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A COMPARISON OF THE EFFECTIVENESS AND EFFICIENCY OF BEHAVIOR CHAINING TECHNIQUES IN THE ACQUISITION OF SELECTED MOTOR FITNESS SKILLS BY INDIVIDUALS WITH SEVERE MENTAL RETARDATION

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A COMPARISON OF THE EFFECTIVENESS AND EFFICIENCY OF BEHAVIOR CHAINING TECHNIQUES IN THE ACQUISITION OF SELECTED MOTOR FITNESS SKILLS BY INDIVIDUALS WITH SEVERE MENTAL RETARDATION

DISSERTATION

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

by

James T. Decker, B.S., M.S.

* * * * *

The Ohio State University

1986

Dissertation Committee:
Paul Jansma, Ph.D.
Robert Bartels, Ph.D.
Walter F. Ersing, Ph.D.
Michael Orlansky, Ph.D.

Approved by
Paul Jansma
Adviser

School of Health, Physical Education and Recreation
To Tom, Theresa and Byrne,

Thanks for being there when I needed you.
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I would like to express by sincere appreciation to the many individuals who were instrumental in the successful completion of this study. I am deeply grateful to Dr. Paul Jansma for his professionalism and guidance throughout this research. Thanks go to the other members of my advisory committee, Drs. Robert Bartels, Walter F. Ersing and Michael Orlansky for their suggestions and comments.

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And finally to my wife Karen for her constant support and encouragement throughout my doctoral program.
VITA

1973-1977 ............ B.S., Brockport State College
              Brockport, New York
1977-1978 ............ Graduate Fellowship Student
              Brockport State College
              Brockport, New York
1978-1983 ............ Adapted Physical Education
              Instructor, School of the
              Holy Childhood,
              Rochester, New York
1983 ................... M.S., Brockport State College
              Brockport, New York
1983-present .......... Research Associate, Department
              of Health, Physical Education
              and Recreation,
              The Ohio State University
              Columbus, Ohio

PUBLICATIONS

"Public Law 94-142 and Physical Education." In Winnick,
J. & Jansma, P. (Eds.) Physical Education Inservice
Manual for the Implementation of the Education for
All Handicapped Children Act (PL 94-142) (Monograph)
State University at Brockport, Brockport, NY 1978.

FIELDS OF STUDY

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              Education
Minor Fields:  Applied Exercise Science
              Exceptional Children
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CHAPTER I
INTRODUCTION

Of critical importance in any attempts to teach new skills is the instructional strategy employed. In particular, this is evident with complex skills which involve multiple steps to complete. Instructional goals or objectives often include skills which can be broken down into a sequence of subtasks forming a complex behavioral response chain (Walls, Zane & Ellis, 1981).

In order to teach new complex behaviors to individuals, chaining procedures are often used. "Chaining procedures are the reinforcement of combinations of simple behaviors already in the repertoire of the individual to form more complex behaviors" (Sulzer-Azaroff & Mayer, 1977; p 237). "A stimulus-response chain is a sequence of discriminative stimuli and responses in which each response except the last produces the discriminative stimulus for the next response" (Martin & Pear, 1983; p 162). Each behavior in a chain has a dual-stimulus function. Each behavior reinforces the behavior that it follows and also serves
as a discriminative stimulus to occasion the behavior that it precedes (Sulzer-Azaroff & Mayer, 1977).

Martin and Pear (1983) describe three major methods of teaching stimulus-response chains. The first method is called total task presentation. With this strategy the subject attempts all the subtasks from the beginning to the end of the chain on each trial with prompting from the instructor when necessary. This is continued until the total skill is mastered. The second method is called backward or reverse chaining. Backward chaining involves the teaching of the chain in a reverse order from that which the chain is actually performed. The last step is mastered, then the next to the last step and so on. The third major method is forward chaining. In forward chaining the initial step of the sequence is taught first, then the first and second steps are taught and linked together and so on until the entire skill is mastered. Researchers have compared the relative effectiveness of these different chaining procedures, however no one method has proven to be clearly superior.

Chaining has been used to teach vocational and recreational skills to retarded individuals. Weber (1978) compared reverse and forward chaining in teaching
an assembly skill to educable mentally retarded adults. The subjects in the reverse chaining group took less time to learn the motor task. Hsu and Dunn (1984) compared forward and reverse chaining in teaching moderately retarded individuals a four step bowling skill. Results indicated that subjects in the reverse chaining group required significantly fewer trials and physical assists than those in the forward chaining group. Walls, Zane & Ellis (1981) compared total task presentation (which they termed "whole task"), forward chaining and reverse chaining in teaching assembly tasks to mentally retarded individuals. Results indicated that both forward and reverse chaining methods were superior to the total task presentation method but not significantly different from each other.

There has been disagreement among researchers as to which chaining method is superior. Blake and Williams (1969) found the total task presentation method superior to the forward chaining method in teaching trigram-numeral pairs to retarded, normal and superior subjects. Nettelbeck and Kirby (1976) found forward chaining produced the fewest errors and quickest time to criterion in teaching mildly retarded girls to use sewing machines.
The importance of teaching psychomotor skills to mentally retarded individuals is well recognized (Council for Exceptional Children, & American Association for Health, Physical Education and Recreation, 1966; Fait, 1971). In this regard, instruction in fitness skills should be implemented for all mentally retarded individuals since most mentally retarded individuals will most likely use physical skills rather than intellectual skills in vocational and recreational pursuits. Motor fitness is also an essential part of habilitative programming (Luckey & Shapiro, 1974) and of great value in predicting vocational success. Increased motor fitness can lead to greater involvement in vocational and recreational activities and activities of daily living.

With regard to severely retarded individuals, Jansma (1982) calls for a reversal of traditional educational priorities, academic-vocational-physical/social to physical/social-vocational-academic for the severely and profoundly handicapped.

Given these data, there is little data-based information on the most efficient skill sequences and motor training techniques for severely handicapped individuals (Haavik & Altman, 1977). Moon and Renzaglia
(1982) state that for the benefit of individuals with mental retardation much more research is needed relative to the investigation of explicit instructional procedures for motor skill acquisition. They go on to state the need for further validation of skill sequences and activities for a variety of fitness needs of the retarded. Tomporowski and Ellis (1984) postulated that behaviorally oriented teaching techniques could be used in the development of prerequisite physical fitness skills by moderately, severely and profoundly mentally retarded individuals. Indeed Stainback, Stainback, Wehman and Spanglers (1983) were successful in teaching five physical fitness skills to three profoundly mentally retarded adults by employing operant techniques.

Relatedly, numerous researchers (Brace, 1948; Brace, 1961; Francis & Rarick, 1959; Howe, 1959; Sengstock, 1966; Stein, 1965) have demonstrated that mildly mentally retarded individuals fall significantly below nonhandicapped individuals in tests of physical fitness. Campbell (1978) found evidence that moderately and severely retarded persons are less fit than their mildly retarded peers. And Londeree and Johnson (1974) found that trainable mentally retarded (TMR) and educable
mentally retarded (EMR) children were significantly less fit than normal children, while the TMR group was significantly more impaired than the EMR group.

**Purpose of the Study**

The literature is inconclusive on the relative merits of specific instructional strategies for teaching complex behaviors. Furthermore, little research has been successfully completed comparing these instructional methods in teaching motor or fitness skills to severely mentally retarded individuals. In light of the great importance of physical and motor fitness for severely mentally retarded individuals, this study attempted to use an applied behavior analytic model using different methods to teach selected motor fitness skills to severely mentally retarded individuals. Specifically, using an alternating treatments single-subject design, the relative effectiveness and efficiency of three instructional methods (forward chaining, reverse chaining, and total task presentation) were evaluated in the acquisition and retention of three (modified supine tuck, modified squat thrust and modified sit and reach) motor fitness skills.
Research Questions

The results of the study were analyzed to answer the following primary research questions:

1. Is there a significant difference between forward chaining, reverse chaining and total task presentation in the celeration required to reach criterion on three targeted motor fitness skills?

2. Is there a significant difference between forward chaining, reverse chaining and total task presentation in the number of trials required to reach criterion on three targeted motor fitness skills?

3. Is there a significant difference between forward chaining, reverse chaining and total task presentation in the amount of time required to reach criterion on three targeted motor fitness skills?

4. Is there a significant difference between forward chaining, reverse chaining and total task presentation in the amount of prompting required to reach criterion on three targeted motor fitness skills?
5. Is there a significant difference between forward chaining, reverse chaining and total task presentation in the retention of three targeted motor fitness skills?

Assumptions of the Study

1. The targeted motor fitness skills were at the appropriate developmental level of the subjects.

2. Seventy-two trials was sufficient for the subjects to have the opportunity to reach criterion in the targeted motor fitness skills.

3. Normal activities of the subjects would not have affected their performance on the targeted motor fitness skills.

4. Subjects selected were representative of the total population of severely mentally retarded individuals.

Limitations of the Study

1. This study was limited to six severely mentally retarded subjects, aged 9 to 20 years old, in one setting.
2. This study was limited to three motor fitness skills (modified supine tuck, modified squat thrust, and modified sit reach).

3. This study was limited to three instructional methods (forward chaining, reverse chaining, and total task presentation).

4. The results of the study would have limited generalizability to the overall severely mentally retarded population, aged 9 to 20, due to the limited number of subjects selected.

5. The psychomotor status of the subjects chosen to participate in this study was not controlled.

**Major Definitions**

**Celeration** - derived from the notion of acceleration and deceleration, respectively. The celeration line predicts the direction and rate of change (Hersen & Barlow, 1979).

**Chaining** - is the reinforcement of combinations of simple behaviors already in the repertoire of the individual to form more complex behaviors (Sulzer-Azaroff & Mayer, 1977).
Forward Chaining - involves the teaching of the initial step of a sequence first, then the first and second steps are taught and linked together, then the first three steps and so on until the entire chain is acquired (Martin & Pear, 1983).

Learning - is defined by Cratty (1975) as:

the rather permanent change in behavior brought about through practice...motor learning may be termed a stable change in the level of skill as the result of repeated trials (p. 337).

Mental Retardation - is defined by the American Association on Mental Deficiency as:

significantly sub-average general intellectual functioning existing concurrently with deficits in adaptive behavior, and manifested during the developmental period (Grossman, p. 11, 1973).

The American Association on Mental Deficiency classifies mental retardation as follows: mild, moderate, severe and profound. The Stanford-Binet Test of Intelligence uses the following classification system:

<table>
<thead>
<tr>
<th>Classification</th>
<th>Intelligence Quotients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild</td>
<td>68-52</td>
</tr>
<tr>
<td>Moderate</td>
<td>51-36</td>
</tr>
<tr>
<td>Severe</td>
<td>35-20</td>
</tr>
<tr>
<td>Profound</td>
<td>19 and below</td>
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</table>
Physical and Motor Fitness - for the purposes of this study the following elements of physical and motor fitness are applicable:

muscular endurance - is the ability of muscles to perform work (Clarke, 1976).

muscular power - is the ability to release maximum muscular force in an explosive manner, that is, in the shortest possible time (Clarke, 1976).

flexibility - is the range of movement in a joint or a sequence of joints (Clarke, 1976).

Reverse or Backward Chaining - involves teaching the last step in a chain first, then the next-to-last step is taught and linked to the last step, then the third to the last step is taught and linked with the last two steps and so on progressively towards the beginning of the chain (Martin & Pear, 1983).

Significance - as used in this research, significance refers to a meaningful change in data which, in the view of the data analyzer is socially or clinically or functionally important (Martin & Pear, 1983).

Stimulus-Response Chain - is a sequence of discriminative stimuli (SD) and responses (Rs) in which
each response except the last produces the $S^D$ for the next response (Martin & Pear, 1983).

**Total Task Presentation** - involves having a subject attempt all the steps of a task from the beginning to the end of the chain on each learning trial until the skill is mastered (Martin & Pear, 1983).
A review of related literature concerning a comparison of the effectiveness and efficiency of behavior chaining techniques in the acquisition of selected motor fitness skills with severely mentally retarded individuals is presented under the following topics: a) Retardation Defined, b) Defining Fitness, c) Physical Fitness, Motor Fitness and the Mentally Retarded, d) Motor Learning and the Mentally Retarded, e) Behavior Chaining, f) Comparisons of Chaining Techniques with Motor Skills of Nonhandicapped Learners, g) Comparison of Chaining Techniques with Motor Skills of Mentally Retarded Learners, and h) Summary of Related Literature.

**Retardation Defined**

Due to a lack of uniformity in the terminology to describe individuals with retarded mental development, considerable confusion has developed. No one definition of mental retardation has been constructed that satisfies
all the professionals (medical, psychological, educational, social and legal) concerned with the retarded (Fait & Dunn, 1984). The American Association on Mental Deficiency (AAMD) has developed the most widely employed definition of mental retardation. The AAMD's 1973 Manual on Terminology and Classification in Mental Retardation gives the following definition:

Mental retardation refers to significantly sub-average general intellectual functioning existing concurrently with deficits in adaptive behavior, and manifested during the developmental period (Grossman, p. 11, 1973).

The terms in the AAMD's definition of mental retardation have important implications for individuals working with the retarded. Specifically the following concepts should be noted: "Mental retardation" implies a slowness in cognitive development. "Sub-average" indicates performance lower than normative expectancies for society, specifically one or more standard deviations below the mean for a given age group on a standardized IQ test. "Adaptive behavior" refers to maturation, learning and the ability to cope with natural and social demands of the environment. A "deficit" exists when an individual cannot adjust responses to environmental
demands. The "developmental period" includes birth through twenty-two years.

**Defining Fitness**

Physical educators, physicians and physiologists have attempted to define fitness for many years. It is a multi-faceted concept with no single way to evaluate the presence or lack of it (Corbin, Dowell, Lindsey & Tolson, 1978). In its broadest sense fitness is a concept which includes an individual's mental and emotional stability, social consciousness, adaptability and organic health (Bucher & Prentice, 1985).

Fleishman (1964) employed factorial analysis to delineate more clearly the subcomponents of fitness. His analysis was delimited to the psychomotor domain. By analyzing previous research he concluded that extent flexibility, dynamic flexibility, explosive strength, static strength, dynamic strength, trunk strength, gross body equilibrium, gross body coordination and cardiovascular endurance are the subcomponents of fitness. By defining fitness in terms of an individual's ability to do muscular tasks, Fleishman differentiated between motor fitness and more general physical fitness.
The President's Council on Physical Fitness and Sports (Clarke, 1971) adopted the generalist view in its definition of physical fitness:

...The ability to carry out daily tasks with vigor and alertness, without undue fatigue and with ample energy to enjoy leisure-time pursuits and to meet unforeseen emergencies. Thus physical fitness is the ability to last, to bear up, to withstand stress, and to persevere under difficult circumstances where an unfit person would quit (Clarke, 1971).

The American Alliance for Health, Physical Education, Recreation and Dance (AAHPERD, 1980) has expanded this concept into a health-related continuum that ranges from death at one end to optimal functional abilities in all aspects of life.

