AN ABSTRACT OF THE THESIS OF

Patricia C. Nearingburg for the degree of Doctor of Philosophy in Education presented on March 31, 1989.

Title: The Effects of Three Levels of Contextual Interference on the Acquisition and Retention of a Sequential Motor Skill by Moderately Mentally Retarded and Nonretarded Individuals.

Abstract approved: Redacted for privacy

John M. Dunn

The purpose of this research was to investigate the effects of three levels of contextual interference on the acquisition and retention of a sequential motor skill, by moderately mentally retarded and nonretarded subjects. The subjects were functioning between an eight and twelve year level. The dependent measures included; Reaction Time (RT), Total Response Time (TRT), and error scores. The experimental task required subjects (N = 36 moderately mentally retarded, and N = 36 nonretarded subjects), to initiate and complete the motor pattern by running as quickly as possible through the three mat pattern.

A 2 (IQ) X 3 (Practice Condition) X 3 (Task) repeated measures design was used to analyze the RT and TRT dependent measures during acquisition and retention. A Multivariate

Analysis of Variance (MANOVA) was initially employed. Significant effects were further analyzed through Univariate Analysis of Variance (ANOVA) procedures. An alpha level of 0.10 was used in this study. In addition to RT and TRT measures, anticipation errors and mat errors were recorded.

A significant main effect for RT and TRT during acquisition was found between intelligence groups. There were no significant differences in RT between the intelligence groups during retention. Significant differences between intelligence groups were found with respect to TRT during retention. There were no statistically significant differences between the practice conditions with respect to RT and TRT. Empirical evidence supported the presence of task differences. Throughout the study, the nonretarded subjects produced fewer anticipation errors and fewer mat errors than moderately mentally retarded subjects. The total frequency of mat errors increased for both the mentally retarded and nonretarded groups, from acquisition to retention.

It was concluded that there were no differences with respect to reaction time or total response time, as a function of contextual practice condition.

The Effects of Three Levels of Contextual Interference on Acquisition and Retention of a Sequential Motor Skill in Moderately Mentally Retarded and Nonretarded Individuals

by

Patt Nearingburg

A THESIS

Submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Doctor of Philosophy

Completed March 31, 1989

Commencement June 1989

APPROVED:

Redacted for privacy

Professor of Physical Education in charge of major

Redacted for privacy

Chair of Department of Physical Education

Redacted for privacy

Dean of School of Education

Redacted for privacy

Dean of Graduate School

Date thesis is presented March 31, 1989

Typed by Nancy Kennedy for Patricia C. Nearingburg

Acknowledgements

I would like to take this opportunity to acknowledge the people that have contributed to this dissertation and to my educational experience at OSU. First of all, I must thank the members of my committee; Dr. Courtney, Dr. Maddox, Dr. Rose and Dr. Tiedeman, for their valuable insights. A special thank you is extended to the chairman of my committee, Dr. John Dunn. Without his encouragement, understanding and tolerance of playpens, the completion of my degree may have been delayed.

I would also like to thank the individuals who participated in my study. Without their involvement, this project would not have been possible.

Numerous people have provided their support during these past four challenging years. I have especially appreciated the friendships of Caron Shake, Karen and Jackson Hayden. Caron's keen sense of humour helped me throughout the project. I will be forever grateful for the kindness and generosity shown Benjamin and me by Karen and Jackson. Although my family has been far away from Oregon, they have continually given me encouragement to complete my goals, and I thank them.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

THE EFFECTS OF THREE LEVELS OF CONTEXTUAL INTERFERENCE ON ACQUISITION AND RETENTION OF A SEQUENTIAL MOTOR SKILL IN MODERATELY MENTALLY RETARDED AND NONRETARDED INDIVIDUALS

CHAPTER 1

INTRODUCTION

Motor learning theorists have directed their experimental efforts in recent years to identifying and describing critical variables which affect motor skill acquisition. It has become evident that many factors influence the learning and performance of motor tasks. The role of Knowledge of Results (KR) (Stelmach, 1970; Magill, 1980; Newell, 1974), observational learning (Martens, Burwitz and Zuckerman, 1976) and influences of practice schedules, are examples of variables which have interested motor learning theorists.

Although much of the motor skill research has concentrated upon college students, similar interest with the mentally retarded has begun to evolve. Studies have focused on comparing the motor skill performance of normal to mentally retarded individuals on selected motor skills (Bruininks, 1974; Rarick, Widdhop and Broadhead, 1979; Rarick and Beuter, 1985). More recent research, originally developed utilizing nonretarded populations as subjects, has generated questions regarding some of the underlying foundational assumptions about the acquisition of motor skills by mentally retarded individuals.

Questions concerning the types of practice conditions which might optimize learning have surfaced. Two concepts which pertain to practice conditions, variability of practice and contextual interference, have received increasing attention. As a result of Schmidt's (1976) schema theory of motor skill learning, the variability of practice hypothesis has been generated. Variability of practice refers to performing a number of variations of the skill which is being learned. According to Schmidt, schemas are developed that serve as rules which provide the learner with a basis for decisions. This theory suggests that variability of practice within a movement class results in the development of stronger recall and recognition schemata. The recall schema is responsible for the production of the movement and represents the relationship between initial conditions (i.e., state of the environment prior to movement), past response specifications (i.e., force, speed or trajectory necessary to complete the movement) and past actual outcomes (i.e., knowledge of results). The recognition schema is developed as the individual forms relationships among initial conditions, past sensory consequences and past actual outcomes. The recognition schema is used to evaluate error by comparing what is expected to occur with what actually occurs.

Variability of practice promotes a more generalized and therefore more flexible motor program (Schmidt,1976). To test the variability of practice hypothesis, subjects work away. On the next trial they may kick the ball to the same target which is now placed 10 feet away. The target remains the same but, in this case, the distance is manipulated. According to Magill (1980), a variety of practice experiences involving variations of a skill allows a more accurate motor response schema to be developed. For example, students may perform a variety of kicking patterns or kick various sized balls to a target. Individuals who experience this variability should then perform a similar but novel task more efficiently than those receiving constant practice.

To better understand how the variability of practice should best be organized, application of contextual interference (CI) theory, initially introduced by Battig (1979), has begun. It is through subsequent investigations utilizing this theory that a reevaluation of traditional motor skill instructional methods has occurred. Contextual interference forces the learner to problem-solve and to draw relationships between skills. Battig originally proposed that verbal tasks presented under conditions of high interference will be more effectively retained than the same tasks learned under low interference conditions. High contextual interference conditions are produced when students practice several different but related skills during the same practice session. When only one skill is practiced during a practice session, low contextual interference is produced.

during the same practice session. When only one skill is practiced during a practice session, low contextual interference is produced.

Battig's theory of the memory processing system is founded upon multiple and variable processing, contextual interference and variety. These elements combine to create a more precise processing of material. These processing strategies enable the learner to generate a more comprehensive representation of the movement which is more resilient to forgetting and transferable across movement contexts. Multiple processing refers to individual items or events being processed in more than one way. Variable processing refers to different types of processing being utilized for different items (Battig and Shea, 1980). These represent problem solving strategies which allow the learner to associate the novel item with other information already in long term memory. If an item has two meanings, both must be processed, thereby using multiple processing. The use of different types of processing produces a more distinctive and memorable encoding. According to Battig, contextual interference and contextual variety refer, respectively, to increased interference or difficulty during the original acquisition of a task and to changes in the context conditions under which such acquisition occurs. Contextual interference and variety are extensions of "intratask interference" which occurs during learning and which typically produces forgetting. This "intratask interference" has been demonstrated to lead to enhanced memory during the retention interval. Contextual interference and variety force subjects to process in multiple and variable ways, thereby producing more effective memory.

Battig is an advocate of the levels-of-processing viewpoint first developed by Craik and Lockhart (1972). He proposed that the multistore approach, which supports a Short Term Storage (STS) and Long Term Storage (LTS) distinction, has created an incorrect understanding of memory processing. The multistore approach to memory has problems with limited storage capacity and coding capabilities. For example, it was believed that information in STS was coded acoustically whereas in LTS, it was stored semantically. This theory remains unclear and is inherently limiting.

The underlying assumption of the levels of processing approach contends that a hierarchy of processing stages exists where greater processing depth implies a greater degree of semantic or cognitive analysis. Memory will be influenced by the semantic meaning that is perceived by the learner. Information that is meaningful to the learner will be more readily retained.

It is the greater degree of cognitive analysis that Battig proposes with a levels of processing viewpoint that has excited motor learning theorists about the contextual interference theory. Although originally used in a verbal learning context, contextual interference theory has been successfully applied to motor skill acquisition. One of the first such studies was conducted by Shea and Morgan (1979), who investigated the effects of random and blocked practice sequences on the acquisition and retention of three similar motor skills. Subjects performing under a random practice schedule or in the high contextual interference group performed a different spatial variation of the barrier task on each successive trial, while those subjects following a blocked practice schedule or in a low contextual interference group performed the same variation on each of the 54 acquisition trials. They developed a six barrier knock down task which subjects performed under either high or low CI conditions. Shea and Morgan's experimental results demonstrated the advantage of learning through a random practice sequence which induced high levels of contextual interference (High CI) as opposed to a blocked practice sequence (Low CI). The low CI group performed better in the acquisition phase. However, after a retention interval, the high CI group not only demonstrated better learning of the skill but also better transfer when shifting to a more complex barrier task. These results suggest that learning which occurs under high contextual interference conditions may force the learner to process the information with greater depth, thereby making it ultimately more resilient in memory as compared to information learned under low contextual conditions.

Several other motor learning researchers (Del Rey, Wughalter and Whitehurst, 1982; Goode and Magill, 1986; Lee and Magill, 1983) have continued to investigate the work of Shea and Morgan (1979) with contextual interference and its effect upon the acquisition and transfer effects of selected motor tasks. Tasks have ranged from laboratory based coincidence anticipation timing tasks to more applied tasks including badminton serves (Goode and Magill, 1986). The results of the completed research involving adults, seem to demonstrate the value of learning a task under high CI conditions if the instructional goal is to retain and then transfer that information to a similar but novel task.

A common limitation of some early contextual interference work was the confounding of practice schedule effects (i.e., random vs. blocked practice schedules) with reaction time paradigm effects (i.e., choice vs. simple reactions). This occurred, for example, in Shea and Morgan's research (1979). As a result, it was difficult to determine the singular influence of practice schedules. Since that time, experiments have been conducted which have altered the procedures used by Shea and Morgan, so that the unconfounded impact of contextual interference may be assessed (Lee and Magill,1983).

The realm of contextual interference research has evolved to include the application of CI theory in the teaching and learning of motor skills with mentally retarded populations. Very little information is available concerning the effectiveness of contextual interference with mentally retarded subjects. Some research investigating this question was conducted by Blake (1984), who examined the effects of CI on the retention of a motor task with educable mentally retarded (EMR) adolescent males. In accordance with findings of earlier studies, subjects performing the task in a blocked practice sequence during the acquisition phase exhibited faster movement times (MT) and made fewer errors when compared to subjects performing under a random practice schedule. The reversal performance effects usually observed for the retention phase did not prove significant in this study. This may have been due to the large within-subject variances observed. A later study done by Edwards, Elliot and Lee (1986) found similar results to those of Blake with respect to the acquisition phases. One difference of note, however, was that, in the more recent study, both Down Syndrome and nonretarded youth were better able to transfer to a novel but related task after having learned the task according to a random practice schedule. Their results suggested that contextual interference may facilitate transfer. These studies also help to support the notion that contextual interference theory may be applicable to disabled populations.

Need for the Study

It is somewhat surprising that more research has not been conducted to investigate the potential ramifications of contextual interference with mentally retarded populations. Research analyzing the possible applications of this approach with the mentally retarded has not been thoroughly explored. The wide spectrum of application possibilities needs attention. Such work is needed to assess whether the commonly accepted formal repeated trial practice used to teach motor skills to the mentally retarded is appropriate.

Research with nonretarded populations has consistently revealed that subjects learning under high contextual interference conditions obtain lower initial acquisition scores as compared to subjects learning under blocked conditions. However, the significant improvements observed in the retention and transfer phases ultimately support a random practice schedule. While the need for immediate success may not be met, the long term value of an instructional approach involving contextual interference may be of greater lasting value to the individual. The instructor's expectations for immediate success may need to be adjusted, as well as those of the students.

The emphasis of instructional goals for the severely retarded differ from those for the more mildly retarded. With severely involved individuals, it is important to foster discrete skills. Their ability to be mainstreamed is less of a priority than learning such things as self-help skills and basic motor skills. For this population, the repeated trial approach has been deemed an effective strategy (Dunn, Fredericks and Morehouse, 1986).

The mildly and moderately retarded populations are more likely to be mainstreamed into society. Hence, the instructional preparation that they receive must be appropriate in order for this to become a reality. The following example illustrates this point. If children are taught soccer skills through a drill or repetitive approach, then it will be difficult for them to join in a recess game of soccer where the environment is rapidly changing. The degree of information processing and elaboration is quite different between subjects learning soccer skills through a blocked format (drill approach: low CI) as opposed to a random condition where the contextual interference is high.

Another instructional goal for the mildly and moderately retarded is the development of lifetime skills that will encourage integration. It is important to not only consider the short term benefits of a particular instructional approach but also the long term ramifications. Through teaching these individuals motor skills such as those involved in a game of soccer, under high CI conditions, they may more effectively adapt to situations that arise in the mainstream of society. They may learn to utilize problem solving skills. The likelihood of their eventual participation in a community soccer game, for example, may then be enhanced.

An exciting aspect of this study's design is the inclusion of a pseudoserial group. Contextual interference research to date has not used this format with mentally retarded subjects. A serial condition was first introduced by Lee and Magill (1983) in their second and third experiments. The serial condition incorporates elements of both the blocked and random conditions. Typically, the serial condition involves completing one trial of each task variation in a predictable order, which is then repeated. In Lee and Magill's (1983) experiment, subjects in the serial group performed the required task variations in a particular testing order (i.e. Task A - Task B - Task C) 18 times, until a total of 54 trials were completed. In the experiment conducted by Goode and Magill (1986) subjects in the serial group performed a different badminton serve each trial (short, long and drive serves) but in a predictable order. This order was then repeated. The serial condition has tended to produce similar results to those obtained for random conditions (Lee and Magill, 1983). Both practice conditions have yielded significantly better results when compared to the blocked group in the retention and transfer phase. It is perhaps a variation of this instructional presentation format, a pseudoserial condition, which may be most applicable to mentally retarded populations. This pseudoserial condition involves completing three consecutive trials of each condition in a repeated order. A pseudoserial format has elements of repetition which may provide a learner with consistency while allowing for a greater degree of contextual interference than a blocked presentation, since there is less event predictability.

The majority of the previously reported research in this area has utilized either college students or adolescents as subjects. If the use of CI is effective in the teaching of motor skills, then perhaps younger children who are exposed to this approach early in their physical education career may benefit greatly. Edwards, Elliott and Lee (1986) used nonretarded subjects who had a Mean Chronological Age (MCA) of 5.8 years (SD = 2.0 years) and mentally retarded subjects who had a mean chronological age of 18.1 years and Mean Mental Age (MMA) of 4.7 years (SD = 1.4 years). As will be discussed in the pilot testing section, it became obvious that moderately retarded children between the chronological ages of 8 and 12 were unable to complete the sequential task presented to them. As a result, moderately retarded subjects and nonretarded subjects were matched according to intelligence level in the present investigation. In a report by Edwards, Moore, Dornier and Poudrier (1988), it was suggested that young nonretarded children are unable to independently develop strategies which would allow them to effectively learn under conditions of high contextual interference. Further investigation was suggested.

The completed research is inconclusive with respect to the effects of contextual interference on the acquisition and retention of motor skills by mentally retarded and nonretarded children. It is unknown if the benefits reported using nonretarded individuals as subjects will occur with a mentally retarded population. It is for these reasons that further research in this area is warranted.

Statement of the Problem

The purpose of this study was to investigate the effects of three levels of contextual interference on the acquisition and retention of a sequential motor skill in nonretarded and moderately retarded individuals. Mental ages of the subjects were estimated to be between 8 to 12 years.

Hypotheses

Hypotheses Pertaining to Acquisition Phase

1. Nonretarded subjects will initiate and complete the sequential motor skill significantly faster and with fewer performance-related errors than moderately retarded subjects.
2. Nonretarded subjects in the blocked group will initiate and complete the sequential motor skill significantly faster and with fewer performance-related errors than nonretarded subjects in the pseudoserial or random groups.
3. Nonretarded subjects in the pseudoserial group will initiate and complete the sequential motor skill significantly faster and with fewer performance-related errors than nonretarded subjects in the random group.
4. Moderately retarded subjects in the blocked group will

initiate and complete the required task significantly faster and with fewer performance-related errors than moderately retarded subjects in the pseudoserial or random practice groups.

5. Moderately retarded subjects in the pseudoserial group will initiate and complete the required task significantly faster and with fewer performance-related errors than moderately retarded subjects in the random practice group.

Hypotheses Pertaining to Retention Phase

1. Nonretarded subjects will initiate and complete the required task significantly faster and with fewer performance-related errors than moderately retarded subjects.

2. Nonretarded subjects in the blocked group will initiate and complete the required task significantly slower and with a greater number of performance-related errors than nonretarded subjects in the pseudoserial and random practice groups.

