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**MELNICK, Merrill Jay, 1940-
THE EFFECTS OF OVERLEARNING ON THE RETENTION
OF A GROSS MOTOR SKILL.**

**The Ohio State University, Ph.D., 1966
Education, physical**

University Microfilms, Inc., Ann Arbor, Michigan

THE EFFECTS OF OVERLEARNING ON THE RETENTION
OF A GROSS MOTOR SKILL

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

By

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* * * * *

The Ohio State University
1966

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ACKNOWLEDGMENTS

The writer wishes to express his appreciation, first of all, to Dr. Bruce L. Bennett of the Department of Physical Education for the encouragement and interest he showed the author throughout the preparation of the study. Appreciation is also extended to Dr. Lewis A. Hess of the Department of Physical Education and Dr. Delos D. Wickens of the Department of Psychology for their reading of the manuscript and the helpful suggestions they gave the writer.

Special thanks must also go to Mr. Bert Price of the Department of Mathematics for the many sessions he spent with the writer in discussing the statistical analysis of these data. The advice of Mr. Michael T. Turvey of the Department of Psychology and Dr. Edward L. Fox of the Department of Physical Education with respect to the experimental design was indispensable for the success of the study. The writer also wishes to thank Mr. James P. Lang for the photographs included in the study and Mr. Clark E. Bowser, the author's roommate, whose kind words and suggestions were very much appreciated.

Finally, the author wishes to take this opportunity to thank the eighty students who served as subjects in the study and who so graciously gave of their time and themselves.

Their dedication to the experiment was far more than the writer could have ever hoped for.

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CONTENTS

Chapter	Page
I. INTRODUCTION TO THE PROBLEM	1
The Problem	15
Statement of the problem	15
Limitations of the study	16
Importance of the study	16
Definition of Terms Used	19
II. REVIEW OF THE LITERATURE	22
Retention as a Function of the Amount of Practice	23
Retention of verbal learning as a function of the amount of practice	23
Retention of motor learning as a function of the amount of practice	37
Retention as a Function of Overlearning	43
Retention of verbal learning as a func- tion of overlearning	44
Retention of motor learning as a func- tion of overlearning	49
III. PROCEDURES	56
Selection of Subjects	56
Construction of the Stabilometer	57
Measurement of Subject Performance	61
Practice Procedure	63
Overlearning Practice	67
Retention Intervals	69
Assignment of Subjects to Overlearning and Retention Groups	70
Measurement of Retention	71
IV. ANALYSIS OF THE DATA	75
Equating of Groups	76
Trials to reach the learning criterion	76
Balancing score on criterion trial	77

Chapter	Page
Results of the Five Measurements of	
Retention	80
Absolute recall	80
Loss	86
Relearning to the learning criterion	91
Saving score	96
Percentage of saving	101
Summary of the Data	106
Findings after one week	106
Findings after one month	107
General findings	108
V. SUMMARY AND CONCLUSIONS	109
Summary	109
Conclusions	112
BIBLIOGRAPHY	121

TABLES

Table	Page
1. Mean Scores, Standard Deviations and Standard Errors of the Mean for the Eight Groups on the Number of Trials Needed to Attain the Learning Criterion	77
2. Computation of t-Ratios between Means among the Eight Groups on the Number of Trials Needed to Attain the Learning Criterion	78
3. Computation of t-Ratios between Means for the One Week and One Month Sub-Groups in each of the Four Overlearning Groups on Trials to Attain the Learning Criterion	79
4. Mean Scores, Standard Deviations and Standard Errors of the Mean for the Eight Groups on the Score of the Criterion Trial	80
5. Computation of t-Ratios between Means among the Eight Groups on the Score Attained on the Criterion Trial	81
6. Computation of t-Ratios between Means for the One Week and One Month Sub-Groups in Each of the Four Overlearning Groups on the Score of the Criterion Trial	82
7. Number of Overlearning Practice Trials Received by Each of the Eight Groups	82
8. Mean Scores, Standard Deviations and Standard Errors of the Mean for the Eight Groups on the Absolute Recall Score	83
9. Computation of t-Ratios between Means among the Four Overlearning Groups on the Absolute Recall Score	85
10. Computation of t-Ratios between Means for the One Week and One Month Sub-Groups in Each of the Four Overlearning Groups on the Absolute Recall Score	86

Table	Page
11. Mean Scores, Standard Deviations and Standard Errors of the Mean for the Eight Groups on the Loss Difference between Pre- and Post-Rest Scores	87
12. Computation of t-Ratios between Means among the Four Overlearning Groups on the Loss Difference between Pre- and Post-Rest Scores .	89
13. Computation of t-Ratios between Means for the One Week and One Month Sub-Groups in Each of the Four Overlearning Groups on the Loss Difference between Pre- and Post-Rest Scores .	91
14. Mean Scores, Standard Deviations and Standard Errors of the Mean for the Eight Groups on the Number of Trials to Relearn to the Learning Criterion	92
15. Computation of t-Ratios between Means among the Four Overlearning Groups on the Number of Trials Needed to Relearn to the Learning Criterion	94
16. Computation of t-Ratios between Means for the One Week and One Month Sub-Groups in Each of the Four Overlearning Groups on the Number of Trials Needed to Relearn to the Learning Criterion	95
17. Mean Scores, Standard Deviations and Standard Errors of the Mean for the Eight Groups on the Difference between Trials Needed for Learning and Relearning to Criterion (Saving Score)	97
18. Computation of t-Ratios between Means among the Four Overlearning Groups on the Difference between Trials Needed for Learning and Relearning to Criterion (Saving Score). . .	99
19. Computation of t-Ratios between Means for the One Week and One Month Sub-Groups in Each of the Four Overlearning Groups on the Difference between Trials Needed for Learning and Relearning to Criterion (Saving Score)	101
20. Mean Scores, Standard Deviations and Standard Errors of the Mean for the Eight Groups on the Per Cent of Trials Saved in Relearning to Criterion	102

21.	Computation of t-Ratios between Means among the Four Overlearning Groups on the Per Cent of Trials Saved in Relearning to Criterion	105
22.	Computation of t-Ratios between Means for the One Week and One Month Sub-Groups in Each of the Four Overlearning Groups on the Per Cent of Trials Saved in Relearn- ing to Criterion	106

FIGURES

Figure	Page
1. Stabilometer and Apparatus Used to Measure the Subject's Balancing Performance	60
2. Subject's Starting Position for Balancing the Stabilometer	65
3. A Comparison of Four Degrees of Overlearning after One Week and One Month of No Practice on the Retention of Stabilometer Learning as Measured by Absolute Recall	83
4. A Comparison of Four Degrees of Overlearning after One Week and One Month of No Practice on the Retention of Stabilometer Learning as Measured by the Loss Difference between Pre- and Post-Rest Scores	88
5. A Comparison of Four Degrees of Overlearning after One Week and One Month of No Practice on the Retention of Stabilometer Learning as Measured by the Number of Trials Needed to Relearn to Criterion	93
6. A Comparison of Four Degrees of Overlearning after One Week and One Month of No Practice on the Retention of Stabilometer Learning as Measured by the Difference between the Number of Trials Needed to Learn and Re- learn to Criterion	98
7. A Comparison of Four Degrees of Overlearning after One Week and One Month of No Practice on the Retention of Stabilometer Learning as Measured by Per Cent of Saving	103

CHAPTER I

INTRODUCTION TO THE PROBLEM

Learning is commonly defined as a rather permanent change in behavior brought about through practice. While physical educators and coaches have endeavored to provide the most favorable practice conditions for the learning of motor skills, considerably less attention has been given to the retention of motor skill learning. A survey of the literature in physical education reveals a considerable number of studies concerned with the acquisition of motor skill but surprisingly few studies devoted to an investigation of the parameters which affect the retention of skill. McGeoch and Milton pointed out the scarcity of retention studies in motor learning when they stated that "the systematic studies of the retention of skill are remarkably few, For the greater part, the study of the retention of skill has been incidental to the study of acquisition."¹ Cratty has similarly concluded that "while numerous studies have been focused on verbal and

¹John A. McGeoch and Arthur W. Melton, "The Comparative Retention Values of Maze Habits and of Nonsense Syllables," Journal of Experimental Psychology, 12:393, October, 1929.

cognitive tasks, little attention has been paid to the forgetting of motor tasks."²

The physical educator who is faced with poor teaching facilities and short teaching periods often apportions the major share of his teaching time to those methods and procedures which facilitate the acquisition of motor skills at the exclusion of those teaching procedures which allow for the best and most economical retention of skill. However, if skill learning is to be permanent, as most will agree it should, then some thought must also be given to the problem of determining under what practice conditions the optimum retention of motor skills occurs. The coach, too, is also concerned with the retention, as well as the learning of motor skills. Each practice session must be planned in such a way that conditions are provided which will allow for the accomplishment of both.

Beginning with Ebbinghaus' classic work on memory in 1885, the study of retention has focused primarily on the retention of verbal materials. With the exception of two early studies by Swift^{3, 4} and recent investigations by

²Bryant J. Cratty, Movement Behavior and Motor Learning (Philadelphia: Lea and Febiger, 1964), p. 233.

³E. J. Swift, "Memory of Skillful Movements," Psychological Bulletin, 3:185-187, June, 1906.

⁴E. J. Swift, "Relearning of Skillful Act: An Experimental Study in Neuro-Muscular Memory," Psychological Bulletin, 7:17-19, January, 1910.

Hill,⁵ Bell,⁶ and Purdy and Lockhart,⁷ the retention of motor skills has received little experimental attention. Because of the diversity in methods, procedures and experimental design, it is difficult to state explicitly and quantitatively, the parameters which govern the retention of motor skills. The retention of verbal and motor learning has been observed to be influenced by such variables as the integrated nature of the task, the degree of original learning, the nature of the interpolated activities occurring between initial learning and recall, the effects of massing versus distributed practice, the effects of whole versus part practice and the length of the retention interval.

In general, the more recent research has found that motor skills are remarkably resistant to extinction. Herein lies a possible explanation for the lack of research devoted to the study of retention in motor learning--it is assumed that once learned, skilled movements are not easily forgotten. This is not to say that all practice variables affect

⁵L. B. Hill, "A Second Quarter Century of Delayed Recall or Relearning at 80," The Journal of Educational Psychology, 48:65-68, February, 1957.

⁶Hugh M. Bell, "Retention of Pursuit Rotor Skill After One Year," Journal of Experimental Psychology, 40:648-649, October, 1950.

⁷Bonnie J. Purdy and Aileene Lockhart, "Retention and Relearning of Gross Motor Skills After Long Periods of No Practice," The Research Quarterly of the American Association for Health, Physical Education and Recreation (hereafter referred to as The Research Quarterly), 33:386-394, October, 1962.

retention equally. There is strong evidence to suggest that retention is primarily influenced by the degree to which the skill has been originally learned. Underwood and Keppel wrote:

. . . it appears that degree of learning is the only variable involved in a substantial way in retention. Indeed, there is good reason to believe that if degree of learning is equal there will be no individual differences in rate of forgetting.⁸

For the same reason, Gagne and Fleishman concluded:

. . . most motor skills, once learned are better retained than other types of skills. Once we learn to skate, typewrite, ride a bicycle, or drive a car, we can perform these skills even after many years without practice . . . this may be due to the fact that motor skills are enormously overlearned.⁹

The field of psychology has chosen the term overlearning to refer to the procedure whereby practice of an act, be it verbal or motor, is carried beyond the point at which the act is considered learned. The surprisingly strong resistance of motor skills to forgetting is, therefore, largely accounted for by the fact that they have received a great deal of overlearning.

While overlearning has been assumed to be of great benefit in the retention of motor skills, its employment in

⁸Benton J. Underwood and Geoffrey Keppel, "Retention as a Function of Degree of Learning and Letter-Sequence Interference," Psychological Monographs: General and Applied, 77:16, No. 4, 1963.

⁹Robert M. Gagne and Edwin A. Fleishman, Psychology and Human Performance (New York: Henry Holt and Company, 1959), p. 260.

verbal learning has prompted educators to write enthusiastically of its merits. Griffith wrote:

It is highly probable that the degree of retention will increase in direct proportion to the amount of previous overlearning. Similarly, material that has barely been learned will, other things being equal, quickly be forgotten.¹⁰

Sawrey has stated:

If forgetting sets in as soon as learning ceases and initially takes place very rapidly, it follows that for recall after an interval, learning must be carried beyond the point where recall is just barely possible. This means that for good retention and recall after a period of time some "overlearning" is necessary.¹¹

Stephens noted:

Retention is clearly affected by the amount of practice during learning . . . For both teacher and student, it is important to realize that practice carried on after we have first reached mastery of the material is of great value to retention.¹²

It would appear that overlearning as applied to the learning and retention of verbal materials is advantageous; however, it cannot be assumed without experimental verification whether similar results would be found for the retention of motor skills. A systematic and thorough investigation of overlearning as it relates to the retention of motor skills would be valuable to both physical educator

¹⁰Coleman R. Griffith, An Introduction to Educational Psychology (New York: Farrar and Rinehart, Inc., 1935), p. 464.

¹¹James M. Sawrey and Charles W. Telford, Educational Psychology (Boston: Allyn and Bacon, Inc., 1958), p. 140.

¹²John M. Stephens, The Psychology of Classroom Learning (New York: Holt, Rinehart and Winston, Inc., 1965), p. 211.

and coach. Concerned with providing the best and most economical practice conditions for the retention of skill, the physical educator could greatly profit from a better understanding of how overlearning affects the learning and forgetting processes. The coach, interested in obtaining the best performance from each player in the game situation, could be considerably aided in organizing and utilizing his practice sessions to best advantage if the concept of overlearning, as applied to motor learning, was better understood.

Leading physical educators have suggested that overlearning a motor skill by means of extended practice and repetition is a desirable teaching technique. Sharman has written:

Other things being equal the repetition of a reaction tends to establish the reaction more firmly and to make it occur more easily and certainly. The more frequently a response is made to a given stimulus the more likely is this response to occur as the result of the stimulus.¹³

Craine stated:

If we are to provide activities for the practice of skills, the more often each activity allows repetition of the skill the more likely is the skill to become thoroughly learned. Therefore an activity that permits each pupil to practice a skill but once in a given time is not as efficient as one that allows several repetitions of the skill in the same time.¹⁴

¹³Jackson R. Sharman, The Teaching of Physical Education (New York: A. S. Barnes and Co., 1936), p. 128.

¹⁴Henry C. Craine, Teaching Athletic Skills in Physical Education (New York: Inor Publishing Co., Inc., 1942), p. 48.

Bucher is of the opinion that "the better a skill is overlearned, the longer the period before it will be lost If one would remember a skill, he should overlearn it through continued practice."¹⁵ Williams made a strong argument for the use of drill as a means for improving retention when he wrote:

Whenever a skill is learned, its retention depends upon the use and practice of it. If several days intervene between the learning of a skill and the performing of it again, about the same number of trials is necessary to perform the act successfully. However, if when the skill is learned there is also overlearning - that is, practice of the accomplishment - then it is easily repeated at some future time.¹⁶

Sharman, in applying the concept of overlearning to the physical education teaching situation, stated:

Teachers should plan their instruction in such a way as to provide for each pupil the maximum amount of satisfying repetition of the fundamental skills which are taught in physical education. It is by this means that they can be overlearned and made automatic, thereby resulting in a high degree of expertness in performance.¹⁷

If, as the research indicates, degree of learning is one of the more important factors affecting retention, and if frequency of repetition can be regarded as an indicator of degree of learning, then many teachers of physical education,

¹⁵Charles A. Bucher, Foundations of Physical Education (St. Louis: The C. V. Mosby Co., 1952), p. 222.

¹⁶Jesse F. Williams, The Principles of Physical Education (Philadelphia: W. B. Saunders Co., 1959), p. 199.