Falls, Baylor & Dishman (1980) differentiated between the two aspects of fitness by categorizing that which is skill related as motor fitness and that which is health related as physical fitness. Physical performance abilities such as power, coordination, agility, speed and balance are considered by them to be motor fitness variables. Physical fitness is characterized by them as the absence of life limiting diseases and conveys a relationship to healthful living (Corbin, Dowell, Lindsay & Tolson, 1981). Relatedly, Bunker (1978) states that both motor and physical fitness are prerequisites to
basic movement abilities, without which, skill development would be impossible. Sherrill (1976) states that, beyond play and sports skills, physical fitness is required for functioning in daily living and motor fitness for the performance of skills.

Clarke (1971) lists seven components that are used most often to define motor fitness:

1. Muscular strength - Characterized by the contraction power of the muscles. This capacity involves the amount of force a muscle can exert.

2. Muscular endurance - Characterized by the ability to perform work. This capacity involves performing a task to exhaustion.

3. Circulatory-respiratory endurance - Characterized by the moderate contractions of large muscle groups over long periods of time, for example, running long distances.

4. Muscular power - The ability to release maximum force in the shortest possible time.

5. Agility - The ability to change body position or direction rapidly.

7. Flexibility - The range of movement in a joint or joints.

There may also be a more rudimentary level of fitness depending on the population in question. In severely handicapped persons, physical fitness involves postural reflexes; muscle tones; adequate strength to lift the head; ability to roll over, sit and creep; and maintenance of sufficient range of motion (flexibility) to prevent contractures (Sherrill, 1982). Also with regard to this population, Auxter (1982) states that the greatest fitness need for severely physically handicapped individuals is to develop strength, endurance and flexibility in the gross musculature so that functional mobility skills can be developed to assist self-sufficiency.

Physical Fitness, Motor Fitness and the Mentally Retarded

It has been well documented that mentally retarded individuals fall significantly below nonhandicapped individuals in tests of motor fitness. This has been shown across most levels of retardation (Campbell, 1973). There is also some indication that moderately and
severely retarded persons are significantly less fit than mildly retarded individuals.

Francis and Rarick (1959) compared the gross motor abilities of 284 normal and mentally retarded children, (ages 7 to 14 years and IQ's between 50-90). A battery of 11 motor performance tasks measuring strength, power, balance and agility was administered. The strength measures showed that both groups followed similar developmental slope patterns, although the mentally retarded children were significantly lagging behind the normal children at all levels. On tests for power and agility the mentally retarded children were behind the normal children by six years. In running speed the retarded again fell behind the normal children four years for both sexes. The authors concluded that mentally retarded children generally are two to four years behind normal children in motor performance and that the discrepancy between groups tends to increase with age.

Supportive results for Francis and Rarick's work were found by Brace (1961) when he used the AAHPER Youth Fitness Test to assess physical fitness of mentally retarded boys. The author matched the results from the group he treated to the national norms, established by
AAHPER, and the results indicated the mentally retarded children to be 80 percent below the median of the national scale.

Sengstock (1966) compared AAHPER physical fitness test item scores of educable mentally retarded children with those obtained by normal children of either the same chronological age or the same mental age. Generally the performance of the EMR boys was midway between the scores of their normal peers.

Campbell (1978) found evidence that moderately and severely retarded persons are less fit than their mildly retarded peers. Londeree and Johnson (1974) found that trainable mentally retarded (TMR) and EMR children were significantly less fit than normal children, while the TMR group was significantly more impaired than the EMR group. Similar results have been found in a study conducted by Stein (1964).

In a review of research on the psychomotor function of the mentally retarded, Stein and Pangel (1966) included the following guidelines based on scientific knowledge: a) for a given age, and sex, normal children were superior to mentally retarded youngsters on most measures of motor proficiency; b) in spite of
underachievement with respect to motor function, mentally retarded children were much closer to the norm physically than mentally; and c) physical proficiency was improved in retarded children as a result of planned and systematic programs of physical education.

Rarick and Dobbins (1972) conducted a 30 month investigation to determine the basic components in the motor performance of educable mentally retarded (EMR) children. The investigators tested 261 EMR boys and girls (CA 6-13 and IQ 41-95) and 145 normal children of the same age and sex. After considerable preliminary investigation, 61 tests were selected for the following basic components of motor performance: static muscular strength, muscular strength-endurance, explosive muscular strength, gross body coordination, cardiorespiratory endurance, limb-eye coordination, manual dexterity, static balance, dynamic balance, kinesthesia, flexibility, speed and coordination of gross limb movements, body fat and body size. It was concluded that EMR children were considerably less able in motor tasks requiring elements of strength and power, gross and fine motor control, flexibility and balance than intellectually normal children of the same age and sex.
Rarick (1973) made the following remarks regarding the motor fitness of mentally retarded individuals:

Mental retardation is almost invariably accompanied by substandard levels of performance in both gross and fine motor skills. It is now well established that on standardized tests of motor performance, educable mentally retarded children will perform well below the average of intellectually normal children of the same age and sex.

This view was supported by Cratty's (1975) findings that the motor proficiency of mentally retarded individuals has been demonstrated to be significantly below that of nonretarded individuals.

**Motor Learning and the Mentally Retarded**

It is essential that individuals involved in instruction in psychomotor skill development maintain a sound knowledge of the developmental aspects of human behavior. Only then can such individuals arrive at appropriate educational procedures and intervention strategies (Gallahue, 1982).

Rarick and Dobbins (1972) studied the motor domain of normal and mentally retarded boys and concluded that the factor structure and basic components of the motor domain were similar. With regard to this study, the
motor development of mentally retarded individuals is, as for the nonretarded, sequential and individual in nature (Rarick & Dobbins, 1972). Therefore careful analysis is required to select appropriate activities which are developmentally appropriate for the developmental level of participants who are mentally retarded.

The ability of mentally retarded individuals to perform motor tasks is affected by their motor learning ability. Cratty (1967) inferred that intelligence was more related to motor learning and motor performance in the severely retarded than in the less severely retarded. Rarick (1973) stated that learning motor tasks was related to the complexity of the task and that a sufficient number of trials enhances performance on motor learning tasks. Further, the ability of the mentally retarded to learn simple, concrete tasks is largely related to the fact that the mentally retarded respond most to demonstrations and physical guidance (Cratty, 1967; Winnick, 1979).

Cratty (1973) postulated that mentally retarded children may lack motor proficiency due to the presence of inadequate programs of physical education for the retarded which fail to meet their needs. Further
research indicates that with an increased amount of verbal pretraining, mentally retarded children can demonstrate learning curves similar to those of nonretarded children (Cratty, 1975). This suggests that if enriched physical education programs are provided for the retarded their fitness level may be substantially improved, even brought to levels seen in their nonretarded peers (Cratty, 1975).

The inadequate motivational development of mentally retarded children also has been cited as a factor in learning and performing motor tasks (Cratty, 1967; Wagner, 1967; Peries, 1973). Motivation explains why an activity is selected, why interest in the activity is sustained, and why certain levels of intensity are reached in learning or performing the activity (Cratty, 1967).

Behavior Chaining

Gange (1965) defines chaining as the connection of a set of individual stimulus-response acts in sequence. Mechner (1967) states that chaining is a sequence of responses where each response creates the stimulus for the next response. Sulzer-Azaroff and Mayer (1977)
define a chaining procedure as "the reinforcement of simple behaviors already in the repertoire of the individual to form more complex behaviors" (p. 237).

Each link in a chaining procedure serves as a discriminative-stimulus ($S^D$) for the next response. Thus a stimulus response produces the $S^D$ for the next response (Martin & Pear, 1983). Each behavior in a chain potentially also has a dual stimulus function. Each reinforces the behavior that it follows, and each serves as an $S^D$ to occasion the behavior that it precedes (Sulzer-Azaroff & Mayer, 1977). All links must be joined for successful accomplishment of the chain.

When a stimulus or event is paired with or directly precedes reinforcement, it will begin to take on the reinforcing properties over time. As stimuli acquire such reinforcing properties they form the links in a chain into a complex response which is strengthened by a single culminating reinforcing event. The skillfully executed tennis serve indicates to the server that a favorable occurrence is at hand, possibly a winning point. The feel of the swing may become reinforcing in itself. This in turn reinforces the correct serving stance prior to the swing. As this occurs the stimulus components of
a complex behavioral chain operate in dual fashion, both as discriminative stimuli, which occasion the subsequent component responses, and as reinforcing stimuli, which reinforce the links which occur immediately before them.

Many everyday skills are examples of behavior chains, such as tying shoes, putting on a coat and brushing teeth. Rushall and Siedentop (1972) demonstrate a behavior chain in a sport setting. They use a front line volleyball player anticipating the movement of an opponent and moving to the next to block a potential spike. This example follows:

1. The original SD is seeing an opponent set the ball up to another opponent who is across from your position
2. The opponent approaches the net
3. The opponent jumps up
4. The opponent spikes the ball
5. Reinforcement (point or side out)
The final reinforcer is the point or side out for your team (p. 132).

Martin and Pear (1983) describe five factors which influence the effectiveness of chaining procedures. The first factor is to break down the behavioral sequence into its individual components via a detailed task analysis. The components should be simple enough to be learned without great difficulty. The second factor is to model the entire sequence while verbally describing the performance of each step to the learner. Third, the learner should be given an initial request to initiate and complete the task. Fourth, during the trials the correct completion of each step should be praised immediately. Fifth, the trainer should decrease extra assistance at each individual step as quickly as possible.

There are three major methods of teaching stimulus-response chains. These methods are forward chaining, reverse chaining and total task presentation (see Figure 1).
When employing total task presentation the learner attempts all the steps from the beginning to the end of the chain on each trial. This continues with total task trials until all the subtasks are administered (Martin & Pear, 1983). Many, if indeed not most, of the skills
humans learn are taught through the use of total task presentation.

In reverse chaining the skill is taught in a reverse order from which it is actually performed. Therefore the last step to be performed is established first, then the next to the last step is taught and linked to the last step, then the third from the last step is taught and linked to the last two steps and so on progressing back to the beginning of the chain. Martin & Pear (1983) demonstrate reverse chaining with the task of teaching an individual to put on a pair of slacks. The task is broken down (task analyzed) into nine steps.

1. Taking the slacks from the dresser drawer
2. Holding the slacks upright from the front, facing away from the individual
3. Putting one leg in the slacks
4. Putting the other leg in the slacks
5. Pulling the slacks to the knees
6. Pulling the slacks to the thighs
7. Pulling the slacks all the way up
8. Doing up the button or snap
9. Doing up the zipper
By starting with step 9, the response of "doing up the zipper" was reinforced in the presence of the snap done up. Therefore, the sight of the "snap done up" became an SD for step 9, "doing up the zipper." On the basis of the condition of conditioned reinforcement, the sight of the "snap done up" became a conditioned reinforcer for whatever preceded it. (p. 164)

It is in this way when using reverse chaining that the reinforcement of the last step with the presence of the appropriate stimulus establishes that stimulus as a discriminative stimulus for the last step and as a conditioned reinforcer for the next to the last step. In this sense reverse chaining has a theoretical advantage of always having a readily available conditioned reinforcer to strengthen each new response that is added to the sequence (Martin & Pear, 1983). It is also in this way that the dual-stimulus function is most clearly operative in reverse chaining.

In forward chaining the initial step of the task is taught first, then the second step is taught and linked together with the first, then the third step is taught and linked together with the first two and so on. An example of this method can be seen in teaching a child to write his or her name. First the initial letter is mastered, then the next letter is taught and paired with
the first one and so on until the entire name is completed.

**Comparisons of Chaining Techniques with Motor Skills of Nonhandicapped Learners**

McGuigan and MacCaslin (1955) found little previous research in the comparative efficiency of chaining methods with complex psychomotor skills. They compared the relative efficiency of forward chaining, a total task presentation procedure and an incomplete total task method with simulated task performance. The subjects were 148 army trainees and the skill employed was learning to fire a rifle. The results indicated that the total task method was superior to forward chaining in learning to fire a rifle.

Cox and Boren (1965) compared reverse chaining, forward chaining and a total task presentation method. Again army trainees were used this time learning a 72-step Nike Hercules missile launching procedure. A comparison of the training-time for each instructional method resulted in no significant differences. The authors concluded that there were no significant differences of one technique over the other.
Wilcox (1974) used both a motor task (paper folding) and a memory task (numerical procedures) to examine the effect of chain length (short, medium and long) and instructional method (reverse chaining, forward chaining and whole method). One hundred and seventy-six female university students were assigned to nine groups defined by chain length and teaching strategy. No advantage was found for backward chaining in the case of the motor chains and the short and medium number chains. There was an indication that backward chaining was superior to forward chaining for long number chains. Both forward and reverse chaining were inferior to the whole method.

Nannay (1970) compared the relative effectiveness of forward and reverse chaining in an industrial education setting. The task used was placing a dado head (two dado blades, two chippers, an arbor collars, and an arbor nut) on a radial arm saw. Sixty-six university students served as the subjects. Results indicated that there was no significant difference between the instructional methods in initial learning of the task or the time needed to complete the task. Also there was no significant difference between the methods on a retention test.
Comparisons of Chaining Techniques with Motor Skills of Mentally Retarded Learners

Behavior chaining techniques have been cited as productive instructional techniques to be employed with moderately, severely and multiply handicapped learners (Greer, Anderson & Odle, 1982; Snell, 1983). Chaining techniques have also surfaced as important instructional techniques specifically with severely and profoundly mentally retarded learners (Azrin & Foxx, 1971; Gold, 1972; Hunter & Bellamy, 1976). Although investigators have studied the effects of the major chaining methods (forward chaining, reverse chaining and total task presentation) with retarded clients there is inconclusive results as to which method is most effective (Bellamy, Horner & Inman, 1979; Sulzer-Azaroff & Mayer, 1977).

The majority of chaining procedures with mentally retarded subjects involve prevocational or vocational tasks. Nettlebeck and Kirby (1976) used a 12 step industrial sewing machine threading procedure with mildly retarded women. The 12 steps were combined to produce four separate component operations, A,B,C,D. Three training methods were compared. One group trained by a pure-part method in which each operation was learned to criterion in isolation before combining all four
operations to complete the task. Another group was trained by a progressive-part method in which operation A and B separately were learned to criterion before combining A and B. Then the subjects learned C, A+B+C, then D, and finally A+B+C+D. The third group learned by a whole task method and practiced the whole task from the outset. The results indicated that both the part methods were superior to the whole method. The part methods took less time to criterion and produced fewer errors. However the pure-part and progressive-part methods were not significantly different from each other. Also there was no significant difference between the three groups on a retention check one month later. This result is in accordance with the findings of Denny (1966) and Gold (1968) that part methods are superior to whole methods for teaching retarded subjects manipulative motor tasks.

Walls, Zane and Ellis (1981) compared forward chaining, reverse chaining and whole task (essentially a total task presentation method) with mildly and moderately retarded vocational rehabilitation students. The tasks employed were six step assemblies of a carburetor, a bicycle brake and a meat grinder. The authors concluded that both forward and reverse chaining
methods were superior to the whole method (total task presentation) in reducing the number and proportion of errors. While reverse chaining resulted in fewer errors than did forward chaining, no practical difference occurred between the two.

Zane, Walls and Thvedt (1981) studied the effects of prompting and fading guidance procedures on reverse chaining and whole task methods. Four different training methods were employed: reverse chaining preguidance, reverse chaining postguidance, whole preguidance and whole postguidance. The preguidance techniques had the experimenter prompt the subjects prior to any response. In the postguidance techniques no guidance was given until the subject responded. Moderately and severely retarded subjects were employed with nine step assembly tasks (truck carburetor, bicycle brake, dishwasher pump and lawnmower engine). The results indicated that the preguidance techniques were always superior to the postguidance techniques with both reverse chaining and whole task methods. The whole preguidance method proved to be the most rapid training procedure.