3. Nonretarded subjects in the pseudoserial practice group will initiate and complete the required task significantly slower and with greater performance-related errors than nonretarded subjects in the random practice group.

4. Moderately retarded subjects in the blocked practice group will initiate and complete the required task significantly slower and with greater number of performance-related errors than moderately retarded subjects in the pseudoserial and random practice groups.

5. Moderately retarded subjects in the pseudoserial group will initiate and complete the required task significantly slower and with greater number of performance-related errors than moderately retarded subjects in the random group.

Statistical Hypotheses

The following statistical hypotheses pertain directly to the theoretical hypotheses stated above.

Statistical Hypotheses Pertaining to Acquisition Phase

MR = Retarded

Nr = Nonretarded

B = Blocked

P = Pseudoserial

R = Random

1. Ho1 : μ Nr $= \mu$ MR

   Ha1 : μ Nr $< \mu$ MR

2. Ho1 : μ NrB $= \mu$ NrP

   Ho2 : μ NrP $= \mu$ NrR

   Ha1 : μ NrB $< \mu$ NrP

   Ha2 : μ NrP $< \mu$ NrR

3. Ho : μ NrP $= \mu$ NrR

   Ha : μ NrP $< \mu$ NrR

4. Ho1 : μ MRB $= \mu$ MRP

   Ho2 : μ MRP $= \mu$ MRR

   Ha1 : μ MRB $< \mu$ MRP

   Ha2 : μ MRP $< \mu$ MRR

5. Ho1: μ MRP $= \mu$ MRR

   Ha1: μ MRP $< \mu$ MRR

Statistical Hypotheses Pertaining to Retention Phase

1. $Ho1 : \mu\ Nr = \mu\ MR$

   $Ha1 : \mu\ Nr < \mu\ MR$

2. $Ho1 : \mu\ NrB = \mu\ NrP$

   $Ho2 : \mu\ NrP = \mu\ NrR$

   $Ha1 : \mu\ NrB > \mu\ NrP$

   $Ha2 : \mu\ NrP > \mu\ NrR$

3. $Ho1 : \mu\ NrP = \mu\ NrR$

   $Ha1 : \mu\ NrP > \mu\ NrR$

4. $Ho1 : \mu\ MRB = \mu\ MRP$

   $Ho2 : \mu\ MRB = \mu\ MRR$

   $Ha1 : \mu\ MRB > \mu\ MRP$

   $Ha2 : \mu\ MRP > \mu\ MRR$

5. $Ho1 : \mu\ MRP = \mu\ MRR$

   $Ha1 : \mu\ MRP > \mu\ MRR$

Definition of Terms

The following terms are defined according to their use in the present study.

Acquisition phase: consists of the initial set of 45 trials involving the three tasks.

Anticipation error: occurs when a subject lifts his\her foot from the startswitch prior to the onset of the light.

Blocked practice: refers to the presentation of all trials of one task prior to the introduction of the next task.

Contextual interference (CI): refers to interference produced by the context of other items in a set and the manner in which they are recalled (Battig,1979).

Down syndrome: a chromosomal abnormality which typically results in mental retardation and a variety of limb deformities (Eichstaedt and Kalakian,1982).

Knowledge of results: refers to information provided to the learner from an external source after the completion of the response (Magill, 1980).

Mentally retarded : refers to significantly subaverage general intellectual functioning existing concurrently with defects in adaptive behavior and manifested during the developmental period (American Association of Mental Deficiency, 1977).

Mildly mentally retarded: includes individuals who exhibit adaptive behavior and possess IQs between 50 and 75 (Eichstaedt and Kalakian,1982).

Moderately mentally retarded: includes individuals with IQs between 30 and 50. Approximately 40 percent are Down syndrome children (Eichstaedt and Kalakian,1982)

Pseudoserial practice: refers to the presentation of each task three times consecutively. This pattern is then repeated until a total of 45 trials is completed.

Random practice: refers to the presentation of each task in no fixed order, over a given number of trials.

Reaction time: refers to the time interval between the onset of a signal and the initiation of a response. In this study it will be the time between the onset of the light stimulus and the subject's release of the footswitch.

Response time: refers to the interval of time between the onset of the signal and the completion of a response. The completion of the response will be signaled by foot impact upon the third switch mat in the sequence performed.

Retention phase: involves the performance and memory parameters of the original tasks after a specified time interval (Zimny, 1981). In this study it will be comprised of 15 randomly ordered trials involving the three tasks.

Transfer trials: refers to the trials of a new task that is similar to, but different from, the task performed during acquisition and retention.

Delimitations

This study included 36 moderately mentally retarded and 36 nonretarded subjects. Subjects had mental ages which fell between the 8 to 12 year level. Subjects were volunteers from various school districts in Oregon, including Albany, Corvallis, Lebanon, Monmouth, Philomath and Salem. All testing occurred in the Women's Building on the Oregon State University campus.

This study was delimited by the number of acquisition and retention trials. There were 45 acquisition trials and 15 retention trials. The number of acquisition trials was based on earlier research conducted by Blake (1984), who studied the effects of contextual interference on educable mentally retarded adolescent males. Reaction time, total response time, anticipation error and total error scores were obtained for each trial. Each subject began each trial at the same starting location. A light, used to cue the subject, was placed above the diagram of each task. Upon illumination of a light, the subject responded and completed the appropriate sequence as quickly and accurately as possible. Subjects then immediately returned to the starting footswitch to await the next signal.

Assumptions

It was assumed that all subjects would perform the task to the best of their capabilities. It was also assumed that information received from parents and school districts accurately reflected each child's intellectual and physical functioning capacity. For example, it was assumed that children classified as moderately mentally retarded functioned at a moderate level. It was assumed that the nonretarded subjects would perform cognitively and motorically at their appropriate age level. It was assumed that prior experience as a result of differing chronological ages would not influence performance on this sequential motor task.

CHAPTER II

REVIEW OF LITERATURE

The concept of contextual interference (CI) first appeared in the verbal learning literature. Battig (1966) reported that CI may be achieved by manipulating task demands across acquisition trials. By structuring the learning situation in such a way that task demands vary from trial to trial, high CI is produced. Multiple variable processing strategies are utilized by the learners in high CI situations. This leads to more effective retention of the original task and an enhanced ability to transfer to another task within the same class (Battig, 1979).

Interest in how the role of CI theory may relate to the acquisition of motor skills has emerged recently. Very few studies have been completed in this area. Those that have will be discussed in chronological order within the following section. This review of research is limited primarily to adolescents and college-aged subjects, as these are the main populations that have been investigated.

Shea and Morgan (1979) were the first to explore CI as it related to the learning and retention of three motor tasks. Seventy-two right handed college students were required to knock over three of six barriers in a prescribed fashion according to three different stimulus light arrangements. Those subjects in the high CI group performed three tasks which were presented in a random order across trials. The low CI group performed all trials in a blocked fashion. All subjects completed a total of 54 acquisition trials (18 per task), 18 retention trials (6 per task) and six transfer trials (3 per task). During early acquisition trials, the blocked group exhibited faster total time (TT) results. At the completion of the six acquisition phase blocks there was little difference between the mean total time results for the blocked and random groups. During retention, subjects in the blocked-random condition performed poorly for both the 10-minute and 10 day retention. The total time (TT) results showed faster times for both the random-blocked and random-random conditions. Significant differences occurred between both the blocked-blocked and random-blocked conditions and the blocked -random and random-blocked conditions. Their results demonstrated that random acquisition trials facilitated retention thereby providing support for Battig's (1978) predictions. When there is an increase in the variety of processing requirements across trials, CI may be produced. The ability to effectively transfer to two different but similar tasks was evidenced by those subjects in the high interference or random acquisition groups.

Shea and Zimny (1983) proposed a theoretical framework to emphasize the central role of cognitive processes in the operation of memory. Multiple and variable processing are also inherent components of this approach. This framework shifts the emphasis away from storage of a precise sensory representation of a movement to a more dynamic view of memory being composed of operations utilized to control action which allows an individual to deal with concurrent tasks in working memory. According to Shea and Zimny, the inter-item processing which occurs in random practice conditions allows the information stored in long term memory (LTM) to be more easily accessed into working memory. This inter-item processing parallels Battig's conceptualization of memory which also has underlying it, multiple and variable processing.

Del Rey, Wughalter and Whitehurst (1982) studied the acquisition and transfer effects of CI using a coincidence anticipation task. Sixty college females between the ages of 18 and 35 years, who reported varying levels of experience in open skills involving predictive judgements, were required to initiate responses that would coincide with the arrival of a light stimulus. Acquisition under random practice conditions resulted in greater error when compared to acquisition under a blocked schedule. Experienced subjects were more accurate and less variable than the novice group. Subjects in the random condition did not know the upcoming speed of the apparent motion compared to subjects in the blocked group. This may have confounded the results since the blocked group had the advantage of event predictability. Unlike the results obtained for the acquisition phase, experienced subjects in the random practice group performed with significantly fewer errors during the transfer phase when compared to the experienced subjects in the blocked group. Transfer to a novel task was apparently facilitated by the random order of trial presentation for the experienced subjects.

Lee and Magill (1983) conducted a series of three experiments designed to further investigate the effects of various levels of CI on the acquisition of a motor skills. College undergraduates were utilized as subjects. The barrier task used by Shea and Morgan (1979) was adopted for these studies. The retention data of Lee and Magill's first experiment supported Shea and Morgan's view that motor skills are more effectively remembered if learned under a random or high contextual interference paradigm.

It appears that the methodological locus of contextual effects occurs as a result of the manipulation of practice schedules. It was Lee and Magill's (1983) contention that if nonrepetition of events produces the contextual interference effect, the serial condition should produce delayed retention results that parallel the random condition. If the contextual interference effect is a result of event predictability then the serial group's delayed retention results should be similar to the blocked practice condition. In order to test this hypothesis, a serial group was added to the second and third experiments conducted.

The serial condition combined components of the blocked and random conditions. Subjects in the serial group were presented one trial of each of three tasks in a predetermined sequence. This sequence was then repeated until a total of 54 acquisition trials had been completed.

The addition of the serial group allowed the investigators to determine the relative influence of repetition effects and event predictability. The retention data provided support for their earlier experimental findings and the results obtained by Shea and Morgan (1979). In addition, the results obtained for serial and random conditions during the acquisition and retention phases of Experiments 2 and 3 were not significantly different. During the acquisition phases, subjects in the random and serial groups performed with similar accuracy and yet were less accurate than those in the blocked group. During the retention phase of the second experiment, subjects in the blocked group exhibited declining performance with respect to movement time, as compared to subjects in the serial and random groups. With respect to the third experiment which involved performing a movement pattern as close to a criterion time as possible, the blocked group's performance during retention trials declined relative to the serial and random groups'. It thus appears that the nonrepetitive nature of practice schedules is important for effective retention of motor skills and the subsequent transfer to other similar but not identical movement contexts.

In summary, it appears from these experiments that cognitive-motor event repetition (Lee and Magill, 1983) as opposed to event predictability, is the primary influencing factor with respect to the retention of motor skills. Event repetitions that facilitate acquisition performance appear to be detrimental to retention performance. Subjects who are forced to utilize problem solving strategies as opposed to passively remembering actions will exhibit superior performances. Lee and Magill (1983) hypothesized that subjects actively regenerate a new movement plan when practicing under random or serial conditions whereas blocked group subjects may passively remember a movement plan for each trial.

Goode and Magill (1986) extended earlier laboratory CI research to a field setting. Specifically, Lee and Magill's second experiment was conducted in an applied setting. Thirty female college students learned three badminton serves. Blocked, serial and random practice schedules were utilized. The results supported earlier CI research. Subjects in the random practice group performed better on retention and transfer as compared to subjects in the blocked group. The acquisition data, however, failed to replicate previous studies (Shea and Morgan, 1979; Del Rey, Wughalter and Whitehurst, 1982; Lee and Magill, 1983). A lack of sensitivity in the scoring system may have masked any group effects. Another factor may have been the blocked group's protocol, as it was a modified version of Lee and Magill's (1976) procedures. In the original experiment, all trials of one pattern for the blocked group were practiced prior to attempting the other pattern. In the present study, the blocked group performed all 36 trials of one serve per session. There were three sessions per week. During the other two days, the remaining serves were practiced. The same procedure was adopted during the following two weeks of testing. As a result, each of the serves was practiced on three occassions as opposed to just once in the format used by Lee and Magill. These factors may have influenced the results.

The effects of contextual interference on the learning and transfer of motor skills by children has received minimal attention. Dornier, Edwards, Moore, and Poudrier (1988) demonstrated that young children do not appear to receive the same benefits from high contextual interference conditions as adults. In their study, subjects were required to move through a simple obstacle course according to three criterion times. Movement times and error scores were obtained for all subjects. Six, nine and twelve year olds were used in the study. Further research is needed to ascertain if indeed young children do not benefit under these high contextual interference conditions.

Contextual Interference Research with Special Populations

There has been little research pertaining to the effects of CI on motor skill learning of mentally retarded individuals. The research that has been completed will be reviewed in the following section.

Blake (1984) examined the effect of CI on the acquisition, retention, recall, recognition and performance of a motor task by EMR and nonretarded adolescent males. Forty-eight subjects learned three similar tasks which involved knocking over three of six barriers in a prescribed fashion. Coloured lights and colour-coded diagrams were paired with each task. Blocked and random paradigms were adopted for this study. Subjects in the blocked group completed 15 trials of the initial task prior to completing the remaining two tasks. Subjects in the random group performed the same tasks as the blocked group but the trials were presented in a random fashion. During acquisition, subjects in the random group repeated the task until a total of 45 correct trials were produced. This may have violated Battig's prescription for an accurate test of the contextual interference effect however. Battig (1966) earlier reported that in order to test the CI effect, the number of tasks and the number of trials per task must be held constant, while varying the practice sequence of these tasks (Shea and Zimny, 1983). During retention, the tasks were presented in a random manner with both groups. Recall and recognition were evaluated by paper-and-pencil tests for both groups.

Perhaps as a result of large IQ differences among the EMR subjects and the subsequent within-subject variances, most of the results of this study were non-significant. There were no statistical differences found among practice conditions with respect to retention performance. As was expected however, the non-retarded subjects performed better than did the EMR group as measured by reaction time, movement time and error scores. Blake concluded that learning motor skills under high CI and possibly rehearsal aids, may promote greater variable processing with EMR individuals and hence a more resilient memory of previously learned motor skills.

The effects of CI during motor skill acquisition and transfer in Down syndrome youth were explored by Edwards, Elliot and Lee (1986). A simple coincident anticipation timing task was adopted for this study. Subjects were required to knock over a barrier with their preferred hand, which in turn would terminate the apparent motion of a light along a Bassin Anticipation Timer runway. These researchers reported that both the Down syndrome and nonretarded youth were better able to transfer to a novel but related task if having previously participated in random acquisition trials. This interaction was not statistically significant however. The large differences in mental ages for the Down syndrome subjects and the differences between the chronological ages of nonretarded subjects and Down syndrome subjects, brings into question the issue of prior exposure to similar tasks or settings. These factors may account for some of the unusual findings. For example, during the acquisition phase, the Down syndrome subjects displayed greater timing consistency than the nonretarded subjects. Another procedural difficulty was the structure of the transfer trials. According to the report, the inside transfer trials were always performed first while the order of the outside transfer trials was balanced within each of the four between-subject cells. The researchers concluded that Down syndrome adolescents may benefit from a practice schedule that promotes action planning strategies as opposed to a drill-type approach.

Recent research conducted by Forbus, Horvat and Roswall, (1989) using mentally retarded Special Olympic basketball players, failed to reveal any significant differences between blocked, sequenced and random practice groups. Researchers suggested that weakness within the experimental design and poor experimental control, may have contributed to the lack of statistically significant findings. A coincidence anticipation timing task was used. Their testing format included 45 acquisition trials, 6 retention trials and 3 transfer trials. Dependent measures included constant error (CE) and absolute error (AE). Further investigation into the application of contextual interference with retarded individuals was encouraged.

Summary of Literature

Review of the literature appears to provide partial support for the idea that contextual interference may enhance the ultimate retention and subsequent ability to transfer to tasks within the same class. It also appears that the initial acquisition of information under high contextual interference conditions may be more difficult and hence produce depressed acquisition performance scores. From the related literature pertaining specifically to mentally retarded populations it appears that they may also benefit from such an instructional strategy. However, the documentation substantiating this view is limited. There is an obvious need for further research in this area.

CHAPTER III

METHODS AND PROCEDURES

The purpose of this study was to investigate the effects of three levels of contextual interference on the acquisition and retention of a sequential motor task, with moderately retarded children and nonretarded children and youth of similar mental ages. A modified field setting was chosen for this study to obtain more "ecologically valid" practical information concerning instructional strategies than might be derived from a laboratory-based investigation. It is critical for researchers to consider the generalizability of their results, especially in such a relatively new field as adapted physical education.