¹⁷Sharman, op. cit., p. 130.

either knowingly or unknowingly, employ overlearning as a teaching technique. In fact, for many teachers practice, in terms of repetition and drill, constitute the chief methods for teaching skills. Fortified by the assumption gained from verbal learning studies that overlearning insures better retention, as well as the generally held belief that the more something is practiced, the better it is remembered, many physical educators and coaches make promiscuous use of repetition in the teaching of skills without being fully cognizant of how it actually operates in the learning process. The historical precedence for the use of repetition in learning lies in antiquity. An old Jesuit proverb--Repetitio mater studiorum (Repetition is the mother of studies)--suggests that repetition and drill were the chief methods used to educate the student hundreds of years ago. The early American psychologists saw in repetition, the best means for learning. The Law of Exercise, as originally proposed by Edward L. Thorndike, asserted that

. . . other things being equal, the more frequently
 S [any situation] connects with or evokes any given
 R [any response which man makes to that situation]
 the stronger becomes the tendency for it to do so
 in the future.¹⁸

It was not until the concept of overlearning was first investigated that the use of repetition as a teaching

¹⁸Edward L. Thorndike, "A Fundamental Theorem in Modifiability," Proceedings of the National Academy of Sciences, 13:15, 1927.

method was called into question. Studies by Cuff,¹⁹ Krueger,²⁰ and Rubin-Rabson²¹ suggested that up to a certain point, overlearning facilitated retention, beyond this point, the phenomenon of diminishing returns appeared and made continued practice uneconomical. Davis summarized several overlearning studies and wrote:

Laboratory experiments using motor and verbal materials indicate that at least 50 per cent of overlearning is highly advantageous for retention. It does not appear, however, that additional amounts result in proportionate increases in efficiency. Some evidence indicates that additional amounts of overlearning become increasingly valuable as the time interval between initial learning and measurement of retention is extended.²²

Bernard also stated:

The gain from overlearning decreases as additional practice increases: 100 to 200 per cent overlearning is better than 50 per cent overlearning, but the additional gain is not proportional to the extended effort. It is therefore recommended that overlearning be confined to from half to double the number of repetitions required for original learning.²³

¹⁹Noel B. Cuff, The Relation of Overlearning to Retention (Nashville, Tennessee: George Peabody College for Teachers, 1927).

²⁰William C. Krueger, "The Effect of Overlearning on Retention," Journal of Experimental Psychology, 12:71-78, February, 1929.

²¹Grace Rubin-Rabson, "Studies in the Psychology of Memorizing Piano Music. VII. A Comparison of Three Degrees of Overlearning," The Journal of Educational Psychology, 32: 688-696, December, 1941.

²²Charles E. Skinner (ed.), Educational Psychology (New York: Prentice-Hall, Inc., 1945), p. 188.

²³Harold W. Bernard, Psychology of Learning and Teaching (New York: McGraw-Hill Book Co., Inc., 1954), p. 277.

Seagoe has summarized the results of several overlearning studies under the following three major findings:

1. Practice alone causes no increase in the amount learned; but practice of a response already learned tends to fix that response.
2. Overlearning results in more permanent retention than learning to mastery alone. There is some increase in retention with each degree of overlearning.
3. A little overlearning is proportionately more effective than a great deal. A law of diminishing returns operates as overlearning progresses. In general, about 50 per cent overlearning seems profitable for retention. More than 50 per cent overlearning is uneconomical for most materials and most time intervals.²⁴

Sorenson has stated the relationship between overlearning and retention in the following way:

Up to a certain extent, time spent in overlearning is profitably used. This matter of extra time and effort for more thorough learning leads to the question of optimum amounts. As in most situations, too little fails to reach the best rewards and too much is wasteful. There is no rule; but in general, 50 per cent more time devoted to overlearning is a good investment for strengthening the learning and increasing retention.²⁵

To the writer's best knowledge, no study has investigated the concept of overlearning as applied to the retention of a gross motor skill, a skill involving the movement of large muscle groups thereby resulting in the whole body being

²⁴May V. Seagoe, A Teacher's Guide to the Learning Process (Dubuque, Iowa: Wm. C. Brown Co. Publishers, 1961), pp. 193-194.

²⁵Herbert Sorenson, Psychology in Education (New York: McGraw-Hill Book Co., Inc., 1964), p. 452.

moved. It would appear that the findings of the overlearning studies using verbal materials may have relevance for the field of physical education. If overlearning, up to a point (approximately 50 per cent), best facilitates the retention of verbal learning, the problem then remains for the physical educator to determine how best to utilize the principle of overlearning as a teaching technique in the gymnasium, in the pool and on the athletic field.

The overlearning studies on the retention of verbal materials have indicated that time spent on repeating the material beyond an arbitrary learning criterion may not yield proportionate retention increments. If this be true, then the physical educator who religiously adheres to the age-old axiom, "Practice makes perfect," in his teaching may be spending needless class time exercising a teaching philosophy which has been found to be experimentally lacking.

The limitations of overlearning as a teaching technique have been noted by several educators and psychologists. Carr suggested some forty years ago that overlearning had limited application in verbal learning. He wrote: "After the material is once memorized so that the subject is able to recall it, any additional repetitions are relatively valueless and sometimes may even be detrimental."²⁶ Cuff was also

²⁶Harvey A. Carr, Psychology: A Study of Mental Activity (New York: Longmans, Green and Company, 1925), p. 244.

critical of repetitive practice in learning when he stated:

Pedagogical formulae continue to emphasize drill, exercise, frequency, and repetition after a number of experimentalists have reached the conclusion that repetition is not a selective factor in learning and that the fixing value of overlearning is questionable.²⁷

Following a general review of experiments using meaningful verbal materials, Welborn and English concluded: "While the evidence is neither extensive nor conclusive, it indicates that repetition is not of major importance in logical memory."²⁸ Estes, a leading exponent of all-or-none interpretation of associative learning, wrote:

Although the principle that retention increases with number of reinforcements is exceedingly well established in the lore of human learning, we must face the possibility that this empirical relation, like the classical acquisition curve, is an artifact of the confoundings inherent in the usual experimental paradigm.²⁹

Kozman, while recognizing the need for repetition in motor learning, also suggested its limitation as a teaching technique. She stated:

Repetition to clinch new learnings is essential. We remember what we have learned most thoroughly; we remember those things that are meaningful to us and

²⁷Noel B. Cuff, "The Law of Use," The Journal of Educational Psychology, 20:438, September, 1929.

²⁸E. L. Welborn and Horace English, "Logical Learning and Retention: A General Review of Experiments with Meaningful Verbal Materials," Psychological Bulletin, 34:11, January, 1937.

²⁹W. K. Estes, "Learning Theory and the New 'Mental Chemistry,'" The Psychological Review, 67:220, July, 1960.

we remember those things we do most often. However, repetition of itself does not do the job of perfecting motor skills. Incorrect as well as correct movements can become "fixed" through practice.³⁰

Mursell is strongly against the over use of repetition and overlearning as teaching methods. He wrote:

. . . the most promising way to bring about better learning is decidedly not to increase the sheer number of repetitions. This can be inferred from experiments on overlearning . . . investigations have shown that retention is likely to be somewhat improved by overlearning, but not in direct proportion to the number of additional repetitions.³¹

If the teacher of motor skills believes that the retention of motor skill learning is as important as skill acquisition, then a better understanding of repetition as it relates to the forgetting process is desirable. Where teaching and coaching time is often at a premium, a knowledge of the practice conditions leading to the most economical retention of motor skills would certainly be to the teacher's advantage. The current use of extended repetition and drill as teaching methods by some physical educators and coaches appears to be unsound, in light of the findings of several overlearning studies employing verbal materials. It is very possible that overlearning bores the learner and stifles class enthusiasm; monopolizes class time which might be better spent in learning new skills; and has limited value in

³⁰Hilda C. Kozman et al., Methods in Physical Education (Philadelphia: W. B. Saunders Co., 1958), p. 76.

³¹James L. Mursell, Psychology for Modern Education (New York: W. W. Norton and Co., Inc., 1952), p. 181.

terms of the retention of motor skill. Although overlearning has been suggested as the reason for the strong resistance of motor skills to the forgetting process, the value of its application in the teaching of motor skills remains to be determined. The need for assessing the relationship between degree of learning (repetition) and retention was suggested by Stroud when he wrote:

It goes without saying that material well learned is remembered longer and more effectively than material poorly learned. There is, however, no a priori reason why a given number of repetitions levied after a list has been committed to memory should have the same effectiveness as an equal number imposed in the interest of reaching a criterion; nor is there any way of predicting, except on the basis of empirical data, whether successive over-learning repetitions increase or decrease in effectiveness.³²

Simpson has stated:

Some overlearning is necessary. That is, some learning over and beyond that required to reach the practical standards of performance is essential to inhibit rapid deterioration. No one knows the degree of retention that is made possible by successive practice.³³

The question of how to best utilize overlearning in the teaching of a new motor skill if the best learning and retention are to be achieved, remains to be answered. Further, the question of when to terminate the practice of a motor skill after it has been adequately learned, is also deserving of investigation. A study of the effects of

³²James B. Stroud, Psychology in Education (New York: Longmans, Green and Co., Inc., 1946), p. 526.

³³Robert G. Simpson, Fundamentals of Educational Psychology (Chicago: J. B. Lippincott Co., 1949), p. 230.

overlearning on the retention of a gross motor skill might provide answers to the following questions, answers which could contribute greatly to teaching methodology in physical education.

1. As a motor skill is practiced beyond a fixed level of mastery, do proportionate increments in retention accrue to the learner?
2. In terms of retention, is 200 per cent overlearning of a motor skill twice as good as 100 per cent overlearning?
3. Does the relationship between the degree of learning (as determined by the number of repetitions) and the degree of retention vary with the length of the retention interval?
4. Is there an optimum amount of overlearning practice for a specific gross motor skill?

A systematic and thorough study of the overlearning and retention of a specific gross motor skill could be of considerable benefit to the physical education profession. Because the relationship between the overlearning and retention of a gross motor skill has never been previously exposed to the rigors of experimental investigation, such a study could prove valuable to any teacher interested in providing the best in motor skill teaching.

The Problem

Statement of the problem

The purpose of this study is to determine the effects of four degrees of overlearning on the retention of a gross

motor skill, balancing on the stabilometer. More specifically, the study will attempt to--

1. Compare differences among the four degrees of overlearning (0, 50, 100 and 200 per cent) after retention intervals of one week and one month.

2. Determine whether the amount of retention varies proportionately as the degree of overlearning is increased from 0 per cent to 200 per cent.

3. Determine whether the relationship between degree of learning and retention varies with the length of the retention interval.

Limitations of the study

The study was limited to eighty male freshman students who were enrolled in the required physical education program at The Ohio State University during the winter quarter, 1966. These students were volunteers from this investigator's classes.

Importance of the study

The major reason for undertaking this study is to investigate the concept of overlearning as it affects the retention of a gross motor skill. Although previously studied in investigations using verbal materials and fine motor skills, the use of overlearning as a teaching technique has never been empirically examined in physical education. Whereas overlearning is frequently assumed to

account for the remarkable resistance of motor skills to forgetting, the findings of studies using verbal materials suggest that overlearning leads to diminishing returns when practice is carried considerably beyond the point of learning. This study, therefore, is an attempt to determine the fixing value of overlearning as well as its effect on the retention of a gross motor skill. Its importance lies in the fact that it is the first of its kind and that its findings may have particular relevance for teachers of motor skills.

This study also has importance for the field of physical education in that it focuses attention on the retention of a gross motor skill, an area of research that has received little, if any consideration in the professional literature. While it is generally agreed that the physical educator should be concerned with the learning and retention of motor skills, an understanding of the course of forgetting in motor learning and the practice parameters which lead to the most economical retention of motor skills is noticeably lacking.

A study in overlearning calls into question the use of repetition and drill as teaching techniques. If it can be shown that prolonged repetition of a motor skill does not noticeably improve retention then a contribution will have been made to teaching methodology in physical education. Since some physical educators and coaches are prone to

abusing the use of repetition as a teaching technique, a study of this type takes on added significance.

Often the physical educator and the coach do not have sufficient time to teach their activities in a manner that leads to the optimum learning and retention of motor skills. Where time is of the essence, a better understanding of the advantages and disadvantages of overlearning as a method of skill teaching is desirable. How long should time be spent on the learning of a new skill before another is undertaken is a question the answer to which, might suggest the best means for utilizing class time in order to achieve the best teaching results.

Finally, a study of overlearning, by nature of its experimental design, brings into question the value of relearning periods, spaced review and "refresher" courses in the teaching of motor skills. If it is found that after periods of no practice, motor skills are largely retained, and if partially forgotten, are quickly relearned, then the use of extended practice and drill in the original learning situation are called into question. If relearning does occur quickly, as suggested by Eysenck,³⁴ Ammons,³⁵

³⁴S. B. Eysenck, "Retention of a Well-Developed Motor Skill after One Year," The Journal of General Psychology, 63: 267-273, October, 1960.

³⁵Robert B. Ammons et al., "Long-Term Retention of Perceptual-Motor Skills," Journal of Experimental Psychology, 55:318-328, April, 1958.

Hammerton,³⁶ and Bell,³⁷ then the physical educator is justified in allotting more class time to the learning of several new skills as opposed to the prolonged practice of a few.

Definition of Terms Used

Forgetting. Failure in the persistence of learned behavior.³⁸

Gross motor skill. A skill which involves the movement of large muscle groups and usually results in the whole body being moved.³⁹

Learning. Is the more or less permanent modification of the response or responses to a stimulus or to a pattern of stimuli as a result of experience with this or with similar stimuli.⁴⁰

Motor learning. The rather permanent changes in motor performance brought about through practice.⁴¹

³⁶M. Hammerton, "Retention of Learning in a Difficult Tracking Task," Journal of Experimental Psychology, 66:108-110, July, 1963.

³⁷Bell, op. cit.

³⁸Eileen K. Bender, "The Relationship Between Rate of Learning and Retention of Certain Sensorimotor Skills" (unpublished Master's thesis, The Pennsylvania State University, 1961), p. 7.

³⁹Elwood C. Davis and Earl L. Wallis, Toward Better Teaching in Physical Education (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1961), p. 111.

⁴⁰Delos D. Wickens and Donald R. Meyer, Psychology (New York: Holt, Rinehart and Winston, Inc., 1961), p. 29.

⁴¹Cratty, op. cit., p. 23.

Motor skill. The effective performance of motor movement patterns in terms of the results achieved.⁴²

Novel skill. An original skill that has not been previously attempted by the subject. In this study, the novel skill is balancing on the stabilometer.

Overlearning. Any amount of learning or practice exacted of the subject over and above that required to reach a criterion.⁴³

Relearning. The resumption of practice of a skill after an extended period without practice in an attempt to bring the skill up to or beyond its level at the completion of an earlier practice period.⁴⁴

Retention. The persistence of the effects of previous learning as measured by the utilization of the products of previous learning when the same situation occurs.⁴⁵

Skill. A term used to denote that some learning has taken place and that a smoothing or an integration of behavior has resulted.⁴⁶

⁴²Joanne Black, "An Experimental Study of the Learning of Motor Skill" (unpublished Master's thesis, The Pennsylvania State University, 1949), p. 3.

⁴³Stroud, op. cit.

⁴⁴Bender, op. cit.

⁴⁵Walter S. Monroe (ed.), Encyclopedia of Educational Research (New York: The Macmillan Company, 1950), p. 682.

⁴⁶Cratty, op. cit.

Stabilometer. An apparatus consisting of a horizontally pivoted board upon which the subject stands and attempts to balance it with a minimum of movement. It requires a large amount of almost continuous physical activity and involves large muscle coordination and balance. See Chapter III, Procedures for a description of the apparatus.

Retention interval. The period of no practice intervening between the subject's last practice trial and his first retention test trial.

CHAPTER II

REVIEW OF THE LITERATURE

An investigation of the effects of overlearning on the retention of a gross motor skill has important practical significance for the field of physical education. Where teaching time is often at a premium, it is to the teacher's advantage to know under what practice conditions the most economical retention of the subject matter occurs. Because far too little attention has been focused on the retentive aspects of learning, particularly in the teaching of motor skills, a better understanding of the role of practice and repetition as a teaching technique is desirable. Many studies may be found in the experimental literature related to the effects of amount of practice and overlearning on the retention of a variety of learning materials. Therefore, for the sake of conciseness and facilitation of review, this chapter will be partitioned under the following titles: (A) Retention as a Function of the Amount of Practice and (B) Retention as a Function of Overlearning.

Retention as a Function of the Amount of Practice

The beneficial aspects of practice upon retention have been demonstrated in many studies in the experimental literature. Nevertheless, some studies have questioned the value of practice and repetition upon retention. This section of the review of literature will present investigations which represent a sampling of both findings as well as the wide assortment of experimental materials used thus far to study the effects of varying amounts of practice upon retention. The materials include nonsense syllables, paired-associates, prose, instrumental responses, pursuit rotors, chain assembling and various athletic skills. In order to facilitate the presentation of this section of the survey of literature, it will be divided into two sections: 1) Retention of Verbal Learning as a Function of the Amount of Practice and 2) Retention of Motor Learning as a Function of the Amount of Practice.

