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The purpose of this study was to compare the reverse-chaining and forward-chaining instructional methods in teaching a motor task to mentally retarded individuals. The subjects were selected from Fairview Training Center, Salem, Oregon. Each of the subjects was classified as mentally retarded with a range from moderate to severe retardation. The subjects' ages ranged from 12 to 21 with a mean age of 15.7 years. The subjects included 6 females and 24 males.

The motor task used in this study was a modified bowling skill using a four-step approach. The bowling skill was analyzed into four subtasks--A, B, C and D.

Thirty mentally retarded individuals were randomly assigned to either the reverse-chaining or the forward-chaining group. The 15 subjects in the reverse-chaining group were taught the last subtask (subtask D) first and then each subsequent subtask was added one by one

(that is, subtasks C and D; then subtasks B, C and D) until the entire skill sequence (subtasks A, B, C and D) was taught. For the 15 subjects in the forward-chaining group, the teaching procedure was opposite of that with the reverse-chaining group. They were taught the first subtask (subtask A) first, and then each following subtask was added one by one (that is subtasks A and B; then subtasks A, B and C) until the entire skill sequence (subtasks A, B, C and D) was taught.

This study found that the subjects in the reverse-chaining group required significantly fewer trials and physical assists to learn the given motor task than the subjects in the forward-chaining group. There was no significant difference in retention between the two groups.

The results of this study supported the relative advantages of using the reverse-chaining method as opposed to the forward-chaining method when teaching mentally retarded individuals a motor task. The reverse-chaining instructional method should be recommended as an appropriate teaching method for mentally retarded individuals.

A Comparison of Reverse- and Forward-Chaining Instructional Methods on a Motor Task with Mentally Retarded Individuals

by

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CHAPTER I

INTRODUCTION TO THE STUDY

The progression and sequence in which a particular task is learned are important factors in the instructional process. This is also true with respect to handicapped individuals. In the past, considerable attention has been devoted to the study of techniques by which materials may be organized for presentation to the learner. Some of this attention has focused on the topic of forward chaining and reverse chaining as applied to the fields of psychology and education.

The term "forward chaining" has been used in reference to situations in which the tasks are taught in their order of occurrence. If a sequence consisting of responses ABCD is to be learned, the student first learns A, then AB, then ABC and finally ABCD (Wilcox, 1974). In reverse-chaining method, the tasks are taught in a backward sequence. If a sequence consisting of responses ABCD is to be learned, the student first learns D, then CD, then BCD and finally ABCD (Wilcox, 1974).

The method of chaining has become a common procedure for training animals to perform motor tasks (Skinner,

1938; Keehn, 1959; Napalkov, 1962; Pierrel and Sherman, 1962; Millenson, 1967; Ferster and Perrott, 1968) and has been recommended for application with human beings (Gilbert, 1962; Mechner, 1967; Parker and Cook, 1972).

Several studies have used reverse-chaining techniques in the teaching of academic tasks (Cote, Bevy and O'Conner, 1962; Sloane, Johnson and Harris, 1968; Balson, 1971) and motor tasks (Risley and Wolf, 1966; Swack and Kokaska, 1970; Parker and Cook, 1972; Baldwin et al., 1976; Popvich, 1981; Stoddard and Gerova, 1981).

Some studies which compared the reverse-chaining method to the forward-chaining method using human subjects reported no difference between these methods (Slack, 1964; Hartely and Woods, 1968; Cox and Boren, 1965; Scott, 1968; Nathan, 1970; Wilcox, 1974; Walls, Zane and Ellis, 1981). However, other studies have detected a difference. The reverse-chaining method was found to be inferior by Johnson and Senter (1965) and Balson (1971). Weber (1978), on the other hand, found the reverse-chaining method to be more effective than the forward-chaining method.

Although reverse chaining has been reported to be an effective method in training animals, the results of studies with humans do not support the superiority of reverse-chaining when compared with the forward-chaining method. However, the evidence which has been reported to date is far from conclusive. As Gagné (1965)

pointed out:

> It is evident that both these methods work. Whether one is more effective than the other, in some or all circumstances, is a question awaiting further evidence (p. 93).

Since no studies have analyzed reverse- and forward-chaining procedures in physical education or motor skill tasks with mentally retarded individuals, there is a need to identify which method is more effective with this population.

Purpose of the Study

The major purpose of this study was to compare the reverse-chaining and forward-chaining instructional methods in teaching a motor task to the mentally retarded. Specifically, the study was designed to determine whether significant differences exist between a group of subjects taught using a reverse-chaining instructional approach and a group taught with a forward-chaining instructional approach, and to determine if differences persist after an interval of three weeks.

Hypotheses

The results of the study were analyzed to determine if the following null hypotheses should be retained or rejected:

1. There is no difference between the reverse-chaining group and the forward-chaining group in the total

number of trials required to reach the criterion on a specific motor task.

2. There is no difference between the reverse-chaining group and the forward-chaining group in the total number of physical assists required to reach the criterion on a specific motor task.
3. There is no difference between the reverse-chaining group and the forward-chaining group in the retention of a specific motor task after three weeks.

Delimitation of the Study

The population of this study was limited to thirty mentally retarded individuals from Fairview Training Center in Salem, Oregon. The functioning levels of the population were from moderately to severely retarded with an age range from 12 to 21 years. A modified bowling skill using a four-step approach was selected as the motor task for purposes of analyzing the learning process.

Limitation of the Study

The study was subject to the following limitations:

1. The subjects of this study varied with respect to the amount of their past participation in physical activity experiences.
2. The information obtained from the Fairview Training Center about the subjects and the data included

on the information forms were assumed to be correct.

3. External factors such as the motivation of the subjects and the shoes worn by the subjects were not controlled.
4. The findings of this study were not applied beyond the group of subjects studied.

Definition of Terms

The following meanings were applied to the terms used in this study.

Chaining. For Gagné (1965) chaining is the sequencing of a set of individual stimuli and responses (S-R). Chain-like skills would include buttoning, using scissors, throwing and catching balls, and countless other examples. In order for the complete act to be successful, each individual link (S-R) in the chain must be mastered. An example of chained behavior would be unlocking a door with a key. Each S-R or link, when completed, serves as the cue or stimulus for the next one until the act is terminated.

Reverse Chaining. The reverse-chaining technique was devised by Gilbert (1962). Reverse chaining is also called Mathetics. The procedure used with this technique is that serial tasks are arranged in sequence and taught in reverse. That is, the last link in the task is taught first and then each preceding link is added on to the

chain one by one until finally the first link in the task is learned.

Forward Chaining. Forward chaining is the opposite of reverse chaining. The procedure used with this method is to teach the first link in the task first and then to add each following link to the chain one by one until finally the last link in the task is learned.

Handicapped. Public Law 94-142 defines handicapped individuals as:

> Those children evaluated as being mentally retarded, hard of hearing, deaf, speech impaired, visually handicapped, seriously emotionally disturbed, orthopedically impaired, deaf-blind, multi-handicapped, or as having specific learning disabilities, who, because of those impairments, need special education and related service (p. 2).

Learning. Cratty (1975) defined learning 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).

In this study, when subjects respond correctly for three consecutive trials, the subjects met the criterion level of acceptable performance for the specified step.

Mental Retardation. The term as defined by the American Association on Mental Deficiency, refers to:

> significantly subaverage general intellectual functioning existing concurrently with deficits in adaptive behavior and manifested during the development period (Grossman, 1973, p. 11).

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:

Classification	Intelligence Quotients
Mild	68-52
Moderate	51-36
Severe	35-20
Profound	19 and below

Motor Task. Motor tasks are often categorized as fine and gross motor skills. A gross motor skill is one that uses the large muscles and often involves the whole body. Examples are running, cycling, and swimming. A fine motor skill is one that is precision oriented. Examples are rifle shooting, typing, and piano playing.

Physical Assist. Physical assist as used in this study meant that the investigator assisted the subject through the correct movement so that the subject could obtain the feel of the correct procedure and experience some success.

Prompt. The investigator used verbal or physical contact to point and remind the subject, when necessary, of the correct movement sequence.

Stimulus-Response (S-R). According to Oxendine (1968), the term is to indicate that:

> A particular stimulus is connected or leads to a particular response. Stimuli which impinge upon the sense organs are found throughout our environment. Some of these stimuli cause automatic responses such as the reaction of the pupils to varying intensities of light. This behavior is unlearned. Other stimuli are connected to responses through learning . . . as when a baseball batter notices that a thrown ball curves and makes the necessary adjustment in his swing (p. 25).

Whole Method. This term has been used in reference to situations in which the total block of material is learned at once. For example, if one were to learn the tennis serve, one would be introduced to the total act of serving by demonstration, explanation, film, or some other method. The total act of serving would then be practiced (Oxendine, 1968).

CHAPTER II

REVIEW OF RELATED LITERATURE

The present study was concerned with determining which approach, forward-chaining or reverse-chaining, was more efficient in teaching a specific motor task to mentally retarded individuals and which of these two approaches lead to the greater retention of the specific motor task.

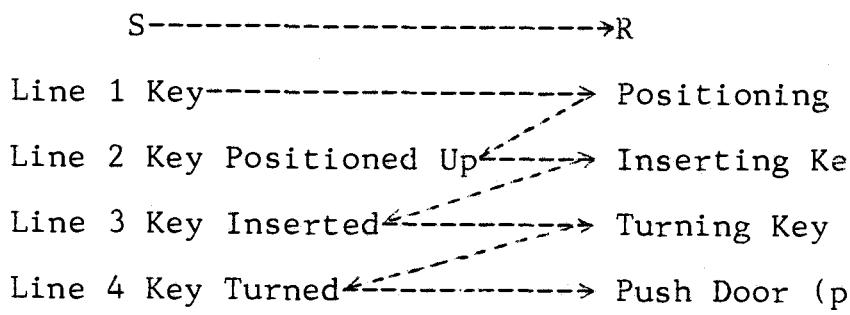
Presented in this chapter is a comprehensive review of the research on reverse-chaining and forward-chaining instructional techniques. The chapter is divided into four major areas. Included are sections on chaining, reverse-chaining and forward-chaining; studies of chaining and its application to academic skills; studies of chaining and its application to motor skills; and studies of chaining and its use in the teaching of motor skills to the handicapped.

Chaining

Chaining is defined by Gagné (1977) as the connection of a set of individual stimulus-response acts in sequence. Mechner (1967) explains that "chaining is a sequence of responses where each response creates the stimulus for the next response" (p. 86).