Pilot Study

A pilot study was conducted in June 1988, with moderately retarded and nonretarded children attending the OSU Special Physical and Motor Fitness Clinic and the OSU Summer Sports Program. Through the implementation of this pilot study, the researcher determined that three moderately retarded children between the chronological ages of 8 and 12 could not successfully complete two of the three pretest trials. As a result, five moderately retarded youth whose chronological ages ranged from 14 to 20 years of age (MCA =

19) were observed. Their mental ages were estimated to be between 8 and 12 years. These subjects were able to successfully complete two of the three pretest trials, which were presented in a random fashion. A retention trial was given to two of the five subjects, and they were able to correctly complete the required sequence. Two nonretarded children between the ages of 7 and 12 years successfully completed the pretest trials. It appeared from the information gained through the pilot study that subjects would have to be selected according to their mental ages rather than their chronological ages.

Subjects

High functioning moderately retarded youth, lower functioning mildly retarded youth and nonretarded children, between the mental ages of 8 and 12 years, were chosen as subjects for this investigation. Down syndrome subjects were included, as there was no reason to expect that their performances in this study would differ significantly from the other moderately mentally retarded subjects. According to the American Association on Mental Deficiency, individuals must exhibit not only a low IQ but impaired adaptive behavior, as well, before being classified as mentally retarded. Mental retardation is characterized by individuals who score at least two standard deviations below the mean. Two major tests, the Stanford-Binet and the

Wechsler, have been used to determine intellectual retardation. Intelligence quotients classify the individuals into four groups: mild, moderate, severe and profound. According to the Stanford-Binet classification, moderately retarded individuals have an IQ which falls in the range of 36-51, whereas, according to the Wechsler, the range falls between 40-54. A general guideline that is most often adopted, according to Fait and Dunn (1984), is that individuals may be classified as trainable (moderately retarded) if their intelligence quotients fall within the range of 30-49. This guideline was adopted for the present study. Mildly retarded individuals generally have IQs within the range of 50 - 75.

Comparative studies have revealed that retarded children do not perform as well as nonretarded children with respect to running speed, reaction time, agility and endurance (Bruininks, 1974; Rarick, 1973). According to Fait and Dunn (1984), mild and moderately retarded children typically fall two to four years behind nonretarded children with respect to motor performance. A study by Fait and Kupferer (1956) suggests that some differences may be due to a failure to understand the task, as opposed to an inability to execute the task. As a result, instructions in the present study were simplified, clear and concise.

The classroom teachers identified moderately mentally retarded students as possible subjects for inclusion in the study. Only those students who did not exhibit any additional physical impairments, perceptual impairments, emotional disturbances or neurological handicaps, which might have compromised their performance in the study were selected. An informed consent form was signed by parents/guardians prior to each child's participation in the study. Moderately retarded subjects were reported to have IQs in the upper range of 30-49 and exhibited adaptive behavior consistent with that associated with moderate mental retardation. Adaptive behavior may be defined as the ability to meet the standards of social responsibility for a particular age group (Fait and Dunn, 1984). It was assumed that the nonretarded subjects were functioning cognitively and motorically at a normal level for their chronological age range. A novel task was chosen in an attempt to control for individual differences in prior experience that may otherwise have confounded the results of the study. Subjects were randomly assigned to blocked, pseudoserial and random groups prior to arriving at the test site.

Instrumentation

A variety of equipment was utilized in the study; including switch mats, a footswitch, an IBM Personal Computer, easels, lights, and diagrams. Three 14" X 23" rubber switch mats, manufactured by Lafayette, were interfaced with an IBM Personal Computer. This allowed accurate recording of each foot's impact. A photograph of the apparatus appears in Figure 1 . The three switch mats, placed on the floor, were five feet apart as measured from the center of each mat, on the diagonal. The mats remained stationary throughout the entire testing period. The mats were made of black rubber and were not colour coded.

The computer stored the correct sequence for each trial, the subjects' responses (RTs and TRTs), and the types of errors that each subject made on each trial. The computer also randomly ordered the acquisition trials for the subjects in the random group, as well as the retention trials for all subjects. The experimenter counterbalanced the order of the task sequences prior to the beginning of the testing.

Three movement patterns were graphically displayed on easels at a distance of 20 feet from the starting position. The mats on the diagrams were colour coded, and numbers were assigned according to which mat should be contacted first, second and third. White mats were always contacted first (#1), green mats second (#2), and yellow mats were contacted third (#3). Arrows between the mats on the diagrams during the acquisition phase assisted the subjects in determining the order in which the mats should be contacted. The diagrams did not include numbers or arrows during the retention phase of the experiment (See Figure 2). Previously cited contextual interference experiments (i.e., Blake, 1984 and Lee and Magill, 1983) offered less cuing than was

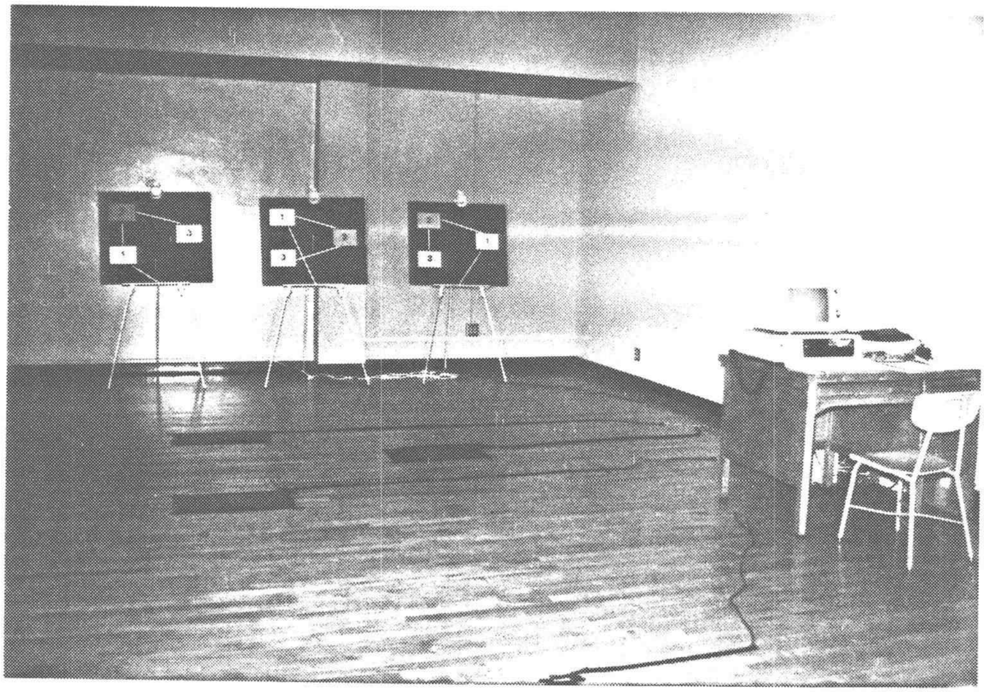

Figure 1. Experimental apparatus with acquisition diagrams.

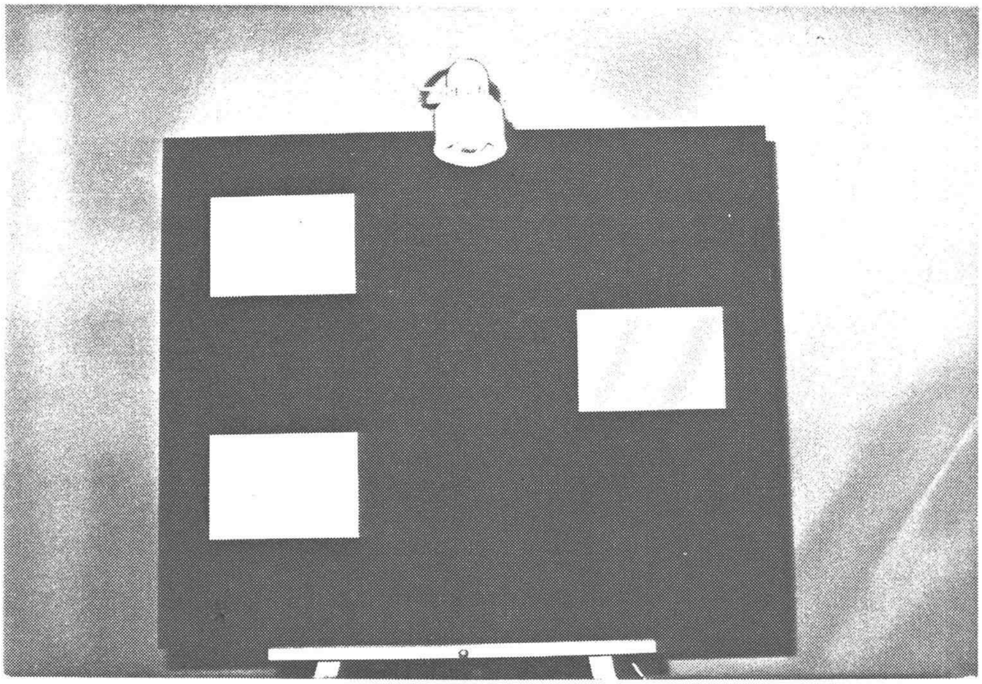

Figure 2. Example of retention diagram.

presented in the present study. It was felt, in consideration of the populations used in this study, that some minimal cueing was necessary.

A light was placed above each of the diagrams for the acquisition and retention phases. When a light was illuminated, it indicated to the subject, that the pattern indicated on the diagram below it, must be performed immediately. The light remained illuminated until three mats had been contacted. There was a variable foreperiod of 2 to 5 seconds from the time the subject placed his/her foot on the starting switch to the time when a light was illuminated. This variable foreperiod was implemented to reduce the likelihood of speed-accuracy tradeoffs. The speed-accuracy tradeoff phenomenon is discussed in the Testing Procedures section.

Procedures for Pretest

All subjects performed three pretest task sequences, which were modifications of the actual experimental tasks. The modifications were necessary to alleviate any possible learning effects that may otherwise have occurred. Only those subjects who successfully completed at least two of the three trials were allowed to participate in the actual study. Blake (1984) also had subjects complete at least three consecutive trials of a pretest similar to the one to be used in her study prior to permitting individuals to participate in the formal study. This was done to ensure that the subjects could understand the task to be performed. Subjects selected to participate in the present experiment were randomly assigned to one of three experimental practice conditions (i.e., blocked, pseudoserial or random).

Procedures During Testing

The instructions given to subjects appear in Appendix D. The task was demonstrated immediately prior to the beginning of the pretest trials. In order to complete a trial, subjects faced the diagrams placed 20 feet away with one foot on the starting switch. Subjects began at the starting foot switch for all trials. Subjects made foot contact with each mat in order to register a recorded time. It was necessary to have only one foot impact each mat. Subjects received a warning cue ("Ready"), and, following a 2 to 5 second foreperiod, a light was illuminated above the diagram which was to be performed. When this occurred, the subject initiated and completed the motor pattern by running as quickly as possible through the three mat pattern. After the trial was completed, the subject received feedback from the investigator, based on his/her performance of the pattern.(The specific types of feedback which were given are outlined in the Acquisition Phase section.) The subject then returned to the starting location, and the next trial began promptly. If an anticipation error occurred, subjects were reminded to wait for the light before initiating their next response. The trial was not repeated. If three anticipation errors occurred in a row by the same subject, the subject was eliminated from the study. Speed-accuracy tradeoff phenomenon effects may occur when subjects sacrifice their speed for the sake of completing the task correctly or when subjects sacrifice the correctness of their response for the sake of completing the task rapidly. It is for these reasons that trials with anticipation errors were not allowed.

Each subject performed a total of 45 acquisition trials which involved each of the three tasks (Figure 1). Each subject performed 15 total trials during the retention phase. The number of total trials performed for each phase was based on earlier work conducted by Blake (1984) and Edwards, et al. (1986), who tested EMR adolescents and Down syndrome adolescents, respectively. Forbus, Horvat and Roswall, (1989) also used a 45 acquisition trial format.

The experimenter explained the task to each subject prior to the acquisition and retention phases of the study. Each subject was asked to move as quickly as possible from the starting location through one of the three mat patterns presented in Figure 1. The subjects were evaluated in terms of their reaction time, total response time and error scores. Errors occurred when subjects moved incorrectly through the sequential pattern sequence or failed to leave the starting location. The dependent measures were recorded with the assistance of a personal computer.

All subjects performed the same three tasks for acquisition and retention. However, there were variations in the cueing used in the acquisition and retention phases. Specifically, during the retention phase, the diagrams were colour coded but the directional arrows between mats, as well as the written numbers on the diagrams, were omitted.

Acquisition Phase

The task was explained to each subject prior to the beginning of their acquisition trials. Each subject performed a total of 45 acquisition trials. At the end of each trial, the subject was orally given knowledge of results (KR) about their attempt. Knowledge of results was especially important for moderately retarded individuals, as their intrinsic motivation is less than the nonretarded subjects. When subjects completed the task correctly, the tester responded with "WOW!!" When subjects made only one error, the tester responded with "Not quite... look closely at the diagram before you move." When subjects made more than one error, the tester responded with "Whoops!!! Let's look very closely at the diagrams on the next trial." Subjects had a five minute rest interval between the acquisition and retention phases of the experiment.

Blocked Practice Group During Acquisition

Subjects in the blocked practice group performed 15 consecutive trials of Task A, 15 trials of Task B and 15 trials of Task C. The presentation order of these blocks was counterbalanced across subjects in the blocked group in order to minimize presentation effects. Each trial began immediately after receiving KR about the previously completed sequence. A 30-second inter-block interval was implemented after the 15th and 30th trial to help reduce any fatigue factor.

Pseudoserial Group During Acquisition

Subjects in the pseudoserial practice group performed three consecutive trials of Task A, three of Task B and three trials of Task C. The presentation order of these blocks was counterbalanced across subjects in the pseudoserial group in order to minimize presentation effects. The order was then repeated until a total of 45 trials were completed. Each trial began immediately after receiving KR about the previously completed pattern. There was a 30-second inter-block interval after the completion of the 15th and 30th trials.

Random Practice Group During Acquisition

Subjects in the random group performed a total of 45 trials involving each task. Each trial began immediately after receiving KR about the previously completed pattern. There was a 30-second interval after the 15th and the 30th trial to help reduce any fatigue factor.

Retention Phase

A total of 15 retention trials were performed by all subjects in the blocked, pseudoserial and random practice groups. Trials from Task A, Task B and Task C were included. These tasks were presented in a random manner for all subjects. The random format selection was based on experimental designs found in previously completed contextual interference work, such as that of Lee and Magill, (1983). During the retention phase, a light was illuminated above the diagrammed pattern which was to be performed. The diagrams remained colour coded, but neither the numbers on the mats nor the arrows between mats were present. It was felt that this partial cueing was necessary for the moderately retarded subjects. Other than the diagram alterations, the procedures remained basically the same as those during the acquisition phase of the experiment. Knowledge of results, however, was not provided during the retention phase. The experimenter simply said "Thank you" upon completion of each trial. Upon completion of this phase, subjects were immediately asked if they noticed anything about the colours and the orders by which they should contact the mats. Their responses were recorded.

Experimental Design

This experiment was based on a three-factor repeated measures design. For the acquisition phase, there were two levels of the first factor (intelligence), three levels of the second factor (practice condition) and three levels of the third factor (tasks). This produced an intelligence X practice conditions X tasks repeated measures design (2 X 3 X 3). For the retention phase the design incorporated a (2 X 3 X 3) model, with repeated measures. The three levels of the second factor refer to the blocked, pseudoserial and random acquisition practice conditions. There were three levels of the third factor (task). Tables 111.1 and 111.2 summarize the experimental designs.

All subjects were given a total of 45 acquisition trials involving all three tasks. For retention, all subjects performed 15 trials involving all three tasks. The tasks were presented according to a random practice schedule for all subjects during retention.

Statistical Procedures

For both acquisition and retention phases, a Multivariate Analysis of Variance (MANOVA) was employed using Reaction Time (RT) and Total Response Time (TRT) as dependent measures (Kenny, 1987). Significant effects from the MANOVA were further analyzed through Univariate Analysis of Variance procedures. An alpha level of 0.10 was used in

Table III.1

Experimental Design of Acquisition Phase

	Treatment		
	Blocked	Pseudoserial	Random
	N	N	N
Groups			
Nonretarded	12	12	12
Mentally retarded	12	12	12

N = Number of subjects per cell

Table III.2

Experimental Design of Retention Phase

	Treatment
	Random
Groups	N
Nonretarded	36
Mentally retarded	36

N = Number of subjects per cell

this study. Reaction time, total response time, anticipation error and mat error scores served as dependent variables. Dependent measures (RT and TRT), for the 45 trials were averaged

for each subject. Averaging was necessary, as subjects in the random group had an unequal number of trials for each task as a result of a program design error. This will be discussed further in Chapter Four. Through these analyses, it was determined if significant differences existed for IQ, practice condition and tasks. Interactions among these factors were also explored. For the 15 retention trials, the scores for the reaction time and movement time scores were averaged, for each subject.

Anticipation errors were tallied for each subject. The number of mats incorrectly contacted was also summed to produce a mat error score for each subject. The same procedures were applied to the retention error information. The error data were reported in percentages.

CHAPTER IV

RESULTS AND DISCUSSION

Introduction

The purpose of this study was to examine the effects of three levels of contextual interference on the acquisition and retention of a sequential motor skill. A total of 36 nonhandicapped and 36 moderately mentally retarded individuals with mental ages of 8 - 12 years participated in the study. Subjects were randomly assigned to three different contextual interference groups: a)random, b) blocked and c) pseudoserial. All subjects were presented with the same tasks (A,B and C) and performed a total of 45 acquisition trials. The presentation order of the tasks was counterbalanced across subjects. A five minute retention interval separated the acquisition and retention phases. During the retention phases of the experiment, all subjects received a total of 15 randomly presented trials involving all three tasks.