Walls, Zane and Thvedt (1980) compared the personal instructional methods of trainers to a whole method
(total task presentation) and reverse chaining. The six trainers involved taught mentally retarded adults eight step assembly skills (lawn mower engine, bicycle brake, roller skate and carburetor). The backward chaining method yielded fewest mean errors and lowest mean rate of errors for each assembly. The authors also felt that it is unclear whether the effectiveness of a training procedure should be measured in terms of the number of errors made, total time to acquisition or some other variable.

Weber (1978) compared forward and reverse chaining with 24 mentally retarded adults. The task involved was a five step assembly task (Remco Science Kit). The results revealed that subjects receiving reverse chaining required significantly less time to learn the task than subjects in the forward chaining group. A check for retention was conducted approximately 20 hours after the original instruction had occurred. Although retention did not differ significantly between the two groups, the author suggested that mean retention scores indicated reverse chaining may have some advantage.

Hsu and Dunn (1984) compared forward and reverse chaining methods with moderately mentally retarded
individuals. This study is significant since it employs a recreational task (a four step bowling approach) rather than the more traditional vocational tasks. Thirty subjects were randomly assigned to either a forward chaining group or a reverse chaining group. Results indicated that the subjects in the reverse chaining group required significantly fewer trials and physical assists to reach criterion in the motor task. A check for retention three weeks after instruction revealed no difference between the instructional groups. The authors cited the advantage of reverse chaining in that the last link in the task serves as a reinforcer. In this case the last link was releasing the bowling ball and watching it roll towards the pins. As this was a pleasurable experience (watching the ball roll and possibly hitting the pins) the authors felt the participants were highly motivated to participate and complete the motor task.

Yu, Martin, Suthons, Koop and Pallotta-Cornick (1980) conducted a single-subject, multi-element design to compare forward chaining, modified forward chaining and total task presentation. Severely and moderately retarded adults were taught to assemble a 13-part bicycle brake, a 5-part Lego car, a 5-part Lego man and two
20-part Lego designs. The tasks and training procedures were counterbalanced across the subjects. In the modified forward chaining procedure the client was not required to perform all the previously learned steps on each trial. Rather they were required to perform only two steps on each trial, the step currently being trained and the last step learned. Across the four experiments the average total training time required for the forward chaining and modified forward chaining procedures was consistently as much or more than that required for total task presentation. No differences were revealed between the training procedures on a retention test. Also no systematic interactions between the procedures and task complexity were identified. The authors concluded that total task presentation is preferred over forward or modified forward chaining in teaching assembly tasks of various lengths to severely and moderately retarded persons.

Martin, Koop, Turner and Handel (1981) compared reverse chaining to total task presentation formats for teaching severely retarded adults complex assembly tasks. Again a multi-element design within clients with counterbalancing of training formats and tasks across
clients was used. The assembly tasks were 18 step telephone operators headsets and bicycle turnsignals. The results indicated that total task presentation produces desirable results more quickly than reverse chaining. In general the authors concurred with Bellamy, Horner and Inman (1979) that: a) research does not indicate that one of the chaining techniques is more appropriate than the other in any given situation, b) total task presentation has practical advantages of requiring the trainer to spend less time in the partial assembly and disassembly to prepare for training, c) total task presentation has a practical advantage of concentrating on teaching response topography and response sequence simultaneously, d) total task presentation maximizes the learner's independence early in the training sequence and, e) for the previous reason total task presentation is to be preferred until research proves otherwise.

Spooner, Weber and Spooner (1983) used a multi-element design to compare the effectiveness of backward chaining and total task presentation with four severely retarded adults. Two 7-part assemblies, a drain and a gate valve, were used in the study. The results
indicated that improvement indices for all participants were affected to a greater extent by the total task presentation method. The authors concluded that while total task presentation was associated with more time in training, the amount of behavior change and amount of behavior change per time appears to be greater with total task presentation. This concurs with Spooner's earlier research (1981) which found total task presentation more effective than reverse chaining in teaching complex assembly skills to severely retarded persons.

In yet another study Spooner (1984) compared reverse chaining and total task presentation in teaching assembly skills to severely retarded adults. The assembly tasks used were again a drain and a gate valve. Also a multi-element design was employed. The total task presentation method resulted in greater rates of learning in each subject. The author postulated that the greater number of stimulus presentations that are necessary in total task presentation was responsible, in part, for the efficacy of the total task presentation method.

In reviewing research comparing the effectiveness of chaining procedures, Spooner and Spooner (1984) found that the effects of the various methods are not clear.
Also it is not clear which procedure produces optimum learning. The authors suggested that one explanation for this confusion was the different dependent variables focused on in the research. They go on to state that both effectiveness (the accuracy with which the task is completed) and the efficiency (how much time it takes a learner to complete a task) are important. While trials to criterion address accuracy there is no reference to efficiency. This is also true when percent correct or percent errors are measured they argue. The authors state that when the rate correct or rate incorrect are the primary variables of interest, then both the effectiveness (accuracy) and efficiency (time) parameters are met. They feel that, while effectiveness is important, efficiency is at least as important and may actually be more important.

Spooner and Spooner (1984) conducted a review of research investigating the comparison of chaining strategies to teach psychomotor skills to handicapped learners. With regard to future research in the comparative effectiveness of chaining strategies with handicapped learners, the authors call for a systematic program of research that manipulates one variable at a
time while holding other variables constant. Among the guidelines they suggest for this comprehensive program of research is attention to procedural variations which may produce superior learning, and charting and tracking data to observe the effect that both corrects and errors have on future learning.

Summary of Related Literature

Physical fitness is a multi-faceted concept which includes an individual's mental and emotional stability and organic health. Fitness may be delineated as health related (a continuum from death to optimum functioning) or motor fitness (comprised of psychomotor attributes).

The motor fitness of mentally retarded individuals has repeatedly been demonstrated to be below that of nonhandicapped peers. Also, as the level of retardation increases the individual's level of fitness further decreases. Yet, while the motor abilities of the retarded are inferior to the nonhandicapped, they are composed of the same basic factor structure. In addition, it has been shown that appropriately planned and implemented programs of physical education can improve motor and fitness levels of the retarded.
Behavior chaining techniques involve the reinforcement of simple behaviors already in the repertoire of an individual to form a more complex behavior. There are three major methods of behavior chaining.

The first method is called total task presentation. With this strategy the subject attempts all the subtasks from the beginning to the end of the chain on each trial with prompting from the instructor when necessary. The second method, called reverse chaining, involves the teaching of the chain in a reverse order from that which the chain is actually performed. The last step is mastered, then the next to the last step is linked to the last step and so on. In the third major method, forward chaining, the initial step of the sequence is taught first, then the first and the second steps are taught and linked together and so on until the entire skill is mastered.

Each of the behavior chaining strategies has been demonstrated to be effective in teaching psychomotor skills to both handicapped and nonhandicapped learners. Each of the chaining strategies has been advocated for application in instructing mentally retarded individuals.
complex skills. Researchers have compared the relative effectiveness and efficiency of the chaining strategies, however no one method has proven to be clearly superior.

It is well acknowledged that the acquisition of motor fitness is a primary programming objective for severely mentally retarded individuals. The identification of the most effective and efficient method of teaching motor fitness skills to severely retarded individuals would be a significant contribution to special education and, specifically, special physical education technology.
CHAPTER III
METHODOLOGY

The purpose of this study was to compare the relative effectiveness and efficiency of behavior chaining techniques in the acquisition of selected motor fitness skills with severely retarded individuals. Methodology information applicable to this study is presented in the following sub-sections: a) Research Site, b) Selection of Subjects, c) Research Setting, d) Selection of Motor Fitness Skills, e) Description of Equipment, f) Background of the Researcher, g) Research Design, h) Description of Trials, i) Forward Chaining, j) Reverse Chaining, k) Total Task Presentation, l) System of Least Intrusive Prompts, m) Reinforcement Sampling, n) Data Collection Procedures, o) Reliability Measurement, p) Procedural Integrity Measurement, q) Social Validation Procedures, and r) Data Analysis Procedures.
Research Site

The Brooks-Yates School was the site for this investigation. Brooks-Yates is a part of the Pickaway County Board of Mental Retardation and Developmental Disabilities. The school is located in Circleville, Ohio and, during the course of this study, served approximately 50 developmentally disabled children. Approval to conduct the study at Brooks-Yates was obtained from the Superintendent and the President of the Board of Directors of the Pickaway County Board of Mental Retardation and Developmental Disabilities.

Selection of Subjects

Six subjects enrolled in the Brooks-Yates School were selected for this investigation. The subjects were classified as severely mentally retarded and were between the ages of 9 and 20. The subjects had no known severe behavior, orthopedic or neurological deficits that would have interfered with the learning of the selected motor fitness skills. The subjects also had no previous experience with the specific motor fitness tasks to be taught. Parent/guardian approval was obtained for each
subject using the informed consent form located in Appendix A.

**Research Setting**

All sessions of the study took place in the motor lab of the Brooks-Yates School. This room was approximately six meters by eight meters in size. It had gymnasium mats and several pieces of physical education and physical therapy equipment. All research equipment was stored in this room. Also all records of subjects' performance was stored in a file cabinet in this room. The subjects were escorted to and from the motor lab from their classrooms by the researcher. During the research sessions the researcher and subject were the only occupants of the motor lab. One subject was instructed at a time.

**Selection of Motor Fitness Skills**

The motor fitness skills employed as dependent variables were intended to impact on what has been found to be high priority motor fitness parameters for mentally retarded individuals (Jansma, 1979). These skills and the motor fitness parameters they impacted on were as
follows: a) the modified supine tuck (abdominal strength), b) the modified squat thrust (overall body strength), and c) the sit and reach (lower back and hamstring flexibility).

A review panel of experts in the motor fitness of the mentally retarded was consulted to determine the content validity of the task analyses of each of these three skills. Table 1 contains an abbreviated description of the task analysis of each of the motor fitness skills involved in this study. Appendix B contains a detailed description of the motor fitness skills task analyses.

Description of Equipment

A modified sit and reach apparatus was employed in the study. The apparatus was used in the modified sit and reach task. The sit and reach apparatus was a specially designed box with a grid (calibrated in centimeters) to measure the length of an individual's sitting reach (and therefore that person's lower back and hamstring flexibility). The design of the sit and reach box (AAHPERD, 1980) was modified to accommodate severely
<table>
<thead>
<tr>
<th>% of Skill</th>
<th>Subtask #</th>
<th>Subtask Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MODIFIED SUPINE TUCK</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.3</td>
<td>1</td>
<td>Back lying position</td>
</tr>
<tr>
<td>28.6</td>
<td>2</td>
<td>Draw up legs, knees 45°</td>
</tr>
<tr>
<td>42.9</td>
<td>3</td>
<td>Wrap arms around knees</td>
</tr>
<tr>
<td>57.2</td>
<td>4</td>
<td>Draw knees towards chest</td>
</tr>
<tr>
<td>71.4</td>
<td>5</td>
<td>Flex neck</td>
</tr>
<tr>
<td>85.7</td>
<td>6</td>
<td>Release knees, feet on ground</td>
</tr>
<tr>
<td>100.0</td>
<td>7</td>
<td>Back lying position</td>
</tr>
<tr>
<td>MODIFIED SQUAT THRUST</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.3</td>
<td>1</td>
<td>Squat, hands on knees</td>
</tr>
<tr>
<td>28.6</td>
<td>2</td>
<td>Hands on mat</td>
</tr>
<tr>
<td>42.9</td>
<td>3</td>
<td>One leg back</td>
</tr>
<tr>
<td>57.2</td>
<td>4</td>
<td>Other leg back</td>
</tr>
<tr>
<td>71.4</td>
<td>5</td>
<td>One leg forward</td>
</tr>
<tr>
<td>85.7</td>
<td>6</td>
<td>Other leg forward</td>
</tr>
<tr>
<td>100.0</td>
<td>7</td>
<td>Stand erect</td>
</tr>
<tr>
<td>MODIFIED SIT AND REACH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.3</td>
<td>1</td>
<td>Sit on mat, legs straight, arm support</td>
</tr>
<tr>
<td>28.6</td>
<td>2</td>
<td>Place feet against apparatus</td>
</tr>
<tr>
<td>42.9</td>
<td>3</td>
<td>No arm support</td>
</tr>
<tr>
<td>57.2</td>
<td>4</td>
<td>Place hands on knees</td>
</tr>
<tr>
<td>71.4</td>
<td>5</td>
<td>One hand on apparatus</td>
</tr>
<tr>
<td>85.7</td>
<td>6</td>
<td>Two hands on apparatus</td>
</tr>
<tr>
<td>100.0</td>
<td>7</td>
<td>Hands overlapped, maximum reach</td>
</tr>
</tbody>
</table>
mentally retarded subjects. The modifications and their rationale follows:

1. The length of the scoring grid was modified from the original 0 to 40 centimeters to -5 to 50 centimeters. This was to accommodate the positively and negatively marked ranges of flexibility in the severely retarded.

2. A wooden block and guide were added to the surface of the scoring grid. This was to provide additional stimuli for a maximum reach by having the subjects "push" the block as far as possible (while their score was measured on the grid).

3. Brightly colored "footprints" were added to the forward vertical surface of the apparatus. This was to heighten the visual stimuli for correct foot placement.

4. An additional wood block (3-1/2" x 3-1/2" x 10-1/2") was added to the inside rear of the apparatus. This was to counterbalance the box and keep it from tipping forward (due to its increased length).

A graphic depiction of the modified sit and reach apparatus is contained in Appendix C.

Background of the Researcher

The researcher who conducted this study had extensive experience in teaching motor skills to mentally retarded individuals. He had been involved in the instruction of special physical education for over nine years. Specifically, the researcher was employed as a special physical education instructor in a day training
program for moderately and severely mentally retarded children and adults. Duties included instruction in gross motor, physical fitness and lifetime/leisuretime recreational skills.

For the last three years the researcher served as a research assistant in a field initiated research project. The project, Project TRANSITION, (Jansma, Ersing & McCubbin, 1986) investigated the development of physical fitness and health/hygiene with severely mentally retarded institutionalized adults. Several of the researcher's duties during Project TRANSITION related directly to the present investigation. Among these experiences were the following: a) selection and task analysis development of motor fitness skills similar to the ones utilized in the present investigation, b) development and utilization of equipment utilized in the present study, and c) instruction of severely mentally retarded adults in selected motor fitness activities.

Research Design

An alternating treatments single-subject research design (Hersen & Barlow, 1979; Tawney & Gast, 1984) was
employed in this study. The basic strategy of this design is the rapid alternation of two or more treatments within a single subject. The order of the treatment presentations are counterbalanced over time. With this design it is possible to examine the differential effects of various treatments on an intrasubject basis. Among the advantages of the alternating treatments design are: a) target behaviors do not need to spend extended periods of time in baseline condition, b) a reversal of behavior is not needed to demonstrate experimental control (this is particularly useful with nonreversible behaviors), c) it permits a rapid comparison of several interventions and individual analysis of each intervention, d) it minimizes experimental phase sequencing problems (condition change effects) by rapidly alternating the interventions, and e) early termination of the study is less critical because differential effects usually are evident early in the investigation (Tawney & Gast, 1984).

