, 400, 600, and 800 grams on the Multiple Serial Discriminator. They reported that the effort variable had no influence on prerest performance, but the intermediate-effort-group was superior to the other three groups in postrest performance.

A similar design was incorporated by Eckstrand (1949). He used three levels of effort and work with the pursuit rotor and found no differences on postrest trials due to degree of task loads.

Ammons and Ammons (1949) inspected the influence of different numbers of responses. Subjects were involved in a card-sorting task involving 8, 10, or 12 card categories at 48, 58, or 68 throws per minute. Slower pacing and fewer categories led to the best performance.

Ellis, Douglas, and Montgomery (1954) investigated the effects of different work-height surfaces with conditions of practice, and found that this variable did not affect performance.

A comparison of complexities involved in fine and gross motor skills was conducted by Baines (1962). Four practice conditions were used with the stabilimeter and with the shuffleboard: massing, alternating two fine and two gross skills, increasing-decreasing schedules from fine to gross skills, and a decreasing-increasing schedule from fine to gross skills. He found no overall difference in the achievement with the motor laboratory skill (stabilimeter) although gains in early periods favored massing. There were, however, significant differences in the motor activity skill (shuffleboard) favoring distributed practice.

Graw (1968) compared two gross motor activities to determine if the same practice schedules obtained the same results with different types of activities. The stabilometer and the Bachman Ladder Climb were used with five combinations of practice and rest. Interesting results were reported for motor tasks such as the ladder climb where physical work per trial increased as skill increased, large intertrial rests were needed; with motor learning tasks such as the stabilometer, where physical work decreased per trial as skill increased, massed schedules were more efficient than distributed schedules.

It appears that massing is better for tasks which are short and which involve insight and problem solving. Distributed schedules favor long tasks, when the possibility of error is high, and when responses are rapid and require a variety of reactions. This conclusion may be drawn only for tasks that involve maze or puzzle work. It is important to test these assumptions under a wider variety of skills to determine if they are valid for other tasks that incorporate similar criteria.

With fine motor skills, the effects of different work loads, as well as body position, have little influence on overall performance. This factor has not been investigated for gross motor activities.

There is, perhaps, a difference in complexity of fine and gross motor activities. One study does not, however, provide adequate evidence for generalizations, but it can provide avenues for additional research. The same problem arises in comparing two gross skills when the amount of physical work increases as skill increases, in contrast to the decrease of physical work as skill increases. It is important to determine if this factor is maintained when a wide variety of skills with similar criteria are compared.

Methods for Recording Scores

The results of experimental studies differ according to the method employed by the investigator for recording scores. Several investigators (Snoddy, 1935; Lorge, 1930; Nance, 1947; Massey, 1959; Nix and Ammons, 1949) have used the pacing technique in which time in seconds and errors are kept equal by telling the subject to go faster when time is in excess of errors or vice versa. It is possible that distribution has a different influence for paced work than it has for unpaced work, as was pointed out by both Nance and Nix and Ammons.

Tsao (1948), Cook (1944), Archer (1956), and Ammons (1953) discussed the effects of amounts of practice and amounts of time to learning efficiency. Tsao found that with equal practice, spaced learning was more efficient than massed but with an equal duration of time the massed group could practice more and reach a higher level of efficiency. Cook and Archer, however, found that results differed when scores were recorded by responses rather than a time element. Response scores favored massed conditions while time scores favored distribution.

Two other measures can be used to determine differences between groups. The increase method compares scores between the performance level at the initial rise of the postrest performance curve and the level of the first postrest trial. The decrement method is used to determine the difference between the performance level on the last prerest trial and the first postrest trial (Adams, 1952; Barch, 1954). Results from experimental studies do vary according to the scoring method used.

Statistical Techniques

Almost all experimental studies require some form of statistical analysis of the data. Descriptive statistics serve as a tool which enables the investigator to assess the attributes of a sample or to describe the current status of the group. Often, however, an investigator is concerned with generalizing the data beyond the specific sample or making inferences from his data to the population from which his sample is taken. This technique is termed inferential statistics and frequently involves tests of significance to determine the reliability of differences between conditions of two or more groups. Inappropriate statistical techniques can affect design, sample, and conclusions.

An analysis of statistical procedures utilized in the 171 studies provided interesting patterns. A subdivision into ten-year periods illustrates both strengths and weaknesses of designs relative to statistical considerations. From 1905 to 1915, seven studies in motor learning were conducted. The results from each experiment were presented in the form of improvement scores for each group, per cent scores, gains, or learning curves. No attempt was made to determine the significance of differences which existed between massed and distributed conditions.

Investigations in the decade 1916-1925 used similar descriptive statistics, although Murphy (1916) described his results in terms of standard deviations. One additional method of examining results was presented by Pechstein (1917 and 1921). Scores were compared by both time and error factors.

From 1926 to 1935, three investigators applied inferential statistics to their data. Goodenough and Brian (1929), Cozens (1931), and Snoddy (1926 and 1935) used the technique of standard error of the standard deviation, standard error of the mean, and mathematical formulas, respectively, to explain their results. Learning curves remained as the most common method of reporting the experimental findings during this decade.

An emergence of refined statistical techniques occurred in reported studies between 1936 and 1945. Eleven of 23 studies (25, 34, 35, 37, 38, 41, 42, 44, 45, 47, 48) used tests of significance including the standard error of the mean, critical ratio, *t* test, and analysis of variance to determine the reliability of differences between massed and distributed schedules. Another technique, the backwards extrapolation of learning curves, was reported by Bell (1942).

From 1946 to 1970, only six investigators failed to use tests of significance when examining their data. In most cases, in the opinion of the present investigator, appropriate statistical techniques were chosen for particular designs. These tests included tools for both parametric and nonparametric experimentation such as regression equations, factor analysis, chi square, straight line fit of least squares, Alexander Trend Test, Mann-Whitney Signed Ranks Test, *t* test for independent and correlated groups, analysis of variance, analysis of covariance, critical ratio, Orthogonal comparisons, and intra-individual variance.

The purpose of examining statistical procedures incorporated by the various investigators was two-fold. The first one has received enumeration. The second purpose was to determine the overall effect upon generalizations related to massed and distributed practice schedules if a large number of studies had employed inappropriate statistical techniques.

Approximately one-fifth (40 studies) of the research designs reported results in terms of gains, per cents, improvement scores, and/or learning curves. No attempt was made by the investigators of these studies to determine if expressed differences were significant.

As early as 1915, Lashley stated, "In comparative studies of learning, it seems that the use of percentages is justified only when it is clear that each step in learning presents the same difficulty to all individuals compared [p. 110]." It is interesting to note that the percentage of gains, errors, and time was the most common method used from 1905 to 1935 to record and report the data. The reliability of these data is challenged even more since later studies (Adams, 1952; Archer, 1954; Bourne and Archer, 1956; Digman, 1956; Baines, 1962; Ostarello, 1967; Whitney, 1968) have detected similar differences between massed and distributed practice when findings have been expressed by learning curves, gains, and percentages but when these differences were subjected to statistical tests of significance, the discrepancy in performance and/or learning scores between the two conditions was not significant. Unfortunately, several studies which are classical examples of the superiority of distributed over massed practice appear in the former category, including those by Dearborn, Pyle, Pechstein, Cook, and Travis.

If these 40 studies were deducted from the total number of 171 investigations, there appears even less support for the contention that distributed practice is more advantageous than massed practice in motor skill learning.

Experimental Environment

The experimental environment in which the investigations were conducted was of importance since artificial settings provide for more carefully controlled conditions while natural situations sometimes increase realistic probabilities of performance at the expense of some decrease in the control of variables.

Some investigators used two or more tasks, therefore, 171 environmental settings were considered. The following results were obtained when the data were examined according to the environmental conditions (artificial or natural) in which fine and gross motor skills were examined. Artificial or laboratory settings were used for 114 studies incorporating fine motor skills while 12 were conducted in a natural environment. In contrast, studies utilizing gross motor skills were frequently conducted in natural surroundings. Thirty-five out of the 49 studies which examined gross motor skills were subject to experimentation under these conditions. The present investigator found that variables were as well controlled in gross motor studies as those using fine motor skills. Most gross motor activities were isolated into a specific or limited number of components which enabled an adequate control of the variables.

In the previous section on the nature of the task, it was pointed out that findings from the laboratory studies often could not be applied to gross motor activities. Perhaps the lack of parallel results for the two different types of motor activities occurs, to some extent, because testing situations are not uniform in providing psychological and/or physiological sets for the subjects.

Experimental Sessions

It was important to the purpose of this inquiry for the investigator to determine if the variable of length of practice time in each reported study had any influence upon performance and/or learning. An analysis was initiated to compare investigations which were conducted during a one-day session with those that were performed over a period of one week, one month, one year, or another time pattern.

The findings from 72 studies were based upon a one day experimental period. Within this group, four investigations found massed practice superior to distributed practice. Results from 45 of these designs concluded that spaced practice was more beneficial than concentrated practice. No difference between conditions of practice during the one day experiment was reported by three investigators. Twenty investigators found distributed practice favorable for performance, although no significant differences were obtained between the conditions when learning was assessed.

In the one week, one month, and one year category of time, five studies were reported. The results from two designs supported the superiority of distributed practice, one indicated no difference, and one favored spaced practice for performance but no difference for learning in the one week time element. One investigator used the one month pattern and reported results suggesting benefits for distribution of effort and practice.

"Other" time schedules offer results with contradictory percentages for each category. Fourteen investigations favored massed practice, 39 showed advantages for distribution, 29 found no difference between the conditions, and six illustrated beneficial effects of distributed schedules during performance with no difference when learning was considered. Seven additional studies found advantages for both conditions in either beginning or late stages or for specific types of activities such as archery-badminton, archery-volleyball, or stabilometer-ladder climb.

Table 4 provides a summary of the relationship between the preferred practice schedules and length of the experimental period.