This chapter will be divided into the following sections: (a) description of subjects, (b) collection and analysis of data, (c) acquisition results, (d) retention results, and (e) discussion. The acquisition and retention sections will be further subdivided with respect to Intelligence Quotient, Reaction Time (RT), Total Response

Time (TRT), and error scores. The RT and TRT means, corresponding standard deviations and standard errors are found in the appendices.

Description of Subjects

The subjects were 36 moderately retarded and 36 nonretarded individuals with mental ages between 8 to 12 years. Participants were obtained from various Oregon school districts including Albany, Corvallis, Lebanon, Monmouth, Philomath and Salem. Nonretarded subjects were assumed to be functioning at their appropriate age level. The moderately mentally retarded subjects were selected on the basis of classification information provided by their classroom teachers. Subjects with perceptual problems or orthopedic impairments, as reported by the classroom teachers, were excluded from participating in the study. The mean chronological age was 10.0 and 16.0 for the nonretarded and mentally retarded subjects, respectively. The study sample was comprised of 27 males and 45 females.

Analyses of Reaction Time, Total Response Time and Error Data

The BMDP and SPSS statistical packages were used to analyze the dependent variables of reaction time and total response time. For both acquisition and retention phases, a multivariate Analysis of Variance (MANOVA) was performed, using Reaction Time (RT) and Total Response Time (TRT) as dependent measures. These measures were then averaged across trials for each subject. This procedure was followed in the analyses of the acquisition and retention data. Significant effects from the MANOVA were further analyzed through Analysis of Variance procedures. Using univariate Analysis of Variance (ANOVA), the following factors were analyzed with respect to reaction time and total response time during the acquisition and retention phases: a) intelligence group, b) task and, c) practice condition. The Newman-Keuls multiple comparison procedure was used for additional analysis of significant effects. Reaction time is defined as the time interval between the onset of a signal and the initiation of a response. In this study, RT was defined as the time (ms) between the onset of the light stimulus and the subject's release of the footswitch. Total response time was defined as the time interval between the onset of a signal and the completion of a response. In this study, the completion of the response was signalled by foot impact with the third switch mat in the sequence.

The number of trials of each task completed by subjects in the random practice condition did not equal the number performed by subjects in the blocked and pseudoserial groups. As a result of this microcomputer program error, an unequal number of completed trials across subjects occurred. Instead of all subjects performing 15 trials of tasks A, B, and C, subjects in the random group performed anywhere from 11 to 18 trials of each task. Hence, reaction times and total response times were averaged across trials for each subject. This procedure was followed for the acquisition and retention phases.

In addition to RT and TRT information, error data were also evaluated. Error data were reported as a function of the percentage of total possible errors. Anticipation errors were recorded for all subjects. Anticipation errors occurred when subjects lifted their foot from the starting switch prior to the onset of the light stimulus. The number of mats incorrectly performed was also recorded. Errors were described with respect to intelligence group, task and practice condition.

Results

Summary of Acquisition Hypotheses

The hypotheses for the acquisition phase are identified in the following section. Information is provided as to whether or not each hypothesis was supported.

1. Nonretarded subjects will initiate and complete the sequential motor skill significantly faster and with fewer performance-related errors than moderately retarded subjects. This hypothesis was supported.

2. Nonretarded subjects in the blocked group will initiate and complete the sequential motor skill significantly faster and with fewer performance-related errors than nonretarded subjects in the pseudoserial or random groups. This hypothesis was not supported.

3. Nonretarded subjects in the pseudoserial group will initiate and complete the sequential motor skill significantly faster and with fewer performance-related errors than nonretarded subjects in the random group. This hypothesis was not supported.

4. Moderately retarded subjects in the blocked group will initiate and complete the required task significantly faster and with fewer performance-related errors than moderately retarded subjects in the pseudoserial or random practice groups. This hypothesis was not supported.

5. Moderately retarded subjects in the pseudoserial group will initiate and complete the required task significantly faster and with fewer performance-related errors than moderately retarded subjects in the random practice groups. This hypothesis was not supported.

Results During Acquisition Phase

Reaction time

Intelligence: During the acquisition phase a significant main effect was found for intelligence, F (1,66) = 19.54, p < .0001. Neither the two-way nor three-way interactions involving the intelligence variable were significant. Mean Reaction Times (RT) as a function of practice condition and intelligence group are presented in Appendix E. The reaction time analysis of variance results are presented in Table IV.1.

Tasks : A significant main effect for task (A,B or C), was obtained, F (2,132) = 2.75, p <.07. Reaction time for the nonretarded group was significantly faster when compared to the moderately mentally retarded subjects. When averaging across all subjects, Task A was initiated significantly faster than Task C. Neither the two-way nor three-way interactions involving the task variable were significant.

Condition : The main effect for practice condition failed to reach significance. There were no RT differences among subjects in the blocked, pseudoserial or random practice conditions (see Table IV.1). Neither the two-way nor three-way interactions involving condition were significant. The RT means for acquisition as a function of practice condition are displayed in Figure 3.

Total response time

Intelligence: A significant main effect for intelligence was found, F (1,66) = 73.55, p <.0001. Table IV.2 summarizes the ANOVA results. The nonretarded performed the task sequences significantly faster than the moderately retarded subjects. The total response time means, standard deviations, and standard errors for acquisition as a function of practice condition, task and intelligence group

Table IV.1

Analysis of Variance

Acquisition analysis for reaction time

Source of Variation	df	Sum of Squares ss	Mean Square ms	Obtained *F*	*p*
Intelligence	1	27159498.80	27159498.80	19.54	0.0001*
Condition	2	739214.87	36907.43	0.27	0.7673
IQ X C	2	2754443.46	1377221.73	0.99	0.3767
Error	66	91739103.39	1389986.41		
Task	2	1132315.74	566157.87	2.75	0.0675**
T X IQ	2	199749.36	99874.68	0.49	0.6166
T X C	4	290900.70	72725.18	0.35	0.8413
T X C X C	4	833466.58	208366.64	1.01	0.4034
Error	132	27162217.04	205774.37		

* Significant at 0.01 level
** Significant at 0.10 level

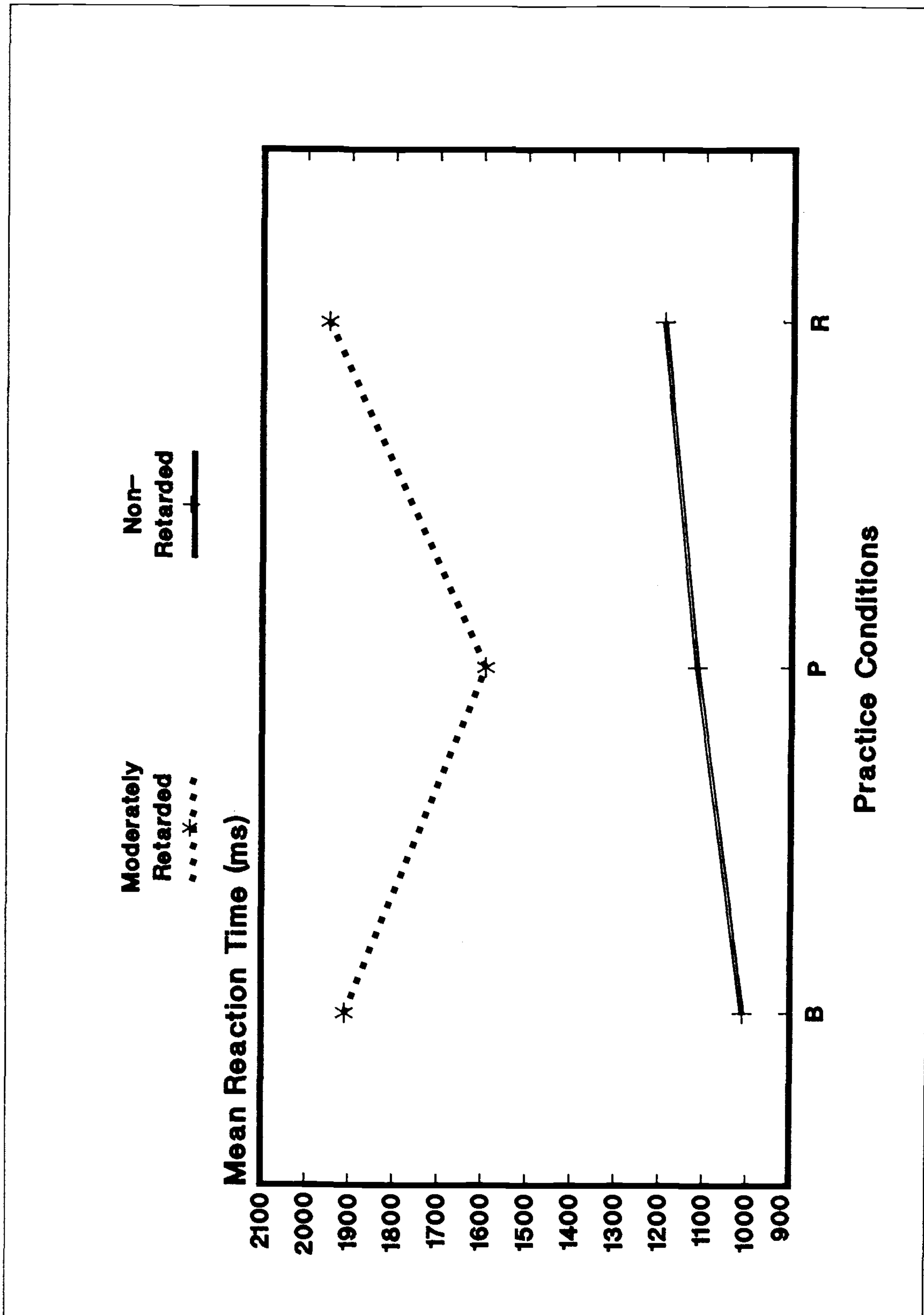

Figure 3. Mean acquisition reaction time (ms) plotted as a function of practice condition.

Table IV.2

Analysis of Variance

Acquisition analysis for total response time

Source of Variation	df	Sum of Squares ss	Mean Square ms	Obtained *F*	*p*
Intelligence	1	2264502325.07	2264502325.07	73.55	0.0001*
Condition	2	11386882.01	5693441.01	0.18	0.8316
IQ X C	2	1465065.23	732532.61	0.02	0.9765
Error	66	2032144858.70	30790073.62		
Task	2	128550658.58	64275329.29	20.31	0.0001*
T X IQ	2	15144778.74	7572389.37	2.39	0.0953**
T X C	4	6242600.71	1560650.18	0.49	0.7407
T X IQ X C	4	5685142.98	1421285.74	0.45	0.7728
Error	132	417642383.25	3163957.45		

* Significant at .01 level
** Significant at .10 level

are reported in Appendix F.

Task: There was a significant main effect for task F (2,132) = 20.31, p <.0001. When averaging across subjects, Task A was completed significantly faster than Tasks B and C. In addition (see Table IV.2), there was a two-way interaction effect between the factors of task and intelligence F (2,132) = 2.39, p <.10). For the nonretarded subjects, Task A was completed significantly faster than Task C. For the mentally retarded, Task A was completed significantly faster than Tasks B and C. The mean TRT for tasks 1, 2 and 3 was plotted as a function of practice condition to determine where the interaction occurred. This illustration is provided in Figure 4. Newman-Keuls post hoc tests were performed using a .10 level of significance. The results indicated that the nonretarded subjects performed all three tasks significantly faster than the moderately retarded subjects. It was also determined that the moderately retarded subjects performed Task A significantly faster than either Task B or C. This effect was not present with the nonretarded subjects.

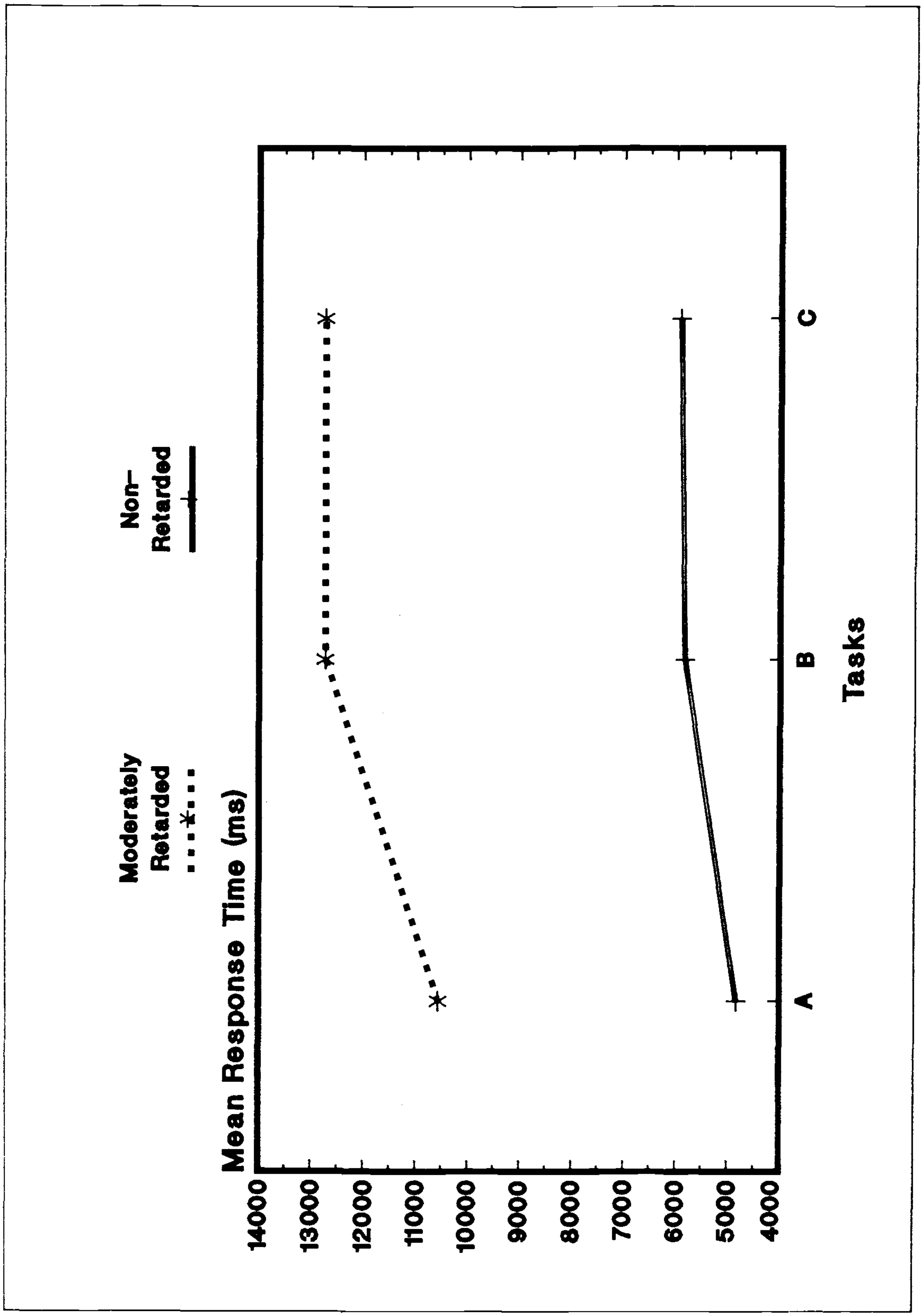

Figure 4. Two-way interaction of intelligence X task for mean response time (ms) plotted function of task sequence.

Condition: There were no significant main effect in total response time for the treatment conditions. Neither the two-way nor three-way interactions involving the condition variable, were significant. However, nonretarded subjects and moderately mentally retarded subjects in the blocked groups, demonstrated faster, though not statistically significant, total response times than subjects performing in the pseudoserial and random practice conditions (See Figure 5). This may be attributed to the fact that RT is a part of response time and the subjects in the blocked groups exhibited longer RTs.

Error analyses

The error data were analyzed using descriptive analyses. Anticipation errors were summed for all individual subjects. The number of incorrectly performed mats was also recorded. Errors were described as a function of intelligence group, task and practice condition and were reported as a percentage of total possible errors.