Retention of verbal learning as a function of the amount of practice

In an early investigation, Good compared the effectiveness of a single reading with two readings of a passage of social science material read at normal rate. He found that a rereading of the passage was not justifiable in terms of the additional information secured in preference to

spending the same amount of time in reading new material.¹ Peterson and others investigated the effects of reviews on the retention of an historical passage. The first review took place one week after learning and the second, when there was one, was given two weeks after learning. Retention of the passage was tested for after three, six and eighteen weeks. The results showed that two reviews produced large and relatively permanent benefits and were superior to one review.²

English and others compared verbatim and substance memorization for the same passage by the same persons under varied conditions of learning and retention. The true-false test items used to measure recognition memory included questions which reproduced verbatim the words of the passage, while others stated the substance or meaning of the passage (paraphrase learning) in entirely different language. Thus, the two kinds of items permitted comparison of memory for the substance (meaning) with verbatim memory (word for word). Five groups heard the passage read once, twice, three, four and five times, respectively. A test on the passage was given at intervals of one, eight, and seventy-one days. The

¹Carter V. Good, "The Effect of a Single Reading Versus Two Readings of a Given Body of Material," The Journal of Educational Method, 5:325-329, April, 1926.

²H. A. Peterson et al., "Some Measurements of the Effects of Reviews," The Journal of Educational Psychology, 26: 65-72, January, 1935.

authors found that repetition favorably affected immediate and delayed recognition of the verbatim items but had little effect upon the recognition of the substance items. However, with the passage of time, there was a loss in the retention of the verbatim items and a gain in the substance items.³

Slamecka divided one hundred and forty students into six groups and had each group receive a different number of presentations of an original passage. The degree of original learning was varied from one to nine presentations. Following a test for immediate recall, the results showed that the susceptibility of forgetting the passage was inversely related to the degree of original learning.⁴

Smith and McDougall used lists of nonsense syllables to determine whether learning and retention was more successful when the will to learn was operative, or when the influence of quasi-mechanical repetition was favored. One group of learners made an effort to learn the sequence of syllables as quickly as possible while another group relied on learning them by maintaining an attitude of passivity except in so far as each subject was required to read aloud each syllable as it was presented.

³Horace B. English et al., "Studies in Substance Memorization," The Journal of General Psychology, 11:233-260, October, 1934.

⁴Norman J. Slamecka, "Studies of Retention of Connected Discourse," The American Journal of Psychology, 72: 409-416, September, 1959.

Judged by the standards of effective recall and retention over both long and short intervals, the authors found that the greater the passivity, the greater was the number of repetitions required in relearning. It was, therefore, concluded that better retention occurred when original learning involved an active learner and that the effects of passive learning wore off much more quickly.⁵

Luh had ten subjects learn twenty lists of twelve nonsense syllables each under four degrees of learning: 33 per cent learning, 67 per cent learning, 100 per cent learning and 150 per cent learning. The intervals used for measuring retention by reproduction, recognition and reconstruction, varied from one hour to two days. It was observed that the effect of an increase in the degree of learning manifested the phenomenon of diminished returns. While there was an increase in the amount of retention through 100 per cent learning, the 150 per cent learning condition had little if any effect upon retention.⁶

Mibai found no evidence of diminishing returns in an investigation into the effects of repetition in retention using lists of twelve nonsense syllables read two, four, six, eight, and ten times. All of the subjects returned twenty-four

⁵May Smith and William McDougall, "Some Experiments in Learning and Retention," The British Journal of Psychology, 10:199-209, March, 1920.

⁶C. W. Luh, "The Conditions of Retention," Psychological Monographs, Vol. 31, No. 3, 1922, pp. 1-87.

hours after learning and relearned the list to one perfect reproduction. The results showed a straight line relationship between number of repetitions and retention in the approximate ratio of one repetition saved in relearning for every three repetitions given in original learning.⁷

The influence of degree of learning upon retention was observed by McGeoch in a retroactive inhibition design. Lists of nine nonsense syllables were learned by the anticipation method, the degree of learning varying according to the number of presentations of each list. The five different numbers of presentations used were six, eleven, sixteen, twenty-one and twenty-six. A second list was presented eleven times following the presentation and learning of the first list, and was followed in turn by the relearning of the original list. The results indicated that the amount of interference provided by the second list varied inversely with the number of presentations given the first list.⁸ Briggs also investigated the effects of degree of original learning in a retroactive inhibition design, except two lists of ten paired-adjectives were used instead of nonsense syllables. Eighty subjects learned the lists to four degrees of learning (two, five, ten and twenty trials) and five degrees of interpolated

⁷Sugi Mibai, "The Effects of Repetitions Upon Retention," Journal of Experimental Psychology, 5:147-151, April, 1922.

⁸John A. McGeoch, "The Influence of Degree of Learning Upon Retroactive Inhibition," The American Journal of Psychology, 41:252-262, April, 1929.

learning (zero, two, five, ten and twenty trials). Retention was based on five relearning trials of the original list and was measured by modified free recall, traditional recall and relearning. The results showed that as the degree of original learning was increased, the recall functions became more extensive in slope and the over-all level of recall increased thus substantiating McGeoch's findings.⁹

Underwood and Keppel tested retention as a function of degree of learning and letter-sequence interference. Two paired-associate lists, each consisting of nine pairs and differing in initial associative strength, were learned to six degrees of learning (two, four, six, ten, fifteen and twenty-five trials). Retention was determined by five relearning trials given one day and seven days after learning. The results gave no support to the letter-sequence hypothesis which predicts more rapid forgetting for the list with the lower initial associative strength. However, it was also observed that while the relationship between degree of learning and recall was not regular, in general, as the degree of learning increased the percentage of recall increased.¹⁰

⁹George E. Briggs, "Retroactive Inhibition as a Function of the Degree of Original and Interpolated Learning," Journal of Experimental Psychology, 53:60-67, January, 1957.

¹⁰Benton J. Underwood and Geoffrey Keppel, "Retention as a Function of Degree of Learning and Letter-Sequence Interference," Psychological Monographs: General and Applied, 77: 1-16, No. 4, 1963.

Ward found support for the common generalization that practice favorably affects retention in a study which had twenty-four subjects learn twelve unit lists of nonsense syllables to different degrees of learning. One group carried learning to the trial on which every item was correctly anticipated, while the second group stopped learning after the first trial on which seven of the twelve syllables were correctly anticipated. Retention was tested after intervals of thirty seconds, two, five, ten and twenty minutes. The author found that at intervals of ten minutes or more, retention, as measured by recall and by savings scores, was directly related to the degree of learning, the lesser the degree of learning, the lesser the retention.¹¹

Kintz employed an easy paired-associates task to investigate short-term retention and long-term retention as a function of practice. Sixty-six subjects received either one, two, three, four or five repetitions of the task followed by three short-term retention intervals of zero, two and four seconds and then three relatively long-term retention intervals of thirty-two, forty-four and fifty-six seconds. The results showed that forgetting decreased as the

¹¹Lewis B. Ward, "Reminiscence and Rote Learning," Psychological Monographs, 49:1-64, No. 4, 1937.

number of repetitions increased. It was concluded by the author that relatively long-term retention improved with practice.¹²

The role of repetition in the formation of verbal associations has been the focus of considerable discussion and debate. On a theoretical level, the issue has centered about two conceptions of the associative process--growth by successive increments versus all-or-none change. The incremental theory asserts that each successive trial adds to the strength of an association, provided the conditions required for the reinforcement of a habit are met. By contrast, the all-or-none theory asserts that on any one trial associations are either fully formed or do not grow at all. The apparent beneficial effects of repetition apply to the acquisition of a series but not to the formation of individual associations.¹³

The five studies which follow are all concerned with the role of repetition in associative learning and are included in this section of the survey of literature because they are relevant to the question of how varying degrees of practice affect retention.

¹²B. L. Kintz, "Short-Term Retention and Long-Term Retention as a Function of Practice," The Journal of Psychology, 72:612-613, December, 1959.

¹³Leo Postman, "Repetition and Paired-Associate Learning," American Journal of Psychology, 75:372-389, September, 1962.

Rock had groups of twenty-five college students each learn lists of twelve letter-number pairs and lists of eight pairs of nonsense syllables to a criterion of one errorless trial. For the experimental groups, a pair was either learned the first time it was seen or it was removed if incorrect and replaced by another pair. For the control groups, the same list of paired-associates was continually presented until a criterion of one errorless trial was reached. The results of a recall test given after every trial showed no significant differences in rate of learning between the two groups. The author concluded that repetition played no role in the formation of associations, other than that of providing the occasion for new ones to be formed on a single trial.¹⁴ Wogan and Waters used Rock's experimental procedure and compared the performance of a control group which learned a constant set of stimulus-items and an experimental group for which new pairs replaced those missed on any trial. Two groups of college students were required to master a list of ten pairs to a criterion of one errorless trial. One week later, the subject recalled and relearned the same list. The results showed that the experimental group not only learned as

¹⁴Irvin Rock, "The Role of Repetition in Associative Learning," The American Journal of Psychology, 70:186-193, June, 1957.

rapidly as the control group but also showed significantly better retention.¹⁵

Clark and others duplicated Rock's experimental methodology and had thirty subjects memorize twelve stimulus cards (a combination of letters and numbers) by the method of paired-associates to a criterion of one correct recall. Again, there was no difference between the experimental subjects (substitution learning) and the control subjects (repetition learning) on trials to reach the learning criterion. Six months later, the subjects were recalled and relearned the series they had previously mastered. The differences, although not highly significant, were in the direction of the experimental subjects, thus suggesting to the authors that the retention of paired-associates is superior in single-trial learning.¹⁶

In a series of four experiments, Battig evaluated the effect of repetition of previously incorrect pairs in paired-associate learning in which each subject learned a single paired-associate list consisting of two equivalent subsets of pairs. In Experiments I, II, and III, each of fifteen subjects learned under conditions whereby the repetition

¹⁵Michael Wogan and Rolland H. Waters, "The Role of Repetition in Learning," The American Journal of Psychology, 72:612-613, December, 1959.

¹⁶Lester L. Clark et al., "Repetition and Associative Learning," The American Journal of Psychology, 73:22-40, March, 1960.

subset consisted of the same pairs repeated on all trials, while pairs of the non-repetition subset were retained in the list only if responded to correctly. In Experiment IV, all non-repetition pairs were presented only for a single trial and were then replaced after each trial by another equivalent subset of six pairs, while the repetition subset included both old pairs responded to incorrectly and new pairs. Tests for retention following the last trial in three of the four experiments showed significant differences in favor of the repetition conditions. It was, therefore, concluded that association formation is not an all-or-none process, but instead builds up gradually through repetition.¹⁷

Finally, Postman sought to determine whether Rock's results might reasonably be attributed to artifacts of procedure. Two experiments were performed in which Rock's method of investigating one-trial learning was examined, with the exception that two control groups were used, one of which learned the initial lists of the experimental subjects (substitution learning) and the other learned the terminal lists in order to assess the amount of systematic selection of easy items. The results showed that the experimental groups learned significantly more slowly than the control

¹⁷William F. Battig, "Paired-Associate Learning Under Simultaneous Repetition and Nonrepetition Conditions," Journal of Experimental Psychology, 64:87-93, July, 1962.

groups (repetition learning). The author concluded that Rock's design for testing the hypothesis of one-trial learning was questionable.¹⁸

Underwood manipulated the degree of original learning under massed and distributed conditions for both serial lists of nonsense syllables and paired-adjective lists. For both types of lists, a low degree of learning was obtained by presenting the list until the subject achieved seven correct responses out of thirteen syllables on a single trial. For the moderate degree of learning, the list was presented until one perfect recitation was given. For the high degree of learning, the list was presented until one perfect trial was achieved, and then seven additional trials were added. Relearning of all lists took place after twenty-four hours. The results showed that the only variable which proved significant for both kinds of material in relearning was degree of original learning. The greater the degree of original learning, the faster was the relearning.¹⁹

Stavrianos conducted an experiment in order to determine the effect of frequency of repetition on retention when separate items within a list were given different amounts of practice. One hundred and seventy-seven subjects memorized a

¹⁸Postman, op. cit.

¹⁹Benton J. Underwood, "Studies of Distributed Practice: XII. Retention Following Varying Degrees of Original Learning," Journal of Experimental Psychology, 47:294-300, May, 1954.

list of meaningful sentences, of which, one sentence was given two successive repetitions and the other, seven successive repetitions. For the control group, all the items within one list were practiced equally. Retention of the test sentences was determined by a learning test, spontaneous recall and prompted recall. The author found that the relationship between amount of practice and degree of retention did not follow the "law of frequency." The factor of inhomogeneity was thought to afford a partial explanation why the more practiced items were not better retained than the less practiced items.²⁰

Reynolds and Glaser studied the effects of repetition and spaced review upon the retention of a complex meaningful learning task. By means of programmed instruction, the topic, Mitosis, was presented to three general science classes under three repetitive conditions. Eleven critical terms relating to the topic were varied in terms of the number of times they were repeated in the programmed sequence. The spaced review condition was obtained by including a section which spaced out the eleven critical terms over several topics rather than presenting them intact. The results of retention tests given two days and three weeks after learning showed that variations in repetitions had only transitory effects

²⁰Bertha K. Stavrianos, "An Experimental Investigation of Retention When Items Within a List are Given Different Amounts of Practice," The Journal of General Psychology, 28:277-295, April, 1943.

upon retention, but that spaced review produced a significantly better retention of the reviewed material.²¹

Summary. Of the four studies presented and reviewed in this part of the survey of literature which studied the effect of repetition on the retention of a passage of prose, all but one found repetition beneficial. Increases in the degree of original learning appeared to be best for the immediate recall of verbatim items as opposed to summary items. With respect to the studies which investigated the effects of repetition on the retention of nonsense syllables, it was generally concluded that increases in the number of repetitions during original learning yielded increases in retention, although there appeared to be a phenomenon of diminishing returns operating in some instances. One study underscored the importance of the subject's effort if repetition is to have a positive influence upon retention. Two studies which investigated the influence of degree of original learning upon retention within a retroactive inhibition design, both concluded that the inhibition varied inversely as the number of presentations of the original learning material increased. The five studies presented on the subject of repetition and associative learning showed three in favor of an all-or-none theory and two in favor of an

²¹James H. Reynolds and Robert Glaser, "Effects of Repetition and Spaced Review Upon Retention of a Complex Learning Task," The Journal of Educational Psychology, 55: 297-308, October, 1964.

incremental theory. The more recent evidence seemed to suggest that the favoring of the all-or-none theory may have been due to an artifact in experimental procedure.

Two studies, one in which the items within a list of meaningful sentences were given different amounts of practice, and the other, which compared repetition and spaced review on the retention of a complex learning task, both found repetition to have little effect upon retention.

Retention of motor learning
as a function of the amount
of practice

Henshaw and Holman employed three groups of thirty subjects each on chain assembling, a task requiring manual dexterity, for a training period of eighty minutes each morning for eight consecutive days. In the afternoon, Group I had another period of eighty minutes of chain assembling; Group II had eighty minutes of cartridge filling (a related task); and Group III was not employed. An analysis of performance of all three groups at the termination of training disclosed almost identical practice curves in spite of the fact that Group I had actually twice as much training as Groups II and III.²²

Mote and Finger trained four groups of eleven rats each in a simple runway problem with four, eight, sixteen

²²Edna M. Henshaw and Portia G. Holman, "A Note on Over-Training," The British Journal of Psychology, 20:333-335, April 1930.

and thirty-two acquisition trials, respectively. Reinforcement was given at the end of each acquisition trial. Twenty-four hours after the last acquisition trial, each rat was tested for retention as determined by latency of response. The results showed that although latency at the end of acquisition was a function of the number of reinforced trials, the average speed of response twenty-four hours later was independent of this factor; all groups responded with virtually identical latencies.²³

Fox and Young, although mainly interested in the effect of reminiscence on learning two badminton skills, also observed the effects of two different periods of instruction, six weeks and nine weeks, on the retention of two badminton skills after nonpractice periods of six weeks and twelve weeks. Based on the results obtained from eighty-eight girls, the authors concluded that an additional three weeks of instruction did not contribute significantly to the long-term retention of the two badminton skills.²⁴

Wagner investigated the effects of different lengths of practice (different numbers of repetitions) on the acquisition and retention of four basketball skills. Forty-two

²³Frederick A. Mote Jr., and Frank W. Finger, "The Retention of a Simple Running Response after Varying Amounts of Reinforcement," Journal of Experimental Psychology, 33: 317-322, October, 1943.