From an analysis of Table 4, it is evident that the one day experimental sessions had a larger percentage of studies which produced results favoring spaced over unspaced practice

TABLE 4

Percentage of Studies in Relationship to Preferred Practice Conditions and Length of Experimental Sessions

One Day (72)[a]				One Week (4)[b]				One Month (1)[c]				Other (95)[d]			
M	D	ND	P-L	M	D	ND	P-L	M	D	ND	P-L	M	D	ND	P-L
6%	63%	4%	20%		50%	25%	25%		100%			16%	45%	32%	7%

a, b, c, d = Number of studies represented in each experimental session
M = Massed practice favored
D = Distributed practice favored
ND = No significant differences between conditions
P-L = Performance findings favored distributed practice; no significant differences were obtained between the conditions when learning was measured

Note: Numbers represent the percentage of studies in their relationship to the practice conditions and the length of the experimental sessions.

conditions. These results were not nearly so well-defined in situations which included longer experimental times. It is a plausible concept that the length of time devoted to experimentation may have an important influence upon performance and/or learning scores, especially since there was a decrease in the percentage of studies favoring distributed practice and an increase in the percentage of studies which found no significant difference between conditions as the experimental session increased in length.

Homogeneity of Groups

For any effect to be attributed to distribution of practice, all groups must be initially comparable in performance. It is important to recognize that the homogeneity of the groups under consideration was evaluated on the basis of initial task performance level and not other factors which often are used to match groups.

Many investigators adequately described the statistical method they employed to determine if groups were equated. Other investigators either failed to describe this procedure or assumed such information could be calculated from the data which were presented. Unfortunately, the latter situation leads to additional problems of interpretation. The following five studies will serve as examples of this dilemma. Travis (1939) listed the percentages of performance scores which varied from 68 to 70 on trial one as nearly equal groups. Kimble's groups (1949) had an even greater range for the first minute of practice. The mean scores for the groups were 28 and 35. Bilodeau and Bilodeau (1954) had a difference of five mean numbers of revolutions between groups performing a cranking task on the first trial, and Adams (1954) expressed a difference between 50 and 100 thousandths of a minute for time on target with the pursuit rotor. It is possible that these groups may have been homogeneous, yet no objective or reliable method was used to determine this factor, in as much as a similar study (Lewis and Lowe, 1956) found that a mean which was varied by one point was significantly different for two groups.

Often investigators assumed that if a random sample of the population was used, it was not necessary to equate groups. This common practice of random sampling is ineffective and inaccurate unless it is combined with some statistical test to assure equality of groups. Only in this manner can the results of a study on performance and learning be attributed to the effects of the independent variables.

Crawford (1947) has demonstrated that data cannot be analyzed effectively if groups are not equated, especially since the superiority of one group over another is maintained for long periods of time. These results indicate that the conclusions of the 78 investigations which failed to establish homogeneity between or among groups may be subject to severe criticism or doubt either when the difference is attributed to the effect of a particular practice condition, or when the results are used to support a generalization concerning spaced and unspaced schedules.

Closely allied with this concept is that of recording scores for baseline performance. Upon what standard will subjects from different groups be measured if an initial score is not taken? Performance, learning, percentages, and gains are expressions which are dependent upon some starting point. It is apparent that in the six studies (39, 120, 122, 142, 156, 157) which did not indicate assessment of a baseline performance, the investigators assumed that all subjects would begin at a zero performance level. Assumptions of this nature can lead to both biased and incorrect conclusions.

The Function of Length of Practice and Rest Periods

The length of practice, the length of rest, and a relationship of these two elements were analyzed in the present study to determine if optimal times for these variables could be obtained.

Practice Periods

Many investigators have sought to determine the influence of the amount of practice upon performance or the effects of various trial lengths upon learning. The question of optimal work loads has been considered by several investigators and the conclusions are varied.

Pyle (1913) compared 15, 30, 45, and 65 minutes of practice in transcribing the alphabet. He found 30 minutes to be the most effective length for practice. It appeared that 15 minutes was too short while 45 or 60 minutes were too long to obtain efficient results.

Books (1919) had elementary school students practice handwriting for either 50, 75, or 100 minutes a week. In terms of learning, the 50 minute group was as good as the other two longer practice groups.

Travis (1939) used six groups and varied the length of practice on the pursuit rotor into 1, 2, and 4 minute sessions. The findings pointed to the superiority of the two minute group while the four minute group produced the poorest scores.

Henshaw and Holman (1930) varied the length of practice on a chain assembly skill. One group practiced for 80 minutes in the morning and 80 minutes in the afternoon; two groups practiced only during the morning session. The investigators concluded that extending the daily training had no effect on the amount of learning.

Duncan (1951) conducted an experiment using the pursuit rotor in which two groups had five minutes work, 10 minutes rest, and five minutes work. One group practiced continually during the work, the other group worked 10 seconds and rested 20 seconds. He reported that the shorter practice session was more beneficial even though less total practice time was used.

A complex reaction time test was used by Riopelle (1950) to determine the influence of conditions upon learning. The conclusions supported the effectiveness of shorter daily practices over longer ones as the experiment continued, implying early as well as late learning.

In mirror-tracing experiments, Harmon and Oxendine (1961) had one group practice two trials per day, one group had five trials, and one group had eight. The longer practice periods were best for the first three practices, while shorter periods were advantageous during late stages of learning.

Oxendine (1965) used the same apparatus but varied the schedules; nine circuits on an increasing plan, nine circuits on a decreasing pattern, and a constant schedule of five circuits per day. A constant practice schedule was superior to increasingly longer or increasingly shorter practice periods.

Knoppers and Coston (1968) compared the performance of three groups using a pencil maze. One group had four 10 second trials for three days; one group had six 10 second trials for two days; and one group had twelve 10 second trials for one day. The one day group was superior to the two or three day groups.

Wagner (1962) developed three different work loads for three groups in four basketball skills. In field goal shooting 5, 10, or 15 trials were given; 1, 2, or 3 circuits were used for speed dribble; 15, 25, or 35 trials were taken in the wall bounce; and 4, 6, and 8 trials were attempted for free throw shooting. He found that the longer practice or trials were significantly greater early in learning but no differences were reported late in learning.

Rest Periods

The length and frequency of rest periods is another factor which affects learning. If distributed practice is superior to massed practice, it is obvious that the variable of rest is the differentiating factor between the two conditions. Consequently, there exists the possibility of an optimal rest interval which is more advantageous than others.

Kimble and his co-workers have been prolific contributors to this area of research. Using the pursuit rotor, Kimble and Horenstein (1948) gave subjects 10 trials of 50 seconds work and 10 seconds rest followed by rest intervals of 10, 30, 150, 300, 600, or 1200 seconds before the final two trials. They reported that performance under both work loads increased with increased rest periods up to 10 minutes, after which increased rest patterns had no effect. An additional study reported by Kimble (1949c) which involved the inverted alphabet printing task with 0, 5, 10, 15, or 30 second trials of practice suggested that after five minutes of work all learning occurred during the rest periods and that the rate of learning progressed in a linear relationship to the length of rest. In contrast, Kimble and Bilodeau (1949) compared the effects of 10 and 60 seconds work with 10 and 60 seconds rest on the Minnesota Manipulation Test. Their results indicated that work was more important than rest. A further analysis by Kimble (1949b) considered the effects of rest when the amount of practice was held constant in inverted alphabet printing. These results pointed to the fact that practice was more important early in learning, whereas the combination of work and rest functioned late in learning.

Travis (1937b) studied the effects of five minutes of work on the pursuit oscillator with variations of rest set at 5 minutes, 20 minutes, 48 hours, 72 hours, and 120 hours. The 20 minute rest was optimal, the five minute rest was too short, and intervals 48 hours and over were too long.

Lorge (1930) used a mirror-tracing device to compare the effects of 20 massed trials with 20 spaced trials separated by either one minute or 24 hours. Both the one minute and 24 hour interval were superior to massed practice although the 24 hour distribution was more advantageous than the one minute interval.

Leuba and Hyde (1905) investigated the influence of the rest period upon the learning ability of transcribing English prose into German script. Rest intervals of 12, 24, 48, and 72 hours were used. The results indicated that the 24 hour rest was best early in learning and the 48 hour rest late in learning.

Using the pursuit rotor, Doré and Hilgard (1937) had groups practice for one or three minutes and rest either 1, 3, or 11 minutes. The 11 minute group performed best followed by the three minute and the one minute groups. Another study by Doré and Hilgard (1938), with the same instrument, led to the conclusion that increasing rests were more efficient than decreasing rests.

Cook and Hilgard (1949) compared increasing and decreasing rest intervals of 3 minutes, 1 minute, and 20 seconds with increasing and decreasing work loads of 6, 11, and 16 trials on the pursuit rotor. Their results indicate that a constant rest period is better than an increasing or decreasing rest schedule. However, Hilgard and Smith (1942) found long rests of three minutes beneficial early in pursuit rotor learning and short, one-minute rest beneficial late in learning.

Ammons (1947, 1951, 1952) investigated the effects of rest upon performance. In two studies the length of practice was held to eight minutes, while one investigation had a 12 minute work period. He reported in all three experiments that a five minute rest was optimum.

Disparity was observed by Ammons (1950) when he varied intertrial rests of 0, 20, 50 seconds, 2, 5, 12 minutes, and 24 hours with 20 second practice trials. In this design, the intermediate rest of 50 seconds was best for the total 12 minutes of work.

Bell (1942) reported that a 10 minute interval in a pursuit rotor task was better than 1, 6, 24, or 30 hours of rest given after the fifth trial of a session which involved 20 one-minute trials. In a number of mirror-tracing experiments, Snoddy (1926, 1935, 1938) found long rests to be beneficial early in learning and short intervals effective late in learning.

Kientzle (1946) studied the effects of 10, 12, 15, 20, and 70 one-minute practice trials with a 3, 5, 10, 15, 30, 45, 60, 90 second, or 7 day interval in an inverted alphabet printing task. She found learning to be an increasing function of the duration of rest up to 60 seconds. The two longest rest intervals produced diminishing returns.

Hardy (1930) found no difference in performance for stylus maze work when intertrial work was investigated, but interpolated rest of four days was better than 12 hours, 1, 2, or 3 days.

Riopelle (1950) in a learning study involving complex reaction time reported an interday rest more beneficial than an intraday rest. Reyna (1944), however, using the pursuit rotor found no significant differences between interpolated rests of six and 24 hours.

Buxton (1943) reported that subjects in pursuit rotor performance with the same intertrial interval but different degrees of practice--5, 25, and 35 per cent established as the learning criterion--obtained maximum performance with interpolated rest of 10 minutes. Troyer (1930) also investigated the effects of different rest periods upon pursuit meter learning. Five groups received 0, 1, 3, 5, or 9 minute rests between blocks of four minute trials. His results indicated that optimal rest occurred somewhere between five and nine minutes. Schucker, Stevens, and Ellis (1953) reported similar conclusions supporting the optimum rest interval of 10 minutes in inverted alphabet printing. They found a 10 minute rest after 20 or 30 trials of massed practice to be as effective as a 30 second intertrial rest for each of 33 trials.