Complex behavior can be viewed as a series of responses chained together by stimulus. Gagné (1977)

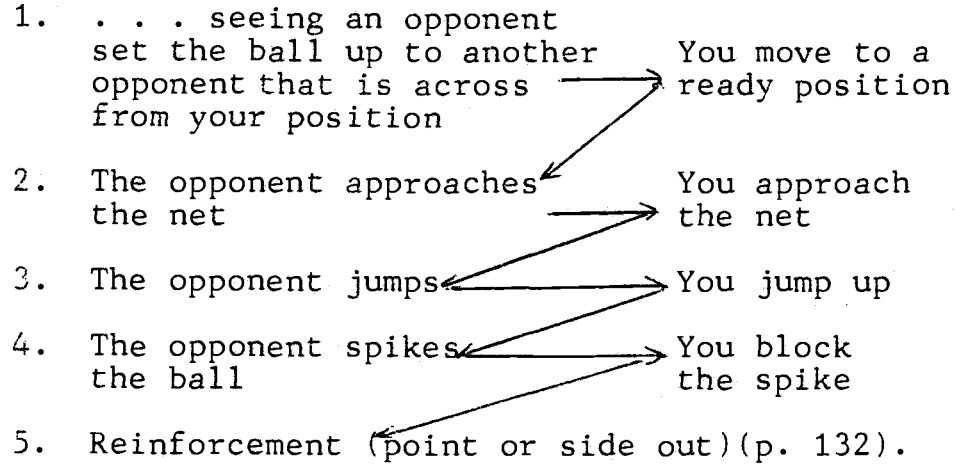
uses "opening a door" as an example of chaining:



Singer (1980), in discussing the general learning theories, points out that Gagné's motor chaining model represents a number of people who view behavior as a series of discrete and related acts. This viewpoint offers an alternative mode of looking at behavior.

The chaining phenomenon is executed in a number of tasks such as tying a shoelace, writing a word, reciting a poem and going through the steps of solving a problem in mathematics (Mechner, 1967).

The field of physical education also provides many examples of chaining. Kelleher (1966) indicates that "even relatively simple motor skills, such as throwing a ball, comprise compelx response sequences" (p. 160). Rushall and Siedentop (1972) use a front-line volleyball player who anticipates the movement of an opponent and moves to the net to jump and block a potential spike to explain the chaining process inherent in many sport skills. This example is explained as follows:



In the educational setting, it is apparent that numerous motor skills must be mastered by the learner. Gagné (1977) observes that throwing, catching, kicking and many other fundamental athletic skills are required as chains in the early years of the individual's life. In the later years of one's educational training, complex and lengthy chains also must be learned.

Gagné (1977) specifies that the following conditions are important in using a chain learning process. The first condition for the establishment of a chain is getting the learner to perform the links one after the other in the proper order. Two different methods to this sequencing are possible: (1) one can begin with the terminal act and work backward (reverse chaining), or (2) one can begin from the start of the chain and work forward (forward chaining). The second condition is that the links in the chain must be executed in close succession so that the stimulus elements in the response can be associated with the next link. The third

condition is that repetition should occur to extinguish residual incorrect connections and prevent forgetting. The fourth condition is that the terminal link (last step) must provide reinforcement.

Reverse Chaining

Reverse chaining or backward chaining is the learning process which requires that serial tasks be arranged in sequence and taught in reverse. Gerry (1963) describes reverse chaining as a sequence of behavior which begins with task accomplishment and, through successive additions of previous behavior segments, ultimately develops the complete chain of behavior prescribed by the instructor.

Gilbert (1962) used a technology called Mathetics in training animals. Gilbert suggested that when a sequence was to be taught, the task should be broken down into chains and taught in reverse chronological order. Gilbert also proposed the extension of reverse chaining from animal work to human learning situations.

Mechner (1967) uses the tying of a shoelace as an example of reverse chaining:

> When teaching a child a manual skill, such as tying his shoelace, start by presenting him with the bow almost completely tied, but not yet tightened, and allow him to tighten it. When he is able to do that, present him with it somewhat more loosely tied, and again let him make it tight. Continue this process, allowing him to complete a longer and longer segment of the chain, until he is able to

> start out with the completely untied laces, and tie them (p. 89).

Using a reverse-chaining approach in teaching handicapped student to walk a balance beam, Dunn and others (1980) describe:

> In a reverse chain sequence, the student is helped with the beginning of the behavior; in this case she is helped to step up on the balance beam, helped to take the ten steps, and then she would be asked to independently step off the balance beam. When she demonstrated that she can can do this task, the student would be asked after being assisted through getting on the balance beam and taking the first nine steps, to independently take the last step and step off the balance beam. After demonstrating this behavior, she would be asked to take the last two steps, and so on, until she was performing the entire task independently (p. 7).

The procedure of reverse chaining may be illustrated for a four-stage chain A-B-C-D as follows (Wilcox, 1974):

> First do D
> Then do C and follow with D
> Then do B and follow with C and D
> Finally do A and complete B, C, and D (p. 175).

Forward Chaining

Forward chaining is the opposite of reverse chaining. The procedure used with this method is to learn the first link in the task first and then to add each following link to the chain one by one until finally the last link in the task is learned.

Traditionally, humans learn the vast majority of sequential tasks from the beginning to the end. For example, in verbal learning, people learn poems and

musical compositions from the beginning to the end. Telephone numbers, zip codes, Social Security numbers, and addresses are usually memorized in the same manner. In motor learning, students learn to play the tune on the piano, to add the second tune to the first and so on. When learning the pivot turn and jump shot in basketball, students learn the pivot turn first and then the pivot turn and jump shot together.

McGuigan and others (1955) used a repetitive part method (which is similar to the forward-chaining method) in military training. The training procedure for the motor skill of firing an Army rifle was divided into eight steps. The instruction started with the first subtask of the firing act. Then the second was combined simultaneously with the first. Then the first, second and third subtasks were performed together, and so on, until all the subtasks were put together into the act of firing.

Using a forward-chaining method in teaching a student to walk a balance beam, Dunn and others (1980) pointed out that a forward-chaining method would require the student to step on the near end of the balance beam and take a prescribed number of steps, then be helped to finally step off the balance beam at the other end.

The procedure of forward-chaining requires that the first subtask in the task be learned and that each following subtask be added to the chain one by one until

the last subtask in the task is learned.

If a task consisting of four subtasks, A-B-C-D, is to be learned, the forward-chaining method can be illustrated as follows (Wilcox, 1974):

> First do A
> Then do A together with B
> Then do A together with B and C
> Finally do A and complete B, C, and D (p. 176).

Studies of Chaining and Its Application to Academic Skills

The reverse-chaining instructional method has been applied to the teaching of French by Cote, Bevy and O'Conner (1962). These authors discuss the reason for using this approach by explaining that:

> the learner is gaining in both accuracy and confidence, since he is always moving onward toward a more-practiced section at the end of each performance, where he knows he can do it correctly; so his confidence increases rather than fades as he practices (p. 536).

Johnson and Senter (1965) tested forward- and reverse-chaining procedures with list memorization tasks. They used three experiments. The first experiment involved each subject reading and learning two different lists of common three-letter nouns. The second experiment involved lists of numbers and of consonants presented by audio means. The third experiment employed an anticipation-confirmation type of serial presentation with consonants, using different groups for the two different procedures.

In the first experiment, the results showed no significant difference between the two techniques. However, in the second experiment, the forward-chaining method was found to be significantly faster. In the third experiment, the forward-chaining method yielded significantly fewer errors.

Scott (1968) investigated the effectiveness of two self-instructional programs, mathetic and progressive chaining. The two programs were similar to reverse-chaining and forward-chaining methods. In the study using the mathetic approach for teaching square root derivation, the last-performed subtask was taught first, the next to the last subtask was taught second and the first-performed subtask was taught last. In the progressively chained program, the first-performed subtask was taught first, the second was taught second and the last was taught last. Sixty-eight high school and university students were selected and randomly assigned to either the mathetically sequenced program or the progressively chained program.

The expectation of higher success for subjects in the mathetically sequenced program was not supported by the data. Subjects viewed the progressively chained program as more exciting and better organized than the mathetically sequenced program.

Nathan (1970) compared reverse chaining to the forward-chaining method in memorizing poetry and prose

passages. The subjects were 97 college students. The subjects were randomly assigned to eight groups. The poem used was a modification of "The Eagle" by Alfred, Lord Tennyson. The prose passage used was adapted from a paragraph about sparrows in an Audubon Nature Encyclopedia. It was hypothesized that the reverse-chaining group would reach perfect recall of the material in faster time than traditional forward-chaining group. This hypothesis, however, was not confirmed. A three-way analysis of variance showed a significant difference in favor of forward chaining with no significant interactions. Nathan concluded that reverse chaining was more effective with non-verbal organisms but was less effective than traditional forward chaining with verbal organisms.

Two additional points were discussed in his study: one, that the subjects in the reverse-chaining groups may have had prior experience at memorizing in a forward-chaining method, therefore biasing the final results; and two, that the reverse-chaining method should be researched with many forms of human learning.

Nathan also points out that the reverse-chaining method might be more effective with humans at pre-cognitive levels. He suggests:

> Perhaps toileting, dressing, or eating behavior chains could be broken down into their respective behavior links and taught youngsters and mental retardates in a backward chaining manner with greater ease and effectiveness (p. 27).

Wilcox (1974) investigated the effect of chain length (short, medium and long) and teaching strategy (backward chaining, forward chaining and whole method) on the acquisition and retention of the number chain and motor chain. The number chain consisted of numerical procedure (basic arithmetic operations), and the motor chain consisted of paper-folding. One hundred seventy-six female students were assigned to nine different groups. The total time, the total number of prompts and the total trials practiced to reach the criterion were recorded. The results indicated that no advantage was found for reverse chaining in the case of the motor chains and the short and medium number chains. For the long number chain, there was some indication that reverse chaining was superior to forward chaining. In general, both methods were inferior to the whole method.

In discussing the failure to find an advantage in favor of the reverse-chaining over the forward-chaining method, Wilcox agrees with Cox and Boren (1965) who suggest that the human learner's ability to hold a long-term goal in mind acts as a reinforcer for each stage of a task which the learner perceives as leading to that goal. Wilcox suggests that at the present time, teachers should regard chaining techniques at least as a potentially useful component of their teaching strategies.