²⁴Margaret G. Fox and Vera P. Young, "Effect of Reminiscence on Learning Selected Badminton Skills," The Research Quarterly, 33:386-394, October, 1962.

seventh grade boys practiced a different number of repetitions on the gross motor skills of field goal shooting, speed dribble, wall bounce and free throw accuracy over a period of six weeks. The results of a retention test administered three weeks after the final practice session showed that none of the mean performance score differences were significant, therefore, leading the author to conclude that after some skill has been developed, relatively short periods of practice (relatively few repetitions) are just as valuable as relatively long practice periods in the learning and retention of gross motor skills.²⁵

The influence of degree of learning upon retention was observed by Duncan and Underwood in a proactive inhibition design. Specifically, the authors investigated the retention of transfer between two tasks as a function of the degree of learning of the first task and the similarity between the two tasks after intervals of twenty-four hours and fourteen months. The testing apparatus involved the association of six colored-light stimuli into six radially arranged slots and required both paired-associates learning and hand steadiness. One pattern of light-slot pairs was defined as Task I while Task II was provided by pairing the lights with different slots. Inter-task similarity was varied by

²⁵Cloyd G. Wagner, "The Effect of Different Lengths of Practice on the Learning of Certain Basketball Skills among J.H.S. Boys" (unpublished Master's thesis, Temple University, 1962).

alternating the number of lights paired with new slots on the second task. The four degrees of learning Task I were ten, forty, eighty and one hundred and eighty trials followed by sixty trials on Task II.

The authors found that after twenty-four hours, the four experimental groups did not differ in their recall of Task II. Following the fourteen month interval, it was noted that while the forgetting of Task II did not vary with the degree of learning Task I, as measured by absolute recall, forgetting of Task II did occur as the mastery of Task I increased when retention was measured by relative proactive inhibition.²⁶

Jahnke studied retention in motor learning as a function of amount of practice and rest. Two hundred and forty high school students practiced either one, two and one-half, five or ten minutes on the pursuit rotor with ten minutes, one day or one week of interpolated rest between work sessions. Following the interpolated rest, all subjects were given three minutes of post-rest practice. The author found that the degree of learning was associated with increases in performance at both initial and final stages of post-rest practice.²⁷

²⁶Carl P. Duncan and Benton J. Underwood, "Retention of Transfer in Motor Learning after 24 Hours and after Fourteen Months," *Journal of Experimental Psychology*, 46:445-452, December, 1953.

²⁷John C. Jahnke, "Retention in Motor Learning as a Function of Amount of Practice and Rest," *Journal of Experimental Psychology*, 55:270-273, March, 1958.

Naylor, Briggs and Reed investigated the variables, amount of training, task organization, and length of the retention interval, and their effects upon the long-term retention of a criterion task composed of two subtasks. One subtask, a procedural task, involved the learning of discrete responses to discrete stimuli (an abstraction of tasks employed in aircraft and manned aerospace), while the other subtest consisted of a 3-dimensional compensatory display. Two levels of each variable were studied--two and three weeks of training (50 per cent more training), high and low organization of the procedural task, and one and four week retention intervals.

The authors found that the amount of training had a significant influence upon the degree of measured retention loss as did task organization under conditions of lesser training. Absolute retention of both subtests was found to be generally related to all three variables although amount of training appeared to be the more important variable of the three.²⁸

Summary. The results of the seven studies presented in this section of the literature show a definite lack of agreement which can be partially accounted for by differences

²⁸James C. Naylor, George E. Briggs and Walter G. Reed, The Effects of Task Organization, Training Time, and Retention Interval on the Retention of Skill. Technical Documentary Report No. AMRL-TDR-62-107, Laboratory of Aviation Psychology, The Ohio State University, Columbus, Ohio, September, 1962.

in experimental design, the use of different measures of retention and retention intervals and the testing of different motor skills and abilities. Three of the studies found extra practice to have no effect on the retention scores of subjects required to do chain assembling (a task of manual dexterity) as well as learn badminton and basketball skills. One experiment which employed rats as subjects, found extra training trials to have no influence on the retention of an instrumental response. Three of the studies presented in this section found that increasing amounts of practice facilitated the retention of motor skill performance. In one experiment, which had subjects learn a paired-associates motor task in a proactive inhibition design, it was observed that the type of retention measure selected and the length of the retention interval were important factors in determining the relationship between degree of learning and retention. Another experiment which made use of pursuit rotor performance, found subject performance to be positively influenced by the degree of learning at both the initial and final stages of post-rest practice. In the third experiment, it was observed that the amount of training on a task requiring hand manipulation and coordination such as that demanded in an aircraft, significantly influenced the retention of the task after one and four weeks of no-practice.

The studies in this section of the literature would seem to suggest that the exact relationship between amount of

training and retention is not fully understood when the learning of motor tasks and athletic skills are involved. It remains for future investigations to specify this relationship more explicitly before the present research on this topic can be accurately summarized.

Retention as a Function of Overlearning

Overlearning, as the term is used in this study, refers to the procedure of continuing practice after some material has been learned to an arbitrary point of mastery. Although it is usually taken for granted that the tasks we remember best are the ones we overlearn the most, experimental verification of the effects of overlearning upon retention are comparatively few in number. This section of the review of literature will present investigations representing the wide assortment of experimental materials and procedures used thus far to study the effects of overlearning upon retention. These materials include nonsense syllables, paired-associates, consonants, digits, nouns, prose, mazes, piano playing and tracking tasks. In order to facilitate the presentation of this section of the review of literature, it will be divided into two sections: 1) Retention of Verbal Learning as a Function of Overlearning and 2) Retention of Motor Learning as a Function of Overlearning.

Retention of verbal learning
as a function of overlearning

The publication by Ebbinghaus in 1885 of the results of his experimental investigation of memory marked the first application of precise scientific method to the study of the "higher mental processes." In order to test the relationship between number of repetitions and retention, Ebbinghaus, acting as his own subject, memorized lists of sixteen nonsense syllables each, by reading each list a given number of times and then, twenty-four hours later, relearned each list to the point of one errorless recall. He repeated the first reading eight, sixteen, twenty-four, thirty-two, forty-two, fifty-three and sixty-four times, achieving a great amount of overlearning in the process. Ebbinghaus found that for each three additional repetitions spent on any given day on the study of a series, he saved, in learning that series twenty-four hours later, on the average, approximately one repetition. Directing his attention to the effects of extreme amounts of overlearning upon retention, Ebbinghaus concluded that the proportion of one repetition saved in relearning for every three repetitions of additional learning gradually ceased to hold with a decided increase in the number of repetitions.²⁹

²⁹Hermann Ebbinghaus, Memory: A Contribution to Experimental Psychology (English translation by Henry A. Ruger and Clara E. Bussenius), New York: Teachers College, Columbia University, Educational Reprints No. 3, 1913.

Cuff attempted to ascertain whether there was an approximate proportionality between the number of readings of a series and the saving of work in relearning the same series to a criterion of one perfect reproduction. Fifty-four subjects memorized testing material which included consonants, digits, and nonsense syllables. The learning of a particular list was continued until the material had been read four, sixteen, or twenty-eight times more than was necessary for the first errorless repetition. After twenty-four hours, the subject relearned the set of materials to the same criterion of one perfect recitation. Cuff found that there was no approximate proportionality between the number of readings of a series and the saving of work made possible thereby. He concluded that more practice after a series is learned may do good, may be wasted, or may be detrimental to retention.³⁰

Krueger investigated the effect of overlearning lists of nouns upon retention by employing three degrees of learning--100 per cent learning, 50 per cent overlearning, and 100 per cent overlearning. The retention intervals following learning for the twenty subjects used in this experiment were one, two, four, seven, fourteen and twenty-eight days. Retention was tested by anticipatory verbal recall and by the saving method. Krueger found that at least 50 per cent overlearning was highly economical from the standpoint of

³⁰Noel B. Cuff, The Relation of Overlearning to Retention (Nashville, Tennessee: George Peabody College for Teachers, 1927).

retention for intervals of two to twenty-eight days and that the larger the interval, the greater was the economy. Further increases of overlearning proved to be uneconomical for most intervals.³¹

Postman also studied retention as a function of degree of overlearning but used naive subjects instead of the well-trained subjects employed in Krueger's study. The experimental material consisted of lists of twelve two-syllable nouns learned to the criterion of one errorless reproduction by three degrees of overlearning--zero per cent overlearning, 50 per cent overlearning and 100 per cent overlearning. Seven days after the end of original learning, the lists were relearned to the criterion. The results showed that there were clear increases in the retention of the lists after 100 per cent overlearning and it was therefore concluded:

While progressive increases in degree of overlearning must eventually yield diminishing returns, this point will be reached more slowly when naive subjects are used and the beneficial effects of continuing practice are measured by the amount of recall.³²

Gilbert investigated the changes which occurred in the retention of meaningful prose by twenty-seven male subjects after 100 per cent learning, 100 per cent overlearning,

³¹William C. Krueger, "The Effect of Overlearning on Retention," Journal of Experimental Psychology, 12:71-78, February, 1929.

³²Leo Postman, "Retention as a Function of Degree of Overlearning," Science, 135:666-667, February, 1962.

and 200 per cent overlearning. Overlearning was established and controlled for by dropping out one item when it was (1) learned to the criterion of one correct recall, (2) learned to the criterion of two successive recalls, or (3) learned to the criterion of three successive recalls. Recall tests for the passage of prose were administered at fifteen minutes, twenty-four and forty-eight hours after learning. The results showed that the phenomenon of diminishing returns, as first noticed in an early study by Cuff, did not appear since proportionally, greater amounts of retention increments took place within overlearning increments from 100 to 200 per cent overlearning than from zero to 100 per cent overlearning.³³

Wollen used paired-associates (consonant syllables paired randomly with nouns) to examine the effect of overlearning upon immediate and delayed retention. Eighteen subjects learned lists of twelve paired-associates in such a way that immediately following each test trial, all correct items were replaced by new ones of equal difficulty. Training continued until either one of three criteria were met and then was followed by a recall test of the original twelve items present on the first trial. Half of the subjects were then given another test on the original list and dismissed. The remaining subjects were then given ten additional learning

³³Thomas F. Gilbert, "Overlearning and the Retention of Meaningful Prose," The Journal of General Psychology, 56: 281-289, April, 1957.

trials to produce an overlearning condition. The next day, all subjects were given five successive test trials on the original twelve items presented the previous day. The major finding of this experiment was that the effects of overlearning upon immediate and delayed retention significantly favored the subjects given overlearning and therefore was in favor of an incremental point of view.³⁴

Hulicka and Weiss also used paired-associates (a geometric design paired with a three-letter man's name) in their investigation of the effects of overlearning upon retention. Ten elderly subjects, after learning nine paired-associates to a criterion of one errorless trial, received additional training amounting to 40 per cent of the trials to criterion. Another group of ten elderly subjects served as a control group and received no further training. Retention was measured after five minutes, twenty minutes, and one week intervals. The results showed that trials beyond the criterion did not enhance the retention scores of the elderly subjects and may have introduced a negative motivational factor.³⁵

Summary. The results of the studies presented in this section of the review of literature indicate that the

³⁴Keith A. Wollen, "One-Trial Versus Incremental-Paired Associate Learning," Journal of Verbal Learning and Verbal Behavior, 1:14-21, July, 1962.

³⁵Irene M. Hulicka and Robert L. Weiss, "Age Differences in Retention as a Function of Learning," Journal of Consulting Psychology, 29:25-129, April, 1965.

retention of verbal learning is enhanced by overlearning, although there does appear to be some evidence for a phenomenon of diminishing returns operating when practice is considerably prolonged. The advantages of overlearning were evident in studies using nonsense syllables, nouns, meaningful prose and paired-associates. It was suggested in one study that 50 per cent overlearning is most economical with intervals up to twenty-eight days. However, one study found overlearning beneficial up to 100 per cent and another found 200 per cent overlearning advantageous. In neither case was the phenomenon of diminishing returns observed. Only one study, that by Cuff, suggested that overlearning might be detrimental to retention. Proof was also provided in one study that overlearning favors an incremental theory of learning but is incompatible with all-or-none theory of learning. Finally, the age of the subject was suggested in one study as having an important bearing on the effects of overlearning on retention; overlearning may serve as a negative motivational factor for an elderly subject.

Retention of motor learning as a function of overlearning

Rubin-Rabson compared two forms of mental rehearsal with keyboard overlearning on the retention of nine musical piano pieces. Nine adult subjects, all skillful pianists, learned the piano music by three different procedures. The first, introduced a four-minute period of mental rehearsal

after five keyboard trials, then continued the keyboard trials to the criterion of perfect memorized performance. The second, carried the keyboard trials to the criterion, then added four minutes of mental rehearsal. The third, like the second, reached the keyboard criterion, then added extra keyboard trials for four minutes of overlearning practice. Retention was tested after two weeks and again, after seven months. The author found that overlearning was no more economical than no overlearning at all because the mid-way period of mental rehearsal produced retention scores which were as good as that offered by the overlearning procedure.³⁶

In a later study, Rubin-Rabson compared three degrees of overlearning upon the retention of piano music. Nine skilled pianists learned nine compositions under three conditions of overlearning. After the criterion of one smooth memorized trial was reached, the trials were continued past this point to either a 50, 100, or 200 per cent overlearning condition. Retention of the memorized music was measured after two weeks and again, after seven months. The results showed that the 100 and 200 per cent overlearning procedures were no more effective than 50 per cent overlearning. The author concluded that degrees of overlearning greater than 50 per cent were apparently ineffective for retention, thus

³⁶Grace Rubin-Rabson, "Studies in the Psychology of Memorizing Piano Music. VI: A Comparison of Two Forms of Mental Rehearsal and Keyboard Overlearning," The Journal of Educational Psychology, 32:593-602, November, 1941.

agreeing with Krueger's findings in an early study dealing with the overlearning of lists of nouns.³⁷ Naylor and Briggs have pointed out, however, that the Graeco-Latin square analysis used by Rubin-Rabson in the treatment of her data has been a misused technique in statistics in that it requires the experimenter to make many assumptions regarding the absence of higher-order interactions with column and row effects. They wrote:

If these interactions do exist, they will, in many cases, tend to disguise main effects that are, in fact, significant. That this may have occurred with the Rubin-Rabson series of experiments is indicated by the perpetual lack of significance obtained for any of the primary variables of interest.³⁸

Krueger in a later study, had six groups of thirty-two college students each, practice tracing eight finger mazes of equal difficulty to four degrees of learning--100 per cent learning, and 50, 100, and 200 per cent overlearning. The subjects were required to relearn the appropriate finger maze to the 100 per cent degree learning criterion after retention intervals of one, two, three, four, seven, and fourteen days. The author found that overlearning was economical and that the increase from the 50 per cent degree

³⁷Grace Rubin-Rabson, "Studies in the Psychology of Memorizing Piano Music. VII: A Comparison of Three Degrees of Overlearning," The Journal of Educational Psychology, 32: 688-696, December, 1941.

³⁸James C. Naylor and George E. Briggs, Long-Term Retention of Learned Skills: A Review of the Literature, ASD Technical Report 61-390, Aeronautical Systems Division, Wright-Patterson Air Force Base, Columbus, Ohio, August, 1961.

of overlearning to the 100 per cent degree was proportionally more economical than the increase from 100 per cent learning to 50 per cent overlearning. With respect to 200 overlearning, Krueger found that the increase from 100 per cent overlearning to 200 per cent overlearning was not as economical as the increase from 50 per cent to 100 per cent overlearning.³⁹

Ammons and others carried out a series of experiments which investigated the long-term retention of perceptual-motor skills. In one of their experiments, subjects were trained on a complex type of compensatory type of pursuit skill under one hour and eight hours of training. After no-practice intervals of one day, one month, six months, one year and two years, the subjects were tested for retention and retrained for two hours. The results of these subjects were compared with the results of a group of six subjects who were given forty-eight hours of training and retrained after a no-practice interval of one year. A comparison of both groups clearly showed that as far as the time-on-target measure of proficiency was concerned, overlearning was not detectably helpful.⁴⁰

³⁹William C. Krueger, "Further Studies in Overlearning," Journal of Experimental Psychology, 13:152-163, 1930.