The internal validity of the alternate treatments design is demonstrated when each intervention results in different levels of responding when compared to the other interventions. The rapid alternation of the interventions controls for maturational and historical
threats to internal validity (Tawney & Gast, 1984). External validity is demonstrated with the alternating treatments design by replication over different settings, behaviors or conditions. In this study the treatment effects were replicated over six subjects.

In accordance with the alternate treatments protocol in this study, each subject underwent four sessions of baseline measurement. In the baseline condition each subject was requested to perform each of the targeted motor fitness skills. The skill was modeled by the researcher then a verbal command was given as follows "Name do the squat thrust." No further prompts were given. This was repeated for each motor fitness skill (modified supine tuck, modified squat thrust, modified sit and reach).

Following the determination of baseline data for each subject, the intervention phase began. For each subject an instructional strategy (forward chaining, = FC, reverse chaining = RC or total task presentation = TTP) was paired with a motor fitness skill (modified supine tuck = MST, modified squat thrust = Squat, or modified sit and reach = MSR). In order to control for an interaction effect of instructional strategy and
modified motor fitness skill, these two elements were counterbalanced across the six subjects. Table 2 illustrates the counterbalancing schema of instructional strategies and motor fitness skills.

| TABLE 2. COUNTERBALANCED INSTRUCTIONAL STRATEGIES AND MOTOR FITNESS SKILLS |
|-----------------------------|-----------------------------|-----------------------------|
| Subjects 1 & 4               | Subjects 2 & 5               | Subjects 3 & 6               |
| FC/MST                      | FC/SQUAT                    | FC/MSR                      |
| RC/SQUAT                    | RC/MSR                      | RC/MST                      |
| TTP/MSR                     | TTP/MST                     | TTP/SQUAT                   |

During each instructional session in the intervention phase each subject was instructed with each of the instructional strategies. Six trials were conducted with each instructional strategy.

Sequential confounding and carryover effects are potential threats to internal validity of the alternate treatments design (Hersen & Barlow, 1979). Sequential confounding refers to the occurrence that one treatment (instructional strategy) may be consistently effective or ineffective only if it always follows another particular
treatment. This is also referred to as order effects. Another threat is carryover effect. Carryover effect refers to the influence of one treatment on an adjacent treatment regardless of overall sequencing. Hersen and Barlow (1979) state that counterbalancing the sequence of presentation of the treatments (instructional strategies) minimizes these threats. Additionally they suggest that the different treatments should be discernible from each other. The discernability of treatments will minimize the potential of carryover threats.

To counter the threats of sequential confounding and carryover effects, the order of presentation of the instructional strategies were counterbalanced across the instructional sessions. Table 3 depicts the counterbalancing of instructional strategies across instructional sessions.
TABLE 3. COUNTERBALANCED ORDER OF INSTRUCTIONAL STRATEGIES ACROSS INSTRUCTIONAL SESSIONS

<table>
<thead>
<tr>
<th>Order of Presentation</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Order of Session</td>
<td>FC</td>
<td>RC</td>
<td>TTP</td>
</tr>
<tr>
<td>1</td>
<td>FC</td>
<td>TTP</td>
<td>RC</td>
</tr>
<tr>
<td>2</td>
<td>RC</td>
<td>TTP</td>
<td>FC</td>
</tr>
<tr>
<td>3</td>
<td>TTP</td>
<td>RC</td>
<td>FC</td>
</tr>
</tbody>
</table>

Instructional Sessions 1&7 2&8 3&9 4&10 5&11 6&12

Twelve instructional sessions were conducted. Instructional sessions took place on Mondays through Fridays. If a subject demonstrated that he or she had learned a skill to criterion before the twelfth session, instruction in that skill was to be terminated. Learning to criterion was demonstrated when a subject performed a skill with only a verbal prompt to initiate two out of two trials consecutively and in two consecutive sessions. If a subject did not demonstrate learning to criterion, instruction was to be terminated on the twelfth instructional session.
A check for retention of each motor fitness skill also was made on each subject. The retention probes were conducted two weeks after that skill was demonstrated to criterion or, if criterion was not reached, two weeks after the twelfth instructional session.

**Description of Trials**

The procedures for each phase (baseline, intervention and retention) of the study were standardized. The procedure during both the baseline phase trials and the retention phase trials were identical. The subject was positioned facing the researcher. The investigator then prompted the subject to watch a demonstration of the skill to be performed (eg. "Watch me do a supine tuck"). The researcher then demonstrated the motor fitness skill. The researcher then prompted the subject to perform the skill (eg. "John, let me see you do the supine tuck"). The subject's performance was then recorded on the subject data sheet. The trial procedures for the intervention phase of the study were dictated by the instructional strategy employed. A description of the trial procedure for each instructional strategy follows.
Forward Chaining

In forward chaining the subjects were taught using the following steps: step 1, teach subtask 1; step 2, teach subtasks 1 and 2 linked together; step 3, teach subtasks 1, 2 and 3 linked together; step 4, teach subtasks 1, 2, 3, and 4 linked together; step 5, teach subtasks 1, 2, 3, 4 and 5 linked together; step 6, teach subtasks 1, 2, 3, 4, 5 and 6 linked together; step 7, teach subtasks 1, 2, 3, 4, 5, 6 and 7 linked together.

Each trial was begun by the investigator modeling and providing verbal instruction of the subtask(s) to be performed. For example, at step 3 the investigator modeled and verbally described subtasks 1, 2 and especially subtask 3 (the newest subtask to be introduced). Following the investigator's model, the subject was asked to perform subtasks 1, 2 and 3. The subject was given mild verbal reinforcement for the accomplishment of subtasks 1 and 2. An individualized reinforcer (selected through reinforcement sampling) was given at the completion of subtask 3. If the subject was unable to perform any of the subtasks correctly or hesitated more than ten seconds, the researcher then employed a system of least intrusive prompts to assist in
the completion of the learning trial. A step was considered learned when the subject performed it independently (only initial verbal prompt) two out of two trials consecutively. When a step had been performed to this learning criterion, the next step was undertaken. When the subject performed the entire skill independently and correctly two out of two trials on two consecutive days the skill was considered learned.

Reverse Chaining

During reverse chaining instruction the subjects were taught using the following steps: step 1, teach subtask 7; step 2, teach subtasks 7 and 6 linked together; step 3, teach subtasks 7, 6 and 5 linked together; step 4, teach subtasks 7, 6, 5 and 4 linked together; step 5, teach subtasks 7, 6, 5, 4 and 3 linked together; step 6, teach subtasks 7, 6, 5, 4, 3 and 2 linked together; and step 7, teach subtasks 7, 6, 5, 4, 3, 2 and 1 linked together.

Each trial was begun by the investigator modeling and providing verbal instruction of the subtasks to be performed. For example at step 3 the investigator modeled and verbally described subtasks 7, 6 and
especially subtask 5 (the newest subtask to be introduced). Following the investigator's model the subject was asked to perform subtasks 7, 6 and 5. The subject was given mild verbal reinforcement for the accomplishment of subtasks 7 and 6. An individualized reinforcer (selected through reinforcement sampling) was given at the completion of subtask 5.

If the subject was unable to perform any of the subtasks correctly or hesitated more than ten seconds, the investigator then employed a system of least intrusive prompts to assist in completion of the learning trial. A step was considered learned when the subject performed it independently (only initial verbal prompt) two out of two trials consecutively. When a step was performed to this learning criterion, the next step was undertaken. When the subject performed the entire skill independently and correctly two out of two trials in two consecutive sessions the skill was considered learned.

**Total Task Presentation**

During total task presentation instruction the subjects were taught by attempting each subtask of the skill from beginning to end on each trial. At each step
the subject was verbally prompted to perform the subtask correctly. A correct response received mild verbal reinforcement and then the subject was prompted to perform the next subtask. When the subject performed a subtask incorrectly or hesitated more than ten seconds, he or she was prompted using a system of least intrusive prompts. The subject was given mild verbal reinforcement for the correct independent accomplishment of each subtask. If the subject performed all subtasks independently and correctly he or she was given an individualized reinforcer selected through reinforcement sampling.

**System of Least Intrusive Prompts**

When a subject failed to perform a subtask correctly or hesitated ten seconds after an initial verbal prompt, a system of least intrusive prompts was provided. A system similar to that reported by Johnson and Cuvo (1981) was employed using the least intrusive prompt necessary for trial success. A description of the prompting levels and the order in which they were presented follows:
1. **Verbal Instruction** - The investigator verbalized the subtask to the subject.

2. **Verbal Instruction + Visual Cue** - The investigator gave a verbal cue and used a gesture such as pointing to the equipment being used.

3. **Verbal Instruction + Modeling** - The investigator performed the step while verbalizing it.

4. **Verbal Instruction + Physical Guidance** - The investigator physically guided the subject while verbalizing the subtask.

**Reinforcement Sampling**

In accordance with the chaining procedures being employed, individualized reinforcement was awarded to each subject at the completion of each learning trial in which the subtasks being taught were performed independently and correctly. In order to insure this individualization of reinforcers, a reinforcer sampling procedure was conducted. As suggested by Alberto and Troutman (1982) and Martin and Pear (1983) the subjects were presented with a "reinforcer menu". The reinforcer menu included nine potential reinforcers from three
categories. The potential reinforcers and their categories included the following: a) social praise category, 1) a smile from the researcher, 2) a hug from the researcher, 3) a handshake from the researcher; b) tangible category, 1) a smile face sticker, 2) a gold star, 3) a good job sticker; and c) edible category, 1) an orange slice, 2) five raisins, 3) 1/3 piece of sugarless chewing gum. The subject was asked to "rank order" his or her preference of these potential reinforcers. This was done four times prior to the intervention phase of the study. At the end of the sampling process the three most requested reinforcers from each category for each subject were determined and used throughout the investigation. One of the three reinforcers was randomly chosen for each learning trial in which the subtasks being taught were performed independently and correctly. In this way it was hoped that the reinforcers were individualized, but that no subject would satiate on a particular reinforcer.

Data Collection Procedures

Data were collected for each trial performed during the investigation. The subject data sheet was the
primary method of data recording. The subject data sheet was filled out by the researcher after each trial. Included on the subject data sheet was the following: the subject's name, the instructional strategy being used, subtasks attempted, amount of prompting required to complete the subtasks and reinforcement earned. Data were also recorded and charted on the number of trials it took for each skill to be learned to criterion (two out of two trials in two consecutive sessions). Also the elapsed time per instructional strategy during each session was recorded. The researcher started a stopwatch when the first trial of an instructional strategy began and stopped the stopwatch when the sixth trial of that instructional strategy was concluded. A copy of the subject data sheet is contained in Appendix D.

Reliability Measurement

An observer was trained to measure the reliability of the data collected by the researcher. Initially the observer became familiar with the protocols of the instructional strategies to be employed. The observer also became familiar with the system of least intrusive prompts to be employed. The observer then scored actual
demonstrations of the instructional process from videotapes including sound.

The scored-trial method (Twaney & Gast, 1984) was used for calculating interobserver agreement. This allows for the comparison of data on a trial by trial basis which permits a rigorous assessment of reliability. The formula for the scored-trial method is given below:

\[
\frac{\text{agreements}}{\text{agreements} \& \text{disagreements}} \times 100 = \text{Percentage of agreement}
\]

When an 80 percent or above reliability was demonstrated from the training videotapes, the observer was considered trained.

Videotapes were recorded for all trials for each subject on two sessions of baseline measurement, three sessions of intervention and two sessions of retention measurement.

The videotape camera was mounted on a tripod and placed approximately four meters away from the subjects. The videotape camera was connected to a videotape recorder and a television set which were located on an audiovisual cart. The audiovisual cart was adjacent to the camera with the front of the equipment facing away from the subjects' performance area. The investigator
used a remote control switch to start and stop the videotape recorder at the beginning and end of each series of trials. The subjects could not see the front of the videotape recorder or television set, nor could they determine if the videotape camera was on. Also no subjects were allowed to view any of the videotape recordings obtained.

**Procedural Integrity Measurement**

An observer was trained to measure the procedural integrity of the instructional strategies employed. As suggested by Peterson, Holmer and Wonderlich (1982) for this type of measurement, an observer should become familiar with the protocols of the instructional strategies and with the system of least intrusive prompts to be employed. The observer then records the actual occurrence or nonoccurrence of the instructional procedures as they have been detailed. The observer in this investigation scored actual demonstrations of the instructional process, including reinforcement delivery, from videotapes incorporating sound.

The scored-trial method (Tawney & Gast, 1984) was used for calculating interobserver agreement. This
allowed for the comparison of data on a trial by trial basis. The formula for the scored - trial method is given below:

\[
\frac{\text{agreements}}{\text{agreements & disagreements}} \times 100 = \text{Percentage of agreement}
\]

Videotapes were recorded for all trials for each subject on two sessions of baseline measurement, three sessions of intervention and two sessions of retention measurement.

**Social Validation Procedures**

As suggested by Kazdin (1977) and Wolf (1978), it is important to demonstrate the applied significance of behavior changes in applied behavior analytic research. This concept includes the evaluation of the importance of the target behavior selected for change, the acceptability of the intervention procedures used to change behavior and the significance of the behavior change results (Kazdin, 1977).

A measure of social validation was employed to demonstrate the perceived importance and acceptability of methods conducted in the present study. A description of the investigation's objectives, methods and subjects and
setting were given to 12 individuals. After reading the study description and asking any questions to the investigator, they filled out a questionnaire. The questionnaire dealt with the individuals' perceived social validity of the investigation.

**Data Analysis Procedures**

Both visual analysis and descriptive statistics were employed with the data. The primary analyses of relative effectiveness and efficiency of the instructional strategies were performed through the use of the "split-middle technique" (White & Haring, 1980). This technique provides a method of describing the rate of behavior change over time, resulting in a celeration line. The celeration lines were also expressed numerically. (To compute the celeration rate in this investigation, the value on the ordinate which the celeration line passed through on trial number 40 was divided into the value on the ordinate which the celeration line passed through for trial number 46.)

Data for number of trials, amount of time, amount of prompting and retention were analyzed through the use of
visual analyses of level and trend and descriptive statistics.

For each research question, data were to be analyzed on both an individual and a group basis.
CHAPTER IV
RESULTS AND DISCUSSION

This chapter presents, interprets and discusses the descriptive data collected during the conduct of this investigation. This chapter is divided into the following sections: a) Introduction, b) Description of Subjects, c) Content Validity Survey Results, d) Social Validity Survey Results, e) Reliability Measurement Results, f) Procedural Integrity Measurement Results, g) Individual Results, h) Discussion of Individual Data, i) Group Results and Discussion, and j) Summary.

Introduction

The primary thrust of this study was to investigate the relative effectiveness and efficiency of three instructional methods in the acquisition and retention of three motor fitness skills with six individuals who were severely mentally retarded.

Results stemming from this investigation were entirely descriptive in nature. Celeration lines and
individual and group graphing of the data were used to describe the acquisition and retention of the three motor fitness skills using the three instructional strategies. The descriptive data allowed the investigator an opportunity to distinguish differences between instructional strategies on both an intrasubject and an intersubject basis.