Bilodeau and Bilodeau (1954)--in four experiments with a cranking task varied the rest intervals for 5, 10, 40, and 80 seconds and 1, 3, 6, and 60 minutes with a total of 4 or 5 minutes in prerest and postrest conditions--found the length of rest to be more important than the length of practice.

In a gross motor activity, Singer (1965) found five minutes interpolated between four blocks of 20 basketball shots to be as effective as 24 hours interspersed between blocks.

Relationship Between Practice and Rest Periods

Several investigators have looked at the relationship and interaction between work and rest rather than the influence of each variable as a separate entity upon practice conditions. This approach has included the establishment of optimal ratios, increasing and decreasing schedules, and an exchange of practice conditions.

Dearborn (1910) found that daily practices with a 24 hour rest interval was better than practice twice a day with a 12 hour rest interval in handwriting tasks.

Humphreys (1937) collected performance scores on the pursuit rotor using five minutes of intertrial rest and four minutes or 24 hours for interpolated rest with 30 trials per day. When these data were compared, rest was found to be a differentiating factor early in learning but the work schedule was most influential in the late stages of practice.

Ammons (1947) conducted an extensive experimental design utilizing 1/3, 1, 3, 8, and 17 minute work periods with 1/3, 2, 5, 10, 20, 60, and 360 minute rest periods. The 34 combinations of work and rest on the pursuit rotor were followed by an eight minute work period. Ammons concluded that work decrement reached a maximum during eight minutes of work, dissipated after two minutes of rest, and reached a maximum at 20 minutes with a five minute rest optimal for the task. He further reported that work was the crucial factor in this study.

Kimble presented the results of two studies in which subjects printed the inverted alphabet. In one study (1949c) he reported that early learning was a function of practice and late learning was a function of rest. The second design (1949b) supported the importance of practice in early learning but work and rest were found to be equally important late in learning. Kimble and Bilodeau (1949) using a different task--Minnesota Rate of Manipulation Test--found the groups with the shorter work periods to have better scores, and the shortening of the practice rather than variation in rest appeared to be the significant variable.

Travis (1937a) used the pursuit rotor to determine the influence of practice and rest. A 2-1 work and rest ratio was found to be effective, or an interposition of one minute rest after two minutes work gave a rise in scores whereas continuous practice decreased performance.

Bilodeau (1952a) found that in a ball chute task the decremental effects of initial massing of practice was an increasing function of the length of the interpolated rest except for the longest rest period. Four minutes of rest were sufficient for both eight and 16 minutes of practice, thus a 2-1 or 3-1 ratio provides for efficient performance. In another study, Bilodeau (1952b) reported that the learning of a cranking task was influenced more by the number of days of practice than by the distribution of practice.

Ammons and Willig (1956) tested for the effects of massed and distributed practice when work and rest loads were different but the same ratio was used. They concluded that spaced practice was superior to unspaced practice for performance and the ratio of 1-2 was the optimal condition.

Plutchik and Petti (1964) conducted a similar study on the pursuit rotor. They found improvement to be a function of the relationship between the time necessary to perform the task and the rest between trials. They also found little difference in mean performance rate when work and rest ratios were held constant at 2-1 rather than a 1-2 ratio. These findings led the investigators to conclude that additional studies were needed with ratios varied over wider limits.

Denny, Frisbey, and Weaver (1955) compared the results from work periods of 3, 6, and 12 minutes separated by five or three minutes. In each work period, the massed practice consisted of continuous effort while distributed practice groups alternated intervals of 30 seconds work and 30 seconds rest. The results indicated the superiority for the 1-1 ratio; however, when conditions were switched from massed to distributed, the performance level converged to the level of the distributed group.

Jahnke (1958) maintains that the initial postrest performance on the pursuit rotor is related to the amount of practice and independent of the length of rest. Final postrest performance is positively related to both amount of practice and length of rest, therefore, longer work periods need longer rest periods. Jahnke and Duncan (1956) and Jahnke (1961) found that a 1-2 ratio gave the best results in pursuit rotor performance.

Two tasks were used by Nance (1947) to determine if the superiority of distributed practice was based upon the magnitude of the work-rest ratio. A 1-2 ratio was used for the pursuit rotor and a 1-1 was adopted for the SAM Complex Coordination Test. The results suggested that a smaller work-rest ratio was superior to a larger one.

Norris (1953) had subjects perform a two-hand coordination task with either 10 or 24 hours rest after 4, 16, or 28 minutes of practice. Longer rests were more advantageous than shorter ones for continued practice while greater gains were made over rest when the prerest practice was short. There was, however, no relationship between the length of rest and the point of interpolation.

Kimble (1950) stated that in pursuit rotor tasks, gains during the first five minutes occur during practice, after which time, all additional gains are made during rest.

Conwell and Ammons (1951) project a similar position. In pursuit rotor learning with combinations of 10 seconds and one minute work and 10 seconds and one minute rest, work was found to be most important in early practices and rest most important in late practices. In contrast, Renshaw and Schwarzbek (1938) using the same apparatus reported that rest was the important variable early in learning while the development of skill through practice was the major criterion late in learning.

Spence, Buxton, and Melton (1949a and b) cited different results when comparing different tasks. A 1-2 ratio or 10 seconds work and 20 seconds rest was clearly superior to continuous work on the SAM pursuit rotor. When the SAM Complex Coordination Test was used with comparable work and rest conditions, no difference appeared until five minutes of practice had elapsed, after which time the distributed groups were slightly superior to the massed groups. The 1-2 ratio did not act as a differentiating variable on the second task until the latter stages of learning had appeared.

Carron and Leavitt (1968) used four minute blocks of practice of four trials each at 50 seconds work and 10 seconds rest. Five minutes were interpolated between five blocks of practice for both pursuit rotor skills and the stabilometer tasks. Rest was important within the first four trials and the first interpolated rest. Thereafter, rest had a minimal effect upon performance.

It is readily apparent that disparity and confusion exist when an attempt is made to determine the influence of massed and distributed practice schedules utilizing the variable of length of practice, length of rest, or an interaction of the two components. In practice, the short or intermediate time periods were superior to longer time elements. Exceptions to this fact occur when trials rather than time are considered. In these studies, one investigator favored greater trials in early learning and no difference in number of trials in late learning; one reported the superiority of a constant number of trials to an increasing or decreasing schedule; two studies advocated long practice in initial learning and short practice for late learning.

Investigations of length and frequency of rest periods yielded similar results. Some designs suggested an optimum rest of 10 minutes; several supported the optimum time of five minutes; a few reported intermediate phases of time to be superior; while others cited advantages for long rest early in learning and short intervals effective late in learning or vice versa.

It also is interesting to note that massed practice was defined by intertrial rest periods up to five minutes while distributed practice was defined by rest intervals from 15 seconds to 120 hours.

The studies concerned with the relationship between practice and rest periods offer no solution to the dilemma. Again, the complexity of the problem is exemplified when four different work-rest ratios are presented as effective for the condition used in the particular experiments. Work appears as the important variable in one task, and rest functions as the major criterion in the next design. Some conditions are listed as massed when the rest is shorter than the work period; other designs refer to distributed practice when the rest period extends beyond 20 seconds; several investigators refer to massed conditions as continuous practice while distributed conditions have some amount of rest interpolated.

As long as the practice of defining massed practice and distributed practice continues to be determined within the conditions of each experiment, as long as different tasks yield incongruous results, and as long as varied phenomena such as warm-up, reminiscence, performance, and learning are investigated under a wide range of conditions but reported as a single set of concepts relative to massed and distributed practice, it is not possible to draw valid generalizations based on data obtained from this discontinuity of method.

Scheduling of Practice Sessions

Many investigators have sought to determine the ideal length of practice and rest when the training sessions are restricted to a limited period of time in which the skills to be mastered must be learned.

Cozens (1931) reported in a study of class work in six track and field events that better results were obtained when four 30 minute practices per event were scattered throughout the semester than when each event was given four practice periods of 30 minutes each in sequence.

Murphy (1916) investigated the effects of practice periods for developing skill in throwing the javelin. His groups practiced for a total of 34 periods, during which time one group threw daily for seven weeks, one group threw three times a week for 12 weeks, and one group threw for a semester. Murphy found no significant differences among the groups although the total period of time involved seven weeks, 12 weeks, and a semester for the practice schedules.

Franklin and Brozek (1947) used the fine motor skill of pattern tracing and a gross motor skill of reaction time to treadmill walking to determine the effects of scheduling. Groups practiced either three times a day for six days, twice a day for nine days, daily for 18 days, three times a week for six weeks, or irregular scheduling for six weeks in both tasks. The investigators concluded that no advantage in economy of learning was attached to any one of the schedules used. Thus, six days of practice was as effective as practice spaced over six weeks.

In pursuit meter learning with sessions of three cycles and three minutes rest, Webb (1933) compared the scores from one sitting for 12 weeks, three weekly sittings for four weeks, daily sittings for 12 days, and 12 sittings for one day. Subjects who practiced over a six hour period acquired as much skill as subjects who practiced over a period of 12 weeks.

Culler (1912) found that massed schedule groups were superior to distributed groups when practicing a pencil maze task. The groups which had 12 trials for one day, six trials for two days, and four trials for three days were better than groups who practiced one trial for 12 days, two trials for six days, and three trials for four days.

Massey (1959) compared the performance of subjects in mirror-tracing when one group practiced three times a week (Monday, Wednesday, Friday) for five weeks, one group practiced for five consecutive days (Monday through Friday) for five weeks, and one group practiced on an additive pattern for nine days. When groups were compared after each had completed nine practice periods no significant differences were found among the groups in degree of acquisition of skill. When 15 practices were compared (groups one and two), a slight advantage occurred for groups practicing Monday through Friday for three weeks over groups practicing Monday, Wednesday, and Friday for five weeks. When performance was judged at the end of five weeks, practice Monday through Friday produced better results than three times a week or the additive pattern but it should be noted that this same group had 10 additional practice periods more than the other groups.

Harmon and Miller (1950) and Miller (1948) had four groups practice billiards daily for nine days, once a week for nine weeks, three times a week for three weeks, and nine days in an additive pattern. The additive group was superior, however, this difference did not occur until after the sixth practice. Consequently, the investigators reported an advantage for concentrated practice periods early in learning and spaced sessions late in learning.