Anticipation error

Intelligence: Moderately mentally retarded subjects made a greater number of anticipation errors (9%) when compared to the nonretarded subjects (3%). Table IV.3 illustrates the percentage of anticipation errors committed by intelligence group and practice condition. The percentages were calculated with respect to the total

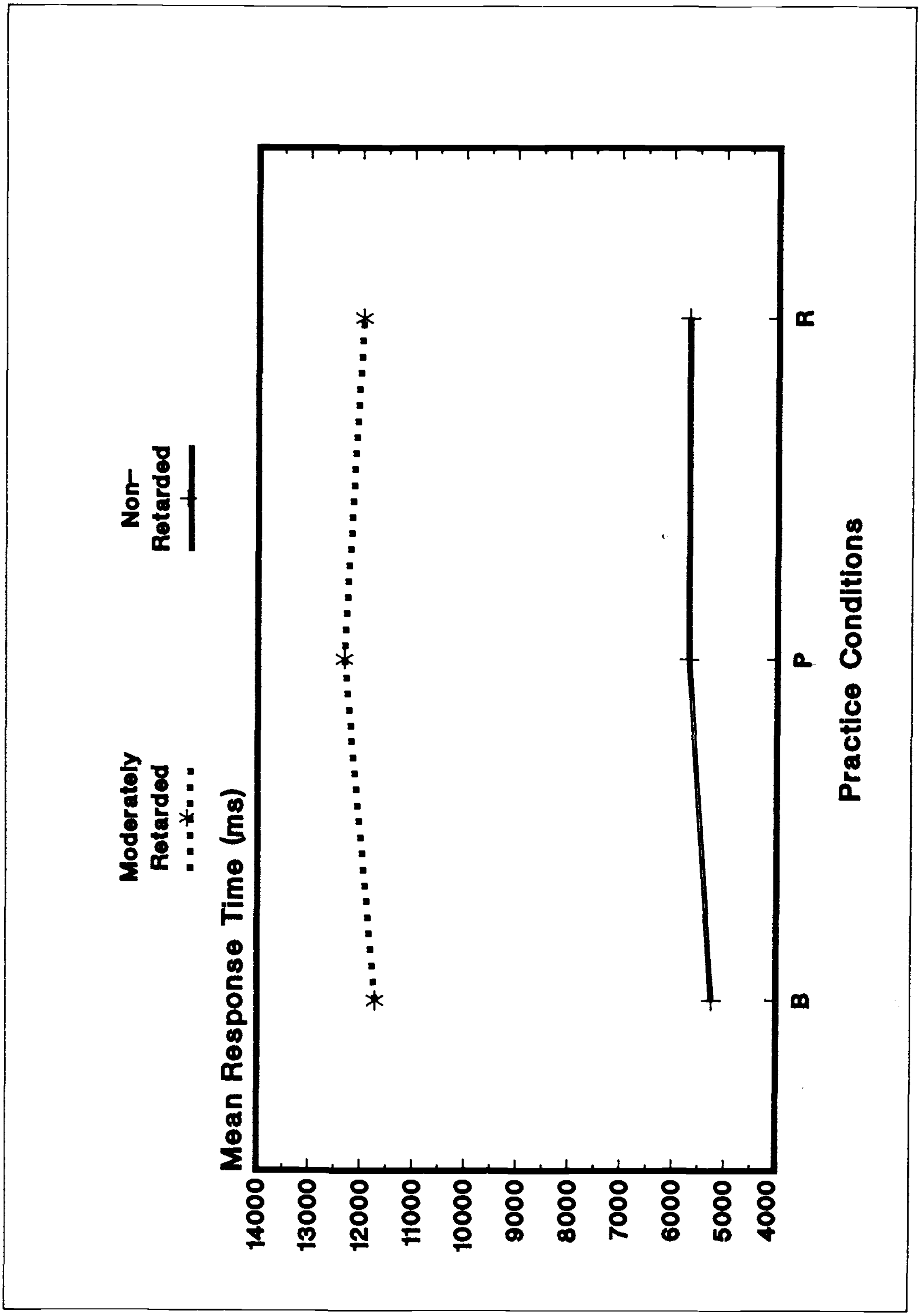

Figure 5. Acquisition total response time means (ms).

Table IV.3

Frequency of anticipation errors as a function of IQ level and practice conditions during acquisition

	Intelligence			
	Moderately retarded		Nonretarded	
	N	Percentage	N	Percentage
Condition				
Random	26	(5%)	17	(3%)
Pseudoserial	38	(7%)	23	(4%)
Blocked	83	(15%)	14	(3%)
Total anticipation errors	147	(9%)	54	(3%)

N = Number of anticipation errors

number of anticipation errors possible during the acquisition phase. Figure 6 provides a visual comparison of the frequency of anticipation errors and number of mats performed correctly.

Condition: During acquisition, the nonretarded subjects in all three practice conditions exhibited similar error frequencies. Subjects in the blocked and random groups committed 3% anticipation errors across acquisition trials, whereas the subjects in the pseudoserial group committed 4% anticipation errors. However, some differences in anticipation errors were noted for the moderately mentally retarded. The moderately retarded subjects in the random group made the fewest anticipation errors (5%), whereas moderately mentally retarded subjects in the blocked group made the greatest percentage (15%).

Mat error

Intelligence: During acquisition, the nonretarded subjects contacted fewer incorrect mats (8%) than the moderately retarded subjects (18%). Table IV.4 reports the percentages as a function of intelligence group and practice condition.

Condition: The number of incorrectly contacted mats for the nonretarded subjects was similar across practice conditions. The blocked group committed 7% errors

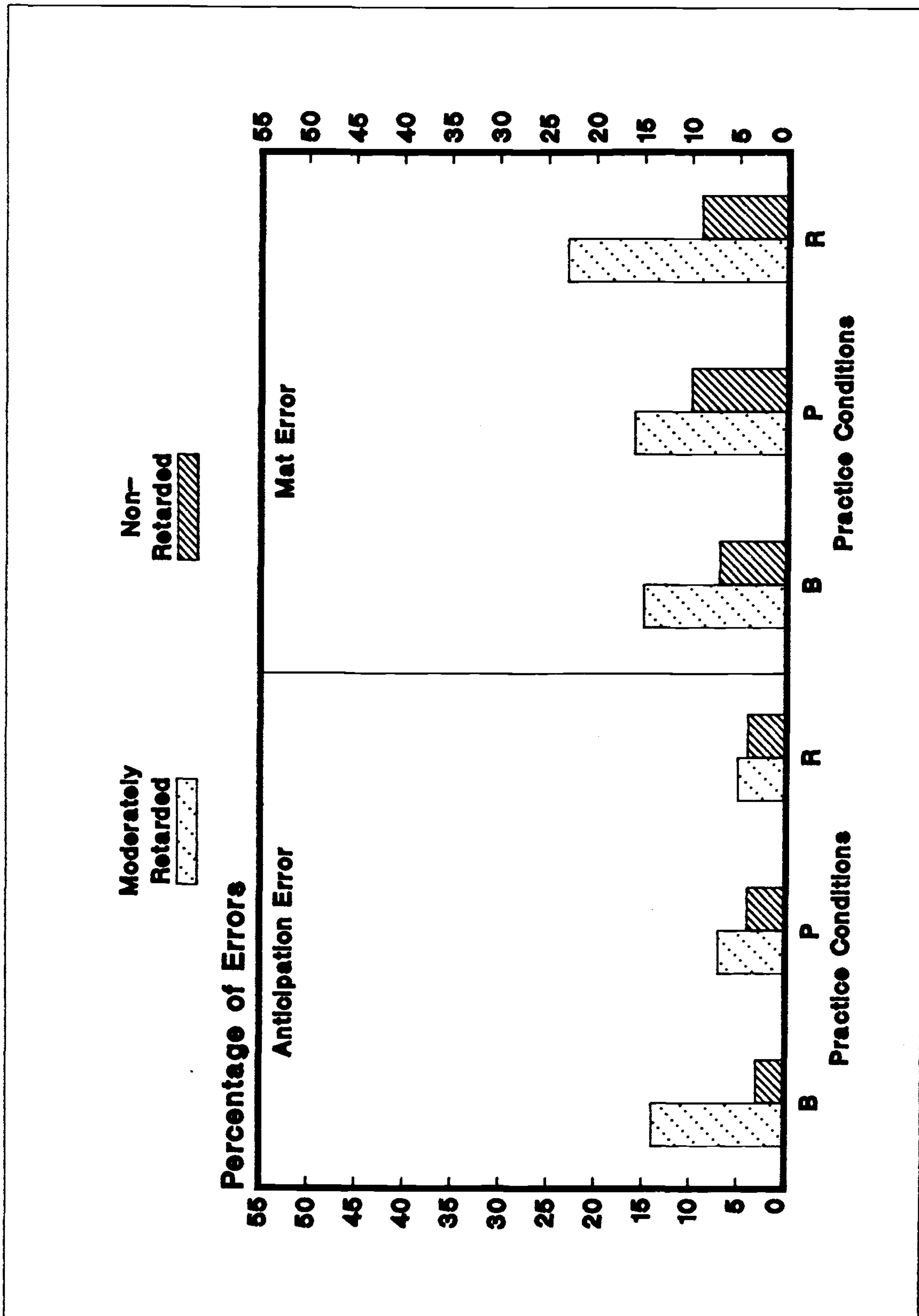

Figure 6. Percentages of anticipation errors and mat errors as a function of IQ level and practice conditions during acquisition.

Table IV.4

Frequency of mat errors as a function of IQ level and practice condition during acquisition

	Intelligence			
	Moderately retarded		Nonretarded	
	N	Percentage	N	Percentage
Condition				
Random	351	(22%)	129	(8%)
Pseudoserial	265	(16%)	141	(9%)
Blocked	249	(15%)	119	(7%)
Total mat errors				
	865	(18%)	389	(8%)

the random group committed 8% errors and the pseudoserial group committed 9% errors. Moderately retarded subjects in the blocked made fewer errors (15%) than moderately retarded subjects in the random group (22%).

Results During Retention Phase

Summary of Retention Hypotheses

The following hypotheses were analyzed with respect to the retention phase of the study. The hypotheses are identified and summarized in this section.

1. The first hypothesis stated that nonretarded subjects will initiate and complete the required task significantly faster and with fewer performance-related errors than moderately retarded subjects. This hypothesis was supported.
2. The second hypothesis stated that nonretarded subjects in the blocked group will initiate and complete the required task significantly slower and with a greater number of performance-related errors than nonretarded subjects in the pseudoserial and random practice groups. This hypothesis was not supported.
3. The third hypothesis stated that nonretarded subjects in the pseudoserial practice group will initiate and complete the required task significantly slower and with a greater number of performance-related errors than nonretarded

subjects in the random practice group. This hypothesis was not supported.

4. The fourth hypothesis stated that moderately retarded subjects in the blocked practice group will initiate and complete the required task significantly slower and with a greater number of performance-related errors than moderately retarded subjects in the pseudoserial and random practice groups. This hypothesis was not supported.

5. The fifth hypothesis stated that moderately retarded subjects in the pseudoserial group will initiate and complete the required task slower and with a greater number of performance-related errors than moderately retarded subjects in the random group. This hypothesis was not supported.

Procedures during Retention

During the retention phase, all subjects completed a total of 15 trials involving retention tasks A ,B and C. These tasks were performed under the random practice condition. Feedback was not given to the subjects during this phase of the study. The retention task was a variation of the acquisition task in that fewer cues were provided to the subjects. The movement sequence cues presented in the form of diagrams differed from the acquisition phase in that they did not contain the numbers or arrows. The same colour coding used to designate mat order during the acquisition phase was retained. As during the acquisition phase, subjects were required to respond as quickly and accurately as possible to the onset of the light stimulus.

Results during Retention Phase

Reaction time:

Intelligence: There were no statistically significant main effects for the intelligence variable during retention (see Table IV.5). Two-way interactions involving the intelligence variable were also not significant. There was a significant three-way interaction between task, intelligence group and condition (F (4,132) =2.44,p <.06), as displayed in Figure 8. Subjects in the nonretarded pseudoserial group exhibited statistically different reaction times from various other intelligence groups and conditions. For example, nonretarded subjects in the pseudoserial group performed Task B significantly faster than mentally retarded subjects in the blocked condition. Disordinal interaction occured with nonretarded subjects in random and blocked groups between Tasks A and B and Tasks B and C. Figure 7 provides an illustration of the retention reaction times averaged and collapsed over trials. The RT means, standard deviations, and standard errors, as a function of practice condition are located in Appendix G.

Task: There were no significant main effects for the the task variable. The two-way interaction involving

Table IV.5

Analysis of Variance

Retention analysis for reaction time

Source of Variation	df	Sum of Squares ss	Mean Square ms	Obtained *F*	*p*
Intelligence	1	354187.92	3548187.92	0.83	0.3660
Condition	2	6066421.27	3033210.63	0.71	0.4962
IQ X C	2	2389703.30	1194851.65	0.28	0.7575
Error	66	282686802.99	4283133.38		
Task	2	568938.12	284469.06	1.20	0.3054
T X IQ	2	365575.52	182787.76	0.77	0.4655
T X C	4	610283.07	152570.77	0.64	0.6335
T X IQ X C	4	2315335.96	578833.99	2.44	0.0504*
Error	132	31373488.59	237677.94		

* Significant at 0.10 level

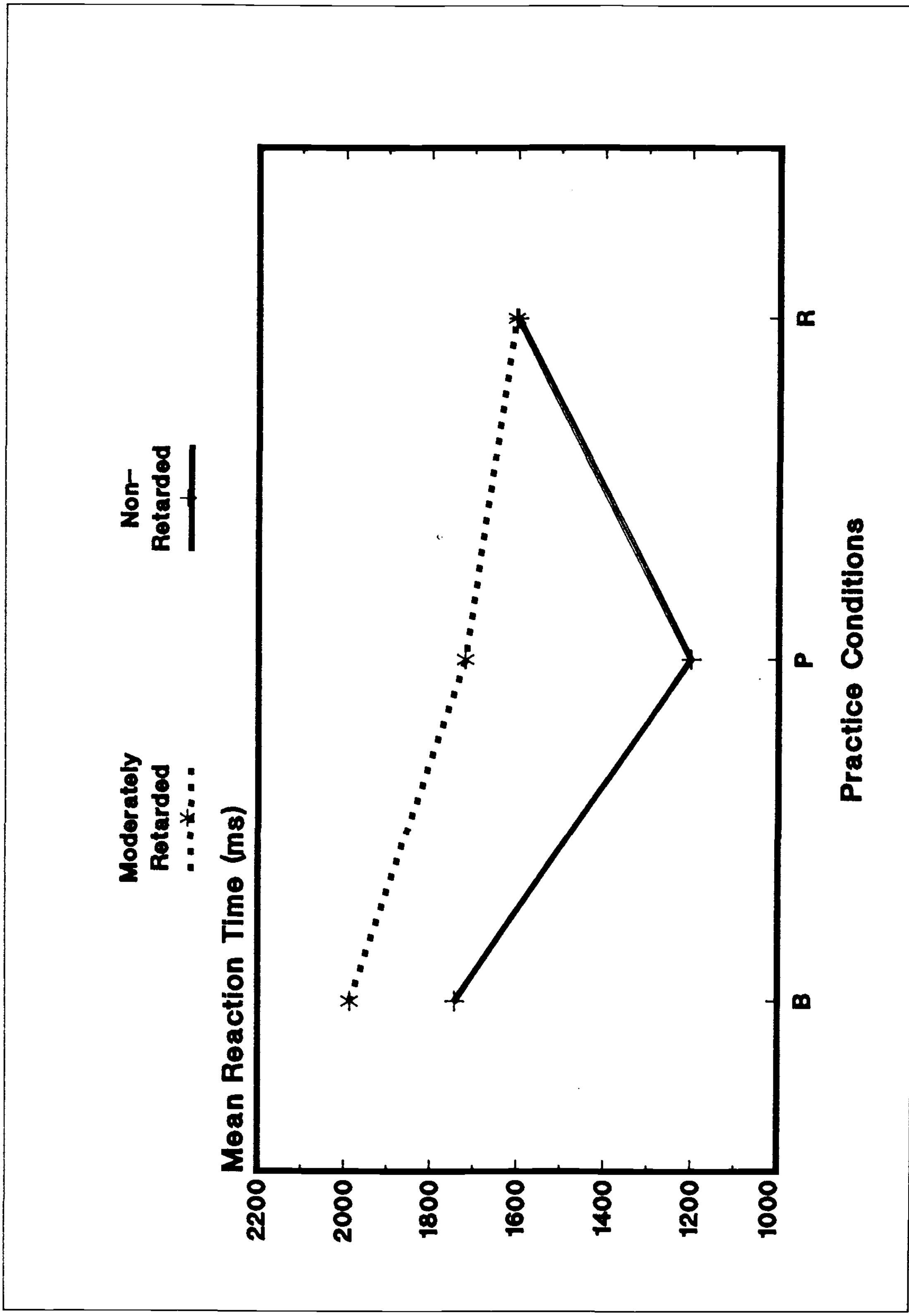

Figure 7. Retention mean reaction times plotted as a function of practice conditions.