Studies of Chaining and Its Application to Motor Skills

Cox and Boren (1965) conducted a study in which subjects were required to learn a 72-step missile-launching procedure. Thirty subjects were drawn at random from the Army Training Center. Three different training techniques were used, ten men being trained with each technique. The first method used backward chaining, the second method used forward chaining and the third used a whole method.

Each subject was required to learn the procedure to one perfect performance. The length of training time was collected as the score for each subject. Comparisons were made between the mean training times for the three techniques. The results demonstrated no difference among the three techniques.

Nannay (1970) compared forward-chaining to reverse-chaining method in teaching a psychomotor task in an industrial education setting. Sixty-six university students were randomly selected and randomly assigned to the two treatment groups--reverse chaining and forward chaining--and to a control group. The psychomotor task in this study was to place a dado head (two dado blades, two chippers, an arbor collar, and an arbor nut) on a radial arm saw.

Two measuring devices were used in this study. A manipulative test was developed to ascertain the

achievement resulting from the specified behavior. An objective test determined the amount of cognitive growth experienced by a subject while viewing the slide-tape sequence and executing the manipulative criterion test.

The findings of this study were that reverse-chaining and forward-chaining groups were significantly superior to the control group. No significance existed between reverse-chaining and forward-chaining groups. In the two-week retention test, the results were similar to those obtained before. However, this study found that both forward-chaining and reverse-chaining methods were effective in the teaching of a manipulative task and related cognitive information to students in an industrial setting.

Nannay suggests that further research is needed to determine the effectiveness of the chaining concept in the teaching of additional psychomotor tasks under different laboratory settings.

Studies of Chaining, Motor Skills with Handicapped People

Reverse chaining appears to be a prevalent training method for handicapped people. Swack and Kosasks (1970) report that the reverse-chaining method is a valuable type of programmed instruction in aiding physically handicapped children in mobility training. Fredericks

and others (1980) indicate three major advantages of using reverse chaining in teaching handicapped students:

> Since the student is continually reinforced at the same point in the sequence, namely, at the completion of the task, the teacher does not have the problem of fading out the reinforcer at a premature point in the sequence. . . .The second advantage of the reverse chain procedure is that each successive step inherently maintains all previous behaviors learned. The third advantage to the reverse chain procedure is that, since the student is physically assisted through those parts of the task he is not expected to perform yet, he is exposed to the way in which those behaviors are to be performed and the order in which they occur (p. 12).

Parker and Cook (1972) observe that the reverse-chaining method is more effective in teaching motor skills. They explain:

> Logic dictates that first things should be taught first, and last things last in a learning sequence. However, for motor chaining the reverse is more often true. Last things should be learned first (p. 13).

Parker and Cook use the catching of a ball as an example of the value of the reverse-chaining method in teaching a handicapped child.

> Using the ball catching example, hand closure around the ball should be shaped first by the teacher thrusting the ball into the child's hands to simulate the last stage of its flight through the air. This phase should be followed by teaching the child to position his hands in readiness to receive the ball (p. 13).

They also suggest that the technique is applicable to academic behavior as well as motor behavior, and to children of average and above ability as well as to slow learners.

Baldwin, Fredericks and Brodsky (1976) found that gross and fine motor skills with handicapped children are learned better by the reverse-chaining method:

> We have found that most activities that require motor skills--such as tying a shoe lace, putting on or taking off clothes, riding a bicycle, writing a letter--are better learned by chaining the parts backward--or learning the last step first (p. 27).

Weber (1978) compared reverse chaining and forward chaining in teaching a motor task to 24 educable mentally retarded adults. The motor task consisted of the five steps required to assemble six plastic pieces from a Remco Science Kit. The experimental results revealed some valuable information that contained implications for therapists and others involved in teaching mentally retarded individuals. The subjects receiving reverse-chaining instruction required less learning time on the motor task than the subjects receiving forward-chaining instruction.

Weber's study also tested for retention. Subjects were tested for retention approximately 20 hours following the initial instruction. No significant differences were found, although the mean score indicated some advantages for reverse chaining in terms of retention levels. Weber suggests that many daily activities could be taught by using a reverse-chaining method.

Nettlebeck and Kinby (1976), using 30 mildly mentally retarded females age 17-33 who were employed at

a vocational rehabilitation center, investigated the effect of three different methods in training subjects to thread an industrial sewing machine. The steps were combined to produce four separate component operations--A, B, C and D. The group trained by the pure-part method learned each operation before combining all four operations in a complete practice of the task. The group trained by the progressive-part method practiced A and B separately and then combined A and B. These subjects then learned C, then A+B+C, then D and finally A+B+C+D. The group trained by the whole method practiced the complete task from the outset. The results showed that the part method was markedly superior to the whole method; fewer errors were made during trials to the criterion, and less time was required. Although the progressive-part method produced satisfactory training with the least errors and in the fastest time, differences between progressive-part and pure-part procedures were not statistically significant.

Walls and others (1981) conducted a study to examine the effects of training by whole task, forward-chaining and reverse-chaining methods in teaching vocational rehabilitation clients the construction of three assembly tasks. Twenty-two subjects learned to assemble a bicycle brake, a meat grinder and a carburetor on three successive days by the three training methods. The subjects were considered mildly to moderately retarded. The

ages ranged from 18 to 46 years.

With each assembly, two baseline trials were given before training. After all baseline trials were completed, a help trial was given. Following each help trial, a test trial was given. If there were errors on the first trial, a help trial always followed. If the subjects committed no errors on two consecutive trials, training was completed. During training, the total number of responses, the total number of errors and the total amount of training time was collected.

The data indicated that both chaining methods--reverse chaining and forward chaining--were superior to the whole method in reducing the number and proportion of errors. The findings also indicated that differences between reverse-chaining and forward-chaining methods were not statistically significant. However, the subjects who learned more slowly benefited substantially from systematic chaining methods.

Summary

Educators have constantly searched for more efficient and appropriate methods to reach desired educational goals. In order to achieve the maximum efficiency in learning rate, it is essential that consideration be given to (1) the materials or tasks which are presented to students, (2) the students' response levels and (3) the teaching or training methods.

It seems logical that when the task is complex and difficult, breaking the task into small parts and progressing step by step facilitates learning.

Researchers have examined both forward-chaining and reverse-chaining methods. However, they have reached no conclusion as to which method is most effective for learning and retention.

In theory, the reverse-chaining method seems to encourage learning by providing the reinforcement of continual success in completing a task. The final response is the goal of the learner, and completion of this link produces the most satisfying and immediate results for the learner. This satisfaction provides a motivational advantage for the learner. Such a psychological advantage is true of mentally retarded individuals, in particular, since they have a relatively short motivation span. Therefore, they should benefit from the reverse-chaining method.

It is the intent of this study to compare the reverse-chaining and forward-chaining methods in the teaching of a motor task to mentally retarded individuals. A comparison of the two methods of learning could provide new information by which to evaluate current teaching approaches and could suggest ways in which to construct newer and more effective programs.

CHAPTER III

METHODS AND PROCEDURES

The purpose of this study was to compare the reverse-chaining and forward-chaining instructional methods in teaching a motor task to mentally retarded individuals. The study was conducted at Fairview Training Center, Salem, Oregon, in the fall of 1982. This chapter, which discusses the methods and procedures used in the study, contains the following sections: preliminary procedures, selection of subjects, selection of motor task, setting, procedures and method of analysis.

Preliminary Procedures

Background of the Study

Prior to initiating this study, the investigator worked for three years at Teaching Research in Monmouth, Oregon, in implementing and testing a special physical education curriculum for the severely and profoundly handicapped developed by Dunn et al. (1980). Since chaining methods were used in teaching severely and profoundly handicapped at Teaching Research, the investigator had the opportunity to practice and develop the necessary skills to successfully conduct motor programs.

The investigator conducted a pilot study using a modified bowling skill as a motor task with three mentally retarded children at Teaching Research. The study

was initiated January, 1982 and extended over a five-week period. The study was conducted to test the procedures associated with this research. Also analyzed were the techniques for teaching the mentally retarded using reverse-chaining and forward-chaining methods and the subjects' reactions to the selected motor task.

Research Permission

A research proposal was developed and presented to the dissertation committee. Permission was secured from the committee to conduct the research. Permission was also secured for subject participation from the the research committee of the Fairview Training Center, Salem, Oregon.

Appendix A contains the form granting approval for the use of human subjects by the Oregon State University Committee for the Protection of Human Subjects. The forms used to obtain written consent of the subjects for participation in this study appear in Appendix B.

Selection of Subjects

The investigator obtained the subjects by contacting Fairview Training Center, Salem, Oregon. The subjects were chosen according to the following criteria: (1) The subjects were classified as mentally retarded. The range of ability included subjects classified from moderately to severely retarded. (2) The subjects had no

known behavior problems or orthopedic handicaps. (3) The subjects had no previous experience with the specific motor task of bowling.

Demographic data including name, sex, date of birth, current age, level of functioning and current ward were obtained for each subject. The form used for the collection of this information is found in Appendix C.

Selection of Motor Task

The motor task used in this study was a modified bowling skill using a four-step approach. Several advantages were associated with this specific task. These included the following:

1. The activity could be taught by either the forward-chaining or reverse-chaining methods of learning.
2. The equipment could be easily transported and setup.
3. The instructional procedures could be easily explained and understood; preferably, a demonstration could show what was to be done.
4. The activity of striking the pins is a natural reinforcer for subjects.
5. The activity has recreational and social purposes.
6. The four-step approach is suggested for beginners, as well as for more advanced bowlers. It is smoother, provides better balance and is less

complicated than other types of approaches (Mackey, 1967).

The modified bowling task was analyzed into the following four subtasks:

Subtask A: From a standing position, the subject will raise the ball to a chest-high position and step with the right foot forward.

Subtask B: The subject will step with the left foot forward and push the ball forward.

Subtask C: The subject will step with the right foot forward and swing the ball backward.

Subtask D: The subject will step with the left foot forward, swing the ball forward, release the ball and strike the pins.

An illustration for each subtask appears in Appendix D.

Setting

Instructional sessions were conducted in a basement at the subjects' living unit at Fairview Training Center. This location was selected because it was relatively free of distractions. The investigator supplied all equipment, which included three plastic pins, one rubber bowling ball and masking tape. The rubber bowling ball had two sets of two finger holes, one set for larger

hands and one set for smaller hands. The pins were arranged in the shape of a triangle. The distance from pin to pin was 12 inches. A line was placed on the floor 20 feet from the wall. A picture of the arrangement appears in Appendix F.

