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Teaching Sequences of Behaviors to Humans by Forward Chaining, Backward Chaining, and Whole Task Training

Janine Mary Scott

August 10, 1990.

A thesis sumitted to the School of Graduate Studies of the University of Ottawa as partial fulfillment of the requirements for the degree of Doctor of Philosophy

ISBN 0-315-67995-6

UNIVERSITÉ D'OTTAWA
UNIVERSITY OF OTTAWA

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This dissertation is dedicated to my supportive family including my mother, Phyllis Mary Scott, my father, John Alexander Scott, and my brother, Kane Alexander Scott and his wife-to-be Corrie and one of my best friends who was there through it all, Kenneth Graydon Richardson.

Acknowledgements

I am grateful to the following people for their support and assistance in the making of this dissertation: Jasmine Ugnat, Janet Sharpe, Shirley Griffith, Susan Kelen, Michael White, Eran Talitsman, Susan Gordon, Lori Moody, Joanne Benedet, Marilyn van Dieten, Goisia Ligezinska, Jeffrey Malcolm, Guy Bourgon, Nadia Kurylyszyn, Kathy Trainor, Barbara Stott, Nedy Aberdeen, and David Latour. I would especially like to thank Dr. Kevin Murphy and Dr. John Jamieson for their statistical advice. I would like to thank my proposal committee members for their words of wisdom, Dr. Cathy Bielajew, Dr Robert Leclerc and Dr. Pierre Mercier. I would like to thank the Lakehead Regional Family Centre for its support especially the Family Services Unit including my supervisor, Richard Landowski and team leader Pat Lewis. And last but definitely not least, my thesis advisor, Dr. Robert Watters.

Summary

The three most common training methods of teaching sequences of behaviors are forward chaining, backward chaining and whole task training. In chaining methods, training involves gradually teaching the sequence by teaching increasingly longer subsequences until the entire sequence has been learned. In forward chaining, training involves gradually teaching the sequence from the beginning. Backward chaining involves gradually teaching the sequence from the end. Training is continued in this manner until the entire sequence is learned. Whole task training does not involve gradual learning. Instead, on each trial, the sequence is attempted in its entirety. Trials of this kind continue until the sequence is learned.

It has been hypothesized that backward chaining is the superior method to teach sequences of behaviors because reinforcement is given at the end of each subsequence (Martin & Pear, 1988; Gilbert, 1962a & b). An example of this reinforcement would be the ball going through the hoop at the end of the sequence of behaviors involved in making a basketball shot.

The six experiments reported in this dissertation examine the training of a sequence of eight behaviors. Each behavior consisted of a unique symbol presented on a monitor screen followed by the subject pushing one of eight keys. The dependent variables were true errors (incorrect responses made after the subject had made a correct response), random errors (incorrect responses made before the subject had made a correct responses), total errors (the sum of random and true errors), total responses (the total of incorrect and correct responses) and time to learn the sequence to criterion. Discussion of the results tends to focus on true errors as a measure of accuracy and total responses and time as an indication of the practicality of training methods.

The first three experiments examined the three commonly used training methods

in conjunction with different consequences following an incorrect response. The within-subject component of each experiment compared the three training methods. The between-subject component compared the consequences following an incorrect response. In the first three experiments, the following consequences were examined: an auditory programmed consequence consisting of a "ZIT" sound, a visual programmed consequence consisting of the screen border changing color, a minimal programmed consequence consisting of no change, a prompt programmed consequence which instructed the subject which was the correct response to make, and a programmed consequence consisting of a three second time-out.

In all three experiments, there were no significant differences between consequences for any of the dependent variables except in Experiment 2. In Experiment 2, the auditory programmed consequence produced more random errors than the prompt programmed consequence. For all consequences, whole task training produced more true errors than forward and backward chaining.

The last three experiments examined factors which contribute to the effectiveness (few true errors) of the forward chaining and backward chaining methods. Three new forms of chaining were introduced to examine these factors.

Random chaining consisted of teaching randomly chosen behaviors within the subsequences. Component behaviors were placed next to each other within the subsequence according to sequence order. Random-2 chaining was similar to random chaining except that the component behaviors were taught within the subsequences in the order in which they were selected. The final subsequence is an exception as it is the sequence taught in sequence order. Random-3 chaining was similar to random-2 chaining except component behaviors were selected with replacement. For each subsequence, selection starts fresh and the required number of behaviors are selected out of the eight possible behaviors.

Whole task training produced more true errors than each chaining method except random-3 chaining. Random-3 chaining produced more true errors than forward, backward, random and random-2 chaining. No significant differences were found between random-3 chaining and whole task training.