⁴⁰Robert B. Ammons et al., "Long-Term Retention of Perceptual-Motor Skills," Journal of Experimental Psychology, 55:318-328, April, 1958.

Hammerton also examined the retention of a difficult tracking skill under overlearning practice conditions. Two groups of nine subjects each, were given five trials per day until each had reached two learning criteria. Trials with Group B subjects then stopped but Group A subjects were then given ten trials per day until they had achieved a learning criterion requiring from 90 to 170 additional learning trials. For all subjects, re-testing began twenty-six weeks after their last learning trial and was continued until all subjects had again reached the first two learning criteria. The results showed that while overlearning improved initial recall, recovery was very rapid for both groups. It was therefore concluded that in cases where recall is important, overlearning of difficult tasks is recommended; when time for a "refresher course" is available, overlearning is not necessary.⁴¹

One of the problems considered by Hubbert in her investigation of the relationship between age and learning capacity was whether the continuance of practice after the solving of a problem would lead to a better retention of the solution to the problem. Rats which had learned the successful navigation of a maze were caused to continue their runs in a maze for more than one hundred and sixty trials after

⁴¹M. Hammerton, "Retention of Learning in a Difficult Tracking Task," Journal of Experimental Psychology, 66: 108-110, July, 1963.

learning was complete. The author found that final efficiency decreased rather than increased when practice was continued beyond learning. It was concluded that the results of the experiment questioned the fixing value of overlearning since continued practice after the problem was learned caused a break in the habit and did not result in an increase in final efficiency.⁴²

Summary. The relationship between the overlearning and retention of motor skills does not appear to be as well-defined as it is for the overlearning of verbal materials. In one study, comparing the overlearning of keyboard trials with an equal amount of mental practice, the latter was found superior for retention. Overlearning was also not detectably helpful in the learning of a perceptual-motor skill. In another study, the immediate recall of a difficult tracking task was enhanced by overlearning, but the author suggested that when there is sufficient time provided for relearning, overlearning is not a necessary practice procedure. Two studies did find overlearning beneficial in terms of retention, one using piano playing as the learned skill, the other requiring the mastery of finger mazes. The results showed that 50 per cent overlearning of keyboard trials and 100 per cent overlearning of finger mazes led to better

⁴²Helen B. Hubbert, "The Effect of Age on Habit Formation in the Albino Rat," Behavior Monographs, 2:1-55, No. 6, 1915.

retention of both skills. Finally, in an experiment using rats as subjects, overlearning was observed to have no effect on the retention of maze learning; the fixing value of overlearning being seriously questioned.

CHAPTER III

PROCEDURES

The purpose of this study was to compare the effects of four degrees of overlearning on the retention of a gross motor skill requiring coordination and balance. Included in this chapter are the methods and procedures relating to each of the following: selection of subjects, construction of the stabilometer, measurement of the subject performance, practice procedure, overlearning practice, retention intervals, assignment of subjects to overlearning and retention groups, and measurement of retention. The skill was taught, practiced and tested in a small room located in the Research Laboratory of the Department of Men's Physical Education, The Ohio State University.

Selection of Subjects

Eighty students enrolled in the required physical education program at The Ohio State University served as subjects for the study. These students were volunteers from the classes which the writer instructed during the winter quarter, 1966. The random population of subjects selected for participation in the study was limited to only those subjects who

reached a learning criterion in no less than four trials nor more than twenty trials. It was felt that any subject who required less than four trials to reach the learning criterion was too skilled and therefore inappropriate for a study requiring the learning of a novel skill. On the other hand, any subject who required more than twenty trials to reach the learning criterion was considered a non-learner and also eliminated from the study. Of a total of one hundred and three volunteers, twenty subjects found the skill too easy and three subjects found the skill too difficult. All were eliminated from the study thus leaving eighty subjects who started and finished the study.

Construction of the Stabilometer

The stabilometer used in this study was a modified version of one built by Turvey¹ which in turn, was based on a design by Mumby² and Bachman.³ This instrument consisted of a horizontally pivoted board, 41 inches by 21 inches, upon which the subject stood. It was connected to the axle of

¹Michael T. Turvey, "The Effects of Change in Environment upon the Posttest Performance of a Gross Motor Skill" (unpublished Master's thesis, The Ohio State University, 1964).

²H. H. Mumby, "Kinesthetic Acuity and Balance Related to Wrestling Ability," The Research Quarterly, 24:327-334, October, 1953.

³John C. Bachman, "Specificity vs. Generality in Learning and Performing Two Large Muscle Motor Tasks," The Research Quarterly, 32:3-11, March, 1961.

rotation by two triangular supports attached to the board on its length sides. The unit of the board and the two triangular supports was the only movable section of the stabilometer, the rest of the instrument functioned as supporting framework. The entire stabilometer measured 46 inches in length, $43\frac{1}{2}$ inches in width, and $23\frac{1}{2}$ inches in height. The axle of rotation passed through a point just below the apex of each triangle. The board was positioned 10 inches below the center of the axle of rotation. The horizontal board was restricted in its range of movement by two wooden beams located underneath each end of the board. The two beams were placed two inches below each end of the horizontal board and were attached crosswise, to the supporting structure. The two beams were positioned so as to allow approximately eight to nine degrees of movement before contact was made between the horizontal board and either wooden beam.

Two normally closed switches were attached, one each, to the center of each wooden beam. The switches in turn were wired in series with a time recording device (hereafter referred to as a clock), manufactured by The Standard Electric Time Company, Springfield, Massachusetts. Any contact between the horizontal board and either of the two switches, each raised one-eighth of an inch above the surface of each beam, broke the circuit in the clock. In this way, no time was registered during such periods when the subject had the board completely out of balance and against either wooden

beam. As long as the horizontal board was free of contact with both switches, the circuit in the clock remained closed and the number of seconds that the subject remained on balance was recorded. The clock was calibrated to measure time to $1/100$ of a second.

An electrical timer, manufactured by the Industrial Timer Corporation, Newark, New Jersey, was preset for thirty seconds and wired to the clock in such a way that the depression of a button on the timer closed the circuit in the clock thus allowing the current to flow. At the end of thirty seconds, the circuit in the clock was broken by the timer which then automatically reset itself. See Figure 1.

The writer recognized an error in the timing apparatus caused by the failure of the one-second timer to break the circuit in the $1/100$ of a second clock after thirty seconds. In order to determine the extent of this error, the writer recorded 200 deviations of the timing apparatus from thirty seconds before the start of the experiment, and again, after the termination of the experiment. The mean deviation for 200 deviations recorded before the start of the experiment was $+.029$ and the mean deviation for 200 deviations recorded after the termination of the experiment was $-.048$. It was felt that while the timing apparatus was not without error, it was sufficiently reliable for the purposes of the study. In other words, it was the writer's opinion that whatever the error in the timing apparatus, it was randomly distributed

FIGURE 1

STABILOMETER AND APPARATUS USED TO MEASURE
THE SUBJECT'S BALANCING PERFORMANCE

The stabilometer and apparatus used to measure the subjects balancing performance consisted of the following: (A) horizontal board; (B) triangular support; (C) wooden beam; (D) pivot bar; (E) clock; (F) timer; and (G) stop watch.

among all experimental groups and that no one group was treated any differently than the others.

Measurement of Subject Performance

After each trial on the stabilometer, the number of seconds that the subject successfully balanced the horizontal board was recorded on an appropriate score card to the nearest one-hundredth of a second.

The learning criterion for performance on the stabilometer was set at a minimum of twenty-eight seconds of being on balance in one thirty-second trial. As soon as the subject met the learning criterion on a given practice trial (provided it was not on the first three trials or after the twentieth trial), it was assumed for the purposes of this study that he had successfully learned the skill of balancing on the stabilometer.

The minimum learning criterion of twenty-eight seconds was chosen in order to facilitate the learning of the skill in approximately ten trials. For this reason, the two wooden cross beams were set two inches below each end of the horizontal board thus allowing the subject approximately eight to nine degrees of free movement. The difficulty of the skill was such that, a subject, given ten consecutive trials on the stabilometer, was capable of balancing the horizontal board for approximately twenty-eight seconds by trial ten.

The selection of a ten trial learning criterion was based on the need for having the criterion reached within two days or a total of twenty trials. A study by Ryan⁴ suggested that a learning plateau is normally reached by the eleventh trial on the stabilometer although Ryan did not mean to suggest that learning was complete since he observed improvement in performance after as many as sixty trials. However, for the purposes of this study, it was felt that a learning criterion that could be reached in approximately one day's practice (ten trials) would best suit the requirements of the study. Studies which have employed the use of the stabilometer have, in general, required no more than ten or eleven trials on any one practice day. The writer also felt that because balancing on the stabilometer requires continuous muscular activity, a practice session consisting of ten trials would be ideal in that bodily fatigue as well as loss in subject motivation would be avoided. In addition, the demands on the subject's time in this study, were such that, a learning criterion that could be attained in approximately one day's practice was necessary.

⁴E. Dean Ryan, "Retention of Stabilometer Performance over Extended Periods of Time," The Research Quarterly, 36: 46-51, March 1965.

Practice Procedure

The eighty male University students used in this study were all naive to the stabilometer task. Each subject was required to attempt to attain a balanced position on the stabilometer. Each practice session consisted of ten trials of thirty seconds duration with a one minute rest between trials, the trials continuing until the subject met the learning criterion. All subjects reaching the criterion in not less than four trials nor more than twenty trials qualified for participation in the study. If the subject failed to reach the learning criterion during the first practice session (ten trials), he returned the following day, at the same time, for a second practice session (ten trials) and continued practicing until the criterion was achieved. Failure of the subject to reach the criterion on the second day of practice forced his elimination from the study.

Each subject on entering the experimental room took a seat in front of and to the right of the experimenter. The experimenter then instructed the subject on the nature of the task, how to board the apparatus, and the signals by which each trial would be started and terminated. In order to insure the fact that each subject received the same orientation and directions, the experimenter recited the following:

In front of you is a stabilometer, an apparatus which measures your balancing ability. It consists of a pivot bar, two triangular supports and a freely moving horizontal board.

All I want you to do on each trial is to balance the board with a minimum of movement so that neither end comes in contact with the two wooden cross beams positioned underneath either end of the board. Each trial will last thirty seconds, following which, you will be asked to carefully step off the apparatus and take a seat in the chair for one minute. Following this one minute rest period, you will be asked to remount the board and position yourself for the next trial.

In mounting the stabilometer, straddle the pivot bar by placing the left foot on the left foot print and the right foot on the right foot print. Place sufficient weight over your right foot so that the horizontal board is off balance and in contact with the wooden cross beam beneath it. Focus your point of vision on the apex of the triangle below you. You may bend your knees, position your arms to the side, and make whatever bodily adjustments you feel necessary in order to balance the board. See Figure 2 for the subject's starting position for balancing the stabilometer.

The signal for the start of each trial will be-- "Ready! 1 - 2 - 3!" On the count of 3, shift your weight towards your left foot and balance the board to the best of your ability. The signal for the end of each trial will be-- "Time!"

The success of this study depends on you giving your best on each trial.

Following the recitation of the directions, the subject mounted the apparatus, positioned himself in the proper manner, and waited for the starting signal. The vocalization of the starting signal, the start of the timer and the balancing of the board were synchronized as carefully as possible, the subject terminating each 30-second trial with the signal, "Time!" The subject then got off the stabilometer, sat down in the chair and rested for a period of one minute, which was determined by a stop watch with a 30-second sweep hand. The subject was then asked to remount the board and to position himself for the next trial.

FIGURE 2

SUBJECT'S STARTING POSITION FOR BALANCING THE STABILOMETER

The subject's starting position for balancing the stabilometer involved all of the following: (A) weight centered over the right foot; (B) knees partially flexed and rotated slightly inward; (C) arms positioned away from the body; and (D) eyes focused on the apex of the triangular support.

In order to approximate a learning situation and motivate the subject to give his best effort, the following verbal encouragements were offered to each subject before each trial--"Give it a good try! Relax, and don't become discouraged! Let's make this a good one!" Also, coaching cues were sometimes offered to the subject during the rest periods in order to help him in the learning of the task.

Each 30-second trial was carried out with the subject facing away from the experimenter. At no time during the experiment was the subject informed of his balancing scores. The experimenter supervised the entire experiment and personally observed and recorded the results of every trial performed during the experiment.

Balancing on the stabilometer was selected as the skill to be used in this study for five reasons. First, it is novel in nature, thus insuring the fact that the subject would have had minimal experience with it. Second, performance on the stabilometer requires a type of large muscle coordination and body balance which are more characteristic of the physical components found in physical education activities and athletics than some of the other motor skills, such as, finger mazes, pursuit rotors and tracking apparatus, which have previously been investigated in retention studies using motor skills. In fact, to the writer's best knowledge, no study has ever investigated the effects of overlearning on the retention of a gross motor skill such as the one under

investigation in this study. Third, balancing on the stabilometer is a challenging and interesting task and serves to maintain the subject's enthusiasm and motivation while engaged in its performance. Fourth, the opportunity for the subject to practice on a stabilometer during the retention intervals of no-practice is minimal. Fifth, the subject's performance on the stabilometer lends itself to objective and quantitative analysis and is not open to the experimenter's subjective judgment.

Overlearning Practice

The amount of overlearning practice that each subject received was determined by (1) the number of practice trials required to reach the learning criterion and (2) the overlearning practice group to which the subject was assigned. For the two zero per cent overlearning groups, practice for each subject continued until the learning criterion was reached and then was promptly terminated. For these subjects, there was no further practice beyond the point at which the learning criterion was attained. For the two 50 per cent overlearning groups, practice was continued until the number of trials was increased by one-half the number required for reaching the learning criterion. For the two 100 per cent overlearning groups, practice continued until the number of additional trials was equal to the number of trials needed to reach the learning criterion. Lastly,

the two 200 per cent overlearning groups received twice the number of trials needed to attain the learning criterion.

Overlearning practice started with the first trial following the trial on which the subject attained the learning criterion, provided that the criterion trial was not the tenth trial of the practice session. In other words, the greatest number of trials that could occur in any one practice session was ten. If the subject failed to complete his required number of overlearning practice trials following the attainment of the learning criterion, he returned the next day, at the same time, and fulfilled his overlearning requirement. This procedure was continued until all overlearning practice trials were completed. For example, if a subject reached the learning criterion on the twentieth learning trial and was assigned to the 200 per cent overlearning condition, he would then have forty additional overlearning practice trials spaced over the next four days (ten trials per day).

All overlearning practice trials were conducted in the same manner as the practice trials--30-seconds for each trial with a one minute rest period between trials. Following the completion of overlearning practice, the subject was told when to return to the experimental room for retention testing and was also cautioned not to practice during the retention interval.

Retention Intervals

The experimenter was guided in his selection of retention intervals by the studies which have investigated the retention of motor skills and by the length of the school quarter (ten weeks) at The Ohio State University. In order to maintain the continuity of the study and also to avoid losing subjects because of the quarter recess and the scheduling of different physical education activity classes, the retention intervals selected had to be shorter than the length of the school quarter. For these reasons, the retention intervals of one week and one month were selected for investigation. One group for each of the four degrees of overlearning returned for retention testing after an absence of seven days and was tested on the eighth day. The other group returned after an absence of twenty-eight days and was tested for retention of the skill on the twenty-ninth day.

All eighty subjects returned to the experiment on the appointed day, although, in some cases, because of factors beyond the subject's control, the time of day for the retention testing was not the same as the time at which the subject practiced the stabilometer task. However, the experimenter did not believe that the discrepancy in times was that great that it influenced the obtained retention results.

Assignment of Subjects to Overlearning
and Retention Groups

A total of eight groups, each composed of ten subjects, took part in this study. The assignment of a subject to one of the eight groups was based on the number of trials he needed in order to reach the learning criterion. Since two of the five methods used for measuring the retention of stabilometer performance were dependent upon the number of trials each subject needed to reach the learning criterion, the use of the variable, trials to criterion, for matching purposes, took on added importance. For example, a subject who needed fifteen trials to reach the learning criterion was matched with a subject who required a similar number of trials and then each was placed in a different group. Also, by using the variable, trials to criterion, as a method for matching the eight groups, both fast and slow learners could be equally distributed among the groups, thus allowing the computation of the other three measures of retention--absolute recall, loss and relearning--without the speed of the subject's learning serving to bias the results. Two of the eight groups were then randomly assigned to each of the four overlearning conditions (0, 50, 100 and 200 per cent), with one of the two groups assigned to the retention interval of one week and the other assigned to the retention interval of one month.