Procedures

The investigator met the staff at Fairview Training Center, Salem, Oregon, to briefly discuss the study with them and obtain information about each subject. The investigator was introduced to the subjects prior to initiating the study so that the subjects would feel comfortable with the investigator.

When conducting the instructional sessions, the investigator went to the subject's residence, accompanied the subject to the site (basement), taught the subject and then escorted the subject back to his or her residence after the instructional period was over. The procedure was repeated until all subjects were taught.

The investigator conducted the instructional sessions using a one-to-one ratio in order to keep the teaching procedures and data recording as manageable and consistent as possible.

Screening Test

To assess the subjects' familiarity with the skill of bowling as well as their general motor ability, the

investigator presented a screening test to each member of the available population. During the screening test, the investigator modeled for each subject the modified bowling skill using a four-step approach. Then each subject was asked to perform the skill. Two trials were administered. If the subject executed the skill properly, he or she was eliminated from the study. Subjects were also eliminated who were unable to grasp the ball properly after receiving instruction from the investigator. The screening test was conducted with one subject at a time. The screening test form appears in Appendix G.

Subjects who were unable to properly perform the modified bowling skill were randomly assigned to either the forward-chaining group or the reverse-chaining group. Each group comprised 15 subjects.

Reverse-Chaining Group

In the reverse-chaining group, the subjects were taught the skill of bowling using the following steps: step 1, taught subtask D; step 2, taught subtasks C and D; step 3, taught subtasks B, C and D; step 4, taught subtasks, A, B, C and D.

During the instructionsl sessions, each trial began with the investigator modeling and providing verbal instruction. For example, when teaching subtask D, the investigator modeled the entire bowling skill while

emphasizing subtask D. Following the investigator's model, the investigator prompted the subject from subtask A to subtask B to subtask C; then the subject was asked to perform subtask D independently. If the subject performed this subtask correctly, the investigator immediately gave the subject high verbal reinforcement. If the subject was unable to perform the skill correctly or hesitated more than ten seconds, the subject was physically assisted to do the skill correctly. If the subject required physical assistance, a mild verbal reinforcer was provided to the subject.

The investigator recorded the data on the program data sheet for each trial. The program data sheet appears in Appendix H. No advancement was allowed until the subjects performed three consecutive correct trials at a particular step. When the subject had performed the modified bowling skill independently and correctly for three consecutive trials, criterion was reached, and the instructional process was completed. The instructional process for the reverse-chaining group appears in Appendix I.

Forward-Chaining Group

In the forward-chaining group, the subjects were taught the skill of bowling using the following steps: step 1, taught subtask A; step 2, taught subtasks A

and B; step 3, taught subtasks A, B and C; step 4, taught subtasks A, B, C and D.

During the instructional sessions, each trial began with investigator modeling and providing verbal instruction. For example, when teaching subtask A, the investigator modeled the entire bowling skill while emphasizing the subtask A. Following the investigator's model, the subject was asked to perform subtask A; then the subject was prompted by the investigator through the rest of the subtasks. If the subject performed the subtask correctly, the investigator immediately gave the subject high verbal reinforcement. If the subject was unable to perform the skill correctly or hesitated more than ten seconds, the subject was physically assisted to do the skill correctly. Then the investigator gave the subject mild verbal reinforcement. When the subject had performed the modified bowling skill independently and correctly for three consecutive trials, criterion was reached, and the instructional process was completed. The instructional process of the forward-chaining group appears in Appendix J.

Because the investigator identified the criterion measure as the process used in bowling rather than as the product or outcome of bowling, no attempt was made to measure the subject's bowling score. Every opportunity was taken to assure that the subjects understood the task they were expected to perform. The data were carefully

recorded after every trial to assure that the subjects progressed according to the defined criterion.

After the criterion was reached and the instructional process was completed, the subjects were not provided opportunities to practice the motor task.

Retention Test

Three weeks after the task was completed, a retention test was given to check whether the task had been retained. Each subject was tested in the same setting in which he or she had been taught earlier. Each subject was given a verbal cue to complete the modified bowling skill. If the subject had an incorrect response, the investigator then modeled the skill. The investigator repeated the testing procedure until the subject performed the motor task independently and correctly for three consecutive trials. Retention was measured by the number of trials each subject required to complete the entire approach.

Method of Analysis

Three types of data were recorded for each subject. During the instructional period, data were collected on the number of trials and the number of physical assists required by each subject to reach the criterion. After the subject met the criterion, retention was conducted after a period of three weeks. Data were also

recorded on the number of trials required to reach the criterion. The data were analyzed at the Oregon State University Computer Center. A One-Way Analysis of Variance (ANOVA) was computed to determine if there were any statistically significant differences between the reverse-chaining group and the forward-chaining group. The .05 level of significance was selected as the measure for significance in this study.

Appendix K presents the entire procedure utilized in this study.

CHAPTER IV

PRESENTATION AND DISCUSSION OF THE FINDINGS

The purpose of this study was to examine two methods, forward chaining and reverse chaining, for teaching a motor task to mentally retarded individuals. Two basic questions were asked in this study: (1) Which method, forward chaining or reverse chaining, is more effective in teaching a motor task to mentally retarded individuals? (2) Does the forward-chaining or reverse-chaining method lead to greater retention after a three-week interim period? Presented in this chapter is a description of the subjects, an analysis of data, a summary of findings and discussion, and the conclusion and implication.

Description of Subjects

A total of 35 mentally retarded individuals took part in this study. A screening test was conducted on each individual to determine the subjects' familiarity with the skill of bowling as well as their general motor ability. Two trials were administered in the screening test. Those subjects who properly executed the modified bowling skill were eliminated from the study. Any subject who was unable to grasp the ball properly was considered to have insufficient motor ability to participate in this study and was thus eliminated.

The result of the screening test showed that all 35 subjects were unable to perform the modified bowling skill correctly. Four subjects were eliminated from the study because they were unable to understand how to properly grasp the ball. One subject was unavailable after the screening test and was therefore excluded from the study.

Using a table of random numbers, the investigator randomly assigned the 30 subjects to either the forward-chaining or the reverse-chaining group. The forward-chaining group contained 2 females and 13 males, ranging in age from 12 to 20, with a mean age of 16.5 years. The reverse-chaining group contained 4 females and 11 males, ranging in age from 13 to 19, with a mean age of 15.1 years.

Table I presents the age and the male-female composition of each group.

Table I

Age and Male-Female Composition of Each Group

Group	N	Age Range (year)	Mean Age (year)	Sex
Forward-Chaining Group	15	12-20	16.5	Male = 13 Female = 2
Reverse-Chaining Group	15	13-19	15.1	Male = 11 Female = 4

Analysis of Data

During the instructional period, data were collected on the number of trials and the number of physical assists required by each subject to meet the criterion for the specific motor task. After the subject met the criterion, a three-week retention test was conducted. Data were also collected on the number of trials required by each subject to meet the criterion for the specific motor task during the retention test.

The mean score and standard deviation for the total number of trials required by each group are reported in Table II. It can be seen that the subjects who were in the reverse-chaining group required fewer trials and a smaller standard deviation than the subjects who were in the forward-chaining group. The reverse-chaining group had a mean score and standard deviation of 46.40 and 7.09 compared to the forward-chaining group's mean score and standard deviation of 52.26 and 8.43.

To determine if there were any statistically significant differences between the two groups in the total number of trials required, the one-way analysis of variance was used. The F value of 4.20 was needed for significance at the .05 level. As reported in Table III, the F value for the total number of trials was 4.24. Thus, hypothesis one, there is no difference between the reverse-chaining and the forward-chaining groups

in the total number of trials required to reach the criterion, was rejected.

Table II

The Mean Score and Standard Deviation for Total Number of Trials Required by Each Group

Group	N	Mean	S.D.	Range
Forward-Chaining Group	15	52.26	8.43	35-64
Reverse-Chaining Group	15	46.40	7.09	37-65

Table III

Analysis of Variance for Total Number of Trials Required by Each Group

Source	df	SS	MS	F
Between Groups	1	258.1	258.1	4.24
Within Groups	28	1702.5	60.8	
Total	29	1960.7		

The mean score and standard deviation for the total number of physical assists provided for each group are shown in Table IV. The reverse-chaining group required fewer physical assists as indicated by the mean

comparisons. The standard deviation for the reverse-chaining group was also smaller than that for the forward-chaining group. The reverse-chaining group had a mean score and standard deviation of 27.26 and 6.18 compared to the forward-chaining group's mean score and standard deviation of 32.93 and 8.54.

The one-way analysis of variance was applied to determine the difference between the two groups. A study of Table V shows that the computed F value of 4.33 was greater than the table F value of 4.20. Therefore, hypothesis two, that there is no difference between the reverse-chaining group and the forward-chaining group in the total number of physical assists required to reach the criterion, was rejected.

Table IV

The Mean Score and Standard Deviation for Total Number of Physical Assists Required by Each Group

Group	N	Mean	S.D.	Range
Forward-Chaining Group	15	32.93	8.54	15-44
Reverse-Chaining Group	15	27.26	6.18	16-40

Table V

Analysis of Variance for Total Number of Physical Assists Required by Each Group

Source	df	SS	MS	F
Between Groups	1	240.8	240.8	4.33
Within Groups	28	1555.9	55.6	
Total	29	1796.7		

The mean score and standard deviation for the total number of trials required by each group to meet the criterion during a three-week retention test are presented in Table VI. The Table indicates that the subjects who were in the reverse-chaining group required slightly fewer trials than the subjects who were in the forward-chaining group.

The one-way analysis of variance was applied to the retention test data to determine if the total trials required by each group to reach the criterion were significantly different.

As can be seen in Table VIII, the F value for the total number of trials requried to meet the criterion was .30. This was insignificant at the .05 level. Consequently, hypothesis three was retained. There is no difference between the reverse-chaining group

and the forward-chaining group in the retention of a specific motor task after three weeks.