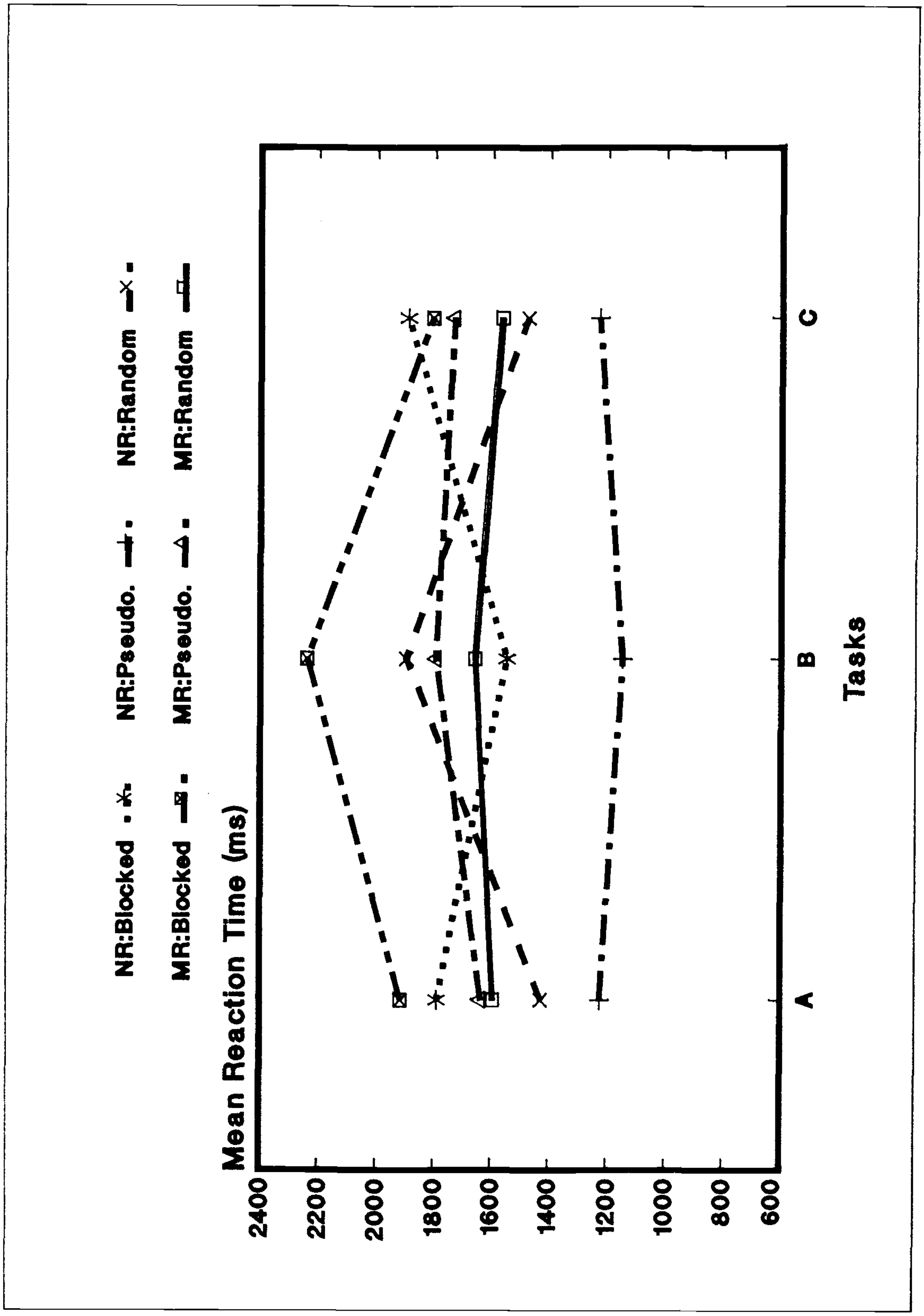

Figure 8. Three-way interaction among intelligence, task, and practice conditions.

the task variable were not significant. There was a significant three-way interaction involving the task variable as earlier discussed. The data do suggest that Task A was consistently responded to fastest when averaging across all subjects. However, this was not statistically significant.

Condition: There were no significant main effects for condition, between the blocked, pseudoserial or random contextual interference practice groups. Table IV.5 provides a summary of the retention reaction analyses. There was a significant three-way interaction between task, intelligence group and practice condition at the .10 level of significance (F (4,132) = 2.44, p <.06).

Total response time

Intelligence: A significant main effect was obtained for the intelligence variable (F, (1,66) = 56.15, p <.0001). Neither the two-way nor three-way interactions involving the intelligence variable were significant. Table IV.6 provides a summary of the retention analyses for total response time. The nonretarded subjects exhibited faster total response times than the moderately retarded subjects. Figure 9 displays the total response times averaged and collapsed over tasks and trials for each practice condition.

Task: A significant main effect for total response

Table IV.6

Analysis of Variance

Retention analysis for total response time

Source of Variation	df	Sum of Squares ss	Mean Square ms	Obtained F	p
Intelligence	1	1529315204.43	1529315204.43	56.15	0.0001*
Condition	2	30635271.86	15317635.93	0.56	0.5726
IQ X C	2	77079117.11	38539558.56	1.41	0.2502
Error	66	1797744393.85	27238551.42		
Task	2	35960272.39	17980136.19	4.00	0.0206**
T X IQ	2	3551118.75	1775559.37	0.39	0.6747
T X C	4	14634981.64	3658745.41	0.81	0.5189
T X C X C	4	8161936.02	2040484.00	0.45	0.7697
Error	132	593879026.95	4499083.54		

* Significant at 0.01 level

** Significant at 0.05 level

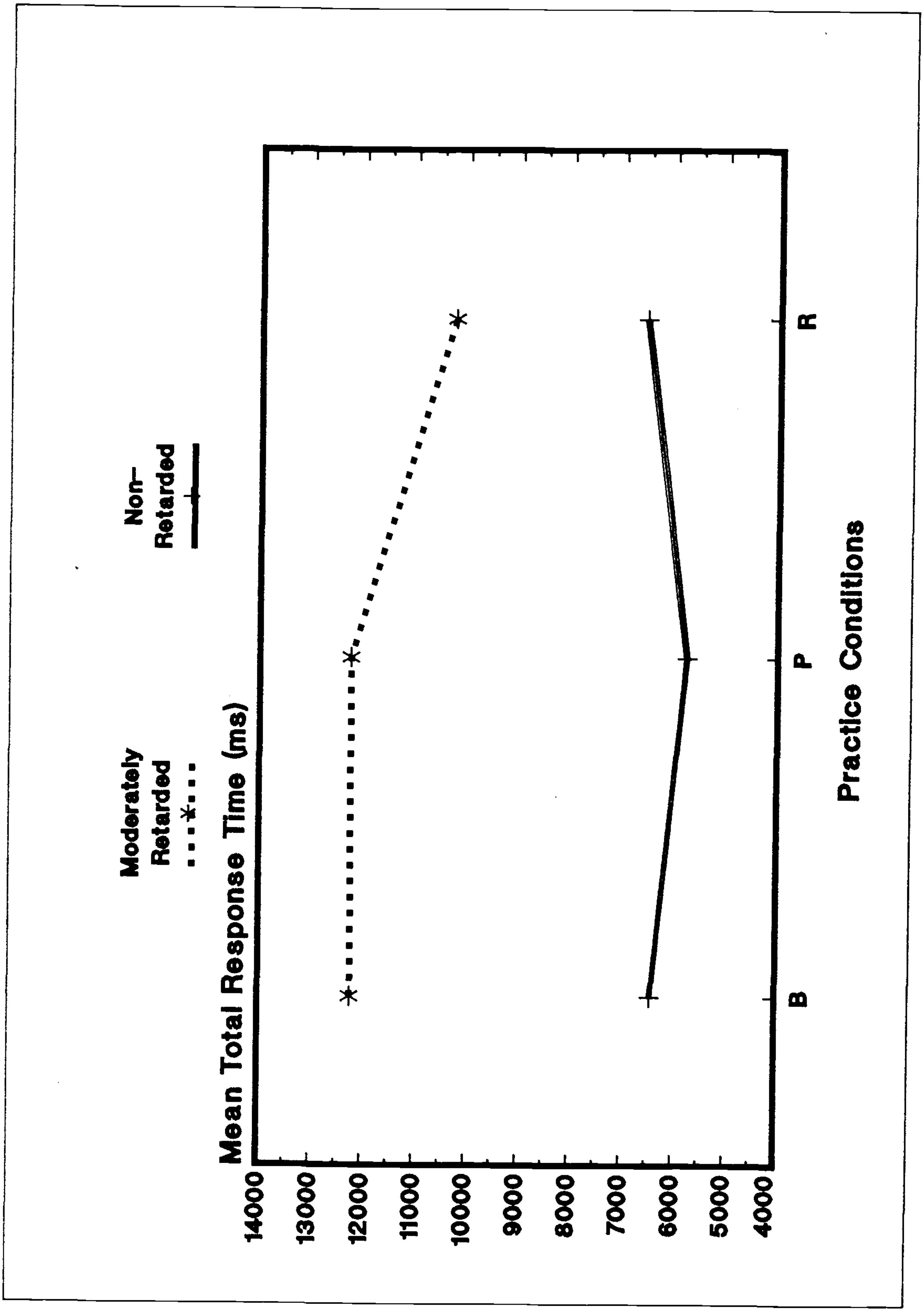

Figure 9. Retention mean response (ms) times averaged and collapsed over tasks and trials for each practice condition.

time was found for the task variable (F, (2,132) = 4.00, p <.03). For both intelligence groups,subjects exhibited the fastest total response times when performing Task A. These times are reported in Appendix H. Neither the two-way nor three-way interactions involving the variable task reached significance.

Condition: There were no significant differences between the subjects in the blocked, pseudoserial or random practice conditions with respect to total response times (see Table IV.6). As indicated in Figure 9, nonretarded subjects in the pseudoserial group had the fastest total response times for that intelligence level. Moderately retarded subjects in the random group had the fastest total response times for their intelligence level. Neither of these findings, however, were statistically significant. Neither the two-way nor the three-way interactions involving the practice condition variable reached significance.

Anticipation error

Intelligence: During retention, the moderately retarded subjects made approximately four times as many total anticipation errors (8%) as the nonretarded subjects (2%). Figure 10 provides an illustration of the frequencies of anticipation and mat errors across intelligence levels and practice conditions.

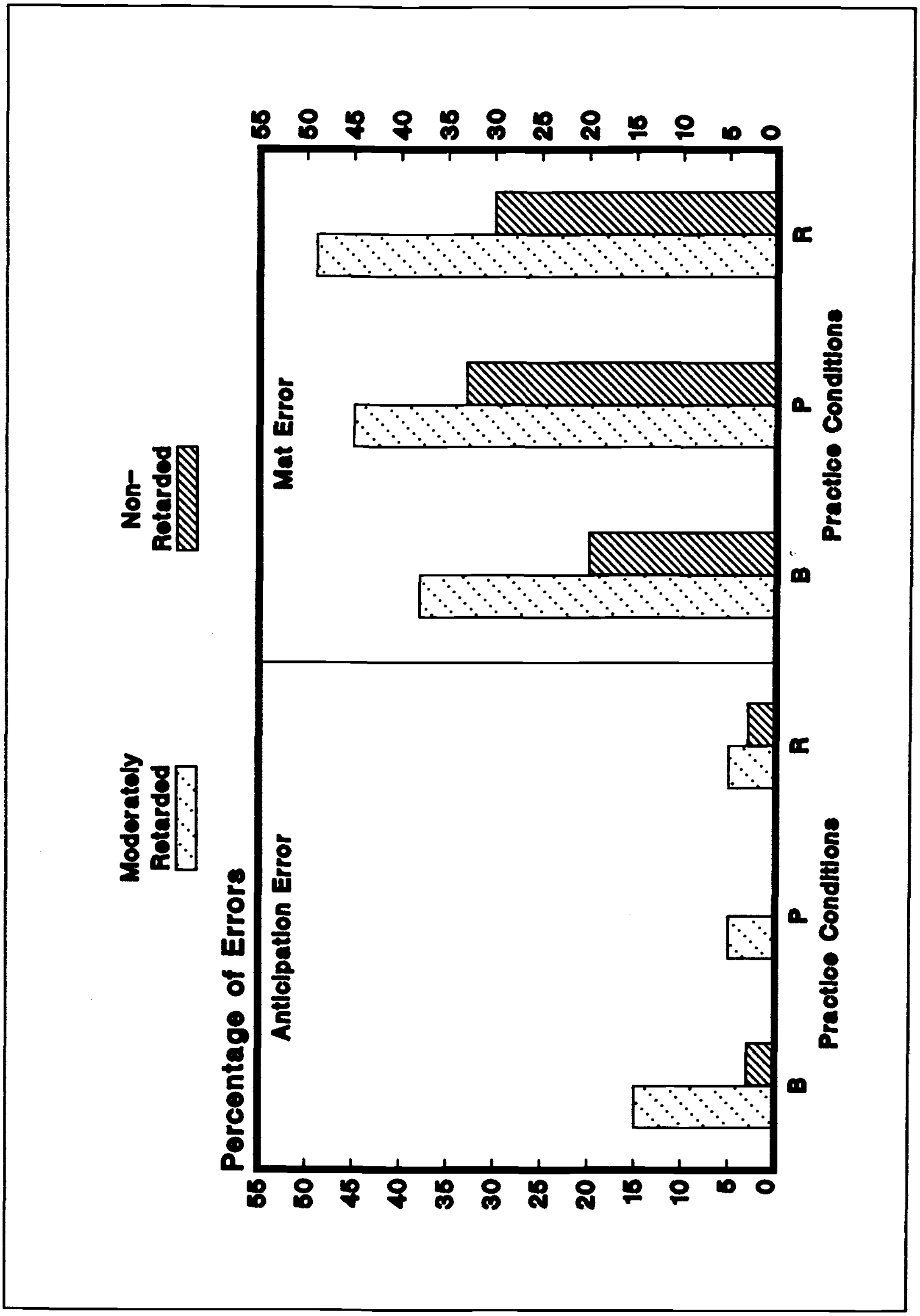

Figure 10. Percentages of anticipation errors and mat errors as a function of IQ level and practice condition during retention.

Condition: The moderately retarded subjects in the blocked group had the greatest number of anticipation errors (16%), as compared to moderately retarded subjects in the random (4%) or pseudoserial (4%) groups. Nonretarded subjects in the blocked and random groups exhibited the same frequency of errors (3%). The nonretarded subjects in the pseudoserial practice condition did not commit any anticipation errors during retention. Table IV.7 summarizes these results.

Mat error

Intelligence: In the retention phase, the moderately retarded subjects made more mat errors (44%) than the nonretarded subjects (28%). Table IV.8 provides a summary of mat error results. The total percentages of mat errors increased from acquisition to retention for both intelligence groups.

Condition: Moderately retarded subjects in the random group made a greater percentage of mat errors (49%) than moderately retarded subjects in the pseudoserial (45%) and blocked groups (38%). Nonretarded subjects in the pseudoserial group made a greater percentage of mat errors (32%) than nonretarded subjects in the random (31%) or blocked groups (20%). During retention, subjects in the blocked groups exhibited the fewest mat errors across practice conditions (See Table IV.8).

Table IV.7

Frequency of anticipation errors as a function of IQ level and practice condition during retention

	Intelligence			
	Moderately retarded		Nonretarded	
	N	Percentage	N	Percentage
Condition				
Random	7	(4%)	5	(3%)
Pseudoserial	7	(4%)	0	(0%)
Blocked	29	(16%)	5	(3%)
Total anticipation errors	43	(8%)	10	(2%)

N = number of anticipation errors

Table IV. 8

Frequency of total mat errors as a function of intelligence and practice condition during retention

	Intelligence			
	Moderately retarded		Nonretarded	
	N	Percentage	N	Percentage
Condition				
Random	262	(49%)	168	(31%)
Pseudoserial	243	(45%)	174	(32%)
Blocked	205	(38%)	108	(20%)
Total mat errors	710	(44%)	450	(28%)

N = number of mat errors

Discussion of Findings

Discussion Pertaining to Acquisition

This discussion will focus on findings related to the dependent variables used in the present investigation. Specifically, reaction time, total response time and error measures will be discussed. The relative impact of intelligence grouping, tasks and practice schedules on the variables will be reviewed. Although many of the results did not reach statistical significance, some observations regarding the nonsignificant findings will be offered.

Reaction time

Reaction time has been utilized as an indicator of information processing capabilities (Sternberg, Monsell, Knoll and Wright, 1978). Significant differences in reaction times have consistently been noted between retarded and nonretarded individuals (Bruininks, 1974; Rarick, 1973). During the acquisition phase in the present study, the nonretarded subjects produced significantly faster reaction times (RTs) than the moderately retarded subjects. This finding was anticipated and is in agreement with earlier research reported by Blake (1984) and by Hoover, Wade and Newell (1981).

Although there were no significant differences across practice conditions, nonretarded subjects in the blocked group, performing under a predictable task presentation order, exhibited faster RTs when compared to nonretarded subjects in the pseudoserial and random groups. A possible explanation for this may be that subjects in the blocked group did not have to scan all three tasks (A, B, or C) prior to executing the upcoming task. As a result, they were faced with only a simple RT task. The degree of information processing required of a simple RT task would therefore be somewhat less than that required of subjects performing under a random or choice reaction time task. Subjects learning under a random practice schedule experienced the lowest event predictability and, correspondingly, exhibited the slowest RTs during acquisition. Blake (1984) reported that nonretarded and educable mentally retarded subjects in her random groups, had significantly slower RTs during acquisition when compared to the blocked groups. These results are also consistent with investigations conducted by Shea and Morgan (1979) and Lee and Magill (1983).

It is interesting to note that for the moderately retarded the fastest reaction times during acquisition were obtained by the random group and the slowest by the pseudoserial group. These findings however, were not statistically significant. In addition the findings do not parallel earlier reported findings related to the mentally retarded population. For example, Blake (1984) found that during acquisition the EMRs in the blocked group produced faster RTs than the random group. One might speculate that in the present study, since the subjects in the random practice condition exhibited the fastest RTs but the highest percentage of mat errors during acquisition, perhaps task accuracy was foresaken for the element of speed. An alternate explanation may be that the blocked group RT increased as a function of their high percentage of anticipation errors, thereby becoming overcautious.