Measurement of Retention

Five different methods of measuring the retention of stabilometer performance over the two retention intervals of one week and one month, were used in this study. As classified by Baer,⁵ they were (1) recall, (2) loss, (3) relearning, (4) saving, and (5) per cent of saving.

An absolute recall score was obtained for each subject by noting the number of seconds that the subject successfully balanced the horizontal board of the stabilometer on the first test trial following the retention interval.

The loss measure of retention was based on the difference between the mean score of the last two pre-rest trials and the subject's score achieved on the first test trial following the retention interval.

The relearning score was based on the number of trials taken by the subject to relearn to the learning criterion of twenty-eight seconds on balance out of a thirty second trial.

The saving score of retention was the difference between the number of trials required for relearning to the learning criterion and the number of trials required for reaching the learning criterion during practice.

⁵Reuben A. Baer, "The Relationship Between Rate of Learning and Retention of Several Motor Activities," (doctoral dissertation, Johns Hopkins University, 1940), p. 53.

The per cent of saving measure of retention was based on the saving score and represented the ratio of trials saved in relearning to the trials required for the first mastery of the learning criterion expressed as a percentage. Hilgard⁶ has suggested that the procedure of subtracting the trials on which the criterion is reached during learning and relearning is best for measuring the per cent of saving because it allows for the possibility of zero per cent and 100 per cent saving. The following formula as developed by Hilgard for determining the per cent of saving was the one used in this study.

$$\text{Per Cent of Saving} = \frac{100 \quad (\text{OL} - \text{C}) - (\text{RL} - \text{C})}{(\text{OL} - \text{C})}$$

Where:

OL = trials required for original learning

RL = trials required for relearning

C = the criterion trial in learning and relearning (equal to one).

The procedure used in testing for the retention of stabilometer performance over no-practice intervals of one week and one month, was identical to the procedure employed during practice and overlearning with the exception that no coaching cues were offered by the experimenter during the rest periods. The subject returned to the experimental room on

⁶Ernest R. Hilgard, "The Saving Score as a Measure of Retention," The American Journal of Psychology, 46:337-339, April, 1934.

the appointed day and at approximately the same hour of the day on which he practiced and overlearned the stabilometer task. The experimenter reviewed the signals for beginning and ending each trial. Directions relating to the proper method for mounting the board were also given and then the subject promptly performed without any warm-up trials. Test trials were continued until the subject relearned the skill to the learning criterion. All subjects were given a minimum of four test trials regardless of their scores. This was done for the purpose of having data available in case the statistical analysis of the results required a comparison of subjects over an equal number of test trials.

The retention trials were conducted in a manner identical with that used for the practice and overlearning trials. All trials were thirty seconds in duration with a one minute rest between trials. If the subject failed to reach the learning criterion in ten trials, he returned the next day, at the same time, and received as many additional test trials as was necessary for him to reach the learning criterion.

Statistical analysis was used to compare the four degrees of overlearning with each other on the retention of the stabilometer task after no-practice intervals of one week and one month. The five measures of retention obtained for each of the groups were analyzed in order to distinguish

statistically any differences that might have been shown. The effects of no-practice on the retention of stabilometer performance were noted by comparing the one week and one month groups for each of the four degrees of overlearning.

CHAPTER IV

ANALYSIS OF THE DATA

The purpose of this chapter is to statistically analyze the effects of four degrees of overlearning on the retention of a gross motor skill--balancing on the stabilometer--after no practice intervals of one week and one month. Eighty male freshman students were distributed equally into eight groups by a matching method. Two groups received no overlearning practice; two groups received 50 per cent overlearning practice; two groups received 100 per cent overlearning practice; while the remaining two groups received 200 per cent overlearning practice. For the zero per cent overlearning groups, practice for each subject continued until a learning criterion was reached and was then terminated. For the 50 per cent overlearning groups, practice continued until the number of trials was increased by one-half the number of trials required for reaching the learning criterion. For the 100 per cent overlearning groups, practice continued until the number of additional trials was equal to the number of trials needed to reach the criterion. For the 200 per cent overlearning groups, practice continued until each subject received twice the number of trials needed to reach the criterion.

One of the two groups for each of the four degrees of overlearning returned after one week for retention testing while the other group returned after one month. Retention of stabilometer performance was measured by (1) absolute recall, (2) loss, (3) relearning, (4) saving, and (5) per cent of saving.

Equating of Groups

Trials to reach the learning criterion

The assignment of a subject to one of the eight groups was based on the number of trials he needed to reach the learning criterion which in this study was the successful balancing of the horizontal board of the stabilometer for a minimum of twenty-eight seconds on one thirty second practice trial. The writer endeavored to equate the eight groups in such a way that the mean scores and standard deviations for all groups would be similar before any of the groups received their assigned amount of overlearning practice. The mean scores, standard deviations and standard errors of the mean for the eight groups are shown in Table 1. In order to make sure that the eight groups were successfully matched, t-Ratios were computed between every possible combination of the eight groups that was relevant to this study. The results of these t-Ratios are shown in Tables 2 and 3. It can clearly be seen that none of the t-Ratios was statistically significant, the

highest of the sixteen t-Ratios being .87 (a t-Ratio of 2.01 is necessary for the .05 level of significance).

TABLE 1

MEAN SCORES, STANDARD DEVIATIONS AND STANDARD ERRORS OF THE MEAN FOR THE EIGHT GROUPS ON THE NUMBER OF TRIALS NEEDED TO ATTAIN THE LEARNING CRITERION

Groups (N=10)	One Week			Four Weeks		
	M.	S.D.	S.E.	M.	S.D.	S.E.
0 per cent	7.7	4.00	1.26	6.4	2.55	.81
50 per cent	7.6	3.10	.98	7.3	3.89	1.23
100 per cent	7.5	3.57	1.13	6.8	3.52	1.11
200 per cent	7.3	1.25	.40	7.1	3.32	1.05

Balancing score on criterion trial

While it was assumed that the eight groups were equated on the variable, trials to criterion, the writer was aware of the possibility that one group might have received a high mean balancing score on the criterion trial while another group, although having a similar mean score for trials to criterion, might have barely managed to meet the learning criterion on its criterion trial, thus spending less time in the successful balancing of the stabilometer. In other words, it was possible for one subject to have met the learning criterion in seven trials with a balancing score of 28.01 seconds on the seventh trial and another subject to have met the learning criterion in the same number of trials

TABLE 2

COMPUTATION OF t-RATIOS BETWEEN MEANS AMONG THE
EIGHT GROUPS ON THE NUMBER OF TRIALS NEEDED
TO ATTAIN THE LEARNING CRITERION

Groups (N=10)	One Week		Four Weeks	
	M.	t-Ratios*	M.	t-Ratio
0 per cent and 50 per cent	7.7	.06	6.4	.61
0 per cent and 100 per cent	7.7	.12	6.4	.29
0 per cent and 200 per cent	7.7	.30	6.4	.53
50 per cent and 100 per cent	7.6	.07	7.3	.30
50 per cent and 200 per cent	7.6	.28	7.3	.12
100 per cent and 200 per cent	7.5	.17	6.8	.20

*A t-Ratio based on 18 degrees of freedom must be 2.01 or larger to be significant at the .05 level and 2.88 or larger to be significant at the .01 level.

but with a balancing score of 29.98 seconds on the criterion trial. Table 14 is a summary of the mean scores, standard deviations and standard errors of the mean for the eight groups on the balancing score achieved on the criterion trial. Tables 5 and 6 show the t-Ratios that were computed between all relevant combinations of the eight groups

on the criterion trial. It can be seen that all of the t-Ratios are insignificant, 2.01 being the significant t-Ratio for the .05 level. The one t-Ratio of 1.94 computed between the one month 0 per cent overlearning group and the one month 200 per cent overlearning group was somewhat higher than the others but it was felt that the .35 of a second mean difference between the two groups was not enough to influence the retention results.

TABLE 3

COMPUTATION OF t-RATIOS BETWEEN MEANS FOR THE
ONE WEEK AND ONE MONTH SUB-GROUPS IN EACH
OF THE FOUR OVERLEARNING GROUPS ON TRIALS
NEEDED TO ATTAIN THE LEARNING CRITERION

Groups	Means		t-Ratio
	One Week (N=10)	Four Weeks (N=10)	
0 per cent	7.7	6.4	.87
50 per cent	7.6	7.3	.19
100 per cent	7.5	6.8	.44
200 per cent	7.3	7.1	.18

In summary, the computation of t-Ratios between all relevant combinations of the eight groups on the number of trials needed to reach the learning criterion and the balancing score achieved on the criterion trial all proved statistically insignificant thus allowing the writer to

conclude that the eight groups were successfully matched before the start of each group's overlearning practice.

TABLE 4

MEAN SCORES, STANDARD DEVIATIONS AND STANDARD ERRORS OF
THE MEAN FOR THE EIGHT GROUPS ON THE
SCORE OF THE CRITERION TRIAL

Groups (N=10)	One Week			Four Weeks		
	M.	S.D.	S.E.	M.	S.D.	S.E.
0 per cent	28.72	.60	.19	28.45	.32	.10
50 per cent	28.83	.39	.12	28.59	.53	.17
100 per cent	28.81	.45	.14	28.59	.42	.13
200 per cent	28.92	.62	.20	28.80	.48	.15

Table 7 shows the number of extra practice trials that each of eight groups received beyond the number of trials needed to reach the learning criterion.

Results of the Five Measurements of Retention

Absolute recall

The absolute recall score was obtained for each subject by noting the number of seconds that he successfully balanced the horizontal board of the stabilometer on the first test trial following the one week or one month retention interval. Table 8 shows the mean scores, standard deviations and standard errors of the mean for the eight groups on the absolute recall score. Figure 3 summarizes

pictorially the mean scores and standard errors of the mean for the eight groups on the absolute recall score.

TABLE 5

COMPUTATION OF t-RATIOS BETWEEN MEANS AMONG THE EIGHT GROUPS ON THE SCORE ATTAINED ON THE CRITERION TRIAL

Groups (N=10)	After One Week		After Four Weeks	
	M.	t-Ratio	M.	t-Ratio
0 per cent and 50 per cent	28.72	.48	28.45	.70
0 per cent and 100 per cent	28.72	.38	28.45	.88
0 per cent and 200 per cent	28.72	.71	28.45	1.94
50 per cent and 100 per cent	28.83	.11	28.59	.00
50 per cent and 200 per cent	28.83	.39	28.59	.91
100 per cent and 200 per cent	28.81	.46	28.59	1.05

The four degrees of overlearning compared after the one week retention interval. An inspection of the mean absolute recall scores for the four overlearning groups after one week shows the group having no overlearning practice (0 per cent) with the lowest mean score, 27.08, and the 200 per cent overlearning group with the highest score, 28.54. See

TABLE 6

COMPUTATION OF t-RATIOS BETWEEN MEANS FOR THE
ONE WEEK AND ONE MONTH SUB-GROUPS IN EACH OF
THE FOUR OVERLEARNING GROUPS ON THE
SCORE OF THE CRITERION TRIAL

Groups	Means		t-Ratio
	One Week (N=10)	Four Weeks (N=10)	
0 per cent	28.72	28.45	1.29
50 per cent	28.83	28.59	1.14
100 per cent	28.81	28.59	1.16
200 per cent	28.92	28.80	.48

TABLE 7

NUMBER OF OVERLEARNING PRACTICE TRIALS
RECEIVED BY EACH OF THE EIGHT GROUPS

Groups	Number of Trials	
	One Week	One Month
0 per cent	0	0
50 per cent	37	36
100 per cent	75	68
200 per cent	146	142

Table 8. Significant differences at the .05 level were found in favor of the 50 per cent and 200 per cent groups over the 0 per cent group. See Table 9. While the mean scores of the 100 per cent and 0 per cent groups were not significantly different, the mean absolute recall score of the 100 per cent group was almost a full second better than the 0 per cent

group. The computation of t-Ratios among the 50, 100 and 200 per cent overlearning groups yielded no significant differences and therefore suggested that neither was superior following the one week interval.

TABLE 8

MEAN SCORES, STANDARD DEVIATIONS AND STANDARD ERRORS
OF THE MEAN FOR THE EIGHT GROUPS
ON THE ABSOLUTE RECALL SCORE

Group (N=10)	After One Week			After One Month		
	M.	S.D.	S.E.	M.	S.D.	S.E.
0 per cent	27.08	1.20	.38	26.60	2.07	.65
50 per cent	28.17	1.00	.32	27.95	.97	.31
100 per cent	27.93	1.11	.35	28.16	1.10	.35
200 per cent	28.54	1.12	.35	28.72	.76	.24

The four degrees of overlearning compared after the one month retention interval. Again, the 0 per cent overlearning group had the lowest mean absolute recall score, 26.60, while the group receiving the greatest number of overlearning practice, the 200 per cent group, had the highest score, 28.72. Significant differences were observed between the 100 per cent group and the 0 per cent group at the .05 level and between the 200 per cent group and the 0 per cent group at the .01 level, both differences being in favor of the two groups having overlearning practice. Although the mean score of the 50 per cent group, 27.95 was

FIGURE 3 (Absolute Recall)

A COMPARISON OF FOUR DEGREES OF OVERLEARNING AFTER ONE WEEK AND ONE MONTH OF NO PRACTICE ON THE RETENTION OF STABILOMETER LEARNING AS MEASURED BY ABSOLUTE RECALL (Means and Standard Errors of the Mean)

higher than the mean score for the 0 per cent group, 26.60, the difference did not prove significant. See Table 9. No significant differences were observed among the 50, 100, and 200 per cent overlearning groups after one month and it was concluded that neither one was superior to the other, although the mean score difference between the 50 per cent and 200 per cent groups was almost statistically in favor of the latter.

TABLE 9

COMPUTATION OF t-RATIOS BETWEEN MEANS AMONG THE FOUR OVERLEARNING GROUPS ON THE ABSOLUTE RECALL SCORE

Groups (N=10)	After One Week		After One Month	
	M.	t-Ratio	M.	t-Ratio
0 per cent and 50 per cent	27.08	2.18*	26.60	1.88
0 per cent and 100 per cent	27.08	1.63	26.60	2.11*
0 per cent and 200 per cent	27.08	2.81*	26.60	3.07**
50 per cent and 100 per cent	28.17	.51	27.95	.45
50 per cent and 200 per cent	28.17	.79	27.95	1.97
100 per cent and 200 per cent	27.93	1.24	28.16	1.33
	28.54		28.72	

*Significant at the .05 level.

**Significant at the .01 level.

A comparison of the two retention intervals for each degree of overlearning. Table 10 presents the t-Ratios that were computed between the two retention interval sub-groups for each of the four degrees of overlearning. All four t-Ratios were low and insignificant thus suggesting that the longer retention interval of one month did not adversely effect the subject's retention of stabilometer performance as measured by his absolute recall score.

TABLE 10

COMPUTATION OF t-RATIOS BETWEEN MEANS FOR THE ONE WEEK AND ONE MONTH SUB-GROUPS IN EACH OF THE FOUR OVERLEARNING GROUPS ON THE ABSOLUTE RECALL SCORE

Groups	Means		t-Ratio
	After One Week (N=10)	After One Month (N=10)	
0 per cent	27.08	26.60	.64
50 per cent	28.17	27.95	.49
100 per cent	27.93	28.16	.47
200 per cent	28.54	28.72	.43

Loss

The loss score was based on the difference between the mean score of the last two pre-rest trials of the subject and the score he achieved on the first test trial following the one week or one month retention interval. Table 11 shows the mean scores, standard deviations, and standard errors of

the mean for the eight groups on the loss score. Figure 4 summarizes pictorially the mean scores and standard errors of the mean for the eight groups on the loss score.