Waglow (1966) compared the performance of students enrolled in classes in handball, golf, and tennis which were scheduled over a 17 week semester with 1,800 minutes of practice with performance scores of classes which met for a 14 week trimester with 1,820 minutes of practice. His results indicated superior performance by subjects when the activity was distributed over 17 weeks rather than 14 weeks.

Knapp and Dixon (1950) found daily practice in juggling more advantageous than juggling on alternate days. Rosenbleeth (1966), however, reported no difference in performance when subjects juggled 10 minutes per day for three days a week and when subjects juggled 30 minutes per day once a week.

Several studies have investigated the influence of practice schedules in archery. No differences in archery skill were reported by Hyde (1934) when classes were scheduled twice a week with either 48 hour (Monday, Wednesday or Tuesday, Thursday) or 96 hour (Monday, Friday) intervals. It should be noted that according to the investigator both schedules involved distributed conditions. Breeding (1958) compared classes which met three days a week for 40 minutes with those that met twice a week for 60 minutes. No significant differences were observed. Young (1954) reported that scores from archery classes scheduled for four days a week for six weeks were superior to classes assigned for two days a week for 12 weeks.

Totten (1953) reported no differences in typing achievement for high school students who practiced for a semester and those who practiced four hours a day for eight weeks. Yuen (1960) also investigated scheduling of typing classes. Classes met 2, 3, 4, 5, or 6 times a week for 40 minute periods. Groups which met four or six times had double periods of 80 minutes for either two or three days. The results for all groups showed no difference in attainment of skill.

Scott (1954) reported no difference in swimming performance for beginners who met 2, 3, or 4 days per week for 30 minutes with regard to the mean number of days needed to reach the point where subjects could pass a 15 minute swimming test, although there was a trend suggesting that the four day group constituted a more satisfactory schedule. Stull (1961) reported that swimming classes which met six days a week for two and a half weeks developed more skill than classes which met for three days a week over a five week period. The spaced schedule, however, was more advantageous for development of swimming endurance. Moncrieff, Morford, and Howell (1962) indicated no difference in performance when swimming schedules involved three days for two weeks or two days for three weeks.

Studies in scheduling for badminton have yielded conflicting results. Young (1954) found two days a week for 12 weeks more efficient than four days a week for six weeks.

Niemeyer (1958 and 1959) compared the results of badminton classes which met three times a week for 30 minutes over a 10 week period to those that met twice a week for 60 minutes during a 10 week period. He reported that early learning in badminton favored a distributed schedule, but there was no difference in badminton skills using the two schedules late in learning.

Kahn (1959) used three schedules to determine the effects of practice in bowling. One group bowled nine consecutive days, one group bowled once a week for nine weeks, and one group had a massed to distributed schedule--or practice on days 1, 2, 3, 5, 8, 13, 21, 34, and 55. No significant differences were reported between any schedule. Stull (1961) found six games per week for three weeks better than three games per week for six weeks when bowling scores were compared.

Peterson (1964), Keough (1962), and Hlavac (1954) investigated the influence of physical education classes scheduled over varied time periods upon motor fitness. Peterson found no difference between subjects who met five days for 40 minutes and those who met three days with blocks of 40 minutes on one day and 80 minutes for two days. Keough compared and reported no differences in groups which practiced daily for four weeks and those that performed two days a week for 10 weeks. The same results were obtained by Hlavac when he compared classes which met three days a week and those that met five days a week.

Morris (1967) compared three groups which practiced 10 volleyball serves per session. One group had eight consecutive days, one group met three days a week for two and a half weeks, and another group practiced two days a week for four weeks. Morris reported no differences among the time schedules which were used. Niemeyer (1958 and 1959) found that there was no difference early in learning for groups which practiced volleyball 30 minutes three times a week and those that practiced 60 minutes twice a week. However, the concentrated schedule was more favorable than the spaced schedule late in learning.

In overall folk dance performance involving four dance elements Johansson (1965) reported no difference in the four dances learned in 50 minute daily classes for two weeks and 20 minute daily classes for five weeks. Step patterns and rhythmic perception favored the spaced schedule while no difference was obtained for ease of movement and style of performance. Barbour (1947) also reported no difference between subjects in tap dance classes which met once a week for six weeks and those that met twice a week for three weeks.

Beale (1965) found no difference in performance scores for tennis forehand and backhand drives when practice was held three days a week for 35 minutes or two days a week for 50 minutes during a nine week experimental period.

Ball-handling skills in softball and basketball were investigated by Howard (1960). She reported that concentrated practice of daily classes for three weeks were better than spaced practice held biweekly for seven and half weeks in each skill.

Dixon (1968) compared four motor fitness components incorporated in 20 gymnastic skills using massed and distributed schedules. The massed group concentrated practice on a specific motor fitness component during five consecutive class periods. Each component practice period involved five gymnastic skills. The group practiced two skills during each class with each skill repeated twice in five days for a total of 28 minutes per skill. The distributed group rotated four times during each class period and practiced one skill for each of the motor fitness components during each rotation for five days. The rotation order was repeated four times so that each skill received 28 minutes of practice. Dixon concluded that one method of practice was not superior to the other in the acquisition of motor fitness components necessary for college women to perform basic gymnastic skills.

The belief that shorter practice time and shorter rest periods extended over a longer duration of time was not upheld in these studies which considered economy of scheduling. The majority of investigators found no significant differences between the two conditions. When differences were found, the overall results were not conclusive. Three studies favored distributed practice, four studies favored massed practice, and two studies distinguished between conditions in early and late learning. The findings, contrary to established concepts, may lead to alterations in traditional methods of scheduling classes that involve skill acquisition since concentrated periods appear to have no detrimental effects upon learning.

Another factor which emerged from the analysis of 171 studies was that in motor learning there is, perhaps, a point of diminishing returns. Eleven studies (8, 17, 22, 44, 49, 59, 77, 89, 105, 128, 134) found that practice beyond a specified number of days or trials had no additional effect upon skill acquisition.

The Rest Interval

The concept of distributed practice is based upon some change that takes place during the interval; consequently, it was necessary to determine what the subjects did during the interval and to list the construct for the inclusion of the interval.

Activity During the Interval

One study had the subjects rehearse the task, and 47 studies had the subjects rest or perform an unrelated task. In the latter category, forms of relaxation such as talking, smoking, and reading were frequently used diversions.

Fourteen investigations (19, 22, 34, 35, 38, 49, 95, 99, 112, 115, 142, 154, 156, 167) had subjects perform the following controlled but unrelated tasks: record feelings, write mode of attack, mirror maze and spool packing activity, music activity, mark tallies and crossbars, warm-up of tallies and crossbars, view slides, button pressing activity, mark out letters, tie knots and symbol cancellation, drive golf balls, practice chipping shot in golf, and serve and volley tennis balls. The remaining 123 investigators gave no instructions or tasks for subjects to follow during the rest interval. It is possible that the designs which did not control the activity during the rest interval represent unreliable findings because it is not possible to determine if subject-chosen activity influenced the results.

Explanation for the Interval

Eight theoretical constructs proposed by learning theorists were reviewed in Chapter II by the present investigator. Each investigator presented suppositions to account for the advantages gained by the introduction of time intervals between practice periods in motor learning. An analysis of the present data yielded 15 different hypotheses which were tested to determine if these explanations were supported under a wide range of conditions.

Reactive inhibition (56 investigations), work decrement (12 designs), fatigue (9 experiments), primary and secondary growth (8 designs), and differential forgetting (8 experiments) appeared as the five concepts most frequently tested.

Snoddy's primary and secondary growth hypothesis was challenged by Doré and Hilgard (1938) and Tsao (1950a and b), each reporting it as an inappropriate theory. Consequently, the work theory which includes reactive inhibition, work decrement, and fatigue and the differential forgetting theory appear to offer the most valid explanation for rapid learning under distributed conditions. If, however, the variety of terms such as set growth (Digman, 1956), set (Gavurin, 1965), reconstruction of response (Renshaw and Schwarzbek, 1938), neural changes and perseveration (Lorge, 1930), mental practice (Lashley, 1915), and consolidation (Webb, 1933 and Carron, 1969) were all used to express forms of neural activity after formal practice, then the perseveration theory is well supported by research.

Proficiency of skill or habit (6), maturation (3), motivation (3), interference (3), reminiscence (1), refractory phase (1), transposition of pattern (1), generalization (1), and development of manual and ocular movements (1) seem to be only occasional factors which have been examined in regard to their effect upon distribution of practice.

Motivation

It has been assumed that a high level of motivation enables one to benefit from longer and more concentrated practices than would be possible with a lesser degree of motivation. The importance of motivational instruction and environmental control in a research design are well known, yet the whole area of motivational control in experimentation is questionable on the basis of the 171 studies analyzed in this investigation.

Forty-two designs (in the present investigation) reported the use of motivational techniques. Casual remarks such as "try hard," "this is an important experiment," "do your best," frequently were used by the investigator. It was also a common practice for the investigators to assume the activity was a motivating experience. For example, the researcher used such statements as "the pursuit rotor is an interesting and challenging task," "students like this task," or "rivalry naturally existed between subjects." Another common practice was to award stars, candy, and/or encouraging remarks.

It is possible that studies which used knowledge of results such as announced scores, audible clicking of apparatus, pictures of performance, and self-rating cards did in fact equally motivate each group. Grades for class work, controlled competition by teams and pairs, announcement of predetermined scores, and paid subjects were techniques also used to induce different levels of motivation. Even though subjects may have been motivated in the experiments, most designs did not test for this variable.

Kimble (1949a) has established a theoretical position to account for motivation during massed and distributed schedules. He states that

> Since I_R is a drive which acts antagonistically to the other drives in the learning situation, it seems logical to assume that the greater the motivation driving the subject to learn the task at hand, the greater the amount of inhibition which must be accumulated to produce the resting response . . . . Accomplishment must, therefore, be considered as a consummatory behavior which reduces the strength of this motivation. As learning progresses, subject will gradually approach a level of performance so great that the need for accomplishment or improvement is satiated [Kimble, 1949a, p. 16].

In the experimental procedure, motivation was assumed to exist since the investigator established, through verbal instructions, a need to master the task. Kimble concluded that the rate of conditioned inhibition developed late in learning may have been due to the drop in motivation late in learning which reduced the tolerable amount of reactive inhibition and therefore increased the development of ${}_SI_R$. It is necessary to point out that the variable of motivation was not controlled and this conclusion was offered to account for a decrease in performance.