This study attempted to investigate five primary research questions. These questions were:

1. Is there a significant difference between forward chaining, reverse chaining and total task presentation in the celeration required to reach criterion on three targeted motor fitness skills?

2. Is there a significant difference between forward chaining, reverse chaining and total task presentation in the number of trials required to reach criterion on three targeted motor fitness skills?

3. Is there a significant difference between forward chaining, reverse chaining and total task presentation in the amount of time required
to reach criterion on three targeted motor fitness skills?

4. Is there a significant difference between forward chaining, reverse chaining and total task presentation in the amount of prompting required to reach criterion on three targeted motor fitness skills?

5. Is there a significant difference between forward chaining, reverse chaining and total task presentation in the retention of three targeted motor fitness skills?

Research questions One through Four dealt with the subjects' achievement of criterion on the targeted motor fitness skills. Criterion was considered demonstrated when a subject emitted a targeted motor fitness skill with only a verbal prompt to initiate two out of two trials consecutively and in two consecutive sessions. However, none of the six subjects involved in the study reached criterion on any of the targeted motor fitness skills. This adversely affected the investigator's ability to fully address research questions One through Four. However, each question, except for question Two, could still be addressed using alternate tactics. Even
though these research questions could not be addressed directly relative to criterion achievement on the targeted motor fitness skills, data were retrieved which gave information at the subtask level relative to time, independent performance, and required prompting.

In order to address research questions One through Four, the following indices were used. Question number One was addressed using the celeration line to analyze subtasks performed independently per trial for each instructional strategy. Question number Two became moot when no subject reached criterion on any of the targeted motor fitness skills. Therefore question Two was not addressed since all subjects received 72 trials during the instructional phase. Question number Three was analyzed with the mean number of subtasks performed independently per minute for each instructional session for each instructional strategy. Question Four was addressed by analyzing the mean number of prompts required per trial for each instructional session for each instructional strategy. For this purpose a numeric value was awarded to each level of prompting provided. Table 4 presents the hierarchy of this prompting intensity score system.
TABLE 4. PROMPTING INTENSITY SCORE SYSTEM

<table>
<thead>
<tr>
<th>Prompting Level</th>
<th>Numeric Value (Prompting Points)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verbal prompt</td>
<td>1</td>
</tr>
<tr>
<td>Verbal prompt and visual cue</td>
<td>2</td>
</tr>
<tr>
<td>Verbal prompt and modeling</td>
<td>3</td>
</tr>
<tr>
<td>Verbal prompt and physical guidance</td>
<td>4</td>
</tr>
</tbody>
</table>

Description of Subjects

Twelve individuals with severe mental retardation took part in this study. A screening test was conducted on these individuals to determine the subjects' familiarity with the motor fitness skills to be used. Two trials were administered in the screening test. Those individuals who properly executed any of the motor fitness skills or any subtasks of these skills were eliminated from the study.

As a result of the screening test, six individuals were eliminated from the study due to their ability to perform the motor fitness skills in whole or in part. The remaining subjects were divided into two age group categories of 9 to 15 years and 16 to 20 years. Each
subject was then randomly selected to receive one of the experimental protocols as determined by the counterbalanced alternate treatments design (Table 2). The subjects are further described in Table 5 as a function of chronological age, sex, intelligence quotient and clinical diagnosis.

### TABLE 5. SUBJECTS' AGE, SEX, IQ AND CLINICAL DIAGNOSIS

<table>
<thead>
<tr>
<th>Subject</th>
<th>CA</th>
<th>Sex</th>
<th>IQ</th>
<th>Clinical Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>19 y 10 m</td>
<td>M</td>
<td>35</td>
<td>Severely Mentally Retarded</td>
</tr>
<tr>
<td>2</td>
<td>17 y 11 m</td>
<td>F</td>
<td>32</td>
<td>Severely Mentally Retarded</td>
</tr>
<tr>
<td>3</td>
<td>17 y 3 m</td>
<td>M</td>
<td>30</td>
<td>Severely Mentally Retarded</td>
</tr>
<tr>
<td>4</td>
<td>9 y 9 m</td>
<td>M</td>
<td>24</td>
<td>Severely Mentally Retarded</td>
</tr>
<tr>
<td>5</td>
<td>9 y 11 m</td>
<td>M</td>
<td>32</td>
<td>Severely Mentally Retarded</td>
</tr>
<tr>
<td>6</td>
<td>10 y 11 m</td>
<td>M</td>
<td>32</td>
<td>Severely Mentally Retarded</td>
</tr>
</tbody>
</table>

**Content Validity Survey Results**

In order to establish the content validity of the task analyses used in this study, a survey was conducted. A review panel of seven Accepted Physical Education professors was employed. Each of the individuals consulted was an expert in the area of task analysis development for the severely impaired. A copy of the
content validity survey questionnaire appears in Appendix F. A six point Likert Scale was employed. The Scale and its corresponding point values were as follows: strongly agree (+3), agree (+2), mildly agree (+1), mildly disagree (-1), disagree (-2), strongly disagree (-3).

Results of the content validity survey were as follows:

1. The task analysis of the modified sit and reach is appropriate for instruction of individuals with severe mental retardation.
   Mean response +2.28

2. The task analysis for the modified squat thrust is appropriate for instruction of individuals with severe mental retardation.
   Mean response +2.43

3. The task analysis for the modified supine tuck is appropriate for instruction of individuals with severe mental retardation.
   Mean response +2.14

The grand mean for all three questions was +2.28. From these results the investigator considered the task analyses used in the study to have sufficient content validity.
Social Validity Survey Results

A measure of social validation was employed to demonstrate the perceived importance and acceptability of methods used in the present study. A description of the investigation's objectives, methods and subjects was given to 12 individuals. After reading the study description and asking any questions of the investigator, they filled out a questionnaire (See Appendix E). The questionnaire measured each expert's perceived social validity of the investigation.

The respondents were comprised of three groups. The groups were a) four instructors of the severely retarded, b) four parents of the severely retarded, and c) four Special Physical Education specialists experienced in working with the severely retarded. A seven point Likert Scale was used in the questionnaire. The Scale and its corresponding point values were as follows: strongly agree (+3), agree (+2), mildly agree (+1), undecided (0), mildly disagree (-1), disagree (-2) and strongly disagree (-3). (The point values were reversed for negatively stated questions.)

Results of the social validity survey were as follows:
1. The acquisition of motor fitness skills is important for severely mentally retarded individuals.

Teacher $\bar{X}$  Parent $\bar{X}$  S.P.E. $\bar{X}$  Grand $\bar{X}$
+2.75     +3.0     +2.5     +2.75

2. The task analyses of the motor fitness skills are appropriate for severely retarded individuals.

Teacher $\bar{X}$  Parent $\bar{X}$  S.P.E. $\bar{X}$  Grand $\bar{X}$
+2.25     +2.75   +2.5     +2.41

3. It is not important to identify which chaining strategy is the most effective and efficient in teaching motor fitness skills to severely mentally retarded individuals.

Teacher $\bar{X}$  Parent $\bar{X}$  S.P.E. $\bar{X}$  Grand $\bar{X}$
+2.25     +2.75   +2.75   +2.58

4. Abdominal strength is an important attribute for severely mentally retarded individuals to develop.

Teacher $\bar{X}$  Parent $\bar{X}$  S.P.E. $\bar{X}$  Grand $\bar{X}$
+1.75     +2.75   +2.5     +2.33
5. Body strength/endurance is an important attribute for severely mentally retarded individuals to develop.

Teacher X  Parent X  S.P.E. X  Grand X  
+2.25  +3.00  +2.5  +2.58

6. Flexibility is an important attribute for severely mentally retarded individuals to develop.

Teacher X  Parent X  S.P.E. X  Grand X  
+2.50  +3.00  +2.5  +2.75

7. The instructional procedures employed in this study are reasonable for use with severely mentally retarded persons.

Teacher X  Parent X  S.P.E. X  Grand X  
+2.50  +2.75  +2.25  +2.50

8. Improvement in motor fitness skills would positively affect the quality of life of severely mentally retarded persons.

Teacher X  Parent X  S.P.E. X  Grand X  
+2.50  +2.75  +2.5  +2.58
9. Results of this investigation will be useful to instructors of severely mentally retarded individuals.

<table>
<thead>
<tr>
<th>Teacher</th>
<th>Parent</th>
<th>S.P.E.</th>
<th>Grand</th>
</tr>
</thead>
<tbody>
<tr>
<td>+2.25</td>
<td>+2.75</td>
<td>+2.5</td>
<td>+2.50</td>
</tr>
</tbody>
</table>

10. The time spent by the subjects in this investigation is not justified by the potential results of the study.

<table>
<thead>
<tr>
<th>Teacher</th>
<th>Parent</th>
<th>S.P.E.</th>
<th>Grand</th>
</tr>
</thead>
<tbody>
<tr>
<td>+1.25</td>
<td>+2.75</td>
<td>+2.75</td>
<td>+2.25</td>
</tr>
</tbody>
</table>

The mean results for all questions by group were: teacher = +2.23, parent = +2.83, S.P.E. = +2.75. The total grand mean for all questions for all respondents was +2.52. From these data, the researcher considered the investigation to have adequate social validity.

**Reliability Measurement Results**

An evaluator was utilized to ascertain the reliability of the data collected. This evaluator was a doctoral student in the Special Physical Education Training Project at The Ohio State University. The evaluator had some familiarity with the subjects, instructional techniques and motor fitness skills under
investigation. However, to familiarize the evaluator further, a research prospectus was made available. The prospectus contained detailed descriptions of the motor fitness skills, task analyses, instructional strategies, trial procedures and the system of least intrusive prompts.

To determine the agreement between the evaluator and the investigator, several individuals were videotaped performing the motor fitness skills under the conditions to be employed in the study. The individuals were moderately and severely mentally retarded subjects who were eliminated from the experimental phase of the study due to screening test results. Approximately eight hours were spent in this reliability training phase by the evaluator and the investigator.

The scored trial method (Twaney & Gast, 1984) was used to calculate interobserver agreement. This allows for comparison on a trial by trial basis which permits a rigorous assessment of reliability. The formula for the scored trial method is given below:

\[
\text{Percentage of agreement} = \frac{\text{agreements}}{\text{agreements} + \text{disagreements}} \times 100
\]

When an 80 percent or above reliability was demonstrated from the training videotapes, the evaluator
was considered trained. Reliability was calculated for each motor fitness skill under each of the instructional strategies being employed. Training reliability data were calculated using the following data categories: a) subject performance, b) prompting employed, and c) time in minutes and seconds for each set of six instructional trials (within 3 seconds). The reliability results for these training sessions are contained in Table 6.
TABLE 6. RELIABILITY TRAINING RESULTS FOR PERFORMANCE, PROMPTING AND TIME ACROSS MOTOR FITNESS SKILLS AND INSTRUCTIONAL STRATEGIES

<table>
<thead>
<tr>
<th></th>
<th>Performance</th>
<th>Prompting</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Modified Supine Tuck</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All Trials</td>
<td>100%</td>
<td>99%</td>
<td>100%</td>
</tr>
<tr>
<td>Forward Chaining Trials</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Reverse Chaining Trials</td>
<td>100%</td>
<td>98%</td>
<td>100%</td>
</tr>
<tr>
<td>Total Task Presentation Trials</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td><strong>Modified Sit and Reach</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All Trials</td>
<td>100%</td>
<td>94%</td>
<td>100%</td>
</tr>
<tr>
<td>Forward Chaining Trials</td>
<td>100%</td>
<td>97%</td>
<td>100%</td>
</tr>
<tr>
<td>Reverse Chaining Trials</td>
<td>100%</td>
<td>90%</td>
<td>100%</td>
</tr>
<tr>
<td>Total Task Presentation Trials</td>
<td>100%</td>
<td>94%</td>
<td>100%</td>
</tr>
<tr>
<td><strong>Modified Squat Thrust</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All Trials</td>
<td>99%</td>
<td>98%</td>
<td>100%</td>
</tr>
<tr>
<td>Forward Chaining Trials</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Reverse Chaining Trials</td>
<td>99%</td>
<td>97%</td>
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<tr>
<td>Total Task Presentation Trials</td>
<td>100%</td>
<td>97%</td>
<td>100%</td>
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<tr>
<td><strong>Total Trials</strong></td>
<td>99%</td>
<td>97%</td>
<td>100%</td>
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</table>

During the study, videotapes were made of randomly selected sessions of each phase (baseline, intervention and retention) for the purposes of reliability measurement. The randomly selected sessions used for reliability measurement included baseline sessions 1 and 3; instructional sessions 3, 6 and 12 (all trials); and
retention sessions 1 and 2. During baseline and retention sessions a measurement of only performance was made. The results of the reliability measurements are contained in Table 7. Based upon these results, the researcher considered the data obtained to be reliable.
TABLE 7. RELIABILITY RESULTS FOR PERFORMANCE, PROMPTING AND TIME ACROSS PHASES, MOTOR FITNESS SKILLS, INSTRUCTIONAL STRATEGIES AND SUBJECTS

<table>
<thead>
<tr>
<th></th>
<th>Performance</th>
<th>Prompting</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Modified Supine Tuck</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>100%</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Retention</td>
<td>93%</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Reverse Chaining</td>
<td>100%</td>
<td>96%</td>
<td>100%</td>
</tr>
<tr>
<td>Forward Chaining</td>
<td>98%</td>
<td>95%</td>
<td>100%</td>
</tr>
<tr>
<td>Total Task Presentation</td>
<td>98%</td>
<td>90%</td>
<td>100%</td>
</tr>
<tr>
<td>All Trials</td>
<td>99%</td>
<td>92%</td>
<td>100%</td>
</tr>
<tr>
<td><strong>Modified Sit and Reach</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>100%</td>
<td>--</td>
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<tr>
<td>Retention</td>
<td>90%</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Reverse Chaining</td>
<td>98%</td>
<td>90%</td>
<td>100%</td>
</tr>
<tr>
<td>Total Task Presentation</td>
<td>100%</td>
<td>94%</td>
<td>100%</td>
</tr>
<tr>
<td>All Trials</td>
<td>94%</td>
<td>96%</td>
<td>100%</td>
</tr>
<tr>
<td><strong>Modified Squat Thrust</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Baseline</td>
<td>100%</td>
<td>--</td>
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</tr>
<tr>
<td>Retention</td>
<td>90%</td>
<td>--</td>
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</tr>
<tr>
<td>Reverse Chaining</td>
<td>93%</td>
<td>93%</td>
<td>100%</td>
</tr>
<tr>
<td>Total Task Presentation</td>
<td>100%</td>
<td>92%</td>
<td>100%</td>
</tr>
<tr>
<td>All Trials</td>
<td>99%</td>
<td>94%</td>
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<tr>
<td><strong>Total Trials</strong></td>
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<tr>
<td></td>
<td>99%</td>
<td>94%</td>
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Procedural Integrity Measurement Results

In order to evaluate the procedural integrity of the instructional procedures employed, the results of the reliability measurement were used. As previously described for reliability measurement, an evaluator coded the performance, prompting level per trial and the elapsed time per set of trials. Additionally, the evaluator coded the presentation of an identified reinforcer. During training sessions to learn procedural integrity measurement, the interobserver agreement for the reinforcer category was 100%.