TABLE 11

MEAN SCORES, STANDARD DEVIATIONS AND STANDARD ERRORS OF THE MEAN FOR THE EIGHT GROUPS ON THE LOSS DIFFERENCE BETWEEN PRE- AND POST-REST SCORES

Groups (N=10)	After One Week			After One Month		
	M.	S.D.	S.E.	M.	S.D.	S.E.
0 per cent	-.54	1.16	.37	-1.11	2.16	.68
50 per cent	-.43	.88	.28	-.45	1.05	.33
100 per cent	-.37	1.12	.35	-.37	.49	.15
200 per cent	-.69	1.30	.41	+.16	1.44	.46

The four degrees of overlearning compared after the one week retention interval. An inspection of the mean loss scores for the four overlearning groups after one week shows that all groups suffered a loss in performance, the losses ranging from a $-.37$ for the 100 per cent group to a $-.69$ loss for the 200 per cent group. The t-Ratios computed among the four groups on mean loss scores after one week were very low and insignificant. Apparently, the overlearning practice of the 50, 100, and 200 per cent overlearning groups did not facilitate the retention of stabilometer performance after one week any better than the group that had no overlearning practice after achieving the learning criterion. In other words, the 0 per cent overlearning group was not placed at a

FIGURE 4 (Loss)

A COMPARISON OF FOUR DEGREES OF OVERLEARNING AFTER ONE WEEK AND ONE MONTH OF NO PRACTICE ON THE RETENTION OF STABILOMETER LEARNING AS MEASURED BY THE LOSS DIFFERENCE BETWEEN PRE- AND POST-REST SCORES
(Means and Standard Errors of the Mean)

disadvantage by having had no overlearning practice; its retention after one week was as good as the retention of the three groups that had overlearning practice. The t-Ratios computed between the mean loss scores of the 50, 100 and 200 per cent overlearning groups were also low and insignificant. See Table 12.

TABLE 12

COMPUTATION OF t-RATIOS BETWEEN MEANS AMONG THE FOUR
OVERLEARNING GROUPS ON THE LOSS DIFFERENCE
BETWEEN PRE- AND POST-REST SCORES

Groups (N=10)	After One Week		After One Month	
	M.	t-Ratio	M.	t-Ratio
0 per cent and 50 per cent	-.54	.24	-1.11 - .45	.87
0 per cent and 100 per cent	-.54	.33	-1.11 - .37	1.06
0 per cent and 200 per cent	-.54	.27	-1.11 + .16	1.55
50 per cent and 100 per cent	-.43	.13	- .45 - .37	.22
50 per cent and 200 per cent	-.43	.52	- .45 + .16	1.07
100 per cent and 200 per cent	-.37	.59	- .37 + .16	1.10

The four degrees of overlearning compared after the one month retention interval. The effects of the longer retention interval of one month were revealed in the mean loss score for the 0 per cent overlearning group. Table 12 shows the 0 per cent group with the greatest mean loss after one month, -1.11 seconds, and the group with the greatest amount of overlearning, the 200 per cent group, with a slight gain, +.16, over it's pre-rest score. This small gain for the 200 per cent group after a no-practice interval of one month suggests that the distributed practice that the subjects in the 200 per cent group experienced may have been responsible for the improvement observed in the scores of the subjects (reminiscence). Although the 50, 100, and 200 per cent groups had smaller mean loss scores than the 0 per cent group, none of the t-Ratios computed were significant, the highest t-Ratio being 1.55, and that between the 0 and 200 per cent groups.

A comparison of the two retention intervals for each degree of overlearning. Table 13 shows that the t-Ratios computed between the one week and one month sub-groups for each of the four degrees of overlearning were insignificant. No proof was offered to support the contention that the mere passage of time is detrimental to the retention of motor skill learning.

TABLE 13

COMPUTATION OF t-RATIOS BETWEEN MEANS FOR THE ONE WEEK AND ONE MONTH SUB-GROUPS IN EACH OF THE FOUR OVERLEARNING GROUPS ON THE LOSS DIFFERENCES BETWEEN PRE- AND POST-REST SCORES

Groups	Means		t-Ratio
	After One Week (N=10)	After One Month (N=10)	
0 per cent	-.54	-1.11	.74
50 per cent	-.43	- .45	.05
100 per cent	-.37	- .37	.00
200 per cent	-.69	+ .16	1.37

Relearning to the learning criterion

The relearning score was based on the number of trials taken by the subject to relearn to the learning criterion of twenty-eight seconds on balance out of a thirty second trial. Table 14 shows the mean scores, standard deviations and standard errors of the mean for the eight groups on the relearning score after one week and one month. Figure 5 summarizes pictorially the mean scores and standard errors of the mean for the eight groups on the relearning score.

The four degrees of overlearning compared after the one week retention interval. It is clear from inspecting Table 14 that all four groups took fewer trials to relearn to the learning criterion after the one week retention interval as a result of their practice and experience with

the stabilometer task during learning. Whereas the average number of trials to reach the learning criterion for the four groups was approximately seven trials, subjects in the 200 per cent overlearning group relearned, on the average, in 1.3 trials. The 0 per cent group, although it took the most trials to relearn to the criterion, 3.1, nevertheless, demonstrated that it too profited from the experience it gained on the stabilometer before the rest interval. In addition, the findings for the 50, 100, and 200 per cent overlearning groups were typical of those found in similar experiments which have investigated the retention of motor skills. It has generally been found in these experiments that while motor skills may be temporarily forgotten after

TABLE 14

MEAN SCORES, STANDARD DEVIATIONS AND STANDARD ERRORS
OF THE MEAN FOR THE EIGHT GROUPS ON THE NUMBER OF
TRIALS TO RELEARN TO THE LEARNING CRITERION

Groups (N=10)	After One Week			After One Month		
	M.	S.D.	S.E.	M.	S.D.	S.E.
0 per cent	3.1	2.81	.89	2.7	2.11	.67
50 per cent	1.1	.52	.16	1.5	.53	.17
100 per cent	1.5	.71	.22	1.8	1.32	.42
200 per cent	1.3	.48	.15	1.1	.32	.10

prolonged periods of no-practice, they are quickly relearned by the subject when provided with a relearning or "refresher" period. In this study, the 50, 100 and 200 per cent

FIGURE 5 (Relearning)

A COMPARISON OF FOUR DEGREES OF OVERLEARNING AFTER ONE WEEK AND ONE MONTH OF NO PRACTICE ON THE RETENTION OF STABILOMETER LEARNING AS MEASURED BY THE NUMBER OF TRIALS NEEDED TO RELEARN TO CRITERION
(means and Standard Errors of the Mean)

overlearning groups took, on the average, less than two trials to relearn to the criterion. Table 15 shows the t-Ratios computed among the four groups. While it is evident that none of the differences are significant, in each case, the group that had overlearning practice had a higher mean score than the group that had no overlearning practice (0 per cent group), the t-Ratios approaching significance in all three comparisons. The computation of t-Ratios among the 50, 100 and 200 per cent overlearning groups yielded no significant differences and therefore failed to indicate the superiority of one degree of overlearning over another. See Table 15.

The four degrees of overlearning compared after the one month retention interval. Table 14 shows that the 0 per cent group took the greatest number of trials to relearn to the criterion, 2.7, and the 200 per cent group took the least number of trials, 1.1. Even after a month retention interval, the 50, 100 and 200 per cent overlearning groups all relearned to criterion in less than two trials, thus suggesting that motor skill learning, in this instance, balancing on the stabilometer, is not easily forgotten after a prolonged period of practice (overlearning). Table 15 indicates that while the 50, 100 and 200 per cent overlearning groups all took less trials to relearn to criterion than the 0 per cent overlearning group, only the mean difference between the 0 per cent and 200 per cent groups proved

TABLE 15

COMPUTATION OF t-RATIOS BETWEEN MEANS AMONG THE FOUR
OVERLEARNING GROUPS ON THE NUMBER OF TRIALS NEEDED
TO RELEARN TO THE LEARNING CRITERION

Groups (N=10)	After One Week		After One Month	
	M.	t-Ratio	M.	t-Ratio
0 per cent and 50 per cent	3.1	1.67	2.7	1.74
0 per cent and 100 per cent	3.1	1.74	2.7	1.14
0 per cent and 200 per cent	3.1	2.00	2.7	2.35*
50 per cent and 100 per cent	1.6	.37	1.5	.67
50 per cent and 200 per cent	1.6	1.36	1.5	2.00
100 per cent and 200 per cent	1.5	.74	1.8	1.63

*Significant at the .05 level.

significant. This finding seemed to suggest that as the retention interval increased from one week to one month the better was the retention of stabilometer performance for the subjects who experienced the 200 per cent overlearning practice. In other words, no significant differences were found between the 0 per cent and 200 per cent groups after one week, but after one month, the 200 per cent group proved to

be significantly better in relearning to the criterion. The t-Ratios computed among the 50, 100 and 200 per cent groups yielded no significant differences although the mean difference between the 50 and 200 per cent groups (t-Ratio 2.00) just missed being significant in favor of the latter.

A comparison of the two retention intervals for each degree of overlearning. Table 16 points out again the fact that the four overlearning groups that waited one month before being tested for retention were not handicapped any more so than the four groups that returned after one week in their ability to retain the stabilometer learning acquired before the retention intervals.

TABLE 16

COMPUTATION OF t-RATIOS BETWEEN MEANS FOR THE ONE WEEK AND ONE MONTH SUB-GROUPS IN EACH OF THE FOUR OVERLEARNING GROUPS ON THE NUMBER OF TRIALS NEEDED TO RELEARN TO THE LEARNING CRITERION

Groups	Means		t-Ratio
	After One Week (N=10)	After One Month (N=10)	
0 per cent	3.1	2.7	.36
50 per cent	1.6	1.5	.43
100 per cent	1.5	1.8	.64
200 per cent	1.3	1.1	1.11

Saving score

The saving score was the difference between the number of trials required for relearning to the learning criterion

and the number of trials required for reaching the learning criterion during practice. A low saving score for a subject who had overlearning practice would tend to indicate that the overlearning practice was not beneficial in that it did not facilitate the "saving" of those trials spent in learning to the criterion. Table 17 shows the mean scores, standard deviations and standard errors of the mean for the eight groups on the saving score. Figure 6 summarizes pictorially the mean scores and standard errors of the mean for the eight groups on the saving score.

TABLE 17

MEAN SCORES, STANDARD DEVIATIONS AND STANDARD ERRORS
OF THE MEAN FOR THE EIGHT GROUPS ON THE DIFFERENCE
BETWEEN TRIALS NEEDED FOR LEARNING AND
RELEARNING TO CRITERION (SAVING SCORE)

Groups (N=10)	After One Week			After One Month		
	M.	S.D.	S.E.	M.	S.D.	S.E.
0 per cent	4.6	3.31	1.05	3.7	3.23	1.02
50 per cent	6.0	2.98	.94	5.8	3.85	1.22
100 per cent	6.0	3.59	1.14	5.0	4.16	1.32
200 per cent	6.0	1.25	.40	6.0	3.40	1.08

The four degrees of overlearning compared after the one week retention interval. An inspection of the mean saving scores for the four overlearning groups after one week shows that the 50, 100 and 200 per cent overlearning groups had identical saving scores (6.0) thus indicating a

FIGURE 6 (Saving)

A COMPARISON OF FOUR DEGREES OF OVERLEARNING AFTER ONE WEEK AND ONE MONTH OF NO PRACTICE ON THE RETENTION OF STABILOMETER LEARNING AS MEASURED BY THE DIFFERENCE BETWEEN THE NUMBER OF TRIALS NEEDED TO LEARN AND RELEARN TO CRITERION
(Means and Standard Errors of the Mean)

substantial "saving" in the number of trials spent in learning to the criterion. The saving score for the 0 per cent overlearning group, although lower (4.6), also suggested that its subjects "saved" the better part of the trials they spent in learning to criterion. That this was so is indicated by Table 18 which presents the t-Ratios computed among the four overlearning groups on saving score. In no case was

TABLE 18

COMPUTATION OF t-RATIOS BETWEEN MEANS AMONG THE FOUR OVERLEARNING GROUPS ON THE DIFFERENCE BETWEEN TRIALS NEEDED FOR LEARNING AND RELEARNING TO CRITERION (SAVING SCORE)

Groups (N=10)	After One Week		After One Month	
	M.	t-Ratio	M.	t-Ratio
0 per cent and 50 per cent	4.6	.99	3.7	1.32
0 per cent and 100 per cent	4.6	.90	3.7	.78
0 per cent and 200 per cent	4.6	1.25	3.7	1.54
50 per cent and 100 per cent	6.0	.00	5.8	.44
50 per cent and 200 per cent	6.0	.00	5.8	.12
100 per cent and 200 per cent	6.0	.00	5.0	.58

the 0 per cent group statistically inferior to either of the 50, 100 or 200 per cent overlearning groups. Since the 50, 100 and 200 per cent overlearning groups all had identical saving scores, there was no need to compute the t-Ratios, evidence again for concluding that all three "extra practice" groups had similar influences on the retention of stabilo-meter performance.

The four degrees of overlearning compared after the one month retention interval. Table 18 shows that the 0 per cent group saved the fewest number of learning trials after the one month interval (3.7) and that the 200 per cent group saved the most (6.0). Both the 50 and 100 per cent groups saved more trials than the 0 per cent group but less than the 200 per cent group. Computation of the t-Ratios among the four overlearning groups one month failed to provide evidence for the superiority of any of the "extra practice" groups over the group that had no such practice (0 per cent group). The t-Ratios computed between the mean saving score differences of the 50, 100 and 200 per cent overlearning groups also failed to yield any significant differences thus allowing for the conclusion that the three degrees of overlearning all had similar affects on the retention of stabilo-meter performance.

A comparison of the two retention intervals for each degree of overlearning. Table 19 gives the t-Ratios computed between the one week and one month retention interval

sub-groups for each degree of overlearning. Again, it can be seen that the four groups that returned to the experiment for retention testing after one month did not do significantly poorer than the four groups that returned after one week. It therefore might be concluded that, time in itself, had little bearing on the retention of stabilometer performance as judged by the intervals of one week and one month.

TABLE 19

COMPUTATION OF t-RATIOS BETWEEN MEANS FOR THE ONE WEEK AND ONE MONTH SUB-GROUPS IN EACH OF THE FOUR OVERLEARNING GROUPS ON THE DIFFERENCE BETWEEN TRIALS NEEDED FOR LEARNING AND RELEARNING TO CRITERION (SAVING SCORE)

Groups	Means		t-Ratio
	After One Week (N=10)	After One Month (N=10)	
0 per cent	4.6	3.7	.62
50 per cent	6.0	5.8	.13
100 per cent	6.0	5.0	.57
200 per cent	6.0	6.0	.00

Percentage of saving

The percentage of saving measure of retention was based on the saving score and represented the ratio of trials saved in relearning to the trials required for the first mastery of the learning criterion expressed as a percentage. Table 20 shows the mean scores, standard deviations and

standard errors of the mean for the eight groups on the per cent of saving after the retention intervals of one week and one month. Figure 7 summarizes pictorially the mean scores and standard errors of the mean for the eight groups on the per cent of saving.

TABLE 20

MEAN SCORES, STANDARD DEVIATIONS AND STANDARD ERRORS OF THE MEAN FOR THE EIGHT GROUPS ON THE PER CENT OF TRIALS SAVED IN RELEARNING TO CRITERION

Groups (N=10)	After One Week			After One Month		
	M.(%)	S.D.	S.E.	M.(%)	S.D.	S.E.
0 per cent	68.7	27.21	8.60	68.5	39.28	12.42
50 per cent	90.9	11.10	3.51	92.1	14.43	4.56
100 per cent	92.3	13.77	4.35	86.2	35.81	11.32
200 per cent	95.2	7.67	2.43	98.4	7.96	2.52

The four degrees of overlearning compared after the one week retention interval. The mean percentages for the four overlearning groups after the one week retention interval ranged from a high of 95.2 per cent for the 200 per cent overlearning group to a low of 68.7 per cent for the 0 per cent overlearning group. The 50 and 100 per cent overlearning groups also showed higher mean percentages of saving than the 0 per cent group after one week, their percentages being 90.9 per cent and 92.3 per cent, respectively. From the mean percentage saving scores it is possible to conclude that the overlearning practice received

FIGURE 7 (Percentage of Saving)

A COMPARISON OF FOUR DEGREES OF OVERLEARNING AFTER ONE WEEK AND ONE MONTH OF NO PRACTICE ON THE RETENTION OF STABILOMETER LEARNING AS MEASURED BY PERCENTAGE OF SAVING
(Means and Standard Errors of the Mean)

by the subjects in the 50, 100 and 200 per cent overlearning groups facilitated the retention of their stabilometer learning after a one week retention interval. See Table 20. Significant differences in favor of the 50 and 100 per cent overlearning groups over the 0 per cent group were observed at the .05 level. The t-Ratio computed between the mean percentages of the 0 per cent and 200 per cent overlearning groups was significant at the .01 level. The computation of t-Ratios among the 50, 100 and 200 per cent groups all proved to be low and insignificant and suggested that the 50 per cent overlearning practice was no less effective than the 200 per cent overlearning practice. See Table 21.