Table VI

The Mean Score and Standard Deviation for Total Number of Trials Required by Each Group for the Retention Test

Group	N	Mean	S.D.	Range
Forward-Chaining Group	15	9.93	3.05	6-15
Reverse-Chaining Group	15	9.40	2.23	5-14

Table VII

Analysis of Variance for Retention Test by Each Group

Source	df	SS	MS	F
Between Groups	1	2.1	2.1	.30
Within Groups	28	200.5	7.2	
Total	29	202.7		

Further analysis of the difference between the two groups for each step of the subtask are presented in Tables VIII and IX and in Figures I and II. The tables and figures indicate that the subjects who were in the

reverse-chaining group performed better in the early steps of the subtask than the subjects who were in the forward-chaining group. Table VIII reports an analysis of variance for the total number of trials needed for each of the four steps in the modified bowling skill. Subjects who were in the reverse-chaining group required fewer trials at all steps of the task. Significant differences ($p<.05$) were found in step 1 and step 2.

Table IX shows an analysis of variance for the total number of physical assists required for each of the four steps. The results parallel those reported for the total number of trials required to learn the bowling skill. The number of physical assists required for steps 1 and 2 were significantly fewer when using the reverse-chaining method.

The tables and figures also show that the total number of trials and physical assists increased from step 1 to step 4 for both groups.

Table VIII

Analysis of Variance for Total Number of Trials Required for Each Step

Step / Group	Step 1		Step 2		Step 3		Step 4	
	Sub-task	Total Trials	Sub-task	Total Trials	Sub-task	Total Trials	Sub-task	Total Trials
Reverse-Chaining Group	D	147 *	C+D	162 *	B+C+D	190	A+B+C+D	197
Forward-Chaining Group	A	187	A+B	199	A+B+C	195	A+B+C+D	202

* $P < .05$

Table IX

Analysis of Variance for Total Number of Physical Assists (P.A.) Required for Each Step

Step / Group	Step 1		Step 2		Step 3		Step 4	
	Sub-task	P.A.	Sub-task	P.A.	Sub-task	P.A.	Sub-task	P.A.
Reverse-Chaining Group	D	78 *	C+D	90 *	B+C+D	111	A+B+C+D	130
Forward-Chaining Group	A	116	A+B	120	A+B+C	125	A+B+C+D	133

* $P < .05$

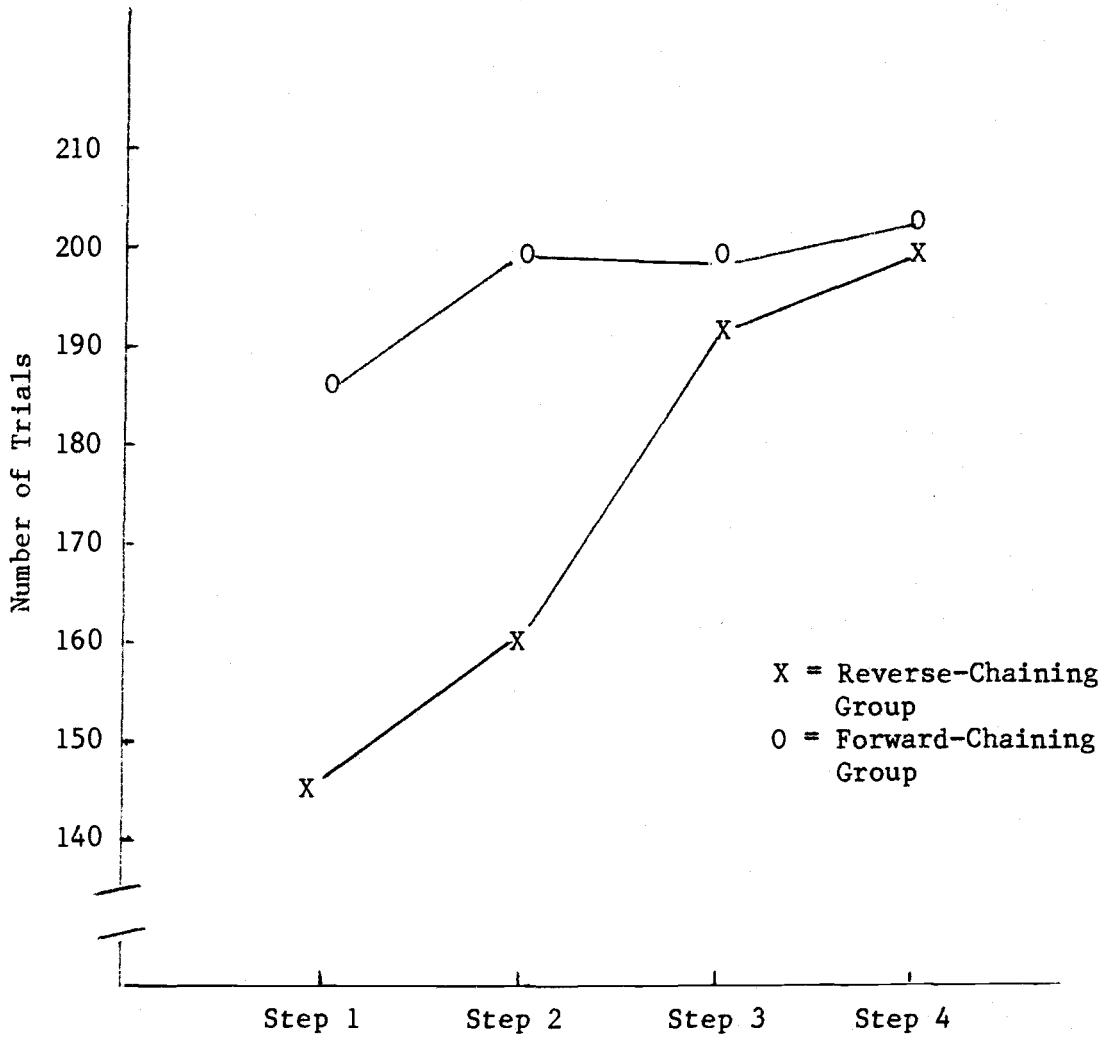


Figure I. Total Number of Trials Required for Each Step in Both Groups

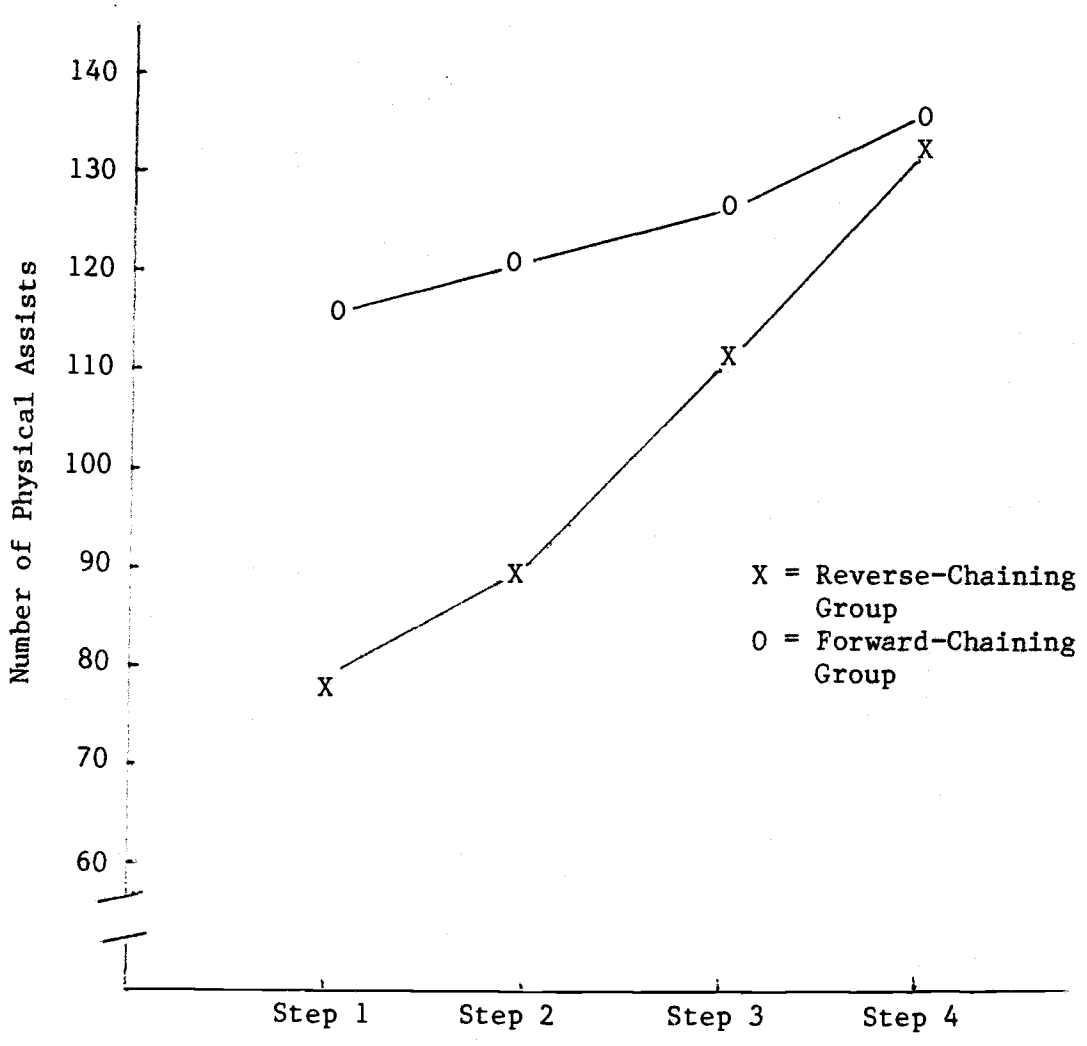


Figure II. Total Number of Physical Assists Required for Each Step in Both Groups

Summary of Findings and Discussion

The first null hypothesis that there is no difference between the reverse-chaining group and forward-chaining group in the total number of trials required to reach the criterion on a specific motor task was rejected on the basis of an obtained F value of 4.24.

The second null hypothesis that there is no difference between the reverse-chaining and the forward-chaining group in the total number of physical assists required to reach the criterion on a specific motor task was rejected on the basis of an obtained F value of 4.33.

The third null hypothesis that there is no difference between the reverse-chaining and forward-chaining group in the retention of a specific motor task after three weeks was retained on the basis of an obtained F value of .30.

The findings of this study support the relative advantages of using reverse-chaining method as opposed to the forward-chaining method when teaching mentally retarded individuals a motor task. The results of this study are consistent with earlier work reported by Weber (1978).