A similar investigation was conducted by Kimble (1950) to determine the role of motivation in pursuit rotor learning. In this experiment, scores were read to subjects after each trial and subjects were tested in teams so that the possibility of "man-to-man" competition existed. The inference was that subjects who failed in competition would be more highly motivated to do well in later trials than those who were successful. When the results were compared for subjects in the high and low groups based upon motivational levels obtained during the first five minutes of practice, significant differences were found which favored the high motivated group, presumably because an increase in motivation leads the subject to tolerate greater amounts of inhibition.

Wasserman (1951) investigated the effect of motivation upon inhibitory potential in motor learning. Eleven groups received different lengths of practice and rest and each group was subdivided into high and low motivation categories. The low motivation group was task oriented. Subjects were told that they were merely helping out with a preliminary design for a future experiment. The high motivation group was ego-oriented. Subjects were told that they were to take a new type of intelligence test. Subjects also were told that the test was to be administered to various psychology classes in order to establish average levels of performance. Wasserman reported that high motivation resulted in performance which was significantly superior to that of subjects with low motivation, the difference becoming progressively greater as practice continued.

Ammons (1952) conducted an experiment to determine the relationship of motivation to method and learning. Ten experimental groups were subjected to various rest patterns in prerest practice. During the postrest period, one-half the subjects in each group practiced continuously for 12 minutes and one-half had trials of 20 seconds separated by five minute rest. Before and after rest, subjects rated their motivation on a prepared sheet of statements designed for both pretest and posttest. The results obtained by analyzing the variance of pre- and post-practice ratings indicated no consistent or significant relationship between distributions of practice and motivation. Motivational levels remained high for both short and long conditions of practice.

Eysenck and Maxwell (1961) and Eysenck (1963) investigated performance as a function of high and low drive status. Subjects were divided into high and low drive groups. The high drive group took the test as a part of an entrance examination for apprenticeship at one of the largest car-making firms in the country. Subjects thought that the scores would be used to determine their position as skilled laymen. The subjects in the low drive group possessed apprenticeship status and were told that new promotions and advanced salaries would not be based upon results. Each group was further divided into sub-groups which had concentrated or spaced practice. The investigators reported that the high and low groups did not differ on prerest performance, however, there was a significant difference favoring the high drive group based on post-rest scores.

Only four studies have utilized the concept of motivation and have attempted to control it as a variable in investigations concerned with massed and distributed practice. Of the four studies, two supported the statement that high motivation leads to better performance as well as sustained performance in concentrated tasks; one study found no difference between group practice and motivation; and one study found no difference between groups with pre-rest practice up to eight minutes, although there was a significant difference after rest. At the present time, it seems that four studies cannot be considered an adequate number of models from which to make generalizations regarding learning theories.

Superiority of Practice

To determine the superiority of one method over the other was not a clear-cut task for the investigator in analyzing 171 studies. The reader will recall that concentrated schedules have been superior to spaced conditions in some experiments and vice versa. In other investigations, one condition was advocated early in learning and the opposite method was favored late in learning or vice versa.

In the 1950's and 1960's investigators turned their attention toward the difference between performance (scores at a specified point in practice) and learning (improvement of performance or gain from an initial performance score to a designated final score). It was necessary, therefore, for the present investigator to assess the effects of practice and to determine if results and conclusions were based upon performance and/or learning.

When the results are classified in the manner indicated in Table 5, doubt is cast upon the traditionally accepted belief that distributed practice is superior to massed practice in motor learning. Seventy per cent of the studies listed in the first five columns represent investigations concerned primarily with performance phenomena rather than learning, and even then, the results are somewhat inconclusive. The last category on the table represents experimentation that has distinguished between performance and learning. It is readily apparent from this analysis that there is superiority of distributed practice over massed practice for effective motor performance, but these findings are not substantiated for motor learning.

An examination of studies which included a retention test offer some evidence as to the permanent effects of massed and distributed schedules upon motor learning. Seventeen designs incorporated retention tests varying in time from one week to nine weeks. Six investigators (8, 17, 22, 29, 38, 118) reported that distributed groups performed better than massed groups on the retention test; 10 investigators (6, 94, 117, 119, 128, 134, 138, 141, 151, 158) found no difference between the groups on the retention test; and one investigator (153) found that the massed group was superior to the distributed group on the retention test. These studies seem to support the contention that massed practice does not have a detrimental effect upon learning.

TABLE 5

A Summary of the Findings for Each Study Based Upon the Superiority of Practice and Classification of Skill

Massed	Distributed		Massed to Distributed Early	Massed to Distributed Late	Distributed to Massed Early	Distributed to Massed Late	No Difference	Performance vs. Learning M^1	D^1	ND^1	M^2	D^2	ND^2
3F	1F	54F	6F	6F	9G	9G	8G		40F			40F	
12F	2F	55F	ND	7G	11F	ND	13G		42F				42F
23F	4F	56F	23F	23G	14F	14F	15G		43F				43F
44F	5F	57F	26F	26F	25F	25F	22F		62F				62F
61F	10F	58F	31F	31F	28F	28F	24G		64F				64F
110G	16F	60F	ND	48F	32F	ND	38G		67F				67F
130F	17F	61F	59F	59F	33F	33F	51G		70F				70F
136G	18F	66F	72F	72F	41F	41F	53F		78F				78F
149F	19F	68F	73F	73F	46F	46F	G		85F				85F
162G	20G	69F	77F	77F	92F	92F	63F		87F				87F
166F	21G	71F	81F	81F	93G	93G	65F		88F				88F
	27F	75F	ND	124G	105F	105F	74F		89F				89F
	29F	76F	134F	134F	109F	109F	82F		90F				90F
	30F	79F	141G	ND	124G	ND	99F		98F				98F
	34F	80F			159G	ND	100F		101F				101F
	35F	83F			161F	ND	107G		102F				102F
	36G	84F			G		108G	103F	103F				103F
	37G	86F					120G		113F				113F
	39G	91F					123F		114F				114F
	45F	94F					126G		116F				116F
	47F	95F					128F		117F				117F
	49F	96F					132F		125F				125F
	50F	97F					138F		133F			133F	
	52F	104F					139G		143F				143F

TABLE 5--Continued

Massed	Distributed		Massed to Distributed Early	Late	Distributed to Massed Early	Late	No Difference	Performance vs. Learning M	D	ND	M	D	ND
	106F	131F					140G		152G				152G
	110G	135F					145G		160G				160G
	111F	137F					147G		165F		165G		165F
	112F	138G					148G		G				
	115F	142G					150G		168G				168G
	118F	144F					154G		169F				169F
	119F	146F					155G		170G				170G
	121F	151F					156G		171F				171F
	122G	153G					158G						
	124G	157G					163G						
	127G	164F					167G						
	129G	167G											
Total 11	72		14		16		34	1	31	0	1	2	29

Massed to distributed = massed favored early in learning; distributed late in learning
Distributed to massed = distributed favored early in learning; massed late in learning
No difference = no significant difference between the two conditions
M[1] = massed practice favored in performance
D[1] = distributed practice favored in performance
ND[1] = no significant difference found in performance
M[2] = massed practice favored in learning
D[2] = distributed practice favored in learning
ND[2] = no significant difference found in learning

Note: Numbers refer to the order of the study listed in Table 1; F designates a fine motor skill and G designates a gross motor skill.

Summary

In Chapter IV of this report, the investigator presented the analysis and interpretation of the data obtained during this experiment with respect to the questions which guided the development of this inquiry. Fourteen variables were discussed upon the basis of the relationships which exist within the two conditions of practice. Data were presented in the form of discussions and tables.

Chapter V will include an additional analysis and interpretation of data collected during this study. The investigator will present these findings in relation to the four selected disciplines and to the purpose of the study.

CHAPTER V

ANALYSIS AND INTERPRETATION OF THE DATA

PART TWO

The analysis and interpretation of the data collected during this study are presented in this chapter in relation to the four selected disciplines and to the major purpose of the investigation.

Experimentation from Selected Disciplines

Physical education, psychology, business education, and music education were selected as disciplines which have primary responsibilities for teaching motor skills. Each should have methodologies and practice schedules which are based upon sound experimental evidence that relate directly to an individual or to a group of individual's acquisition of motor habits.

The majority of studies concerning the effects of the distribution of practice upon learning have been conducted by psychologists. From the 171 designs reviewed in the present investigation, 109 were reported in psychological journals. Leaders in physical education have been concerned with the applicability of these laboratory findings to gross motor skills, and, consequently, these investigators have conducted experimentation specific to physical education. Fifty-one designs were listed in the physical education literature which are related to the question of massed and distributed practice. A void was found in the field of music education. The one classical example designed by Rubin-Rabson (1940) and frequently cited by music educators appeared in a psychological bulletin. Two studies were reported in business education journals, both concerned with achievements in typing. However, four additional studies related to length of practice and schedules in typing could not be obtained by the present investigator. Insufficient documentation was given for one study, therefore, it could not be secured for review, and copies of three papers that were cited in the literature had been lost and were therefore not available to the investigator.

Nine studies were listed in resources that were interdisciplinary, such as the publication Perceptual and Motor Skills.

This analysis was not intended to stereotype research endeavors conducted in the various fields of study. It should be noted that psychologists such as Lashley and Murphy have used the gross activities of archery and javelin in their experimental work while physical educators have incorporated designs with mirror-tracing, pursuit rotor, and puzzles. In addition, numerous psychological studies have used a typing task in which the findings have been applicable to business education. This approach does point, however, to the fact that the disciplines of business education and music education need to follow the experimental lead of psychology, and more recently of physical education, to determine if these findings are suitable for skill development when an individual learns to play a musical instrument or when one learns to operate an adding machine, keypunch, and/or other business machinery which involve motor dexterity.

Published and Unpublished Papers

An analysis and evaluation of the published and unpublished studies cited revealed that only 171 of the total number reviewed (433) could be considered relevant. From this number, 37 were unpublished papers--six from psychology and 31 from physical education. The present investigator regarded experimental designs as relevant if they were related to massed and distributed practice schedules in motor skill learning. On the pages that follow, the investigator will use the term relevant as stated in the aforementioned definition and the term competent will imply that the research design was appropriate and adequate to the stated hypotheses.