Through analyzing the coded data of the previously described categories, the investigator was able to ascertain the procedural integrity of the instructional procedures employed. Specifically the results were analyzed to discover two basic elements of procedural integrity. These elements were a) correct subtask(s) taught, and b) reinforcement correctly awarded or withheld as planned. Based on the videotaped data analyzed, procedural integrity (the percentage of time the dual elements were performed correctly) was calculated for each motor fitness skill for each
instructional strategy. Results of the procedural integrity measurement are contained in Table 8.

<table>
<thead>
<tr>
<th>TABLE 8. PERCENTAGE OF CORRECT PROCEDURES PERFORMED FOR SUBTASKS TAUGHT AND REINFORCEMENT PROVIDED ACROSS MOTOR FITNESS SKILLS, INSTRUCTIONAL STRATEGIES AND SUBJECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Subtasks Taught</strong></td>
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<tr>
<td>-----------------------</td>
</tr>
<tr>
<td><strong>Modified Supine Tuck</strong></td>
</tr>
<tr>
<td>Forward Chaining</td>
</tr>
<tr>
<td>Reverse Chaining</td>
</tr>
<tr>
<td>Total Task Presentation</td>
</tr>
<tr>
<td>All Trials</td>
</tr>
<tr>
<td><strong>Modified Sit and Reach</strong></td>
</tr>
<tr>
<td>Forward Chaining</td>
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<tr>
<td>Reverse Chaining</td>
</tr>
<tr>
<td>Total Task Presentation</td>
</tr>
<tr>
<td>All Trials</td>
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<tr>
<td><strong>Modified Squat Thrust</strong></td>
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<tr>
<td>Forward Chaining</td>
</tr>
<tr>
<td>Reverse Chaining</td>
</tr>
<tr>
<td>Total Task Presentation</td>
</tr>
<tr>
<td>All Trials</td>
</tr>
<tr>
<td><strong>Total Trials</strong></td>
</tr>
</tbody>
</table>
Individual Results

Subject 1

The results for Subject 1 (Figure 2) indicate that reverse chaining proved to be the most effective instructional strategy employed. The celeration rate for subtasks performed independently for reverse chaining was 1.33. Both forward chaining and total task presentation demonstrated a 0.00 celeration rate. Although forward chaining and total task presentation failed to result in a positive celeration rate, some improvement was evident. Forward chaining resulted in one subtask being performed independently on four trials. Total task presentation resulted in one subtask being performed independently on seven trials and two subtasks performed independently on one trial.

Subject 1's results for rate of independent subtask demonstration (Figure 3) indicate that reverse chaining was the quickest relative to acquisition of motor fitness skill. The mean rate of skill acquisition for reverse chaining was 0.35 subtasks performed independently per minute. The mean rate of subtasks performed independently per minute for both forward chaining and total task presentation was 0.04. This finding concurs
FIGURE 2. BASELINE, INTERVENTION AND RETENTION OF MOTOR FITNESS SKILL SUBTASKS PERFORMED INDEPENDENTLY ACROSS THREE INSTRUCTIONAL STRATEGIES FOR SUBJECT 1.
FIGURE 3. MEAN SUBTASKS PERFORMED INDEPENDENTLY PER MINUTE ACROSS THREE INSTRUCTIONAL STRATEGIES AND MOTOR FITNESS SKILLS FOR SUBJECT 1.
with the findings for celeration of subtasks performed independently.

Results for amount of prompting (Figure 4) required indicate that forward chaining required the least prompting with a mean of 1.96 prompting points per trial. Reverse chaining required a mean of 5.11 prompting points per trial and the mean for total task presentation was 18.30.

None of the training procedures resulted in retention of independent performance of any subtasks of the targeted motor fitness skills (Figure 2).
FIGURE 4. MEAN PROMPTING SCORE PER TRIAL ACROSS THREE INSTRUCTIONAL STRATEGIES FOR SUBJECT 1.
Subject 2

The results for Subject 2 (Figure 5) indicate that none of the instructional strategies proved effective in the independent performance of subtasks. Both forward chaining and reverse chaining resulted in a 0.00 celeration rate. Total task presentation resulted in a negative celeration rate of -1.50.

Forward chaining resulted in no subtasks being performed independently. Reverse chaining resulted in one subtask being performed independently on five trials and two subtasks being performed independently on four trials. Total task presentation resulted in 16 trials demonstrating one subtask performed independently and eight trials with two subtasks performed independently. However, 19 of the trials in which independent performance was demonstrated occurred prior to the median trial (trial number 40). This resulted in a negative celeration rate.

Subject 2's results for rate of independent subtask demonstration (Figure 6) indicate that total task presentation was responsible for the quickest acquisition of motor fitness skill. The mean rate of subtasks performed independently was 0.16 per minute. Reverse
FIGURE 5. BASELINE, INTERVENTION AND RETENTION OF MOTOR FITNESS SKILL SUBTASKS PERFORMED INDEPENDENTLY ACROSS THREE INSTRUCTIONAL STRATEGIES FOR SUBJECT 2.
FIGURE 6. MEAN SUBTASKS PERFORMED INDEPENDENTLY PER MINUTE ACROSS THREE INSTRUCTIONAL STRATEGIES AND MOTOR FITNESS SKILLS FOR SUBJECT 2.
chaining resulted in 0.11 subtasks performed independently per minute and the rate for forward chaining was 0.00 per minute.

Results for the amount of prompting delivered (Figure 7) indicate that reverse chaining required slightly less prompting than forward chaining. The mean of prompting points per trial was 3.39 for reverse chaining and 4.00 for forward chaining. Total task presentation resulted in the highest amount of prompting delivered with a mean of 22.62 per trial. The forward chaining mean (4.00) reflects the fact that the subject required verbal cue and physical assistance on all 72 instructional trials.

None of the training procedures resulted in retention of independent performance of any subtasks of the targeted motor fitness skills (Figure 5).
FIGURE 7. MEAN PROMPTING SCORE PER TRIAL ACROSS THREE INSTRUCTIONAL STRATEGIES FOR SUBJECT 2.
Subject 3

The results for Subject 3 (Figure 8) indicate that all three instructional strategies demonstrated similar effectiveness. The celeration rate for independent performance of subtasks was as follows; total task presentation 1.32, reverse chaining 1.23, and forward chaining 1.14. All three of the instructional strategies resulted in the performances of six subtasks independently (nonconsecutively) on several trials (forward chaining, 4 trials; reverse chaining 5, trials; and total task presentation, 9 trials). Total task presentation also resulted in seven subtasks being performed on two nonconsecutive trials.

The results for Subject 3 indicate that all three instructional strategies demonstrated similar rates of independent subtask demonstrations. The mean rates of subtasks performed independently per minute were as follows; reverse chaining 2.92, forward chaining 2.57, and total task presentation 2.40 (Figure 9). These results concur with the celeration data for subtasks performed independently.

Forward chaining required the least prompting overall with a mean of 1.57 prompting points per trial.
Figure 8. Baseline, intervention and retention of motor fitness skill subtasks performed independently across three instructional strategies for subject 3.
FIGURE 9. MEAN SUBTASKS PERFORMED INDEPENDENTLY PER MINUTE ACROSS THREE INSTRUCTIONAL STRATEGIES AND MOTOR FITNESS SKILLS FOR SUBJECT 3.
(Figure 10). Reverse chaining required a mean of 2.57 prompting points per trial. Total task presentation resulted in the most prompting with a mean of 17.38 prompting points per trial.

Both total task presentation and reverse chaining resulted in a mean of 4.25 subtasks performed independently in retention sessions. Forward chaining resulted in a mean of 3.75 subtasks demonstrated in retention sessions (Figure 8).
FIGURE 10. MEAN PROMPTING SCORE PER TRIAL ACROSS THREE INSTRUCTIONAL STRATEGIES FOR SUBJECT 3.
Subject 4

The results for Subject 4 (Figure 11) indicate that none of the three instructional strategies demonstrated a learning trend. The celeration rate of subtasks performed independently was 0.00 for all three strategies. No trial resulted in an independent performance of a subtask for any of the three strategies.

Since no subtasks were performed independently on any trial, the rate of independent subtasks demonstrated was 0.00 for all three strategies (Figure 12).

Results for amount of prompting (Figure 13) delivered indicate that forward and reverse chaining were almost identical with mean rate of 3.93 and 9.00 prompting points per trial respectively. Total task presentation resulted in a mean of 23.83 prompting points per trial.

None of the instructional procedures resulted in retention of independent performance of any subtasks of the targeted motor fitness skills (Figure 11).
FIGURE 11. BASELINE, INTERVENTION AND RETENTION OF MOTOR FITNESS SKILL SUBTASKS PERFORMED INDEPENDENTLY ACROSS THREE INSTRUCTIONAL STRATEGIES FOR SUBJECT 4.
FIGURE 12. MEAN SUBTASKS PERFORMED INDEPENDENTLY PER MINUTE ACROSS THREE INSTRUCTIONAL STRATEGIES AND MOTOR FITNESS SKILLS FOR SUBJECT 4.
FIGURE 13. MEAN PROMPTING SCORE PER TRIAL ACROSS THREE INSTRUCTIONAL STRATEGIES FOR SUBJECT 4.
Subject 5

The results for Subject 5 (Figure 14) indicate that total task presentation proved to be the most effective instructional strategy demonstrating a mean celeration rate of 1.17 subtasks performed independently. Both forward chaining and reverse chaining demonstrated no change with identical celeration rates of 0.00 subtasks performed independently. Forward chaining resulted in no subtasks being performed independently on any trials. At least one subtask was performed independently on 19 trials in reverse chaining. Also reverse chaining resulted in four subtasks being performed independently on two nonconsecutive trials.

The results for rate of independent subtask demonstration (Figure 15) show that total task presentation had the quickest rate with a mean of 0.94 subtasks performed independently per minute. Reverse chaining resulted in a mean rate of 0.28 subtasks being performed independently per minute, while the rate for forward chaining was 0.00.

Forward chaining resulted in the least amount of prompting delivered (Figure 16) with a mean of 4.00 prompting points per trial. This is indicative of the
FIGURE 14. BASELINE, INTERVENTION AND RETENTION OF MOTOR FITNESS SKILL SUBTASKS PERFORMED INDEPENDENTLY ACROSS THREE INSTRUCTIONAL STRATEGIES FOR SUBJECT 5.
FIGURE 15. MEAN SUBTASKS PERFORMED INDEPENDENTLY PER MINUTE ACROSS THREE INSTRUCTIONAL STRATEGIES AND MOTOR FITNESS SKILLS FOR SUBJECT 5.
FIGURE 16. MEAN PROMPTING SCORE PER TRIAL ACROSS THREE INSTRUCTIONAL STRATEGIES FOR SUBJECT 5.
fact that Subject 5 was given a verbal cue and physical guidance on subtask 1 for all 72 forward chaining trials. Reverse chaining demonstrated a mean of 6.75 prompting points per trial. The largest amount of prompting was delivered with total task presentation with a mean of 15.33 prompting points per trial.

None of the instructional strategies resulted in retention of any independent performance of any subtasks of the targeted motor fitness skills (Figure 14).
Subject 6

The results for Subject 6 (Figure 17) indicate that reverse chaining demonstrated the most effectiveness with a celeration rate of 1.15 subtasks performed independently. Forward chaining resulted in a celeration rate of 0.00 subtasks performed independently, however this was at the 2.0 level. Total task presentation resulted in a celeration rate of 0.00 subtasks performed independently. The results for forward chaining are interesting and unique in this study. Forward chaining resulted in a quick initial rate of learning but failed to sustain it over the 72 trials.

The results for rate of independent subtask demonstration (Figure 18) show that forward chaining had the quickest mean rate with 1.23 subtasks performed independently per minute. Reverse chaining resulted in a mean rate of 0.63 subtasks performed independently per minute while the rate for total task presentation was 0.06.

Both forward chaining and reverse chaining resulted in similar amounts of prompting delivered (Figure 19). The means for prompting points per trial were 2.25 for forward chaining and 2.60 for reverse chaining. Total
FIGURE 17. BASELINE, INTERVENTION AND RETENTION OF MOTOR FITNESS SKILL SUBTASKS PERFORMED INDEPENDENTLY ACROSS THREE INSTRUCTIONAL STRATEGIES FOR SUBJECT 6.
FIGURE 18. MEAN SUBTASKS PERFORMED INDEPENDENTLY PER MINUTE ACROSS THREE INSTRUCTIONAL STRATEGIES AND MOTOR FITNESS SKILLS FOR SUBJECT 6.
FIGURE 19. MEAN PROMPTING SCORE PER TRIAL ACROSS THREE INSTRUCTIONAL STRATEGIES FOR SUBJECT 6.
task presentation resulted in a mean of 26.89 prompting points per trial.

Reverse chaining demonstrated the most retention with a mean of 5.0 subtasks performed independently (Figure 17). Forward chaining resulted in a mean of 1.5 subtasks performed independently. Total task presentation resulted in a mean of 0.75 subtasks performed independently.

**Discussion of Individual Data**

The data obtained on each individual shed little light on the most effective and efficient instructional strategy for teaching motor fitness skills to individuals with severe mental retardation. The data are inconclusive and somewhat conflicting. Of the six subjects, only one (Subject 3) demonstrated a significant learning trend under all three instructional strategies. Of the other subjects, one demonstrated no learning trend (Subject 4); two demonstrated a learning trend in only one instructional strategy (Subjects 1 and 5); one demonstrated initial learning which disappeared, resulting in a deceleration trend in one instructional strategy and no learning in the other strategies (Subject
2); and one subject demonstrated a learning trend in one strategy, and a stable learning rate in another strategy, resulting in a celeration rate as neither increasing or decreasing (Subject 6).

Looking at just the instructional strategy which proved most effective (highest celeration rate) for each individual yielded the following results: reverse chaining was best twice (Subjects 1 and 6) and total task presentation was best twice (Subjects 3 and 5).

In the only subject where all three instructional strategies resulted in a learning trend (Subject 3), all strategies demonstrated similar celeration rates (total task presentation 1.32, reverse chaining 1.23 and forward chaining 1.14).

The number of subtasks performed independently over time is an indication of the efficiency of the instructional strategy. Here again mixed results were obtained. All three strategies proved most efficient at least once, reverse chaining (Subject 1), forward chaining (Subjects 3 and 6) and total task presentation (Subject 5). However, the results for Subject 2 are suspect as no significant learning trend was demonstrated. Also suspect are the results for Subjects
1 and 5 where only one instructional strategy demonstrated a learning trend. Forward chaining was the most efficient for both Subjects 3 and 5. While forward chaining was most efficient for both Subjects 3 and 5 respectively, it should be noted it was the third and second respectively for effectiveness (celeration).

The amount of prompting required with each instructional strategy is another indication of efficiency. In five out of six subjects, forward chaining resulted in the lowest amount of prompting points. Only in Subject 4 was reverse chaining lower in mean prompting points. However this low rate of prompting was indicative of no significant learning trend (and therefore no advancement in subtasks being taught) in Subjects 1, 4 and 5. It is interesting to note that in Subject 3, forward chaining demonstrated the least amount of prompting and the lowest rate of celeration for subtasks performed independently. Also Subject 3 demonstrated his highest prompting rate (17.38) with total task presentation, which also resulted in the most positive celeration rate for subtasks performed independently. The results for Subject 3 indicate that
the most effective instructional strategy may be the least efficient strategy relative to prompting required.