However, these findings contradict the results of studies by Cox and Boren (1965), Scott (1968), Nannay (1970), Nathan (1970), Wilcox (1974), and Walls, Zana and Ellis (1981), all of which reported that there was

no difference between reverse-chaining and forward-chaining instructional methods.

The findings of this study also differ from earlier studies by Johnson and Senter (1965), and Balson (1971) which reported the inferiority of the reverse-chaining method as compared to the forward-chaining method.

One possible interpretation of this discrepancy is that the majority of previous studies used number or random letter tasks rather than a motor task. As Weber (1978) pointed out:

> . . . motor chains have more reinforcing value in repeated goal attainment because each step meaningfully relates to the goal. This may not be so in a number or random letter chain task (p. 388).

One of the advantages of reverse chaining is that the last link in the task serves as a reinforcer. In this study, the completion of the last subtask in a motor sequence--roll the ball and strike the pin--appeared to be the most rewarding part of the total task. Rolling the ball and seeing the pins fall appeared to be a pleasurable experience for subjects in the reverse-chaining group. Thus, the subjects were highly motivated to participate. Consequently, they required fewer total trials and physical assists than did the forward-chaining group.

Most of the difference between the reverse- and forward-chaining method was attributed to steps one and two. This finding would support the observation

that the final aspect of the task, rolling of the ball, was subsequently more reinforcing than the initial aspect of the task, raising the ball to the chest.

When using the reverse-chaining method in motor task instruction, the subjects for each trial always perform the final subtask, a process which provides a meaningful understanding of the specific task. This technique is useful with individuals, particularly with mentally retarded persons, who require a specific concrete goal. The results of this study indicate that reverse chaining is superior to forward chaining. Therefore, the reverse-chaining method should be recommended as an appropriate teaching method for mentally retarded individuals who have difficulty comprehending the complexities inherent in many motor tasks associated with sport and leisure skills.

Nanney (1970), Wilcox (1974), and Weber (1978) compared the forward-chaining method with the reverse-chaining method to determine which method enhanced the subject's ability to retain the learned task. The present study failed to find a significant difference between the two groups on the retention test. This finding is consistent with the findings of Nanney (1970), Wilcox (1974), and Weber (2978). It is commonly accepted that specific factors contribute to and detract from the retention of a skill. Some researchers have found that relatively rhythmic, continuous and fluid motor tasks

are retained more easily than those that are disconnected responses (Cratty, 1973). Bowling is relatively rhythmic and requires progressive movement. Therefore, in this study, the skill should have been retained longer. It is possible that three-weeks was too short a time in which to see the differences in retention resulting from the two instructional methods.

One of the instructional principles suggested by Dunn (1978) is to provide success-oriented experiences for the mentally retarded. Therefore, when teaching a skill, such as a modified bowling task, it is important to start with a step which is easy to master and easy to achieve. From the investigator's point of view, the significance between the two groups in steps 1 and 2 demonstrated that the reverse-chaining instructional method is better than the forward-chaining instructional method when teaching a modified bowling skill to mentally retarded individuals.

The two groups in this study exhibited some similarity in the learning progression. In examining both groups for the total number of trials and the total numer of physical assists required to meet the criterion for each step, the investigator observed that the longer the sequence of movement, the more trials and physical assists required. This correlation may be attributed to the increased complexity of the task with each additional step. This observation is consistent with the

statement of Staats (1965), who observed:

> the more behavior sequences in each member of the chain, the weaker will be the disposition at the start of the chain (p. 495).

A chain containing numerous response links would require more trials and physical assists to master.

The data also revealed that the movement involved in subtask B required the highest total number of trials and total number of physical assists for subjects in both groups. This might indicate that the hardest part of the modified bowling task was pushing the ball forward while taking a step. The high number of trials and physical assists required by the subjects to reach the criterion on subtask B provides valuable teaching information. Breaking subtask B into smaller subtasks may be necessary in order to help the learner achieve the criterion and master the specific skill.

Oxendine (1968) found that mentally retarded individuals usually learned best if the task was divided into component parts. Cratty (1973) reported that the progressive-part method, which is similar to chaining methods, is helpful with mentally retarded individuals. In this study the modified bowling skill was broken down into four subtasks--A, B, C and D. The subjects were taught one subtask at a time; then each proceeding subtask was added one by one until the whole task was learned. This instructional procedure allowed the mentally retarded subjects to master each new subtask step

by step and thus facilitated the learning process.

In the prompting procedure used in this study, as described in Chapter III, the investigator used verbal or physical contact to remind the subject of the correct movement sequence. The prompting procedure exposes the subjects to the way in which subtasks are to be performed and the sequence which subtasks follow. As Fredericks and others (1980) have pointed out, such a procedure facilitates acquisition. Therefore, the prompting procedure should be recommended as an important technique in teaching motor tasks to mentally retarded individuals.

One of the most often mentioned learning characteristics of the mentally retarded is a short attention span. The investigator observed that the mentally retarded subjects in this study were enthusiastic and interested in participating in the study. This might be because the task, modified bowling, provided an enjoyable and successful experience for them. Another reason might be that the instructional method of chaining provided a meaningful step-by-step experience for the subjects. This observation agrees with that of Winnick (1979), who explained:

> the retarded have been observed to engage in tasks over prolonged periods provided that they are interested in the tasks and are successful in performing them (p. 349).

Thus, when planning programs for mentally retarded people, teachers should consider activities which are enjoyable

and which can be participated in successfully. Furthermore, the instructional strategy should be easy to understand and follow.

Conclusion and Implication

On the basis of the findings of this study and within the limits of the investigation, it was concluded that the subjects in the reverse-chaining method group required significantly fewer trials and physical assists to learn the given motor task than the subjects in the forward-chaining method group during the instructional period. However, there was no significant difference in retention between the two groups.

The reverse-chaining method should be recommended as an appropriate teaching method for mentally retarded individuals who have difficulty comprehending the complexities inherent in many motor tasks associated with sport and leisure skills. Motor skills which require a sequence of movements, in particular, would appear to respond favorably to the reverse-chaining instructional approach.

CHAPTER V

SUMMARY, CONCLUSION AND RECOMMENDATIONS

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

Summary

The purpose of this study was to compare reverse-chaining and forward-chaining instructional methods in teaching a motor task to mentally retarded individuals. The subjects were selected from Fairview Training Center, Salem, Oregon. Each of the subjects was classified as mentally retarded with a range from moderate to severe retardation. The subjects' ages ranged from 12 to 21 with a mean age of 15.7 years. The subjects included 6 females and 24 males.

The motor task used in this study was a modified bowling skill using a four-step approach. The bowling skill was analyzed into four subtasks:

Subtask A: From a standing position, the subject will raise the ball to a chest-high position and step with the right foot forward.

Subtask B: The subject will step with the left foot forward and push the ball forward.

Subtask C: The subject will step with the right foot forward and swing the ball backward.

Subtask D: The subject will step with the left foot forward, swing the ball forward, release the ball and strike the pins.

To assess the subjects' familiarity with the specific motor task as well as their general motor ability, a screening test was presented to each member of the available population. If a subject executed the skill properly, he or she was eliminated from the study. Subjects were also eliminated who were unable to grasp the ball properly after receiving instruction from the investigator.

Thirty-five mentally retarded individuals took part in this study. As a result of the screening test, five individuals were eliminated from the study. The remaining 30 subjects were randomly assigned to either the forward-chaining or the reverse-chaining group. The 15 subjects in the reverse-chaining group were taught the last subtask (subtask D) in the skill first, and then each subsequent subtask was added one by one (that is, subtasks C and D; then subtasks B, C and D) until the entire skill sequence (subtasks A, B, C and D) was taught. For the 15 subjects in the forward-chaining group, the teaching procedure was the opposite

of that with the reverse-chaining group. They were taught the first subtask (subtask A) first, and then each following subtask was added one by one (that is, subtasks A and B; then subtasks A, B and C) until the entire skill sequence (subtasks A, B, C and D) was taught.

During the instructional period, a new subtask was begun only after the subject had accomplished the previous subtask without error for three consecutive trials. After the subject reached the criterion by demonstrating the entire skill sequence--subtasks A, B, C and D--correctly and independently for three consecutive trials, the instruction period stopped. Three weeks after the task was completed, a retention test was given to determine whether the task had been maintained.

Three types of data were collected for each subject in this study. During the instructional period, the number of trials and the number of physical assists required by each subject to reach the criterion was recorded. The number of trials required by each subject to reach the criterion during the retention test was also recorded.

A one-way analysis of variance (ANOVA) using a .05 level of significance was selected for rejecting or retaining the following null hypotheses:

Null Hypothesis 1. There is no difference beween the reverse-chaining group and the forward-chaining

group in the total number of trials required to reach the criterion on a specific motor task. This null hypothesis was rejected on the basis of an obtained F value of 4.24, which was greater than the tabled F value of 4.20.

Null Hypothesis 2. There is no difference between the reverse-chaining group and the forward-chaining group in the total number of physical assists required to reach the criterion on a specific motor task. This null hypothesis was rejected on the basis of an obtained F value of 4.33, which was greater than the tabled F value of 4.20.

Null Hypothesis 3. There is no difference between the reverse-chaining group and the forward-chaining group in the retention of a specific motor task after three weeks. This null hypothesis was retained on the basis of an obtained F value of .30, which was less than the tabled F value of 4.20.

The results of this study demonstrated the relative advantages of using the reverse-chaining method as opposed to the forward-chaining method when teaching mentally retarded individuals a gross motor task.

When using the reverse-chaining method in motor task instruction, the learner for each trial will always perform the final subtask. This process provides for a meaningful understanding of the specified motor task. The reverse-chaining method is useful with individuals,

particularly those who are mentally retarded, who require a specific concrete goal. Therefore, the reverse-chaining instructional method should be recommended as an appropriate method for teaching mentally retarded individuals motor tasks.

Conclusion

On the basis of the findings of this study and within the limits of the investigation, it was concluded that the subjects in the reverse-chaining method group required significantly fewer trials and physical assists to learn the given motor task than the subjects in the forward-chaining method group. However, there was no significant difference in retention between the two groups.

Recommendations for Future Studies

After conducting and analyzing the results of the present study, the investigator recommends the following additional studies:

1. A study similar to the present one should be conducted using a three-step approach bowling skill as a motor task.
2. A study similar to the present one should be conducted using other motor tasks. A comparison of tasks with greater than and less than four subtasks would be valuable.