The results clearly did not support the hypothesis that backward chaining is superior to other training methods for the sequence of behaviors taught in the experiments. The discussion involves an analysis of the training methods into a number of factors which may influence their effectiveness and some suggestions for future research.

Chapter One

Introduction

Many tasks involve a sequence of behaviors. Examples in everyday life include bed-making, shoe-lacing, dressing, grooming and food preparation. More modern tasks include operating a VCR, making a budget on a home computer and turning on a microwave. Sporting tasks include throwing a basketball and striking a baseball. Military tasks include dive bombing and carrier landing. Assembly tasks include construction of bicycle brakes, and fishing reels. Arbitrarily designed tasks include making a series of key presses each preceded by a distinctive visual stimulus. What all of these tasks have in common that they can be broken down into a sequence of behaviors.

Behavior problems can be studied as a sequence of behaviors. For example, a child may be drawing on the walls. Closer examination reveals that he draws on the walls in his father's study after going to talk to his father and being ignored. The behavioral sequence could be as follows: 1) the father goes to his study to work; 2) while he is working his son goes to talk to him; 3) the father ignores the child; 4) the father's work is interrupted when the child draws on the walls; 5) the father gives the child verbal attention. By changing the behavioral sequence or teaching a new sequence of behaviors, the behavior problem can be eliminated. The behavior sequence could be changed to the following: 1) the father goes to his study to work; 2) while he is working his son goes to talk to him; 3) the father tells the child he has work to do but they could work together; 4) the father works while the child draws on paper; 5) when the father has finished his work he talks and plays with the child (Dryden, 1989; Frankel, 1975).

Methods of Teaching Sequences of Behaviors

There are three widely used methods for teaching sequences of behaviors: forward chaining, backward chaining, and whole task training.

In forward chaining, training involves gradually teaching the sequence of behaviors according to sequence order. Sequence order refers to the arbitrarily defined fixed order of the component behaviors in the sequence. The subject learns to perform the first behavior in the sequence. When this has been learned, the subject learns the first behavior followed by the second behavior. Then the subject learns to perform the first behavior followed by the second, and followed by the third behavior. Training is continued in this manner until the entire sequence is learned (Watters, 1989).

Backward chaining involves gradually teaching the sequence of behaviors in reverse. In backward chaining, the subject learns the last behavior in the sequence. When this has been learned, the subject learns the second last behavior followed by the last behavior. Then the subject learns to perform the third last behavior, followed by the second last behavior, followed by the last behavior, and so on. Training is continued in this manner until the entire sequence is learned in its sequence order (Watters, 1989).

The third method is called whole task training or total task presentation. Whole task training does not involve gradual learning. Instead, on each trial, the sequence is attempted in its entirety, according to sequence order. Trials of this kind continue until the sequence is learned (Watters, 1989).

In reviewing the research on human sequenced behavior, it is difficult to draw conclusions about the best method of teaching sequences due to the great variation in guidance and instructions, tasks, subjects, design format, proficiency criteria and dependent variables. The following sections will describe this variability, and where applicable, will examine the problems resulting from the variability. The proposed solution is a series of overlapping parametric experiments.

Guidance and Instructions

The following section gives examples of the variability in guidance and instructions. Examples include verbal instructions, physical guidance, modeling and no assistance of any kind. The timing of the assistance may vary. For example, verbal instructions may be given at the beginning of the experiment or throughout the experiment.

Walls, Dowler, Haught and Zawlocki (1984) instructed the subject, "to watch me and do what I do", and subsequently modeled the behavior before the first attempt in whole task training and before the first attempt at subsequences in the chaining methods. Weber (1978) used modeling and verbal instruction before the addition of each behavior when using forward and backward chaining techniques. Zane, Walls and Thvedt (1981) used baseline, help and test trials. During help trials, the experimenter taught by backward chaining or whole task training methods. Assistance given during training consisted of either preguidance or postguidance. Preguidance was given prior to performance of a component behavior and consisted of the experimenter modeling the correct performance. Postguidance was guidance given following a behavior and consisted of the experimenter modeling the correct response after the subject had made an incorrect response. During test trials, the experimenter said or did nothing to assist the subject in putting the apparatus together or to correct responses that were incorrectly made. Each training session consisted of a baseline trial which was followed by a help trial. After this help trial was given, a test trial was given. Help and test trials alternated throughout training. Test trials consisted of the subject performing the task unassisted by the instructor.