In all but two of the subjects (Subjects 3 and 6), no independent performance of subtasks was demonstrated on retention checks. The highest retention rate was a mean of 5.00 subtasks performed independently with reverse chaining in Subject 6. Subject 3 also demonstrated a strong retention effect with reverse chaining yielding a mean of 4.25 subtasks performed independently. Overall, Subject 3 had strong retention effects with each strategy (total task presentation also demonstrated a mean of 4.25 and forward chaining resulted in a mean of 3.75). It is logical to find the subject demonstrating the strongest learning trends also demonstrating the strongest retention trends.

Group Results and Discussion

The six subjects in this study were divided into two groups based on age. One group contained subjects between the ages of 9 to 11 years old while the other group contained subjects between the ages of 17 to 20 years old. Each subject was then randomly assigned to three pairs of instructional strategies and motor fitness
skills in a counterbalanced manner (Table 2). In reviewing the individual results obtained, it can be seen that for one subject in each age group no learning trend (celeration of subtasks performed independently) was achieved for any of the instructional strategies employed. The remaining six instructional strategy data sets for each group yielded a learning trend in only four for the older age group and two for the younger age group. Based on these data, no trends are identifiable for the age group triplets. Therefore the group discussion will center on the combined results of all six subjects.

The combined mean celeration trends for each instructional strategy are graphically depicted in Figure 20. The group mean for all forward chaining trials was a celeration rate of 1.07 for subtasks performed independently. Both reverse chaining and total task presentation demonstrated similar celeration trends. The celeration rate of subtasks performed independently was 1.20 for reverse chaining and 1.22 for total task presentation. This suggests that reverse chaining and total task presentation are similar in effectiveness and efficiency and both are superior to forward chaining.
FIGURE 20. GROUP MEAN ACCELERATION OF MOTOR FITNESS SKILL SUBTASKS PERFORMED INDEPENDENTLY ACROSS THREE INSTRUCTIONAL STRATEGIES.
A post-hoc analysis was performed on the celeration of subtasks performed independently across the three instructional strategies across the group for each motor fitness skill. The analysis for the modified supine tuck (Figure 25) reveals that reverse chaining was most effective with a celeration rate of 1.21. Total task presentation resulted in a celeration rate of 1.15, while forward chaining resulted in a celeration rate of 0.00.

The results of the post-hoc analysis for the modified squat thrust (Figure 26) demonstrate that total task presentation achieved the highest celeration rate of the instructional strategies with a 1.27. Reverse chaining demonstrated a celeration rate of 1.20 and forward chaining demonstrated a celeration rate of 0.00.

The results of the post-hoc analysis for the modified sit and reach (Figure 27) demonstrate that forward chaining was the only instructional strategy to demonstrate a learning trend. The celeration rate of subtasks performed independently was 1.16 for forward chaining and 0.00 for both reverse chaining and total task presentation.

The results of these post-hoc analyses further describe effectiveness of the three instructional
strategies. In both the modified supine tuck and modified squat thrust, reverse chaining and total task presentation each resulted in the highest and the second highest celeration rate once. These results are similar to those obtained in the group analysis (Figure 20) where reverse chaining and total task presentation were superior to forward chaining. However, results for the modified sit and reach show forward chaining to be superior to both reverse chaining and total task presentation. These results indicate that the effectiveness of the instructional strategies was divided between the three motor fitness skills. Reverse chaining and total task presentation proved more effective than forward chaining with both the modified supine tuck and modified squat thrust. Forward chaining was more effective than the other two instructional strategies with the modified sit and reach. There is no clear indication of why differential effects were demonstrated across the three motor fitness skills. This area remains fertile for future research.

The results for number of subtasks performed independently per minute are an indication of efficiency. Group results for the number of subtasks performed per
minute (Figure 21) indicate that little difference was demonstrated between instructional strategies. The highest (most efficient) group mean was 0.60 subtasks performed independently per minute for forward chaining. Reverse chaining resulted in a group mean of 0.49 subtasks performed independently per minute. The group mean for total task presentation was 0.33 subtasks performed independently per minute. The range of only 0.33 subtasks performed independently per minute suggests little difference in time efficiency between the three instructional strategies.

The amount of prompting required per trial is an indication of an instructional strategy's efficiency. Group results for mean prompting intensity per trial (Figure 22) reveal a wide gap between total task presentation and the other two instructional strategies. Forward chaining resulted in a group mean of 2.95 prompting intensity points per trial and reverse chaining resulted in a mean of 3.99. Total task presentation resulted in a group mean of 20.40 prompting intensity points per trial. These data clearly reflect the step wise progression of both forward and reverse chaining versus the whole method of total task presentation.
FIGURE 21. GROUP MEAN SUBTASKS PERFORMED INDEPENDENTLY PER MINUTE ACROSS THREE INSTRUCTIONAL STRATEGIES AND MOTOR FITNESS SKILLS.
FIGURE 22. GROUP MEAN PROMPTING SCORE PER TRIAL ACROSS THREE INSTRUCTIONAL STRATEGIES
Retention is an indication of the permanence of a subject's motor fitness skill acquisition. The subjects were tested 14 days after the training sessions ended to evaluate retention. Figure 23 graphically depicts the group mean results for retention of motor fitness skill acquisition. Reverse chaining demonstrated the highest group retention rate with a mean of 1.54 subtasks performed independently. The other two instructional strategies resulted in lower retention rates. The group retention of subtasks performed independently was 0.88 for forward chaining and 0.83 for total task presentation. This suggests that reverse chaining is superior to the other instructional strategies for rate of skill retention for these subjects.

Summary

Results from this investigation are inconclusive as to the relative effectiveness and efficiency of forward chaining, reverse chaining and total task presentation for teaching motor fitness skills to persons with severe mental retardation. The research questions for this investigation were based on the belief that the subjects would reach a criterion level of performance. Criterion
FIGURE 23. GROUP MEANS FOR SUBTASKS PERFORMED INDEPENDENTLY DURING RETENTION TESTING ACROSS THREE INSTRUCTIONAL STRATEGIES.
achievement was considered to occur when a subject demonstrated a targeted motor fitness skill with only a verbal prompt to initiate two out two trials and on two consecutive sessions. However, none of the six subjects involved in the study reached criterion on any of the targeted motor fitness skills. And even when the shift in data analysis moved from whole skill to sub-skill task completion, there were insufficient data trends on both an individual and group basis to provide clinically significant answers to any of the five research questions.

Research Question One asked if there was a significant difference between the three instructional strategies in the celeration required to reach criterion on the three targeted motor fitness skills. This was analyzed in terms of the number of subtasks performed independently per trial. Only Subject 3 demonstrated a learning trend with all three instructional strategies. Total task presentation proved the most effective with Subject 3 demonstrating a celeration rate of 1.32. Total task presentation also demonstrated the superior celeration rate (1.22) when all subjects were combined. Reverse chaining demonstrated a 1.20 celeration rate for
all subjects combined. Both of these instructional strategies were superior to the combined celeration rate for forward chaining (1.07).

Although these results are not clinically significant, they suggest that both reverse chaining and total task presentation are more effective than forward chaining. This supports the findings of Weber (1978) and Hsu and Dunn (1984) that reverse chaining is more effective than forward chaining. However this is in conflict with the results of Walls, Zane and Ellis (1981) who concluded that both forward and reverse chaining methods were superior to total task presentation.

Research Question Two asked if there was any significant difference between the instructional strategies in number of trials to criterion. This question became moot when no subject reached criterion on any of the targeted motor fitness skills and all subjects, therefore, received 72 instructional trials.

Research Question Three asked if there was any significant difference between the instructional strategies in the amount of time they took to reach criterion. This was addressed by comparing the number of
subtasks performed independently per minute for each instructional strategy. Forward chaining demonstrated the highest individual means (2.25 for Subject 3 and 1.23 for Subject 6) in this area. Forward chaining also demonstrated the highest combined rate of 0.60 in this area. However, based upon the weakness of this trend, no statement of support for any of the strategies is warranted in this area.

Research Question Four asked if there was a significant difference between the three instructional strategies in the amount of promptness required to reach criterion. This area was analyzed though the use of a promptness intensity scale (Table 4). The results indicate that regardless of the skill acquisition demonstrated, total task presentation required the most prompting. This is logical and not surprising due to the nature of this instructional strategy.

In five out of six subjects forward chaining required less prompting than reverse chaining. However, this meant little in the subjects who demonstrated no learning trend with one or both of these strategies. Yet two subjects (Subjects 3 and 6) demonstrated a learning trend in both forward and reverse chaining. In both of
these subjects forward chaining required less prompting. These results suggest that forward chaining requires less prompting than the other two instructional strategies.

Research Question Five asked if there was a significant difference between the instructional strategies in the retention of the targeted motor fitness skills. In only two subjects (Subjects 3 and 6) was any retention demonstrated. In both instances the order of retention magnitude (number of subtasks performed independently) was the same as the order of magnitude for the celeration rate of subtasks performed independently. On a combined basis reverse chaining was almost twice that of forward chaining and total task presentation. This suggests that although reverse chaining and total task presentation demonstrate similar rates of initial learning, reverse chaining is superior when it comes to retention. This concurs with Weber's (1978) suggestion that reverse chaining may have an advantage in retention.

As stated, the overall results of this investigation are inconclusive as to the relative effectiveness and efficiency of the three instructional strategies for teaching motor fitness skills to individuals with severe mental retardation. However many implications regarding
motor fitness skill acquisition with the severely retarded can be identified. The inconclusive results are partially a result of the lack of skill acquisition demonstrated by the six subjects involved. Each of these subjects had met the criteria for inclusion (page 46) in the study and demonstrated no familiarity with the motor fitness skills to be employed. However, a lack of motor fitness prerequisite skills (e.g. balance, strength, flexibility) may have limited some subjects' ability to acquire the targeted motor fitness skills. To combat this variable, a prerequisite motor skills evaluation could be calculated in future research. Also the motor fitness skills used in this study exhibited some overlap of prerequisite motor skills required. Therefore a lack of such prerequisite skills may have negatively affected some subjects' ability to acquire more than one of the targeted motor fitness skills. Future research should endeavor to utilize motor fitness skills which have different prerequisite motor skill requirements.

The task analyses employed in the investigation were deemed appropriate for individuals with severe mental retardation. This was confirmed by results of a content validity survey conducted with seven Special Physical
Education experts in the area of task analyses with the severely handicapped and also confirmed by the positive results of a social validity survey completed by 12 other appropriately targeted respondents. However, it appears caution must be used when using task analyses with the severely impaired. It became apparent throughout this study that the six subjects in the study ideally required an "individualized task analysis" as described by Jansma (1982) for the targeted motor fitness skills. In this way the individual differences of subjects could have been accommodated.

An effort was made to make each subtask of the targeted motor fitness skills as discrete as possible. However gross motor activities such as the motor fitness skills used in this study do not lend themselves to as finite an operational description as do assembly and disassembly tasks. Such assembly and disassembly tasks have been successfully used in behavior chaining research (Walls, Zane and Ellis, 1981; Weber, 1978; Yu, Martin, Suthons, Koop and Pallotta-Cornick, 1980; Zane, Walls and Thvedt, 1981).

Individual differences also played a role relative to the behavior of the subjects. For instance Subject 6,
when bored by the repeated trials, would lose attention and become noncompliant with the investigator. Subject 5 often was resistant to physical guidance. Subject 4 found being physically guided a pleasurable experience, a reinforcement in itself.

The alternation of the three instructional strategies and motor fitness skills may have proved too rapid for these subjects. During each instructional session subjects were taught each of the three motor fitness skills, each utilizing a different instructional strategy. Approximately one minute of rest was allowed between each set of six instructional trials. The consecutive teaching of three skills with three instructional strategies may have resulted in confusion (and nonlearning) among the subjects. This may have been added to by conducting instructional sessions on consecutive days (Monday through Friday). The time span of approximately two and one-half weeks in which to learn three motor fitness skills may have been too short for these subjects.

A major difficulty was also encountered with the reinforcement density for several subjects. It was decided a priori that subjects would be given identified
individualized reinforcers after each trial during which they performed all the subtasks being worked on independently. Only mild reinforcers (e.g. instructor saying "Good work reaching both hands") could be given for the accomplishment of a decrease in the level of prompting. However, with the small increments of progress demonstrated by the severely impaired subjects in the study, major reinforcement may have been warranted each time a subtask was performed with less prompting. That is, the jump to independence may have been too much to expect from these severely impaired subjects.

The system of prompting employed in this study proved to be somewhat inefficient. A system of least intrusive prompts was used. After a demonstration of the subtask(s) being taught, the subject was verbally prompted to initiate performance. If a subject failed to perform a subtask correctly or hesitated ten seconds, then the individual was prompted. The prompting was given in a least to most intrusive manner as described on page 61. However, it was the experience of the researcher that this order of presentation of prompting frequently was highly inefficient. Regardless of the
subjects' response or non-response, it took considerable
time to progress through the system of least prompts to
the necessary one which was actually required. This was
particularly wasteful with regard to time and effort with
individuals who needed physical guidance. Possibly a
more efficient strategy with the severely impaired when
prompting is required is to use the level of prompting
one step above (less intrusive) than the one previously
used on the last trial. This is a modified "most to
least" intrusive system in that physical assistance is
not necessarily always used. This may result in
occasional "over prompting" but would probably be more
time and energy efficient.

The addition of another prompting level may also be
beneficial. An additional level between verbal
instruction & modeling and verbal instruction & physical
guidance may be called for. Such a level could be
entitled "verbal instruction & physical touch." This
would add further description to the degree of actual
physical assistance provided.
CHAPTER V
SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter is divided into three sections. The first section summarizes the purpose, procedures and results of the study. The second presents the study's conclusion. The third identifies areas in which future study is recommended.

Summary

The purpose of this study was to evaluate the relative effectiveness and efficiency of forward chaining, reverse chaining and total task presentation in the acquisition of targeted motor fitness skills with individuals with severe mental retardation. Three motor fitness skills (modified sit and reach, modified supine tuck and modified squat thrust) were task analyzed into seven subtasks each.

After a screening procedure, six individuals with severe mental retardation were selected and divided into two age groups. The age groups were 9 to 11 and 17 to 20.

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The subjects were then randomly selected to receive instruction in each of the motor fitness skills, each paired with one of the instructional strategies. The mixture of instructional strategies and motor fitness tasks was counterbalanced throughout the study.

The subjects were then given four baseline trials in which the skill was demonstrated by the investigator and a verbal command was given to the subject to perform the task. Following baseline trials the subjects were instructed in each of the motor fitness skills using the designated instructional strategies. Twelve instructional sessions were performed. During each instructional session six learning trials were conducted on each motor fitness skill. The order of presentation of the skills was counterbalanced over the 12 instructional sessions. Two weeks after the instructional sessions ended four retention trials were conducted identical to the baseline trials.

The data were analyzed employing both visual analysis and descriptive statistical methods. Additionally, measurements were gathered and reported relative to content validity, social validity, reliability and procedural integrity.
Based on the data obtained, the following results are reported in connection with the primary research questions posed in this study:

1. There is no significant difference between forward chaining, reverse chaining and total task presentation in the celeration required to reach criterion on three targeted motor fitness skills.