3. A study similar to the present one should be conducted with subjects of different ages and sex.
4. A study similar to the present one should be conducted comparing the effect of using chaining instructional methods on handicapped subjects as opposed to non-handicapped subjects.
5. A study similar to the present one should be conducted using retention period greater than and less than three weeks.
6. A study similar to the present one should be conducted comparing reverse-chaining and forward-chaining instructional methods on product as well as process measures.

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APPENDICES

APPENDIX A

OREGON STATE UNIVERSITY

Committee for Protection of Human Subjects

Chairman's Summary of Review

Title: A Comparison of Reverse- and Forward-Chaining Instructional Methods on a Motor Task with Mentally Retarded Individuals

Program Director: John M. Dunn (Grad. Student Pao-Yin Hsu)

Recommendation:

X Approval*

_____ Provisional Approval

_____ Disapproval

_____ No Action

*The informed consent forms obtained from each subject need to be retained for the long term. Archives Division of the OSU Department of Budgets and Personnel Service is willing to receive and archive these on microfilm. At present at least, this can be done without charge to the research project. Please have the forms retained in Archives as well as in your files.

Remarks: The investigators should be reminded that the subjects must not be identified in any publications resulting from this work.

Date: August 4, 1982 Signature

If the recommendation of the committee is for provisional approval or disapproval, the program director should resubmit the application with the necessary corrections within one month.

APPENDIX B(1)
CONSENT FORM

Dear Parents:

I am a graduate student Oregon State University working on a PhD degree in education. At present I am conducting a study to compare two instructional methods, reverse chaining and forward chaining, in teaching a motor task to mentally retarded individuals. The individuals will be taught in 30 minutes per session to learn a lead up task to the modified bowling skill. A description of the study is included.

Chaining methods appear to be prevalent instructional methods for handicapped people. Forward-chaining and reverse-chaining methods are frequently used in the special education classroom but their application in the physical education setting has not been studied.

I would like to ask permission for your child to participate in the study. Your child's participation and individual learning records will be confidential. Also, your child may withdraw, with your permission, from participation at any time he or she chooses.

I will be happy to answer any questions regarding the study that you may have. A summary of the results will be available at your request.

Thank you for your time.

Sincerely,

Pao-Yin Hsu
Department of Physical Education
Oregon State University
Corvallis, Oregon 97331
503-754-3266

APPENDIX B(2)

CONSENT FORM

Participant's Name _____

DESCRIPTION OF THE STUDY

The purpose of this study is to compare the effects of two instructional methods in teaching a modified bowling skill to mentally retarded individuals. The two methods employed will be:
Reverse-Chaining Method: A method in which the modified bowling skill will be sequenced in order and taught in reverse. That is, the last subtask in the skill will be taught first and then each subsequent subtask is added one by one until the entire task sequence is learned.
Forward-Chaining Method: Forward-chaining method is the opposite of reverse-chaining method. The procedure used with this method is to teach the first subtask in the modified bowling skill first and then each following subtask is added one by one until the entire task sequence is learned.

The subjects will be divided into two groups: (1) reverse-chaining group and (2) forward-chaining group. The subjects will be taught in 30 minutes per session. The instructional sessions present no risks to the participants. By knowing the effects of teaching methods on the motor skill learning, we can better plan sound, progressive physical education for the mentally retarded individuals.

This is to certify that I agree to allow my child to participate in this study. I understand the purpose of the research. I further understand that if I have any questions they will be answered by the researcher in person or by mail:

Pao-Yin Hsu
Department of Physical Education
Oregon State University
Corvallis, Oregon 97331
754-3266

I hereby give my consent for _____
to participate in the study. I reserve the right to withdraw my consent and discontinue participation at any time.

_____
(Parent/Guardian's Signature)

_____
(Parent/Guardian's Name Printed)

_____
Date

APPENDIX C
DEMOGRAPHIC DATA FORM

Number _____

Name _____

Sex: Male _____

Female _____

Date of Birth _____ Current Age _____
day month year

Level of Functioning: Mild _____

Moderate _____

Severe _____

Profound _____

Ward of Residence: Kozer _____

Holman _____

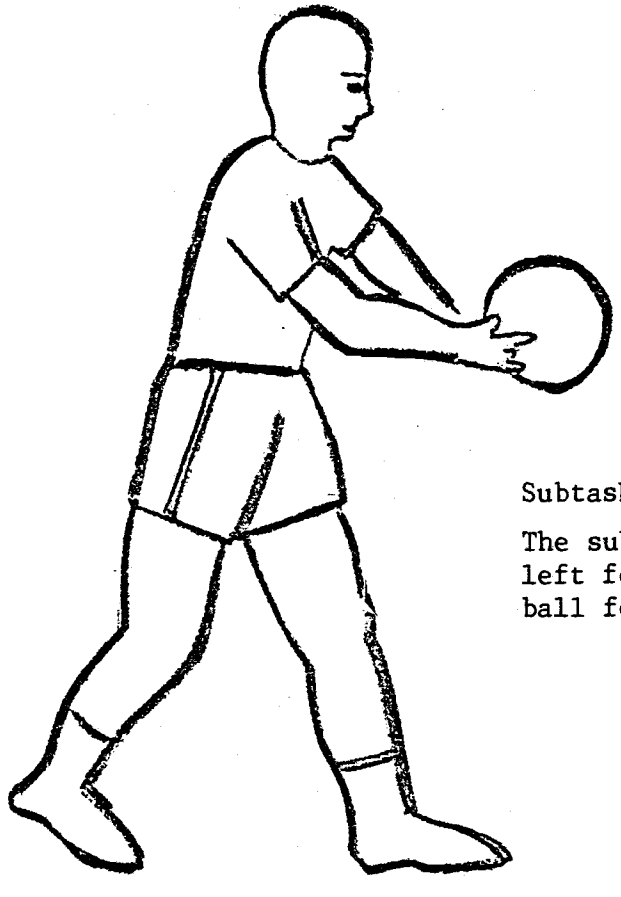
Pierce _____

Shell _____

APPENDIX D

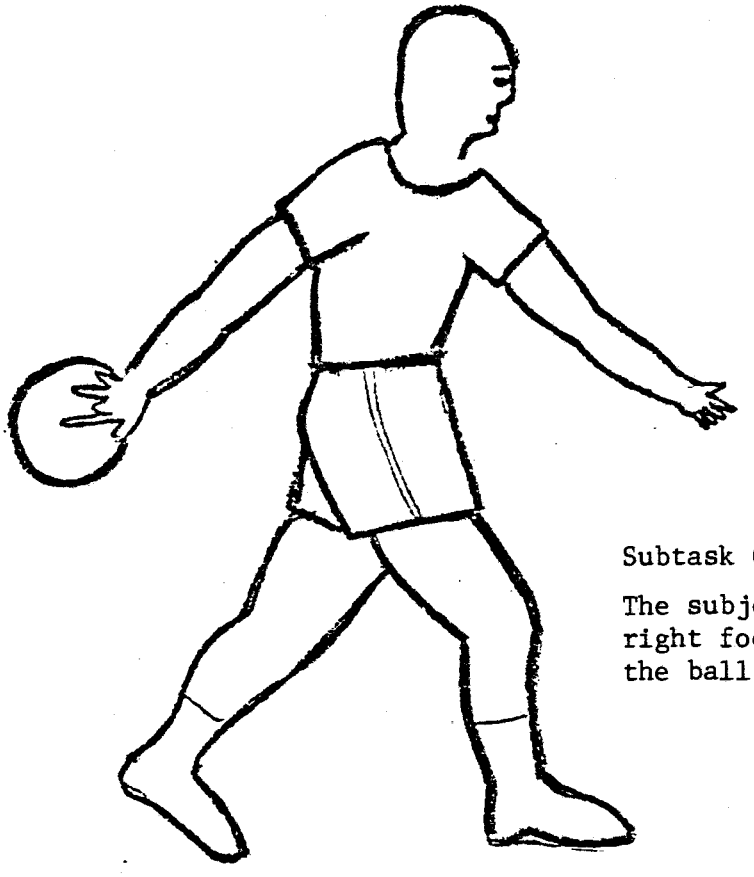
Subtask A

The subject from a standing position will raise the ball to a chest-high position and step with the right foot forward.



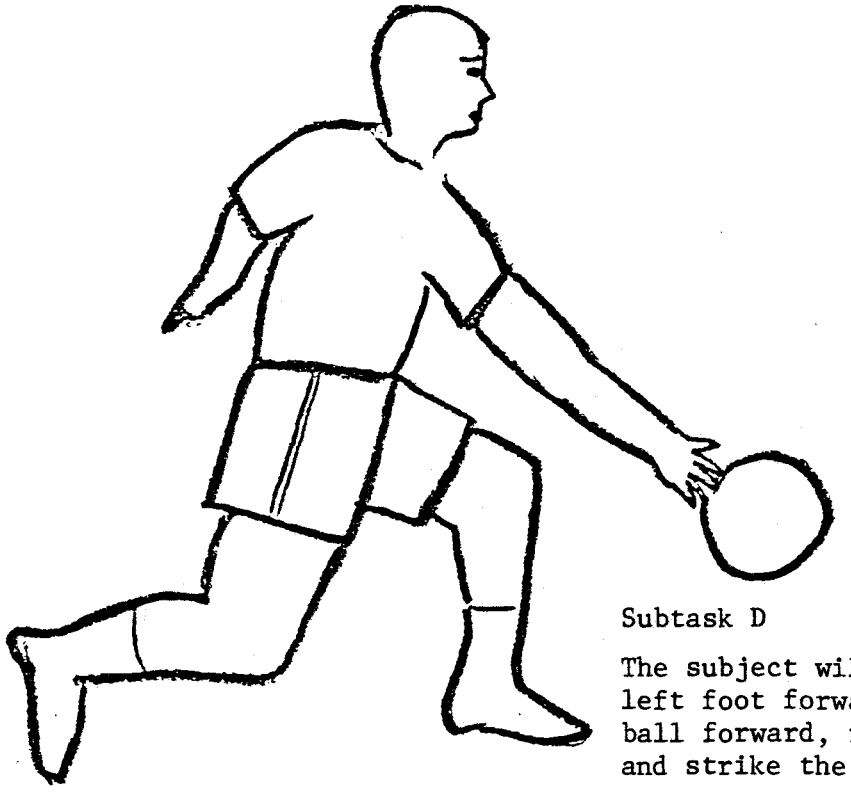
Subtask B

The subject will step with the left foot forward and push the ball forward.