Kayser, Billingsley and Neel (1986) used levels of assistance consisting of full assistance, partial physical assistance, physical prompts and gestural cues. Before training, subjects were assessed for level of assistance to be given. The level of assistance used for the instruction of each behavior in the sequence was determined by allowing the subject three seconds to perform the behavior. If there was no response or an incorrect response, the trainer provided increasingly intrusive levels of assistance until a level of assistance required to produce a correct performance of a behavior was determined. For each behavior of the sequence, if the level of assistance was the same on at least two of the three assessment sessions, that level of assistance was used initially in training. If the level of assistance was different across all three assessment sessions, the most intrusive level of assistance was used initially in training. Level of assistance was re-evaluated throughout training. Each correct performance of a behavior was rewarded with a small bite of a snack. As subjects improved in performance of a behavior in the sequence, the level of assistance decreased until the subject was performing the behavior unassisted.

At the other extreme, no assistance was provided in the computer run experiments of Deitz, Fredrick, Quinn & Brasher (1986), Deitz, Gaydos, Lawrence, Quinn, Brasher & Frederick (1987), Watters (1989; in press) and Weiss (1978). Verbal instructions were given at the beginning of the task only and no asssistance was provided once training started.

With this diversity of guidance and instruction, it is not clear whether the differential results are due to the three training methods (forward chaining, backward chaining and whole task training), the different forms of instructions or a combination of these. The following series of dissertation experiments use a computer program to teach the sequenced behavior by the three training methods. Verbal instructions are given at the beginning of each experiment. No other form of assistance is given throughout each experiment with the exception of Experiment 2. In Experiment 2, when an incorrect response is made a prompt appears on the screen indicating the correct response.

Tasks

This section gives examples of the categories of tasks used in the reviewed studies. Some of the dimensions on which tasks differ will be discussed. These dimensions may be factors that influence the choice of training method for a particular task.

Examples of task categories include ordinary activities such as dressing (Azrin, Schaeffer & Wesolowski, 1976; Inglesfield & Crisp, 1985), and washing (Giles & Morgan, 1989), construction of marketable products such as a meat grinder (Walls, Zane & Ellis, 1981), military tasks such as dive bombing (Bailey, Hughes & Jones, 1980), sports activities such as shooting a basketball (Chelladurai & Stothart, 1978), mathematical activities such as mathematical computations (Wilcox, 1974) and artificial experimental tasks such as learning an arbitrarily ordered set of behaviors (Deitz, et al, 1986; Vaughan, 1985; Watters, 1989; Weiss, 1978).

These tasks vary in homogeneity of component behaviors. Component behaviors refer to individual behaviors in a sequence of behaviors. Construction of an object such as a meat grinder (Walls et al, 1981) consists of heterogeneous behaviors whereas a sequence of key presses each preceded by a unique symbol (Weiss, 1978) consists of relatively homogenous behaviours.

These tasks vary in the familiarity of task itself and component behaviors. Familiarity with task varies from dressing (Azrin et al, 1976; Inglesfield et al, 1985) which is a daily occurrence to construction of a dishwasher pump which is a relatively unfamiliar task (Zane, Walls & Thvedt, 1981). In artificial experimental tasks, subjects learn a sequence of key presses each preceded by a unique symbol. The task is basically a fairly familiar typing task as compared to the construction of an object such as a meat grinder. Component behaviors consist of key presses which are relatively familiar behaviors. But the symbols preceding each keypress may be familiar ones such as alphabet letters (Weiss, 1978) or less familiar arbitrarily assigned symbols such as "*", "%", "-", " ", " " (Watters, 1989; in press). The familiarity of the symbols may affect the learning of the sequence of key presses.

Tasks may differ in the complexity of the component behaviors and in the relationship of the component behaviors. A mathematical problem solving sequence consisting of mathematical calculations involves more complex component behaviors (Wilcox, 1978) than learning a sequence of key presses (Watters, 1989, in press). The relationship between component behaviors in assembly of objects such as meat grinders (Walls et al, 1981) involves interconnections of parts to form an end product and a fixed sequence of behaviors. If the subject does not put the parts together in the correct order, the meatgrinder will not work. However, in learning a sequence of key presses each preceded by a unique symbol, there is no inherent interconnection between the component parts. The symbols appear on a screen one at a time. By pushing the correct key the next symbol appears. The sequence is ordered arbitrarily.