The four degrees of overlearning compared after the one month retention interval. The mean percentages for the four overlearning groups after one month ranged from a low of 68.5 per cent for the 0 per cent overlearning group to a high of 98.4 per cent for the 200 per cent overlearning group. Both the 50 and 100 per cent overlearning groups showed higher mean percentages than the 0 per cent group, their percentages reading, 92.1 per cent and 86.2 per cent, respectively. Based only on the mean percentages for each of the four groups, it was apparent that the "extra practice" by the subjects in the 50, 100 and 200 per cent groups resulted in a greater retention of stabilometer learning. See Table 21. Although the 50, 100 and 200 per cent groups had higher mean percentages than the 0 per cent group, only the

mean difference between the 0 per cent and 200 per cent groups proved significant. The computation of t-Ratios among the 50, 100 and 200 per cent groups yielded no significant differences, again failing to indicate the superiority of either of the three groups. See Table 21.

TABLE 21

COMPUTATION OF t-RATIOS BETWEEN MEANS AMONG THE FOUR
OVERLEARNING GROUPS ON THE PER CENT OF TRIALS
SAVED IN RELEARNING TO CRITERION

Groups (N=10)	After One Week		After One Month	
	M.(%)	t-Ratio	M.(%)	t-Ratio
0 per cent and 50 per cent	68.7 90.9	2.39*	68.5 92.1	1.78
0 per cent and 100 per cent	68.7 92.3	2.45*	68.5 86.2	1.05
0 per cent and 200 per cent	68.7 95.2	2.96**	68.5 98.4	2.36*
50 per cent and 100 per cent	90.9 92.3	.25	92.1 86.2	.48
50 per cent and 200 per cent	90.9 95.2	1.01	92.1 98.4	1.21
100 per cent and 200 per cent	92.3 95.2	.58	86.2 98.4	1.05

*Significant at the .05 level.

**Significant at the .01 level.

A comparison of the two retention intervals for each degree of overlearning. Table 22 presents the t-Ratios computed between the one week and one month sub-groups for each of the four degrees of overlearning. It can be seen that none of the t-Ratios approach significance thus indicating that the one month retention interval was no more detrimental to the retention of stabilometer performance than the one week interval.

TABLE 22

COMPUTATION OF t-RATIOS BETWEEN MEANS FOR THE ONE WEEK AND ONE MONTH SUB-GROUPS IN EACH OF THE FOUR OVERLEARNING GROUPS ON THE PER CENT OF TRIALS SAVED IN RELEARNING TO CRITERION

Groups	Means (%)		t-Ratio
	After One Week (N=10)	After One Month (N=10)	
0 per cent	68.7	68.5	.01
50 per cent	90.9	92.1	.21
100 per cent	92.3	86.2	.50
200 per cent	95.2	98.4	.91

Summary of the Data

Findings after one week

1. The 0 per cent overlearning group showed the poorest retention of stabilometer performance on four of the five measures of retention.

2. The 200 per cent overlearning group showed the best retention of stabilometer performance on four of the five measures of retention.

3. On the retention measure, absolute recall, both the 50 and 200 per cent overlearning groups showed significantly better retention of stabilometer performance than the 0 per cent overlearning group.

4. On the retention measure, per cent of saving, the 50, 100 and 200 per cent overlearning groups showed significantly better retention of stabilometer performance than the 0 per cent overlearning group.

5. No significant differences were found among the 0, 50, 100 and 200 per cent overlearning groups on the retention of stabilometer performance as measured by loss, relearning and saving.

6. No significant differences were found among the 50, 100 and 200 per cent overlearning groups on any of the five scores used to measure retention.

Findings after one month

1. The 0 per cent overlearning group showed the poorest retention of stabilometer performance on all five measures of retention.

2. The 200 per cent overlearning group showed the best retention of stabilometer performance on all five measures of retention.

3. On the retention measure, absolute recall, both the 100 per cent and the 200 per cent overlearning groups showed significantly better retention of stabilometer performance than the 0 per cent overlearning group.

4. On the retention measure, trials to relearn to criterion, the 200 per cent overlearning group showed significantly better retention of stabilometer performance than the 0 per cent overlearning group.

5. On the retention measure, per cent of saving, the 200 per cent overlearning group showed a significantly higher percentage of saving than the 0 per cent overlearning group.

6. No significant differences were found among the 0, 50, 100 and 200 per cent overlearning groups on the retention of stabilometer performance as measured by loss and saving.

7. No significant differences were found among the 50, 100, and 200 per cent overlearning groups on any of the five measures of retention.

General finding

1. No significant differences in retention were found between those groups returning after one week and those groups returning after one month. This was true for all four degrees of overlearning and all five measures of retention.

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

The resistance of motor skill learning to forgetting as demonstrated by our ability to retain motor activities such as swimming, skating and bicycling, over long periods of no practice, is generally accounted for by the fact that these activities are tremendously "overlearned." By overlearning it is meant any amount of learning or practice required of the subject beyond that needed to reach a learning criterion. While this relationship between overlearning and retention has been more or less assumed by many in the field of physical education, little if any attention has been devoted to the empirical investigation of retention of motor skill learning as it is affected by varying degrees of overlearning. While the practice parameters which govern the acquisition of motor skill learning have received a great deal of attention in the professional literature, superficial treatment has been extended to the determination of those parameters which allow for the best and most economical retention of motor skills. One of these parameters is degree of learning. The degree to which a motor skill is practiced

in order to insure the most economical retention of that skill, both in terms of the time and energy spent by the learner, is a question the answer to which may have important implications for teaching methodology in physical education.

This study was an attempt to discover the effects of four degrees of overlearning on the retention of a gross motor skill--balancing on the stabilometer--after no-practice intervals of one week and one month. Eighty male freshman students who were enrolled in this instructor's classes in the required physical education program at The Ohio State University during the winter quarter, 1966, served as subjects in the study.

The procedures employed in this study included (1) selection of subjects, (2) measurement of subject performance, (3) determination and conduct of overlearning practice, (4) assignment of subjects to overlearning and retention groups, and (5) measurement of retention after intervals of one week and one month.

Subject performance during learning, overlearning and retention was based on two measures, trials and balancing score in seconds. The statistical analysis used for comparing the four degrees of overlearning after the two retention intervals included the following statistics: mean scores, standard deviations, standard errors of the mean and t-Ratios. For the subjects in the 0 per cent overlearning group (no extra practice), practice continued until a

learning criterion was reached and was then terminated. The subjects having 50 per cent overlearning practiced until the number of extra trials was increased by one-half the number required for reaching the learning criterion. The subjects having 100 per cent overlearning practice continued practicing until the number of additional trials was equal to the number of trials needed to reach the learning criterion. The subjects having 200 per cent overlearning practiced until they received twice the number of trials each needed to reach the learning criterion.

One-half of the number of subjects in each of the four overlearning conditions (ten) returned after one week for retention testing while the other half (ten) returned after one month. The retention of stabilometer performance was measured by (1) absolute recall, (2) loss, (3) relearning, (4) saving, and (5) per cent of saving.

Following the one week retention interval, it was observed that the 0 per cent overlearning group performed the poorest of the four groups on four of the five measures of retention while the 200 per cent group showed the best retention of stabilometer performance on four of the five measures. Significant differences in favor of the 50 and 200 per cent overlearning groups over the 0 per cent overlearning group were found on the absolute recall score. Similarly, significant differences were found in favor of the 50, 100 and 200 per cent groups over the 0 per cent group

on per cent of saving. No significant differences were found among the 50, 100 and 200 per cent overlearning groups on any of the five measures of retention.

Following the one month retention interval, it was observed that the 0 per cent overlearning group did the poorest on all five measures of retention while the 200 per cent group showed the best retention of stabilometer performance as determined by all five measures of retention. On the retention measure, absolute recall, both the 100 and 200 per cent groups showed significantly better retention than the 0 per cent group. On the retention measures, relearning and per cent of saving, only the group receiving 200 per cent extra practice showed significantly better retention than the group receiving no extra practice beyond the learning criterion. No significant differences were found among the 50, 100 and 200 per cent overlearning groups on any of the five measures of retention.

No significant differences in retention were found between those groups returning for retention testing after one week and those groups returning after one month. This was true for all four degrees of overlearning and all five measures of retention.

Conclusions

One of the questions which this study attempted to answer was whether retention varies proportionately as the

degree of overlearning varies from 0 to 200 per cent. Learning psychologists have suggested that up to 50 per cent overlearning is advantageous for retention but that additional amounts do not result in proportionate increases in retention efficiency. With respect to the findings of this study, no significant differences were found among the 50, 100 and 200 per cent overlearning groups on any of the five measures of retention either after ⁷one week or one month intervals. Although the mean scores for the 200 per cent overlearning group were better on nine of the ten comparisons made between the groups, none of the mean differences proved significant. Therefore, no evidence was found to substantiate the belief that increases in degree of original learning are associated with proportionate increments in retention.

A second question which this study endeavored to answer was whether the relationship between degree of learning (as determined by number of repetitions) and retention vary with the length of the retention interval. Following the one week retention interval, the findings showed that both the 50 and 200 per cent overlearning groups demonstrated significantly better retention of stabilometer performance than the 0 per cent overlearning group, as measured by the retention measures, absolute recall and per cent of saving. Since the 50 and 200 per cent groups did not significantly differ from one another on these two measures it might

therefore be concluded that 50 per cent overlearning practice was as effective as 200 per cent overlearning practice following an interval of one week. However, a different situation prevailed after the one month retention interval. On the same two retention measures, absolute recall and per cent of saving, 100 per cent overlearning proved as effective as 200 per cent overlearning but the latter was the only one of the three "extra practice" groups to show significantly better retention than the group having no additional practice trials (0 per cent) when retention was measured by per cent of saving. On the retention measure, trials to relearn to criterion, the 200 per cent overlearning group, again, was the only one of the three "extra practice" groups to show significantly better retention of stabilometer performance over the 0 per cent group. Within the limits of this study, one might conclude that 50 per cent overlearning is as effective and therefore more economical than 200 per cent overlearning when retention is tested by absolute recall and per cent of saving after a relatively short retention interval (one week). However, as the length of the retention interval becomes longer (one month), a higher degree of overlearning (200 per cent) becomes more effective for the retention of a gross motor skill requiring body balance and coordination. That this statement is true for the findings of this study can be seen by the fact that of the five significant retention differences found after the one week interval, only

two involved the 200 per cent overlearning group whereas after the one month interval, of the four significant retention differences found, three involved the 200 per cent overlearning group and one involved the 100 per cent overlearning group.

The purpose of having four overlearning groups return for retention testing after one week and four matched groups return after one month was to see whether the factor of "disuse" plays a role in the forgetting of motor skills. If it does, then one might expect poorer retention and greater forgetting by the subjects returning after the one month interval. With respect to the question of forgetting and disuse, McGeoch wrote:

. . . the two necessary conditions for the appearance of forgetting in organically intact human beings are interpolated activities and altered stimulating conditions Disuse, when it is correlated directly with forgetting, is interpreted to be the framework in which the effective factors operate It bears to forgetting the same logical relation that time bears to any of the processes of nature.¹

Deese in arguing against disuse as a cause of forgetting stated:

. . . disuse does not explain forgetting if disuse only implies the passage of time, for time in itself does not cause anything. Events happen in time; certain conditions change over time, and it is these that provide explanations. Thus we find

¹John A. McGeoch, "Forgetting and the Law of Disuse," Psychological Review, 39:367, July, 1932.

find that forgetting is not determined by passage of time alone, but by the nature of the events which fill a time interval.²

The results of this study provide a strong argument against any attempt to explain forgetting by the concept of disuse. The findings showed that no significant differences were found between the groups returning after one week and the groups returning after one month. This was true for all four degrees of overlearning and all five measures of retention. In other words, the longer retention interval of one month was no more detrimental to the retention of stabilometer performance than the one week retention interval.

When one looks only at the results of the comparisons that were made between the three groups that had "extra practice" beyond the learning criterion (50, 100 and 200 per cent overlearning groups) and the group that had no such practice (0 per cent overlearning group), it becomes apparent that the 0 per cent group's retention of stabilometer performance, after one week and one month, was not decidedly poorer than the retention shown by the three "extra practice" groups. Out of a total of thirty comparisons made between the 50, 100, and 200 per cent groups and the 0 per cent group over each of the retention intervals and the five measures of retention, only nine proved significant. If overlearning is the principle reason why motor skills are

²James Deese, The Psychology of Learning (New York: McGraw-Hill Book Co., Inc., 1958), p. 255.

not easily forgotten, then one might have expected a greater number of significant differences occurring between the groups although it is recognized that the length of the retention interval has a bearing on what the retention results will be. The competition theory of forgetting is generally regarded as one of the better explanations of the forgetting process and enjoys a considerable popularity among learning psychologists today. Deese has summarized the theory in the following way:

The competition theory . . . asserts that there will be mutual interference between two sets of responses to the extent that the responses from the two sets compete with one another at recall. The extent to which one set of responses will compete with another depends upon the relative associative strength of the sets of responses to common stimuli and the inability of the individual to re-code the responses in such a way as to give them distinctive contexts.³

Deese concludes that ". . . what produces forgetting is, to a considerable extent, simply mutual competition among things we have learned."⁴ Therefore, the fact that relatively few differences were found between the 50, 100 and 200 per cent overlearning groups and the 0 per cent overlearning group may possibly be explained by the fact that although the subjects in the 0 per cent group had no overlearning practice, they were not confronted during either of the two retention intervals with stimulus-response situations that called for movements that were antagonistic or competitive to the ones

³Ibid., p. 261.

⁴Ibid., p. 267.

learned during the experiment. In other words, since balancing on the horizontal board of the stabilometer was a new and novel skill for each subject and since there was a minimal chance for the subject to have practiced on the same or a similar apparatus during the retention intervals, there was little reason to suspect that the subject's forgetting would be great when he returned to the experiment for retention testing. However, the fact that nine of the comparisons between the 50, 100 and 200 per cent overlearning groups and the 0 per cent overlearning group proved to be significantly in favor of the former remains to be accounted for. Although all of the subjects in the 0 per cent overlearning condition accomplished the learning criterion, it would be somewhat naive to believe that all of the subjects "learned" the skill of balancing on the stabilometer equally. There is reason to believe that an unknown number of subjects may have accomplished the learning criterion by chance and it is these subjects who may have accounted for the significant differences that were found on the retention measures of absolute recall and relearning, two measures which were dependent upon how much practice the subject received before his retention interval.

Summarizing, the results of this study seem to suggest that overlearning may not be as important a factor in the retention of motor skills, such as swimming and skating, as is commonly believed. The fact that the opportunities for

practicing and learning interpolated competing response skills are unlikely tends to insure the permanence of the originally learned skill even after long periods of no practice.

Finally, this study strongly suggested that the type of retention measure selected by the investigator plays an important role in determining the results of the experiment. In this study, five measures of retention were used--absolute recall, loss, relearning, saving and per cent of saving. Following the one week retention interval, no significant differences were found among the four degrees of overlearning when retention was measured by loss, relearning and saving. Significant differences were found when retention was measured by absolute recall and per cent of saving. Following the one month retention interval, no significant differences were found among the four degrees of overlearning when retention was measured by loss and saving. Significant differences were found for the retention measures of absolute recall, relearning and per cent of saving. These findings would seem to suggest that absolute recall and per cent of saving, as measurements of retention, are more sensitive to the effects of varying degrees of overlearning on retention than either the loss or saving measures.

It remains for future investigators to further study the practice parameters which govern the retention of different motor skills over different retention intervals. Physical educators should be as concerned with the retention

of their skill teachings as they are with their acquisition. The retention results of this study have suggested that 50 per cent overlearning is as effective as 200 per cent overlearning for the retention of a gross motor skill requiring body balance and coordination over a short interval of no practice. However, as the retention interval becomes longer, higher degrees of overlearning, such as 200 per cent, become more effective. Overlearning was also questioned as an explanation for the persistence of motor skills over prolonged periods of no practice. The competition theory of forgetting was suggested as an alternate interpretation for the resistance of motor skills to forgetting. The results of this study are presented in the hopes that they may stimulate further investigations into the retentive aspects of motor learning. Such investigations may hold the key to better curriculum planning, improvements in teaching methods and to a better understanding of the learning and forgetting processes.

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