Subtask C

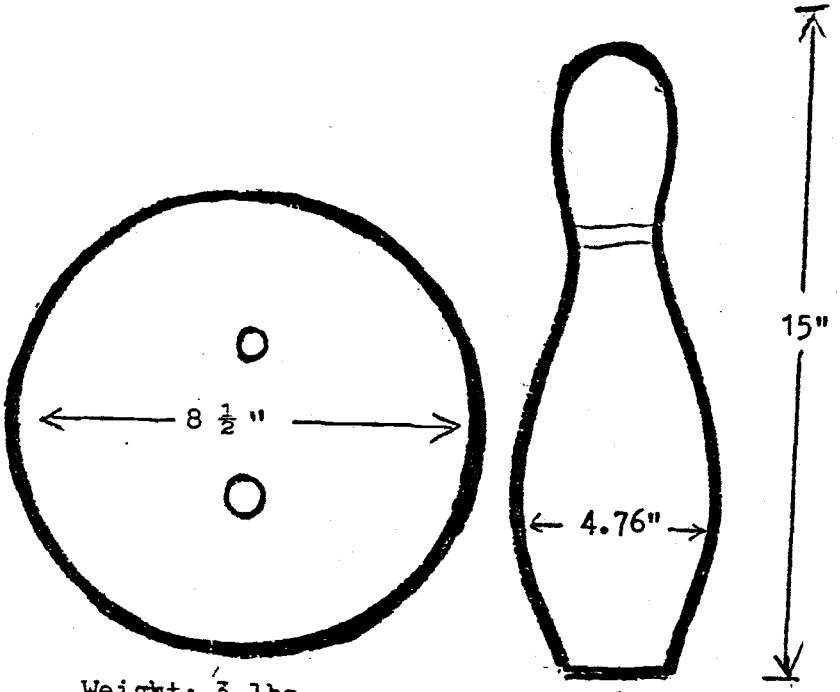
The subject will step with the right foot forward and swing the ball backward.



Subtask D

The subject will step with the left foot forward, swing the ball forward, release the ball and strike the pins.

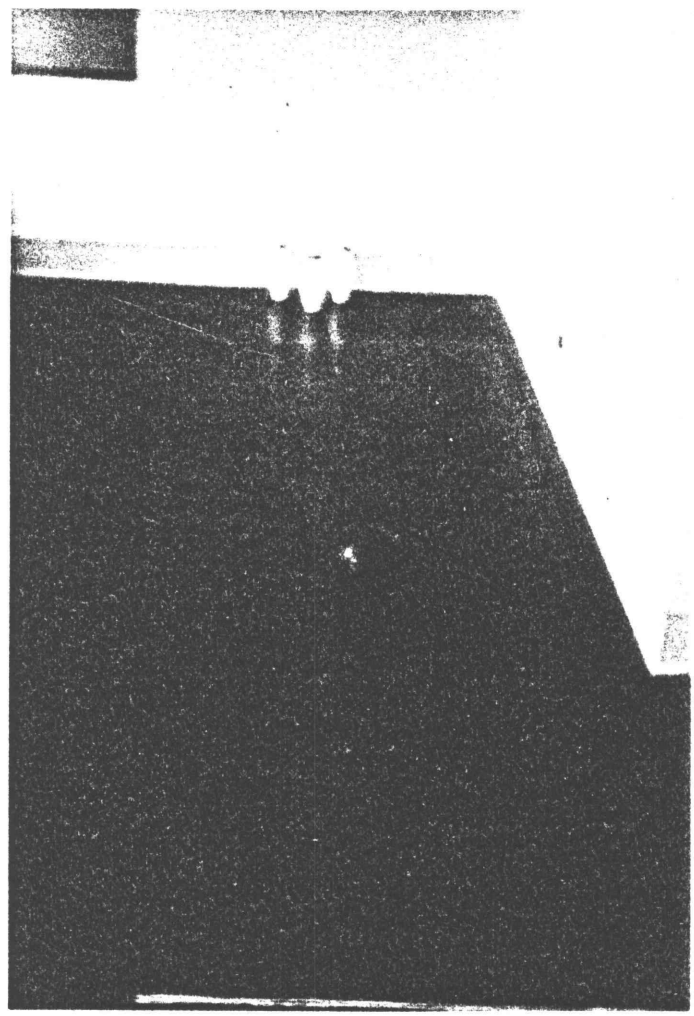
APPENDIX E
EQUIPMENT



Weight: 3 lbs
Composition: Rubber

Composition: Plastic

APPENDIX F
SETTING PICTURE



APPENDIX G

SCREENING TEST FORM

X = Correct
0 = Incorrect

Number	Name	Data	Yes/No	Comment

APPENDIX H
PROGRAM DATA SHEET

Number _____

Name _____

X = Correct
O = Incorrect

Step	Trials							Comments	Date

Total Number of Trials Required to Reach Criterion _____

Total Number of Physical Assists Required to Reach Criterion_____

Retention Test

Total Number of Trials Required to Reach Criterion _____

APPENDIX I
INSTRUCTIONAL PROCESS

Instructional Method: Reverse chaining

Criterion: Three consecutive correct trials at each step

Teaching Sequence: Step 1, teach subtask D

Step 2, teach subtask C and following with subtask D

Step 3, teach subtask B and following with subtasks C and D

Step 4, teach subtask A and following with subtasks B, C and D

Subtask D: The subject will step with the left foot forward swing the ball forward, release the ball and strike the pins.

Subtask C: The subject will step with the right foot forward and swing the ball backward.

Subtask B: The subject will step with the left foot forward and push the ball forward.

Subtask A: The subject from a standing position will raise the ball to a chest-high position and step with the right foot forward.

APPENDIX J

INSTRUCTIONAL PROCESS

Instructional Method: Forward chaining

Criterion: Three consecutive correct trials at each step

Teaching Sequence: Step 1, teach subtask A

Step 2, teach subtasks A and B together

Step 3, teach subtasks A, B and C together

Step 4, teach subtasks A, B, C and D together

Subtask A: The subject from a standing position will raise the ball to a chest-high position and step with the right foot forward.

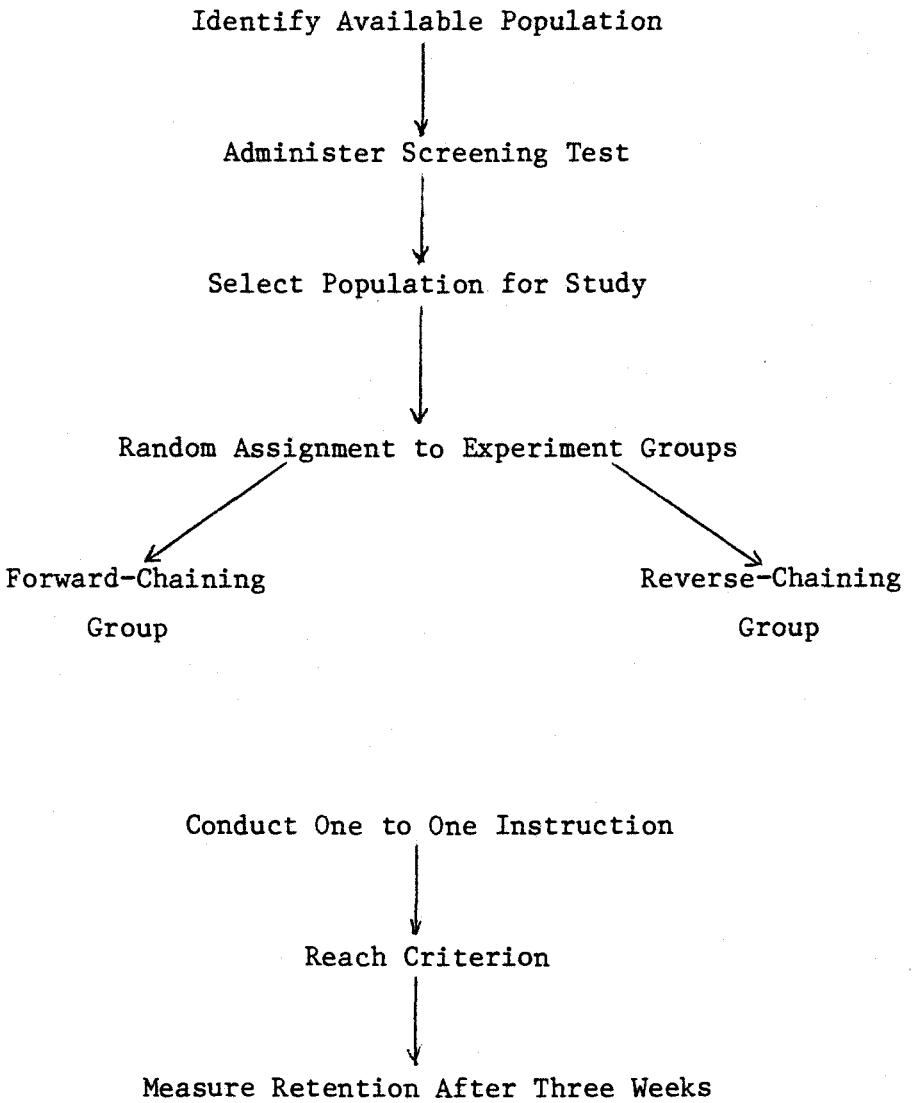
Subtask B: The subject will step with the left foot forward and push the ball forward.

Subtask C: The subject will step with the right foot forward and swing the ball backward.

Subtask D: The subject will step with the left foot forward, swing the ball forward, release the ball and strike the pins.

APPENDIX K

RESEARCH PROCEDURES



APPENDIX L

RAW DATA

Column

1-2	Number: 1-15 Forward-Chaining Group 16-30 Reverse-Chaining Group
3	Sex: 0 Male 1 Female
4-5	Age
6-7	Total Trials
8-9	Total Physical Assists
10-11	Retention (Total Trials)

01017351608	16013533008
02014543314	17013483007
03018514115	18114381610
04017513208	19013512909
05016553307	20115433512
06015613908	21116654010
07116594308	22016371909
08112513308	23017392212
09019643807	24015462610
10020634410	25017492910
11017543814	26016503209
12018361506	27015422114
13017523114	28114472705
14016522910	29013472507
15015462912	30019412809