Of the nine doctoral dissertations analyzed, all but one study were found to be both relevant and competent research. Twenty-two masters' theses were reviewed. The present investigator considered 16 designs to be relevant and competent; six were considered relevant but not competent. Five studies conducted in motor learning laboratories were examined, two of which were considered relevant but not competent. These investigations were completed at 19 institutions of higher education.

Fewer of the published reports, as compared percentage-wise with dissertations and theses, were considered relevant and competent research. Forty-nine published studies were considered relevant but not competent. Possible reasons for this unexpected finding can be attributed, perhaps, to the fact that most topics for theses and dissertations were well-defined and limited to an investigation of one variable while in published studies investigators often attempted to find answers to many questions, increasing both the scope of the design and lack of control of the variables. Secondly, it is probable that the published write-up of the research manuscript was somewhat aborted when it was synthesized for publication.

The research represented by the 37 unpublished papers generally involved experimentation concerned with variations of schedules and differences between performance and learning. Published studies represented ideas of major contributors, the influence of specific variables to the teaching-learning process, and performance phenomena.

Experimental Inadequacies

Major inadequacies found in the investigations which were examined were of several types. In many cases, the problem stated by the investigator proved to be different from that which was investigated. Four studies did not give data pertinent for tabulation or discussion. In some cases, the purposes were not clearly and succinctly stated, and they had to be deduced by the present investigator. Several studies had less than eight subjects involved in the total experiment or in each experimental condition, yet investigators generalized the results. In a few studies, the information given and the data analysis were incomplete. In other studies, conclusions were inappropriate for the data reported.

Some of the above inadequacies warrant additional discussion. A major weakness in reported research was that of inappropriate conclusions. It was interesting to compare conclusions with an analysis of the data for, often, investigators permitted bias to emerge when stating the conclusions of the study. Several examples will illustrate the point.

Oxendine (1965) states that during a retention test all groups performed at a level equal to the last regular day of practice. This performance level to which he refers was best for the group which practiced at a constant rate, the increasing schedule group, and the decreasing schedule group, respectively. The retention advantage, however, did not prove to be statistically significant, but this information was omitted from the conclusions.

Cook and Hilgard (1949) reported in their summary that distributed practice was notably advantageous on the first day, and continued to show some advantage over massed practice on the third and final day of the experiment. In the conclusions which preceded the summary, the investigators emphasized that the difference at the end of practice between the groups was not significant. It seems that it would have been more appropriate for Cook and Hilgard to report the summary of their findings prior to the conclusions. In addition, the conclusions should have been stated in relationship to the hypotheses.

A major fallacy of many studies was to incorporate in the conclusions a trend that was detected rather than stating specific findings.

Niemeyer (1958) reported that there were differences in effectiveness of massed and distributed practice in late and overall learning in large muscle activities. In early learning, distributed practice seemed to be best. The results suggest that practice periods should be short and more frequent in early learning, and after the activity is learned, practice periods perhaps could be longer. Niemeyer suggested that further study of this possibility would seem to be desirable. A careful analysis of this reported investigation provides information which challenges the manner in which the data were reported. Niemeyer used two activities to test the effects of massed and distributed practice. In volleyball, no statistically significant differences were found in early learning while in late learning the results significantly favored the massed practice group. Overall performance was not influenced by practice distribution. In badminton, distributed practice was significantly better than massed practice in early learning although no significant differences were found between the two conditions in late learning. In overall learning, distributed practice was better than massed practice. This overall difference was limited solely to the significantly better learning phase of the distributed group early in learning, since the improvement in late learning was the same for both groups. Niemeyer reemphasized that the distributed group in both activities had thirty minutes less practice each week. Perhaps this is the reason for indicating a favorable trend for distributed groups in early learning even when the scores for one activity were not significant. It is also interesting to note that the investigator was not positive about the benefits of long practice sessions late in learning and suggested additional research although one of the two activities did show significant differences supporting the advantages of massed practice late in learning.

Nix and Ammons (1949) stated that "phenomena characteristic of post-rest performance observed by Ammons and others for rotary pursuit were identified, but specific conclusions concerning them are withheld until more stable data can be obtained [p. 16]." The investigators did not find significant interaction between length of rest and amount of pre-rest practice. This finding was not reported in the conclusions. The present investigator wonders if the results, even with weaknesses in the design, would have been given if the data had been consistent with the findings of other investigations.

Kimble's findings (1949c) can be criticized upon the basis that he compared the performance of the massed group after 10 minutes of rest with the performance of the distributed group after only 30 seconds of rest and for using individual _t_ tests without first establishing a true difference between groups (Bourne & Archer, 1956).

Singer (1965) divided his three groups into (a) massed with 80 shots in basketball, (b) distributed with 24 hours rest after blocks of 20 trials, and (c) distributed with five minutes rest after blocks of 20 trials. In the conclusions, the group originally termed distributed with five minutes rest was referred to as the "relatively massed" group.

The investigator is of the opinion that researchers who rely on reading the abstracts of previous research or rely only on the summary and conclusions of reported research such as the studies just cited can and do unintentionally perpetuate a fraud in their own written reviews of previous research.

Classification of Experiments

An analysis of the studies used in the present investigation reemphasized the contention that there exists a confusion in semantics as to what represents distributed and massed practice schedules. This variance of opinion was illustrated in Chapter IV when massed conditions were defined by rest pauses or intervals up to five minutes while distributed practice was varied from 15 seconds to 120 hours. Specific examples are presented to show the magnitude of the problem.

Massey (1959) suggested that caution should be taken when comparing results of her study with those obtained in other investigations which involved massed practice since each of her patterns--Monday, Wednesday, Friday; Monday through Friday; and additive--represented distributed schedules only. Murphy (1916) also labeled his schedules of daily, three times a week, or once a week as distributive although these groups met for seven weeks, twelve weeks, or one semester, respectively.

Morris (1967) defined distribution as practice with a twenty-four hour or more interval, thus each of three groups with practice either daily for eight days, three days a week for two and one-half weeks, or two days a week for four weeks were defined as distributed practice schedules.

In contrast, Young (1954) categorized forty minutes practice two days a week for twelve weeks as distributed practice and forty minutes practice four days a week for six weeks as massed practice. Knapp and Dixon (1950) labeled distribution as five minutes of daily practice and massing as fifteen minutes of practice on alternate days.

It would seem that no advantage can be ascribed to either schedule unless there is a standardization of what constitutes the condition. Massey first compared groups after nine practices at which time practice periods were equal but the total duration of time was 10, 18, and 34 days. This implies that some practices were concentrated into a shorter duration of time while others were spread over longer durations of time. The same principle applies to the designs of Murphy, Morris, and Young. In the study by Knapp and Dixon, one practice period was short and held frequently and the other was longer and held less frequently. This review illustrates two methods that can be used to classify conditions--varying the length of practice per session or varying the total duration of time.

Bases for Generalizations

It appears that it is necessary to read a study in its entirety in order to fully understand the results of the investigation. This need arises because often the investigator does not accurately state the findings of a study in his conclusions, or the findings are misinterpreted by the individual who uses the results. Both inadequacies have led to misrepresentation when generalizations related to massed and distributed practice schedules have been issued.

The above indictment can best be justified by citing discrepancies found between the review of the experimental designs reported in the seven selected textbooks which enumerated generalizations related to massed and distributed practice schedules and the present investigator's analysis of the same studies.

Lawther (1968) reported that Niemeyer advocated 30 minutes of practice three times a week rather than two 60 minute periods in teaching swimming, badminton, and volleyvall. Niemeyer's study did involve three activities, but only volleyball and badminton were used to test the effects of massed and distributed practice. Likewise, Niemeyer's conclusions were not supported by his results. Lawther also reported that Cozens found three practices per week, one hour each, extending over an entire school year, to be better than six practices per week, one hour each, for one semester. Lawther was correct inasmuch as he duplicated the conclusions given by Cozens. This conclusion, however, was a broad generalization on the part of Cozens since the experiment proper was conducted for only one semester in which massed practice groups had each of six events in four consecutive practices while the distributed group had four practice periods on each event scattered throughout the semester.

Singer (1968) states that Murphy favored practicing the skill of javelin throwing three times a week or once a week over five times a week. It must be pointed out that Murphy found no significant differences among the groups and that his conclusion was issued and justified in terms of the amount of learning time necessary for the activity and the demands of a school schedule.

Cratty (1967) evaluated Young's study in which badminton and archery were taught. He labeled two days a week for 12 weeks as massed and four days a week for six weeks as distributed. Lawther (1968) classified the two schedules in opposite frames of reference to that given by Cratty, while Singer (1968) merely stated the findings without labeling the schedules. Both Singer (1968) and Oxendine (1968) failed to mention that the two-day and four-day groups had different total time durations which would influence the way in which the conditions would be defined.

The major inadequacy found in the theory of learning books in psychology was of a different nature. In most cases, the studies were competently reviewed, but generalizations were issued based upon research in both verbal and motor learning.

Similar discrepancies were discovered in the review of literature set forth by investigators conducting research. For example, Riopelle (1950) stated that Franklin and Brozek reported massed practice to be superior to spaced practice. An analysis of this study indicates that no significant differences were reported for the groups.

Perhaps misconceptions have existed because of common definitions used for massed and distributed practice. In general, massed practice has been defined as <u>continuous</u>, <u>concentrated</u>, or <u>unbroken</u> periods of work while distributed practice has been defined as <u>short</u>, <u>frequent</u> practices <u>spread</u> over many sessions and divided by rest intervals or intervals of alternate skill learning. It must be remembered that these definitions were first established for use in verbal learning. Secondly, the underlined word was sufficient for earlier studies in verbal learning that were conducted over a period of one day or in laboratory sessions less than one week in length. As psychologists began to test for similar factors in motor learning, initial experimentation (the first ten studies conducted in this area) involved: (1) the same amount of total time but groups had either continuous practice (M) or spaced practice (D); (2) short work periods daily (D) or two or more sessions daily for a specified number of days (M); and (3) a given amount of practice scheduled over many short periods (D) or scheduled and concentrated in a few long periods (M).

Often current investigators have failed to apply one of the three accepted models that define massed and distributed practice. They have differentiated between the two conditions of practice within the limits of their experiment.

There is, indeed, an important need to redefine the conditions of massed and distributed practice to include the extensive range of schedules which can be applied to research designs in motor learning. There is also a need to reevaluate generalizations which have been presented in textbooks on learning which were established upon a combination of research in verbal and motor learning and upon inaccurately stated or inaccurately interpreted findings in research.