For the acquisition phase, there was a main effect for RT, as a function of task. When scores were averaged according to task sequence across all subjects, Task A was responded to the fastest. This task had the least complexity of the three tasks. Mat 1 was placed closest to the starting footswitch, mat 2 was the next closest and mat 3 was the furthest from the starting footswitch. Upon examining intelligence group differences with respect to tasks, it appears that the nonretarded subjects exhibited the fastest RTs when performing Task C whereas the moderately retarded responded to Task A in the shortest amount of time. During acquisition, both intelligence groups performed the slowest when performing Task B. Although all tasks were assumed to be relatively equal in terms of difficulty, it was anticipated at the outset that Task A might be performed the most easily by subjects, as the numbers on the mats did ascend according to the mat's distance from the starting footswitch. In order to minimize any distortion that may have occurred as a result of subjects performing a disproportionate number of trials of Task A, in particular, trials were averaged according to task sequence.

Total response time

It was hypothesized that during acquisition, the nonretarded subjects would complete the tasks quicker than the moderately retarded subjects. During acquisition, the nonretarded subjects did achieve significantly faster total response times than the moderately retarded subjects. Application of the Newman-Keuls post hoc comparisons revealed that nonretarded subjects performed all three tasks significantly faster than the moderately retarded subjects. These results support the work of Blake (1984) and the literature pertaining to motor behaviour characteristics of the mentally retarded (Karper and Martinek, 1985; Rarick and Beuter, 1985).

There were no statistically significant differences between the three practice conditions with respect to total response time. Subjects in both pseudoserial groups produced the slowest total response times during acquisition, while subjects in both blocked groups produced the fastest total response times. Blake (1984) reported that during acquisition nonretarded subjects in the blocked group performed significantly faster than the nonretarded subjects in the random group. This finding also occurred with the EMR group, according to Blake.

Empirical evidence was found to support the presence of significant differences among tasks with respect to total response times. During acquisition, the moderately retarded subjects performed Task A significantly faster than either

Task B or Task C. However, this effect did not reach significance with the nonretarded subjects.

Error information

During acquisition, the nonretarded subjects committed fewer anticipation and mat errors than the moderately retarded. This finding was expected and coincides with other investigations comparing mentally retarded and nonretarded subjects. In the present study, the moderately retarded subjects were often unable to keep their feet securely positioned on the footswitch during the variable 2 - 5 second foreperiod. In other cases, they forgot to wait for the light and simply began to repeat the previously completed trial sequence. Subjects were reminded to wait for the light. Moderately retarded subjects in the blocked group committed more anticipation errors than the subjects in the pseudoserial or random groups. These results contrast with the nonretarded findings. Within the nonretarded intelligence group, subjects in the blocked, random and pseudoserial groups produced similar numbers of anticipation errors.

The large number of anticipation errors committed by the mentally retarded subjects was tolerated in this study, as the original requirements for completing the task specified only that when three consecutive anticipation errors were committed would subjects be eliminated from the study. Two mentally retarded subjects were eliminated on this basis.

Although one must speculate that the number of anticipation errors might decline during the retention phase, the percentage of anticipation errors was similar across the acquisition and retention phases.

Discussion Pertaining to Retention

A number of factors may have been instrumental in the lack of statistically significant results in the retention phase. Three of these factors are discussed initially and others are elaborated upon in the sections that follow. One possible factor may have been the selection of the retention task itself. Although the task used for the acquisition and retention phases was similar, fewer cues were provided for the retention phase. In the acquisition phase, subjects were provided with a diagram that contained numbers, arrows and colours. Only colours were retained for the retention phase. As a result, there were relatively greater information processing demands placed on the subjects. In the present study, the poor retention performance may be attributed to the subjects' inability to remember colours and/or to associate the colours with a specific mat sequence order. Subjects also may not have utilized colours as their predominent cue during acquisition. Nine of the nonretarded subjects and ten of the mentally retarded subjects who did not successfully complete the majority of the retention trials, commented that they relied on the number cues to help them perform the sequences correctly during acquisition. Without the numbers during retention, it is not surprising that these subjects, and perhaps others who failed to articulate this difficulty, had great difficulty completing the tasks successfully. In addition, three of the mentally retarded subjects commented that they used the arrow cues to help them complete the sequences correctly during acquisition. They then encountered difficulty when the arrows were absent from the retention diagrams. These results suggest that the cues may have been used but not retained or, the cues were not used. Research conducted by Edwards et al.,(1988), found that with six, nine and twelve year olds, strategies for learning were not spontaneously employed unless given prior instruction to do so. Failure to provide rehearsal strategies in the present study, may also have attributed to these individuals' inability to perform successfully during retention.

Research on the influence of low versus high contextual interference retention practice schedules has generally supported the use of high contextual interference practice schedules during retention (Blake, 1984; Lee and Magill, 1983; Shea and Morgan, 1979). Within this study a less challenging indication of what subjects retained from acquisition to retention may have been attained if the same diagrams had been presented under a blocked practice schedule (i.e., 5 trials of Task A, 5 trials of Task B, and 5 trials of Task C), counterbalanced across subjects. This format may have been enough of a challenge for the moderately retarded subjects in particular. Perhaps future experimental endeavours should include both low and high contextual interference retention practice schedules to attain a clearer measure of their respective impacts on the mentally retarded. This has been done in the form of transfer trials with nonretarded subjects (Shea and Zimny, 1982).

Another factor to consider is the length of the delay interval between acquisition and retention. Research has indicated that no differences exist between 10 minute and 10 day delay periods from acquisition to retention (Shea and Morgan,1979) when measuring recall with nonretarded subjects. Perhaps subjects could be retested using the same cues as in the acquisition phase, after a longer delay interval period. This may provide a greater understanding of the retention of the original task. All of these factors may have been instrumental in the retention results and their departure from other contextual interference findings.

Reaction time

During retention, there were no statistically significant differences between intelligence groups with respect to reaction time. Conversely, Blake (1984) found significant differences in reaction times between mentally retarded and nonretarded subjects. In the present study, perhaps the change in task complexity during retention may have slowed the reaction times of the nonretarded enough to prevent a significant difference between the two intelligence groups. During acquisition, it was perceived that the nonretarded subjects found the task to be relatively simple. As a result, these subjects concentrated on increasing their speed on each successive trial. The lack of statistically significant differences between intelligence groups during the retention phase of the investigation is somewhat surprising. One explanation may be attributed to the retention trial format. It is proposed that since subjects did not receive feedback after each retention trial they may have not had the same degree of confidence in their upcoming responses as they did during acquisition. As a result, they may have been processing whether or not they believed they had completed the previous trial correctly or not. Knowledge of results, while important for mentally retarded and nonretarded, is particularly critical to the nonretarded subjects, who rely on this information to generate strategies to complete the next response successfully. If the absence or presence of knowledge of results, is the critical issue with respect to performance during retention, then there should be little difference between retention schedules that follow a blocked format as opposed to a random format. Further research incorporating these elements is needed to determine the locus of the effects of knowledge of results on retention performance.

Greater variability was observed within the nonretarded subjects' reaction times during retention as compared to the mentally retarded (See Appendix H). This was unexpected since, if anything, one might expect there to be greater variability within moderately retarded subjects. Other researchers have also noted differing levels of variability within mentally retarded goups, although primarily during the acquisition phase. This was evident in work by Edwards, Elliott and Lee (1986), who reported that, during acquisition, the Down syndrome subjects displayed greater timing consistency than the nonretarded subjects across all practice conditions. The explanation forwarded was that the differential experience the groups may have had with similar tasks prior to the present experiment, may have contributed to the variability. These results, in addition to those reported in this study, provide impetus for further contextual interference research with mentally retarded subjects, to determine if in fact the variability across subjects is the result of a specific task or attributed to the subjects themselves.

It was interesting to note the pattern in subjects' reaction times across the three tasks. Task A tended to be initiated the fastest by both intelligence groups. However, this main effect for task, was not significant. Again, the pattern involved in Task A had the least complexity of the three tasks and was expected to be learned and retained the easiest. Other researchers have also reported significant differences in reaction times as a function of tasks. For example, Blake's (1984) barrier knockdown task resembled the mat sequencing concept used in the present study. She found differences in the response times across the tasks; however, there were no noteable similarities between her fastest task and the present study's fastest task.

Total response time

With respect to total response time during retention, the nonretarded subjects performed significantly faster than the moderately retarded subjects. These results again support Blake (1984) and the motor behaviour literature pertaining to the mentally retarded. For the moderately retarded and nonretarded subjects combined, the statistically fastest total response times were exhibited when performing Task A.

There were no statistically significant differences in TRT during retention as a function of the type of practice condition. During retention, the moderately retarded subjects in the random practice conditions produced the fastest total response times, though not to a statistically significant extent. It is possible that since RT is a component of total response time, the response time results in the present study, may have been confounded. Blake (1984) failed to determine any significant differences in movement times across practice conditions during retention. Findings reported by Blake indicated contrary to the present study, that the EMR subjects performed fastest movement times under a blocked practice schedule. Blake also reported that, during retention, nonretarded subjects performing in the random practice condition exhibited faster RTs than nonretarded subjects performing under a blocked practice schedule. In the present study, nonretarded subjects in the random group had the slowest total response times.

Error information

The total number of mat errors committed by both the moderately retarded and nonretarded subjects increased from acquisition to retention. One might speculate that the increase in errors during retention, is attributed to the increase in task complexity. The absence of knowledge of results may also have contributed to the inflated error scores.

During retention, for the moderately retarded subjects, the most anticipation errors and fewest mat errors occurred in the blocked practice condition. This pattern also prevailed in the acquisition phase. It is clear that the moderately retarded subjects were extremely anxious to begin trials throughout both phases of the experiment and had difficulty waiting for the stimulus. The generation of relatively few mat errors by the blocked group during acquisition may be a function of the fact that these subjects experienced the highest event predictability. If the concept of contextual interference applied in this situation, it would be expected that subjects who performed under a blocked practice schedule during acquisition would then exhibit the greatest number of mat errors during retention. This did not occur. Experimental findings obtained by Forbus et al.(1989), also failed to provide support for the idea that higher levels of CI facilitated retention with moderate mentally retarded adults. It is unclear if contextual interference may be effectively utilized with mentally retarded or nonretarded populations.

Summary of Discussion

The primary purpose of this investigation was to examine the effects of contextual interference on the learning and retention of a sequential motor task with moderately retarded and nonretarded individuals. It is clear from the findings that the moderately retarded individuals experienced greater difficulty in performance than the nonretarded subjects. It is also clear that neither the moderately mentally retarded nor nonretarded subjects benefited differently from a particular practice schedule. However, the lack of statistically significant results should not reduce the importance of the present findings. Other researchers conducting contextual interference research with mentally retarded populations have also reported statistically nonsignificant findings. For example, Blake noted that the majority of her results did not reach significance. A recent report published by Forbus, Horvat and Roswall (1989), also failed to reveal any significant differences across blocked, random and sequential practice groups. What remains unclear however, are the reasons underlying the similar effects found across the three practice schedules on the learning and retention of some motor skills. Perhaps the increasing number of studies that have reported nonsignificant findings should be studied to determine the underlying reasons. One recommendation is to replicate the studies where statistically significant results have been found and to utilize a variety of different target populations. It may be that learning under high contextual interference conditions may not benefit certain groups performing certain tasks. Through a methodical selection of target populations and tasks, the benefits of structuring a learning environment to incoroprate high levels of CI, may be determined. Further research is indeed warranted. Another suggestion is to replicate studies that have had inherent weaknesses and to increase the power and experimental control within their respective designs.

One of the original goals of this study was to explore and compare the effects of pseudoserial and random practice schedules. Previous contextual interference research had suggested that serial and random groups typically produced similar results. It was surmised that the implementation of a pseudoserial group may have provided enough predictability, yet a greater degree of complexity than a blocked format. Unfortunately, there were no discernible similarities between the random or pseudoserial groups in the present study. This study was the first to incorporate a pseudoserial group into its design. It may be that the nature of the task used in this study (high processing demands) supressed the benefits from learning under such a format. It may also be that the pseudoserial format of completing only three trials of one task before completing the other two tasks, did not provide ample time for subjects to foster a strong representation of the task. Further research involving a pseudoserial group is needed to ascertain if there are instances where this type of format may be appropriate.

Another facet of this study was to implement contextual interference practice schedules with young children. Very little research had been done previously with children. Perhaps the mental ages of the subjects in the present study were too young to benefit from contextual interference during learning. In a report by Edwards, Moore, Dornier and Poudrier (1988), it was suggested that young children are unable to independently develop strategies which would be useful to complete tasks learned under high contextual interference conditions. To better assess if this was indeed a difficulty in the present study, a number of suggestions for future research are offered in the following chapter.

CHAPTER V

SUMMARY AND CONCLUSIONS

The purpose of the study was to analyze the effects of three levels of contextual interference on the learning and retention of a sequential motor skill by moderately retarded and nonretarded individuals. The mental ages of the subjects were between 8 and 12 years. Both males and females were used in this study.

This chapter is divided into the following sections: (a) summary of procedures, (b) summary of findings, (c) implications, and (d) recommendations for future research.

Summary of Procedures

Prior to the experimental session, subjects performed three practice trials which were variations of the experimental tasks to be used. Only those subjects who successfully completed at least two of the three trials were included in the study. Thirty-six moderately retarded and 36 nonretarded individuals were randomly assigned to one of three contextual interference practice schedules. Each subject performed a total of 45 acquisition trials and 15 retention trials. All subjects performed the same three acquisition and retention tasks. The order of task sequences were counterbalanced across subjects during each phase of the experiment. Reaction Time (RT), Total Response Time (TRT), anticipation and mat error scores were recorded and analyzed for all subjects.

Each trial was initiated by having the subject place one foot on a starting footswitch. When a light illuminated, the subject was required to respond immediately by executing the appropriate sequence as quickly and accurately as possible. Upon completion of the trial, the subject returned promptly to the starting location and again depressed the footswitch to begin the next trial. Oral feedback was given prior to the initiation of each trial during acquisition. A five minute delay interval was inserted between the acquisition and retention phases. During the retention phase, subjects followed basically the same procedures, with a few modifications in the tasks. These procedural changes included the elimination of knowledge of results after each trial and a reduction in the amount of information provided on the diagrams.

The design of the acquisition phase incorporated a 2 X 3 X 3 (IQ X Practice Conditions X Tasks) model with repeated trials. For the retention phase the same model, a 2 X 3 X 3 (IQ X Practice Conditions X Tasks) with repeated measures, was used. For both the acquisition and retention phases, a Multivariate Analysis of Variance (MANOVA) was performed using RT and TRT as dependent measures. The trials were averaged for each task. Significant effects from the MANOVA were further analyzed using Analysis of Variance procedures. Significance was established at an alpha level of .10. An alpha level of .10 was chosen due to the exploratory nature of this investigation. This alpha level would provide a more liberal estimate of the differences between groups, than a traditional .05 level of significance. Means, standard deviations and standard errors were reported for RT and TRT. Dependent measures were analyzed as a function of intelligence group, practice condition and task. In addition to reaction time and total response time, error data were also evaluated. Error data were reported with respect to percentages of total possible errors. Anticipation errors were recorded when subjects lifted a foot from the starting footswich prior to the onset of the stimulus. The number of mats incorrectly contacted was also recorded as another form of error.

Summary of Findings

Statistically significant differences were found between the moderately retarded and nonretarded subjects' total response times, during both the acquisition and retention phases of this study. There were also significant differences between the reaction times of the moderately retarded and nonretarded subjects, during acquisition. There were no significant differences between moderately mentally retarded and nonretarded subjects' reaction times during retention. There were no statistically significant differences between the blocked, pseudoserial or random practice conditions with respect to reaction time and total response time. Empirical evidence supported the existence of differences among tasks (A,B, and C), with respect to RT and TRT. The one exception occurred, however, with respect to reaction times during retention. There were no significant main effects for tasks in this case.

Throughout the study, the nonretarded subjects produced fewer anticipation errors and fewer mat errors than the moderately retarded subjects. The total frequency of mat errors increased for both the mentally retarded and nonretarded groups, from acquisition to retention.

Implications

This investigation has added to the body of knowledge pertaining to the acquisition and retention of motor skills with mentally retarded and nonretarded individuals. Evidence gained from the present investigation has substantiated earlier research indicating significant differences in reaction times and total response times between mentally retarded and nonretarded children. When teaching motor skills, especially in an integrated setting, it is important to take these performance differences into account.

Although statistically significant differences were not found among the three practice conditions, there were instances where the findings followed the patterns reported in other contextual interference investigations. The findings of this study are inconclusive and more research is needed to ascertain if the mentally retarded may benefit from structuring the learning environment to involve higher levels of contextual interference.

The tasks themselves appeared to affect the reaction times and the response times of subjects. It was anticipated that the least complex task would be performed the fastest, and this was indeed the case. This information is valuable to physical educators and reinforces the need to pay attention to task parameters when structuring motor activities. In the present investigation, simply altering the movement patterns for example, changed the complexity of the task and the resulting performance.

Recommendations for Future Research

As a result of this investigation, a number of recommendations for future research have evolved. These are outlined in the following section.