2. There is no significant difference between forward chaining, reverse chaining and total task presentation in the number of trials required to reach criterion on three targeted motor fitness skills.

3. There is no significant difference between forward chaining, reverse chaining and total task presentation in the amount of time required to reach criterion on three targeted motor fitness skills.

4. There is no significant difference between forward chaining, reverse chaining and total task presentation in the amount of prompting required to reach criterion on three targeted motor fitness skills.
5. There is no significant difference between forward chaining, reverse chaining and total task presentation in the retention of three targeted motor fitness skills.

**Conclusion**

On the basis of the findings of this study and within the limits of the investigation (i.e. N=6), it can be concluded that there is no significant difference between forward chaining, reverse chaining and total task presentation in the acquisition and retention of motor fitness skills relative to individuals with severe mental retardation.

**Recommendations for Future Study**

1. A study similar to the present one should be conducted in which a motor fitness prerequisite evaluation is employed.

2. A study similar to the present one should be conducted using greater reinforcement density as a function of less prompting required.

3. Studies similar to the present one should be conducted using motor fitness skills with fewer
than seven subtasks and using different motor fitness skills than those employed in this study.

4. A study similar to the present one should be conducted using individuals with moderate mental retardation.

5. A study similar to the present one should be conducted using and comparing systems of "least to most" and "most to least" intrusive prompts.

6. A study similar to the present one should be conducted in which only two instructional strategies are compared.
REFERENCES


APPENDIX A

Informed Consent Form
The experimental (research) portion of the treatment or procedure is: to teach selected motor fitness skills utilizing different instructional strategies to the subjects involved.

This is done as part of an investigation entitled: A comparison of the effectiveness and efficiency of behavior chaining techniques in the acquisition of selected motor fitness skills by individuals with severe mental retardation.

1. Purpose of the procedure or treatment: The purpose of this investigation is to identify the optimum instructional method for teaching motor fitness skills to individuals with severe mental retardation.

2. Possible appropriate alternative methods of treatment: Mentally retarded individuals could be physically prompted through the entire skill repeatedly until the individual can perform it independently.

3. Discomforts and risks reasonably to be expected: Possible muscle strain could result from performing motor fitness skills.

Possible benefits for subjects/society: This study attempts to identify the optimum instructional method to be employed in teaching motor fitness skills to individuals with severe mental retardation.

4. Anticipated duration of subject's participation: The study will entail approximately 16 sessions over a maximum of 5 weeks.

I hereby acknowledge that: James V. Docker has provided information about the procedure described above, about my rights as a subject, and has answered all questions to my satisfaction. I understand that I may contact him/her should I have additional questions. He/she has explained the risks described above and I understand these. He/she has also offered to explain all possible risks or complications.

I understand that, where appropriate, the U.S. Food and Drug Administration may inspect records pertaining to this study. I understand further that records obtained during my participation in this study may be made available to the sponsor of this study and that the records will not contain my name or other personal identifiers. Beyond this, I understand that my participation will remain confidential.

I understand that I am free to withdraw my consent and participation in this project at any time after notifying the project director without prejudice future care. No guarantee has been given to me concerning this treatment at procedure.

In the unlikely event of injury resulting from participation in this study, I understand that immediate medical treatment is available at University Hospital of The Ohio State University. I also understand that the costs of such treatment will be at my expense and that financial compensation is not available. Questions about this should be directed to the Human Subject Review Office at 432-5056.

I have read and fully understand the consent form. I sign it freely and voluntarily. A copy has been given to me.

Date: ____________________ Time: ____________________ AM
Witnessed: ____________________ Signed: ____________________
Projected (Subject) ____________________ (Person Authorized to Certify for Subject if Minors)

I certify that I have personally completed all blanks in this form and explained them to the subject or his/her representative before requesting the subject or his/her representative to sign it.

Signed: ____________________ (Signature of Project Director or Authorised Representative)
APPENDIX B

Motor Fitness Skills Task Analysis
MODIFIED SIT AND REACH

Terminal Objective
The subject will sit with legs fully extended, feet slightly apart, arms back supporting trunk. The subject will place feet against the sit and reach apparatus. The subject will extend arms forward, placing hands on top of the sit and reach apparatus, fingers extended, palms down. The subject will reach directly forward, pushing the block as far as possible in a smooth motion (maintaining extended legs) and hold for one second.

TASK ANALYSIS

<table>
<thead>
<tr>
<th>Subtask</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The subject will assume an upright sitting position on the mat with legs fully extended, shoulders rotated back, hands on the mat, arms supporting trunk.</td>
</tr>
<tr>
<td>2</td>
<td>The subject will place feet against the sit and reach apparatus.</td>
</tr>
<tr>
<td>3</td>
<td>The subject will rotate shoulders forward, bringing arms to sides (not supporting trunk).</td>
</tr>
<tr>
<td>4</td>
<td>The subject will place hands on knees.</td>
</tr>
<tr>
<td>5</td>
<td>The subject will extend one arm forward placing hand (palm down) on the sit and reach apparatus.</td>
</tr>
<tr>
<td>6</td>
<td>The subject will extend other arm forward placing hand (palm down) on the sit and reach apparatus.</td>
</tr>
<tr>
<td>7</td>
<td>The subject will reach directly forward, pushing the block as far as possible in a smooth motion (maintaining extended legs) and hold for one second.</td>
</tr>
</tbody>
</table>
MODIFIED SQUAT THRUST

Terminal Objective
The subject will start in a standing position. The subject will assume a squat position with hands on knees. The subject will extend both arms forward placing hands flat on the mat. In a sequence, the subject will: fully extend one leg back, fully extend other leg back; then bring one leg forward and then other leg forward (returning to squat position). (A piked hip position may be maintained when legs are extended.) The subject will then stand erect with hands at sides.

TASK ANALYSIS

<table>
<thead>
<tr>
<th>Subtask</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>From a standing position the subject will squat with hands on knees, feet shoulder width apart, rising on balls of feet.</td>
</tr>
<tr>
<td>2</td>
<td>The subject will extend both arms forward placing hands on the mat, shoulder width apart, remaining on balls of feet.</td>
</tr>
<tr>
<td>3</td>
<td>The subject will fully extend one leg back, planting toes on the mat, maintaining arm position.</td>
</tr>
<tr>
<td>4</td>
<td>The subject will fully extend other leg back, planting toes on the mat, maintaining arm position. (A piked hip position may be maintained.)</td>
</tr>
<tr>
<td>5</td>
<td>The subject will return one leg (either leg) to squat position.</td>
</tr>
<tr>
<td>6</td>
<td>The subject will return other leg to squat position.</td>
</tr>
<tr>
<td>7</td>
<td>The subject will stand erect with arms at sides, feet shoulder width apart.</td>
</tr>
</tbody>
</table>
MODIFIED SUPINE TUCK

Terminal Objective
The subject will assume a back lying position with legs straight, arms at sides, head resting on the mat and then draw legs up until feet are flat on the mat and the knee joint is at approximately a 45° angle. The subject then wraps both hands around the knees and draws knees to chest and flexes the neck, bringing the head as close as possible to the knees. The subject then releases the knees, relaxes the neck and returns to a straight leg position with arms at sides and head resting on the mat.

TASK ANALYSIS

<table>
<thead>
<tr>
<th>Subtask</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The subject will assume a back lying position with legs straight, arms at sides and head resting on the mat.</td>
</tr>
<tr>
<td>2</td>
<td>The subject will draw both legs up until both feet are flat on the mat and the knee joint is at approximately a 45° angle.</td>
</tr>
<tr>
<td>3</td>
<td>The subject will wrap both hands around the knees (raising feet off the floor).</td>
</tr>
<tr>
<td>4</td>
<td>The subject will draw knees towards the chest, pulling with the arms.</td>
</tr>
<tr>
<td>5</td>
<td>The subject will flex the neck, bringing the head as close as possible to the knees.</td>
</tr>
<tr>
<td>6</td>
<td>The subject will relax the neck and release legs so feet are flat on the mat and the knee joint is at approximately a 45° angle.</td>
</tr>
<tr>
<td>7</td>
<td>The subject will slide legs back to straight position and place arms at sides with head resting on the mat.</td>
</tr>
</tbody>
</table>
APPENDIX C

Sit and Reach Apparatus
SIT AND REACH BOX CONSTRUCTION PROCEDURES

1. Using any sturdy wood or comparable construction material (3/4 inch plywood seems to work well) cut the following pieces:

   2 pieces 12" x 12"
   2 pieces 12" x 10-1/2"
   1 piece 12" x 23"
   2 pieces 1/4" molding x 23"
   1 piece 3-1/4" x 1/2" board x 6"
   1 piece 3-1/2" x 3-1/2" board x 10-1/2"

2. Assemble the plywood pieces using nails or screws and wood glue. For convenience a handle can be made by cutting a 1 x 3 inch hole in the rear panel.

3. Inscribe the top panel with one centimeter gradations. It is crucial that the 23 centimeter line be exactly in line with the vertical panel against which the subject's feet will be placed. The gradations should be marked from -5 centimeters to 50 centimeters.

4. Place molding on top of scale, 6 inches apart (enough room so the wood block can slide through). Inscribe one centimeter gradations on top of the block.

5. Place 3-1/2" x 3-1/2" board 10-1/2 inches long inside the box in the bottom rear section to counterweight the box and keep it from tipping forward.

6. Using paint or an indelible ink, outline and fill in two footprints on the front portion of the box to be an additional visual cue.

7. Cover the box with two coats of polyurethane sealer or shellac.
FIGURE 24. GRAPHIC REPRESENTATION OF SIT AND REACH APPARATUS.
APPENDIX D

Subject Data Sheet
### SUBJECT DATA SHEET

<table>
<thead>
<tr>
<th>NAME</th>
<th>DATE</th>
<th>PHASE</th>
<th>INSTRUCTIONAL STRATEGY</th>
<th>SKILL</th>
<th>ORDER</th>
<th>ELAPSED TIME</th>
<th>SUBTASKS</th>
<th>REINFORCEMENT</th>
</tr>
</thead>
</table>

**INSTRUCTIONAL STRATEGY**: 

**SKILL**: 

**ORDER**: 

<table>
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<tr>
<th>TRAILS</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
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</tbody>
</table>

**KEY**

- = INCORRECT  
+ = CORRECT  

**PERFORMANCE LEVEL**

1 = INDEPENDENT  
V = VERBAL PROMPT  
VC = VERBAL PROMPT AND VISUAL CUE  
VM = VERBAL PROMPT AND MODELING  
VF = VERBAL PROMPT AND PHYSICAL GUIDANCE
APPENDIX E

Social Validation Survey
SOCIAL VALIDATION SURVEY

It is necessary for applied research involving the severely disabled to demonstrate practical and important areas of investigation. The social validity of research procedures involves the perceived value of the target behaviors selected for change, the acceptability of the intervention procedures employed to change the behavior and the significance of the behavior change that results. Through the surveying of professionals in special education and interested nonprofessional individuals (parents, siblings, peers) an evaluation of the social validity of research endeavors can be obtained.

The following survey attempts to evaluate the social validity of the present investigation. Based on your knowledge and understanding of the study (A comparison of the effectiveness and efficiency of behavior chaining techniques in the acquisition of selected motor fitness skills with severely mentally retarded individuals) please respond to the following statements.

After reading each statement please circle the one term which most closely describes how you feel about that statement. The choices you may select are the following: strongly agree, agree, mildly agree, undecided, mildly disagree, disagree, strongly disagree. Also there is a space provided to write any comment you may have concerning each statement.

1. The acquisition of motor fitness skills is important for severely mentally retarded individuals.

STRONGLY MILDLY MILDLY STRONGLY
AGREE AGREE AGREE UNDECIDED DISAGREE DISAGREE DISAGREE

COMMENTS:

2. The task analysis of the motor fitness skills are appropriate for severely mentally retarded individuals.

STRONGLY MILDLY MILDLY STRONGLY
AGREE AGREE AGREE UNDECIDED DISAGREE DISAGREE DISAGREE

COMMENTS:
3. It is not important to identify which chaining strategy is the most effective and efficient in teaching motor fitness skills to severely mentally retarded individuals.

<table>
<thead>
<tr>
<th>STRONGLY</th>
<th>MILDLY</th>
<th>MILDLY</th>
<th>STRONGLY</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGREE</td>
<td>AGREE</td>
<td>AGREE</td>
<td>UNDECIDED</td>
</tr>
<tr>
<td>DISAGREE</td>
<td>DISAGREE</td>
<td>DISAGREE</td>
<td>DISAGREE</td>
</tr>
</tbody>
</table>

COMMENTS:

4. Abdominal strength is an important attribute for severely mentally retarded individuals to develop.

<table>
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<tr>
<th>STRONGLY</th>
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<th>MILDLY</th>
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</thead>
<tbody>
<tr>
<td>AGREE</td>
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COMMENTS:

5. Body strength/endurance is an important attribute for severely mentally retarded individuals to develop.

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COMMENTS:

6. Flexibility is an important attribute for severely mentally retarded individuals to develop.

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COMMENTS:
7. The instructional procedures employed in this study are reasonable for use with severely mentally retarded persons.

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COMMENTS:

8. Improvement in motor fitness skills would positively affect the quality of life of severely mentally retarded persons.

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COMMENTS:

9. Results of this investigation will be useful to instructors of severely mentally retarded individuals.

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COMMENTS:

10. The time spent by the subjects in this investigation is not justified by the potential results of the study.

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COMMENTS:
APPENDIX F

Content Validity Survey
CONTENT VALIDITY SURVEY

The following survey attempts to evaluate the content validity of the attached motor fitness skills task analyses. These task analyses were designed for use in instructing individuals with severe mental retardation. They are intended for use in a study comparing the effectiveness and efficiency of behavior chaining techniques in the acquisition of motor fitness skills with individuals with severe mental retardation.

After reading each statement, PLEASE CIRCLE the one term which most closely describes how you feel about that statement. The choices you may select are the following: strongly agree, agree, mildly agree, mildly disagree, disagree and strongly disagree. Also there is a space provided to write any comments you may have concerning each statement.

1. The task analysis of the modified sit and reach is appropriate for instruction of individuals with severe mental retardation.

   STRONGLY AGREE MILDLY AGREE MILDLY DISAGREE STRONGLY DISAGREE

   COMMENTS:

2. The task analysis of the modified squat thrust is appropriate for instruction of individuals with severe mental retardation.

   STRONGLY AGREE MILDLY AGREE MILDLY DISAGREE STRONGLY DISAGREE

   COMMENTS:

3. The task analysis of the modified supine tuck is appropriate for instruction of individuals with severe mental retardation.

   STRONGLY AGREE MILDLY AGREE MILDLY DISAGREE STRONGLY DISAGREE

   COMMENTS:

   Thank you for your assistance in this research investigation.
APPENDIX G

Post-Hoc Analysis Graphs
FIGURE 26. Celeration of motor fitness skill subtasks performed independently across three instructional strategies and all subjects for the modified squat thrust.
FIGURE 27.CELERATION OF MOTOR FITNESS SKILL SUBTASKS PERFORMED INDEPENDENTLY ACROSS THREE INSTRUCTIONAL STRATEGIES AND ALL SUBJECTS FOR THE MODIFIED SIT AND REACH.