Summary

In Chapter V of this report, the investigator presented the analysis and interpretation of the data obtained in this experiment. The results were discussed in relation to the contributions of the four disciplines of physical education, psychology, business education, and music education. Findings were stated and evaluated with respect to relevancy and competency of investigations, classification of experiments, inadequacies found within the designs, and bases for generalizations.

Chapter VI will include a summary of this investigation, the conclusions drawn from the analysis of the data, implications of the findings, and recommendations for future studies.

CHAPTER VI

SUMMARY, CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS FOR FUTURE STUDIES

Included in this chapter are a summary of the present investigation, analysis of the data related to generalizations concerned with massed and distributed practice schedules cited in specified textbooks, conclusions and implications based upon the findings, and recommendations for future studies.

Summary of the Investigation

A major objective of many research efforts is to find a basis for improvement in the methods and conditions of teaching and learning. In an attempt to formulate an adequate description of the learning process, exploration of the effect of time and practice in the acquisition of a motor skill has been undertaken.

The deficiency of systematic data either supporting or rejecting the superiority of distributed or massed practice for learning motor skills lends credence to the necessity for additional endeavors to systematize, in-depth, the methods, materials, and procedures employed in research designs which permeate the literature.

The present study involved a documentary analysis and an in-depth examination of the experimental research designs related to massed and distributed practice schedules reported in the professional journals, books, abstracts, and unpublished research in physical education, psychology, business education, and music education. The investigation was undertaken to determine the credibility of generalizations associated with the two practice conditions cited in books related to theories of learning and books related specifically to motor learning. The following generalizations were presented:

1. Many investigators have found that initial massing with subsequent spacing of practices produces the highest performance levels.
2. Early spacing with a later massing of trials proves effective. Such factors as fatigue or boredom are counteracted by distributed practice.
3. Distributed practices are generally more efficient for learning and performance than are massed practices.
4. Relative short practices (in time or in number of repetitions) make for more efficient learning than do longer practices.
5. Proficiency which has been gained over a long period of time is retained better than that which is developed within a short period of time.

6. A higher level of motivation enables one to benefit from longer and more concentrated practices than would be possible with a lesser degree of motivation.
7. Practice sessions should be shorter for children than for older persons.
8. Longer practices are more beneficial to the highly skilled since they can effectively practice that activity for longer periods of time than can persons or groups who are less competent.
9. Relatively constant lengths for practice sessions seem to produce more learning than regular increases or decreases in sessions.
10. In motor learning, there is a point of diminishing returns or an upper limit to the advantage of spreading practice out in time.
11. The relative effectiveness of the distributed practice depends upon the absolute and relative lengths of the work and rest periods.
12. The effectiveness of the distribution of learning depends to a large extent upon what one does during the rest interval.
13. The optimal length and spacing of practice periods is dependent upon the nature of the learning task.
14. In gross motor activities, the number of repetitions (shots, throws, dives) should be considered as the

unit of practice rather than the time spent at the work session.

It was necessary to develop guidelines for classification of variables which influenced massed and distributed practice. The following questions were constructed for that purpose and were used to direct the development of the study.

1. What constitutes massed and distributed practice? Is massed practice in one study comparable to distributed practice in another study?
2. Are designs equivalent when data are collected during one experimental session as compared with data collected over a period of a week, a month, or a year?
3. Distributed practice involves work and rest periods. Which of these two variables is of greater importance?
4. How have the optimal work loads and rest intervals been determined in the research designs? What are the optimal work loads and rest intervals?
5. What did the investigator have the subjects do during the interval of distributed practice--rest, rehearse, or perform an unrelated task?
6. Is there a point of diminshing returns in either type of practice schedule?

7. In learning, there is a correlation between motivation and level of skill. Has this factor been controlled in the studies related to massed and distributed practices to support the statements that distributed practice should be used when motivation is low?
8. Is there a difference in practice schedules utilized in learning fine motor skills and gross motor skills?
9. Generalizations in the literature provide the statement that highly skilled performers can practice for a longer period of time than performers with low skills, and older individuals are able to practice longer than younger ones. Which and how many studies support these guidelines?
10. Is there a difference in male and female subjects with regard to the effectiveness of massed and distributed practices?
11. Does massed and/or distributed practice affect performance or learning?
12. Of the activities investigated, what aspects of the skills were chosen for the study? Is there a need for replication of these studies?
13. How many of the investigations related to gross motor skills occurred in an artificial setting?

14. Was the homogeneity of the two practice groups established prior to the experiment?
15. Did the investigators obtain a baseline performance level for the task?
16. How were the data treated statistically and was the treatment adequate?

An historical and theoretical perspective of massed and distributed practice schedules was undertaken to determine the types of theoretical models which had been formulated to explain what occurs during the two conditions of practice and to determine to what extent these theoretical positions affected subsequent investigations.

These early theories used the principle of perseveration, recovery from fatigue, changes in motivation, rehearsal, differential forgetting, and reactive inhibition to account for the superiority of distributed practice. The majority of these hypotheses was reclassified and discussed under the major headings of work theories, perseveration theories, and differential forgetting theories. A detailed explanation of each theory was presented in Chapter II.

Method of Inquiry

The development of the present inquiry was presented in Chapter III of this manuscript. This information was discussed under the major headings of sources of data, forms and written materials, and conduct of the experiment.

Generalizations issued for massed and distributed practice schedules were obtained, after consultation with qualified persons in the chosen disciplines, from the following three books in psychology related to theories of learning and four books in physical education related specifically to motor learning:

1. Cratty, B. J. Movement Behavior and Motor Learning, 1967.
2. Deese, J., and Hulse, S. The Psychology of Learning, 1967.
3. Kingsley, H., and Garry, R. The Nature and Conditions of Learning, 1962.
4. Lawther, J. D. The Learning of Physical Skills, 1968.
5. McGeoch, J., and Irion, A. The Psychology of Human Learning, 1952.
6. Oxendine, J. B. Psychology of Motor Learning, 1968.
7. Singer, R. N. Motor Learning and Human Performance, 1968.

A working bibliography of the available documentary sources of data was prepared using eleven references and indices which were pertinent to the overall purpose of the experiment or specific to a selected discipline. These sources included the "Medlars" search request, Cummulated Index Medicus, Education Index, Music Index, Evaluation and Synthesis of Research Studies Related to Music Education, Master's Theses in Health, Physical Education, and Recreation, Completed Research in Health, Physical Education, and Recreation, The Business Education Index, Bibliography of Research Studies in Stenographic Secretarial Training and Work Reported Prior to 1959, Ten Years of Shorthand References, and the Typewriting Research Index.

An additional examination of twenty-four periodicals and magazines (Appendix) from the publication of Volume I to the volume published in 1970 served as a guide in the preparation of a working bibliography.

It was necessary to develop a format for recording and systematizing the data. Two forms were constructed which provided for an in-depth examination of each experimental design as well as the principle variables involved in massed and distributed schedules which might affect the conditions of practice. Form A was used for the purpose of summarizing and evaluating the study; Form B was developed to facilitate a numerical count of fourteen variables which exist within the two conditions of practice and which affect learning.

The investigation began in April, 1970, and continued through February, 1971. A total of 433 studies were examined. Two hundred and sixty-two were omitted because the criteria for selection were not fulfilled. The remaining 171 psychomotor studies were subjected to a documentary analysis and an in-depth examination to determine the credibility of generalizations related to massed and distributed practice schedules.

Conclusions

Conclusions based upon the findings of this inquiry related to massed and distributed practice schedules may be stated as follows:

A. General Conclusions

1. From the four selected disciplines, psychologists (109) have been the most prominent investigators, succeeded by physical educators (51), business educators (2), and music educators (1), respectively.
2. There is a need for the fields of business education and music education to conduct experimentation to determine if research findings are appropriate for skill development specific to these disciplines.
3. Fewer published reports, as compared percentage-wise with dissertations and theses, were considered relevant and competent research.
4. Unpublished papers generally involved experimentation concerned with variations in schedules and differences between performance and learning.
5. Published papers represented ideas of major contributors, the influence of specified variables--e.g., sex, age, warm-up--to the teaching-learning process, and performance phenomena.

6. Two major inadequacies found in research techniques were: (1) the recording of inappropriate conclusions in relationship to the findings of the study, and (2) the generalization of findings that should have been restricted to the condition of the investigation.

B. Specific Conclusions Related to Generalizations

The acceptance or rejection of each generalization was based on the number of studies from the 171 investigations that were devoted to the specific topic and on the relevancy and competency of the studies involved.

1. "Many investigators have found that initial massing with subsequent spacing of practice produces the highest performance levels." The findings from Table 5 indicate that a total of 13 studies from the 171 investigations found these conditions to be advantageous. <u>Rejected.</u>

2. "Early spacing with a later massing of trials proves effective." The findings from Table 5 indicate that a total of 15 studies from the 171 investigations found these conditions to be advantageous. <u>Rejected.</u>

3. "Distributed practices are generally more efficient for learning and performance than

are massed practices." The findings from 72 studies supported the superiority of distributed practice when no distinction was made between performance and learning. In the 32 investigations that considered both performance and learning, 31 found distribution to be beneficial for performance although 29 of these investigations reported no significant differences between conditions when learning was assessed. Rejected.

Distribution is more efficient than massed practice for performance. Accepted.

Distribution is more efficient than massed practice for learning. Rejected.

4. "Relative short practices (in time or in number of repetitions) make for more efficient learning than do longer practices." Thirty-four studies investigated this aspect of scheduling. Three designs favored distribution, 4 favored massing, 2 distinguished between early and late learning, and 25 found no significant differences between conditions. Rejected.

5. "Proficiency which has been gained over a long period of time is retained better than that which is developed within a short period." Seventeen designs incorporated retention tests

varying in time from one week to nine weeks. Six investigations reported superiority for distributed groups; one found massing to be more efficient than distributed; ten investigations found no significant differences between conditions on the retention test. Inconclusive Results.

6. "A higher level of motivation enables one to benefit from longer and more concentrated practices than would be possible with a lesser degree of motivation." Only four studies have utilized the concept of motivation and controlled this variable in investigations concerned with massed and distributed schedules. Two designs supported the concept that high motivation leads to better performance than low motivation; one found no difference between group practice and motivation; and one found no difference between groups with spaced and concentrated pre-rest practice although there was a significant difference after rest favoring the highly motivated group. Inconclusive Results.