1. The present study should be replicated, with a number of possible alterations.

a) Moderately mentally retarded and nonretarded adults should be used as subjects. Research has suggested that young children may not be able to develop problem-solving strategies sufficiently to benefit from learning under high contextual interference conditions. Perhaps by utilizing adults as subjects initially and then choosing increasingly younger individuals, it may become clearer who will benefit from structuring a learning environment in this manner. Another alternative would be to compare adults and children in one study.

b) The number of acquisition trials should be increased. By doing so, this would ensure that an adequate representation of the task had been formulated by the subjects.

c) Variations in the amount of cueing during acquisition should be provided and counterbalanced across subjects. As posed in the discussion section, it is critical to structure some investigations in the future to incorporate gradients of acquisition cueing and to provide various levels of overt startegies concerning how to utilize these cues. This would allow researchers to identify the amount and type of cueing necessary to complete the retention task successfully.

d) All subjects should perform the same number of trials of each task, based on a trials-to-criterion format. This would alleviate unnecessary averaging of scores and provide greater consistency in treatments across subjects.

2. Replications should be conducted of CI studies where statistical significance was found and of studies where original experimental design problems could be controlled, using a variety of target populations as subjects. Knowledge may then be gained as to which groups appear to benefit from learning under various contextual

interference practice conditions.

3. Further field based research involving instruction with selected motor skills, under various levels of contextual interference, is needed. It is important for research in physical education to have practical relevance to the teacher or coach.

4. When utilizing mentally retarded subjects, the availability of intelligence scores may be helpful in allowing for further analyses within intelligence classifications. This information may also help to clarify some of the variability often noted in research involving these populations.

References

Adams, J.A. (1987). Historical review and appraisal of research on the learning, retention, and transfer of human motor skills. Psychological Bulletin, 101, (1), 41-74.

Battig, W.F. (1966). Facilitation and interference. In E.A. Bilodeau (Ed.), Acquisition of Skill. New York: Academic Press.

Battig, W.F. (1979). The flexibility of human memory. In L.S. Cermak and F.I.M. Craik (Eds.), Levels of Processing in Human Memory. New Jersey: Erlbaum.

Battig, W.F., & Shea, J.B. (1980). Levels of processing of verbal materials: An overview. In P.Klavora and J. Flowers (Eds), Motor learning and biomechanical factors in sport. Toronto: University of Toronto Press.

Blake, P.D. (1984). The effect of contextual interference on retention in educable mentally retarded adolescent males, through the use of a blocked and random learning paradigm. Unpublished master's thesis, Pennsylvania State University, University Park.

Bruininks, R. (1974). Physical and motor development of retarded persons. In N.R. Ellis (Ed.), International Review of Research in Mental Retardation. 7: 209-261. New York: Academic Press.

Cohen, J. (1969) Statistical Power Analysis for the Behavioral Sciences. New York: Academic Press.

Craik, F.I., & Lockhart, R.S. (1972). Levels of processing: A framework for memory research. Journal of Verbal Learning and Verbal Behavior, 11, 671-684.

Del Rey, P., Wughalter, E.H., & Whitehurst, M. (1982). The effects of contextual interference on females with varied experience in open sport skills. Research Quarterly for Exercise and Sport, 53(2), 108-115.

Dornier, L., Edwards, R., Moore, J., & Poudrier, C. (1988). Paper presented at the North American Society for the Psychology of Sport and Physical Activity Conference. Knoxville, Tennessee.

Dunn, J.M., Morehouse, J.W, & Fredericks, H.D. (1986). Physical Education for the Severely Handicapped: A Systematic Approach to a Data Based Gymnasium. Texas: Pro-Ed Publishing.

Edwards, J.M., Elliott, D., & Lee, T.D. (1986). Contextual interference effects during skill acquisition and transfer in Down Syndrome adolescents. Adapted Physical Activity Quarterly, 3, 250-258.

Eichstaedt, C.B., & Kalakian, L.H. (1982). Developmental / Adapted Physical Education. Minneapolis: Burgess Publishing.

Fait, H.F., & Dunn, J.M. (1984). Special Physical Education. Philadelphia: Saunders College Publishing.

Fait, H.F., & Kupferer, H. (1956). A study of two achievement tests and its implication inplanning physical education activities for the mentally retarded. American Journal of Mental Deficiency, 60, 728-732.

Forbus, W.R., Horvat, M.A., & Roswall, G. (1989). Contextual interference effects on open motor tasks. Advocate: National Consortium on Physical Education and Recreation for the Handicapped, 17, (2),p.3.

Franks, B.D., & Schuyler, W.H. (1986). Why does everyone use the .05 significance level? Research Quarterly for Exercise and Sport, 57 (3), 245-249.

Goode, S., & Magill, R.A. (1986). Contextual interfernce effects in learning three badminton serves. Research Quarterly for Exercise and Sport, 57 (4), 308-314.

Hoover, J.H., Wade, M.G., & Newell, K.M. (1981). Training moderately and severely mentally retarded adults to improve reaction and movement times. American Journal of Mental Deficiency, 85, 389-395.

Karper, W., & Martenek, T. (1985). The integration of nonhandicapped children in elementary physical education. Adapted Physical Activity Quarterly, 2 , 314 - 319.

Kenny, D.A. (1987). Statistics for the Social and Behavioral Sciences. Boston: Little, Brown and Company.

Lee, T.D., & Magill, R.A. (1983). The locus of contextual interference in motor skill acquisition. Journal of Experimental Psychology, 9 (4), 730-746.

Magill, R.A. (1985). Motor Learning Concepts and Applications. (2nd Ed.). Dubuque, Iowa: Wm.C.Brown Publishers.

Martens, R., Burwitz, L., & Zuckerman, J. (1976). Modeling effects on motor performance. Research Quarterly for Exercise and Sport, 47, 277-291.

Newell, K.M. (1974). Knowledge of results and motor learning. Journal of Motor Behavior, 6, 235-244.

Rarick, G.L. (1973). Motor performance of mentally retarded children. In G.L.Rarick (Ed.). Physical Activity: Human Growth and Development (pp.225-256). New York: Academic Press.

Rarick, G.L., & Beuter, A.C. (1985). The effect of mainstreaming on the motor performance of mentally retarded and nonhandicapped students. Adapted Physical Activity Quarterly, 2, (4), 277-283.

Rarick, G.L., Widdhop, J.H., & Broadhead, G.D. (1970). The physical fitness and motor performance of educable mentally retarded children. Exceptional Children, 36, 509-519.

Schmidt, R.A. (1976). The schema as a solution to some persistent problems in motor learning theory. In G.E. Stelmach (Ed.), Motor Control: Issues and Trends (pp. 41-65). New York: Academic Press.

Schutz, R.W. (1977). Absolute, constant and variable error: Problems and Solutions. In D. Mood (Ed.), The Measurement of Change in Physical Education. Boulder: University of

Colorado Press.

Shea, J.B., & Morgan, R.L. (1979). Contextual interference effects on the acquisition retention, and transfer of a motor skill. Journal of Experimental Psychology, 57 (4) 179-187.

Shea, J.B., & Zimny, S.T. (1982). Context effects in memory and learning movement information. In R.A. Magil (Ed.), Memory and Control in Motor Behavior, Amsterdam: North Holland Press.

Stelmach, G.E. (1970). Learning and response consistency with augmented Feedback. Ergonomics, 13, 421-425.

Sternberg, S., Monsell, S., Knoll, R.L., & Wright, C.E. (1978). The latency and duration of rapid movement sequences: Comparisons of speech and typewriting. In G. E. Stelmach (ed.), Information processing in motor control and learning (pp. 118 - 152). San Fransisco: Academic Press.

Zimny, S.T. (1983). The use of verbal protocal analysis to investigate the basis for contextual interference in the learning of a motor task. Unpublished master's thesis, University of Colorado.

APPENDICES

APPENDIX A

HUMAN SUBJECT COMMITTEE APPROVAL

Vice President for
Research, Graduate Studies,
and International Programs

Oregon State University

Corvallis, Oregon 97331-2135 (503) 754-3437

September 8, 1988

Principal Investigator:

It has been determined that the following project is exempt from review by Oregon State University's Committee for the Protection of Human Subjects under guidelines from the U.S. Department of Health and Human Services:

Principal Investigator: John M. Dunn

Student's Name (if any): Patricia Nearingburg

Department: Health & Physical Education

Source of Funding:

Project Title: The effects of three levels of contextual interference on acquisition and retention of a sequential motor skill in moderately retarded and non-retarded children

Comments:

A copy of this information will be provided to the Chair of the Committee for the Protection of Human Subjects. If questions arise, you may be contacted further.

Redacted for privacy

Mary E. Perkins
Research Development Officer

cc: CPHS Chair
7-87

APPENDIX B

INFORMED CONSENT

The primary objective of this study is:

To study the effects of three levels of contextual interference on acquisition and retention of a sequential motor skill in moderately mentally retarded and nonretarded children.

PROCEDURES

At the onset of a light, your child will perform as quickly and accurately as possible, a sequential motor pattern illustrated on an illuminated diagram. A total of three diagrams will be displayed on easels. Only the illuminated diagram will be performed during each trial. Subjects will run to each mat in the order prescribed on the diagrams. There will be three rubber swich mats placed on the floor in the same configuration as those on the diagrams. These mats will be computer interfaced and hence reaction times, total movement times and errors will be recorded. The subjects are not physically attached to the equipment in any manner. The testing session will last approximately 60 minutes.

CONFIDENTIALITY

Confidentiality of all information collected will be ensured by using an assigned number for each subject. Recorded data will be accessible only to the primary investigator. You and/or your child may withdraw from the study at any time.

PARTICIPATION VALUE

The information gained through this study may provide valuable insights concerning the information processing capabilities of moderately retarded and nonretarded children. Previous research has suggested that subjects may retain information more effectively if during acquisition, the material has not been presented under a repeated trial format.

I would be pleased to discuss my research study further with you. Please contact me at my office during the day, 754-2176, or at home in the evenings at 752-8437. I would be happy to familiarize you with the testing environment at your convenience.

Thank you for your assistance.

Sincerely,

Patt Nearingburg
College of Health and Physical Education
Oregon State University
Corvallis, Oregon 97331

I am aware of the procedures outlined and give my voluntary informed consent for my child to participate in the above described research study.

Participant's Name (print)___________________________________

Parent/Guardian's Signature___________________________________

Date_________________

APPENDIX C

LETTER OF INTRODUCTION

Dear

My name is Patt Nearingburg and I am a PhD student in the College of Health and Physical Education at Oregon State University. My area of specialization is Adapted Physical Education. I have worked with a variety of disabled populations in a wide range of settings over the past ten years. Currently I serve as the Coordinator of the OSU Special Physical and Motor Fitness Clinic which operates each Friday of the academic school year.

I am especially interested in gaining a better understanding of how mentally retarded children acquire motor skills. For this reason I have chosen this area of research as my PhD focus. My study involves children running through sequential motor patterns using three mats, according to diagrams placed ahead of them. Subjects will be assessed with respect to how quickly they begin the task once the warning signal is given (reaction time), how quickly they complete each movement pattern (total movement time) and how correctly they complete each pattern (error scores). There will be three blocks of 15 trials during the acquisition phase and a brief rest period between blocks. There will also be three blocks of 5 trials during the retention phase of the experiment. The total testing time will be approximately 45 minutes. Your child may withdraw from the experiment at any time.

Confidentiality of all information collected will be ensured by using an assigned number for each subject. Recorded data will be accessible only to the primary investigator.

I would be happy to provide you with further information concerning my research. Please do not hesitate to contact me at 754 - 2176 during the day or 752 - 8437 in the evenings.

Thank you for your cooperation

Sincerely,

Pat Nearingburg

APPENDIX D

INSTRUCTIONS TO SUBJECTS

Hi, (name), thanks for coming today! I am Patt Nearingburg and I am a graduate student in Physical Education at Oregon State University. I am interested in studying how people learn movement patterns. This is the equipment that we'll be using for the study. There will be three parts of this testing. The first part will be practice trials. The second part will require you to learn the movement patterns shown on these diagrams. We'll have a brief rest after this part. In the third part you will try to complete the movement patterns using less information. It is important for you to look very closely at the diagrams because there are clues on those diagrams which will help you figure out the order in which you should contact the mats.

Please come here to our starting point. This footswitch will be our starting point for each trial. After you have finished the movement pattern, come back here and place one foot on this footswitch. Place your other foot behind the footswitch. Can you see the three diagrams clearly (pointing to A, B and C). Can you see that the mats on the floor are arranged in the same order as those on the diagrams? (Wait for response) There are three mats on the diagrams and three mats on the floor.

Above each diagram there is a light (pointing to the lights). When one of these lights comes on you'll perform the pattern on the diagram below. Try to finish running the mat pattern as quickly and correctly as you can. When you finish contacting the third mat in the pattern, come directly back to this starting point so that I may tell whether you completed the pattern correctly or not. It is just as important to do the pattern correctly as it is to do it quickly. Remember to only contact three mats. Remember to place your entire foot on the mat.

Now I am going to demonstrate this skill for you. Watch closely. If this light comes on (demonstrating) you'll perform this pattern (moving through the pattern). This is mat number one (stepping on it). This is mat number two (stepping on it). Finally, this is mat number three (stepping on it). Remember to wait for the light to come on before you move. Do not lift your foot from the starting switch until the light comes on. Do you have any questions?

Let's try three practice trials. Remember to place one foot on the footswitch and watch for the light.

** The following instructions will be given according to which condition the subject is in.

Blocked - Your first diagram will be A, B or C. You will practice this one pattern first. Then we will practice the other two patterns.

Pseudoserial - Your first diagram will be A, B or C. You will practice one movement pattern, indicated by the light, for three trials and then we will practice three trials of each of the other two mat patterns.

Random - Your first movement pattern will be A, B or C. Each trial you will practice a different pattern as indicated by the light above the diagram.

I want to remind you that the purpose of this study is to see how well you remember the three movement patterns.

Retention - Now you will have to remember the correct order that these mats should be performed in. You will practice a total of 15 trials. You will perform a different diagram on each trial.
Do the best that you can.

This is the end of the test. Did you notice anything about the colours on the diagrams? Was there anything that you liked/disliked about the test? Thanks for coming today!!

APPENDIX E

REACTION TIME MEANS (MS) AND STANDARD DEVIATION (SD)

Mean Reaction Times (ms) and Standard Deviations (SD) as a Function of Practice Conditions and Intelligence Group

TASK

	A		B		C	
Non-retarded						
Practice Conditions	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Blocked	1046	402	1077	259	905	301
Pseudoserial	1058	323	1285	421	1001	255
Random	1135	457	1277	569	1166	650
Mentally Retarded						
Practice Conditions						
Blocked	1692	669	2173	1096	1863	1113
Pseudoserial	1606	1028	1585	1359	1584	1289
Random	1864	632	1975	934	2010	680

SE of RT as a function of:		
	Intelligence:	197
	Practice Condition:	241
	Task:	93

APPENDIX F

MEAN REACTION TIME (MS) AND STANDARD DEVIATIONS (SD)

Mean Total Response Times (ms) and Standard Deviations (SD) During Acquisition as a Function of Practice Conditions and Intelligence Group

	TASK					
Non-Retarded	A		B		C	
Practice Conditions	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Blocked	4596	946	5495	905	5648	1055
Pseudoserial	4927	1510	6082	1298	6072	1593
Random	4961	892	5900	1409	6216	1456
Mentally Retarded						
Practice Conditions						
Blocked	9766	3148	12721	5853	12648	5967
Pseudoserial	10918	4895	13301	5143	12772	12909
Random	10987	4633	12157	5253	12772	35760

SE of TRT as a function of: Intelligence: 925
Practice Condition: 1133
Task: 363

APPENDIX G

MEAN REACTION TIME (MS) AND STANDARD DEVIATIONS (SD)

Mean Reaction Time (ms) and Standard Deviations (SD)
During Retention as a Function of Practice
Conditions and Intelligence Group

TASK

Non-Retarded	A		B		C	
Practice Conditions	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Blocked	1788	2033	1547	1404	1894	2454
Pseudoserial	1223	482	1147	378	1230	427
Random	1426	1112	1899	1991	1475	1249
Mentally Retarded						
Practice Conditions						
Blocked	1915	1372	2239	1688	1807	777
Pseudoserial	1634	6302	1795	929	1731	831
Random	1592	704	1657	857	1565	778

SE of RT as a function of: Intelligence: 345
Practice Condition: 422
Task: 100

APPENDIX H

MEAN TOTAL RESPONSE TIMES (MS) AND STANDARD DEVIATIONS (SD)

Mean Total Response Times (ms) and Standard Deviations (SD) During Retention as a Function of Practice Conditions

	TASK					
	A		B		C	
Non-Retarded						
Practice Conditions	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Blocked	6186	2890	6226	2096	6856	2404
Pseudoserial	5332	2066	5639	1116	6273	1198
Random	5886	2149	7299	2627	6518	1961
Mentally Retarded						
Practice Conditions						
Blocked	12129	6477	12551	6616	11962	3765
Pseudoserial	11052	2738	12779	4897	12890	5212
Random	9399	1861	10842	3188	10506	2104

SE of TRT as a function of: Intelligence: 870
Practice Condition: 1065
Task: 433