7. "Practice sessions should be shorter for children than for older persons." Only five studies were devoted to this topic when both age and practice conditions were considered. Three

studies found no difference in performance achievement of age groups, and two studies found a progressive increase in skill accompanying an increase in age. Inconclusive Results.

8. "Longer practices are more beneficial to the highly skilled since they can effectively practice that activity for longer periods of time than can persons or groups who are less competent." Only seven investigators used highly skilled performers. Two reported that distribution was more effective than massing at this level of proficiency, while five pointed to the fact that highly skilled performers could effectively practice under either type of condition. When investigators established arbitrary standards for proficiency in a task, eleven studies reported massed practice to be advantageous for skilled performers and thirteen studies reported distributed practice to be advantageous for skilled performers. Inconclusive Results.

9. "Relatively constant lengths for practice sessions seem to produce more learning than regular increases or decreases in sessions." Five studies used an increasing or a decreasing session of work or rest, but only one was

involved specifically with lengths for practice sessions in which one practice group had a constant pattern of work. Inconclusive Results.

10. "In motor learning, there is a point of diminishing returns or an upper limit to the advantage of spreading practice out in time." Eleven investigations reported that practice beyond a specific number of days or trials had no additional effect upon skill acquisition. Inconclusive Results.

11. "The relative effectiveness of the distributed practice depends upon the absolute and relative length of the work and rest periods." No consistent, optimal work and rest patterns were obtained. Massed practice was defined by intertrial rests up to 5 minutes and distributed practice was defined by rest periods from 15 seconds to 120 hours. Likewise, no consistent length for practice periods was found to be more effective than others. It was reported, however, that the relationship between work and rest was more important to learning than either work or rest alone. Inconclusive Results.

12. "The effectiveness of the distribution of learning depends to a large extent upon what one does during the rest interval." The majority of the

investigations (123 studies) did not control activity during the rest interval; therefore, results may be inappropriate to findings when the rest interval was not controlled. It was assumed by most investigators that certain constructs were at work during the interval. Reactive inhibition, work decrements, fatigue, differential forgetting, and perseveration were the theoretical models most frequently used to explain the rest interval even if the interval activity was not controlled. Rejected.

13. "The optimal length and spacing of practice periods is dependent upon the nature of the learning task." Fine and Gross Skills. Distributed practice was superior to massed practice when fine motor skills were employed. Fifty-eight studies supported the contention that distributed practice was more efficient to learning than massed practice; 27 investigators reported that distribution was superior to massing for performance although there was no difference between the conditions for learning; and only 12 fine motor studies reported no difference between the conditions. In contrast, 27 or 49 studies (over 50 per cent) using gross motor skills reported no difference between conditions or no difference in learning

although performance was effective under distributed conditions. Findings from laboratory studies frequently cannot be applied to gross activities. Complexity of Tasks. Eighteen studies investigated the complexity of the task in relationship to conditions of practice with maze and puzzle work, weight loads or resistance, category responses, work surface height, and physical effort in fine and gross tasks. Results varied according to the task employed and to the nature of the task. Accepted.

14. "In gross motor activities, the number of repetitions (shots, throws, dives) should be considered as the unit of practice rather than the time spent at the work session." Forty-two per cent of the gross motor studies used the number of repetitions as a unit of practice, and fifty-eight per cent used the time spent at the task to determine the effectiveness of the conditions. Inconclusive Results.

C. Conclusions Related to Questions Which Guided the Development of the Study

1. The greatest productivity represented by the number of investigations conducted during ten-years was 1946-1955 (65), 1956-1965 (40),

1936-1945 (23), 1966- (18), 1926-1935 (12), 1905-1915 (7), and 1916-1925 (6), respectively.

2. The findings of 13 studies were inconclusive when performance scores as a function of practice schedules were tested in relationship to the influence of sex. The consistent superiority of male subjects occurred only when the task involved the use of the pursuit rotor.

3. Forty of the 171 investigations did not use a statistical test of significance to determine if the discrepancy in performance and/or learning scores between the two conditions was significant. The findings from four of these studies supported the superiority of massed practice; findings from 20 of these studies supported the superiority of distributed practice; findings from seven of these studies indicated no difference between the conditions; and findings from nine of these studies supported the superiority of massed practice in early learning and distributed practice in late learning or vice versa.

4. Artificial or laboratory settings were used in 91% of the studies which employed fine motor skills; 71% of the studies using gross motor skills were conducted in natural settings.

5. One day, one week, one month, and other time periods were used for experimental sessions. Excluding the one month category which had one study, an increase in the length of the experimental sessions produced a reduction in the percentage of studies supporting the superiority of distributed practice over massed practice and an increase in the percentage of investigations which found no significant differences between the conditions.
6. Seventy-eight studies failed to establish homogeneity between groups and six studies did not obtain a baseline performance.

Implications

One major implication seems warranted by the findings of this investigation. Administrators and educators must be warned against using the current research findings and generalizations regarding the well-established benefits of distributed over massed practice to support scheduling practices. A similar admonition is given to those who advocate the use of distributed conditions to produce the most effective learning.

A systematic, in-depth analysis of methods, materials, and procedures employed in research designs using massed and distributed practice schedules was not beneficial in providing data to either support or reject the superiority of either condition when learning motor skills. It was beneficial, however, in magnifying inadequacies and erroneous concepts related to massed and distributed practices and to isolate aspects of the problem which need additional investigation. The composite of all the studies reviewed point to the fact that the advantages of either condition are accompanied by restrictions with respect to the type of task studied, the nature of the responses made, the definition of the trials, the difference in environmental settings, the establishment of homogeneity for the groups, and whether learning or performance is investigated.

Recommendations for Future Studies

The findings of the present investigation have led to the following recommendation for future experimentation of the influence of massed and distributed practice schedules.

Book (1908) stated that

> There is no more important or necessary step in learning than to fix definitely all the elemental habits later to be used in the formation of the higher-order habits finally to be obtained. . . . It would be worth much to know the proportion of practice and rest that would give the best results in the different fields of learning and to know more definitely all that this period of rest means, but much painstaking investigation will yet be needed before we shall arrive at this knowledge [p. 84].

This challenge is both applicable and pertinent to the topic of massed and distributed practice in the 1970's. Although an extensive number of investigations have been conducted, educators still have few stable and concrete factors upon which they can rely when development of motor skills is considered with respect to the duration of practice and rest. Too many methods, tasks, and definitions have been determined within the condition of each experiment to consolidate the information or to draw generalizations from the findings.

The present investigator recommends: (1) that an interdisciplinary team of investigators from psychology, physical education, business education, music education, industrial arts, and the performing arts apply for a national grant to conduct research related to massed and distributed practice schedules; (2) that this study be longitudinal in nature to determine the influence of age, sex, and varied populations; (3) that a series of 10 or more tasks in both fine and gross skills from each of the five different fields of study be designed and based upon comparable practice and rest patterns; (4) that massed and distributed practice be assessed according to each of the three accepted models which can be used to define the conditions; and (5) that the findings be published so that generalizations may be issued as a result of one comprehensive, systematic exploration of experimental materials, methods, conditions, and variables related to massed and distributed practice schedules.

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Bond, M. A. "A Comparative Study of the Accomplishments of Second Semester Typewriting Pupils in Forty-Five and Sixty-Minute Periods." Unpublished Master's Thesis, University of Southern California, 1935.

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Murphy, C. F. "The Effect of a Split Period in Learning to Typewrite." Unpublished Master's Thesis, Colorado State College, 1937.

Radtke, R. "A Comparison of Achievement in Typewriting of Students in A Forty-Two Minute Period With Those in a Fifty-Five Minute Period." 1962. [Insufficient documentation.]

Young, B. A. "A Study to Determine the Relative Efficiency of Single and Double Periods in Typewriting in High Schools." Unpublished Master's Thesis, State University of Iowa, 1931.

APPENDIX

A LISTING OF PERIODICALS AND MAGAZINES FROM THE PUBLICATION OF VOLUME I TO THE VOLUME PUBLISHED IN 1970 EXAMINED BY THE INVESTIGATOR

Research Quarterly

Perceptual and Motor Skills

Physical Educator

Journal of Health, Physical Education, and Recreation

Journal of Psychology

Journal of Educational Psychology

Psychological Abstracts

Journal of Applied Psychology

Journal of Experimental Psychology

Journal of General Psychology

Journal of Comparative and Physiological Psychology

American Psychologist

Psychological Monographs

Business Education Forum

Business Education World

National Business Education Quarterly

Journal of Business Education

School Musician

Music Teacher

Instrument

Instrumentalist

Music Educators Journal

Journal of Research in Music Education

Music Quarterly

SAMPLE OF FORM A AND HOW IT WAS USED

1. Title (Bibliographic Material)--Travis, Roland C. "Practice and Rest Periods in Motor Learning." Journal of Psychology, 3: 183-187, 1937.

2. Major and Sub-Hypotheses (Purpose)

To determine the effect of work and rest periods varying in length on the rapidity of learning a complex motor task.

Is the continuous work period more effective than one broken up by spaced rest periods on the acquisition of skill? Does the relative duration of practice and rest periods have any effect on the learning process?

3. Task

Koerth Pursuit Rotor task using four male subjects.

Eight practice periods of six minute duration were given. Three subjects had a rest period of three days between each practice and one subject had a rest period of seven days between practice.

After practice period, each subject worked in two different situations. Each subject was given two trials in each of the continuous and discontinuous work situations on two consecutive days approximately seven days after the learning period. The discontinuous work period consisted of six two minute trials alternated with one minute rest periods. The continuous work period involved twelve consecutive minutes of task performance.

4. Treatment of Data (Statistical)

Learning curves and graphs.

5. Conclusions of Study (Entirety) Page 187

1. All subjects practically reached the maximum point in learning within eight trials with a continuous practice period of six minutes each trial.

2. The learning curves were fairly typical of learning curves generally.

3. During the first five trials of practice, the score for the first minute of each successive trial was notably higher than the average score for the previous trial.

4. The interposition of rest periods of one minute between work periods of two minutes resulted in a consistent rise in the learning curve. In continuous

practice without rest periods for the same length of time a fairly consistent progressive decrease in efficiency was obtained.

6. Comments by Richardson

The graph of the discontinuous work group continued to rise while the continuous work group performance declined--was the difference statistically significant?

How valid is the study with only four subjects?

Did verbal urging of students to perform to their capacity in both types of conditions equally motivate them?