Naylor and Briggs (1963) addressed the issue of how the specific dimensions of a task may affect the choice of training method. They hypothesized an interaction between task complexity, organization, and training method. Task complexity refers to the difficulty of performing each behavior in the sequence and task organization refers to the nature of the interrelationship between the behaviors in the sequence. The data supported the following principle: For a relatively highly organized (integrated) task such as object assembly, whole-task training is superior to a part schedule (such as forward or backward chaining) at all levels of task complexity; however, for a relatively unorganized (all task dimensions independent) task such as pushing buttons, an increase in task complexity will result in a part-task training schedule becoming superior to whole training (Naylor & Briggs, 1963 p.218)

Stammers (1980) examined the first part of this principle by use of the highly organized task of two-dimensional pursuit tracking, using a joystick and cathode ray tube (CRT) display. Task complexity was varied by having two levels of display-control relationship. Low complexity consisted of a compatible relationship between the joystick movement and the pursuit spot on the CRT. An up or down movement made the spot move up or down, a left or right movement made it move left or right. The spot moved in two dimensions simultaneously. High complexity consisted of "rotating" this relationship through 90 degrees. Thus an up movement made the spot move to the right, a down movement moved it to the left, a right movement made it go up and a left one down. Part versus whole practice were compared by the use of two conditions, one requiring early changeover and the other requiring late changeover to whole practice. Part practice was not clearly enough defined to determine whether backward or forward chaining or some other form of part practice was used. No significant differences were found between the two training methods in early changeover at either level of complexity. Whole practice was superior to part in the high complexity task at later changeover, but only in the first block of practice. No differences were found at low complexity. The experiment offered limited support for Naylor and Briggs' (1963) hypothesis. A relationship between task complexity, organization and training method may exist, but what this relationship is remains unclear.

For certain types of tasks, the material in front of the subject at the beginning of training differs with the method used. When an individual begins to assemble a carburetor (Zane et al, 1981) by backward chaining it is completely assembled except for one missing piece. In forward chaining and whole task training, at the beginning of a training trial, the carburetor is a group of pieces on the table. By contrast, when teaching a sequence of key presses each preceded by a unique symbol (Watters, 1989; in press), the material in front of the subject at the beginning of training is the same for all methods of training (forward chaining, backward chaining and whole task training). When training commences, all subjects see a symbol on a screen with a keyboard in front of the screen.

Unlike the case of instructions and guidance, the problem with tasks is not the variability in tasks in itself. In the guidance and instruction section, variability directly affected or even altered the training method. But for tasks, the question may be what is the best method to teach an object assembly task. The best method for teaching object assembly may not be the same as for teaching another task involving sequenced behavior such as pressing buttons. To determine the best training method for teaching object assembly tasks, investigators would experiment with different methods of teaching object assembly tasks and similarily run separate experiments on every task involving human sequenced behavior. This could be very time consuming. One solution could be that a framework such as the one proposed by Naylor and Briggs (1963) may be developed. Let us assume for this discussion that Naylor and Brigg's (1963) hypothesis is true. The hypothesis states that for a relatively highly organized (integrated) task, whole task training is superior to a part schedule; however, for a relatively unorganized (all the dimensions independent) task, an increase in task complexity will result in part-task training schedule becoming superior to whole task training. It would have taken just a few well thought out experiments to prove this rule. Then, tasks could be classified by complexity and organization to determine what is the best method to teach the task. In our everchanging industrial society, new tasks are constantly being created which involve teaching sequences of behaviors. If no rules were determined, then each time a new task was developed it would have to be studied directly in a time consuming and extensive experimental manner in order to determine the best training procedure to teach it. If rules similar to the rules hypothesized by Naylor and Briggs (1963) had been determined, then the new task would be classified according to its complexity and organization to determine the best training method to teach a new task.

In the following experiments, a simple task will be chosen to allow the development of rules as mentioned previously which could be applied to more complex tasks. The task will consist of a set of key presses each preceded by a unique visual symbol presented on a computer screen. An arbitrarily ordered sequence will be used. The component behaviors will be relatively homogeneous. There is no inherent interconnection between component parts. Symbols will be relatively unfamiliar (eg. "*", "%", "$" etc.) with no associated predetermined order to them. Most tasks are relatively unfamiliar when we begin to learn them. The experiments will be performed in a laboratory environment. The task is relatively simple, unfamiliar and will be run by a computer to decrease errors in administration and recording of results.

<u>Subjects</u>

In the reviewed literature, subjects are drawn mainly from the mentally disabled (both adult and child) populations. Some studies use subjects from the normal and adult populations. Subjects also differ in aptitudes and abilities. These differences may be important factors in choosing the method of teaching a sequence of behaviors to a particular population.

The applicability of the three training methods in teaching the mentally disabled is illustrated by the large number of studies that employ this population. However, it is not clear which of the three produces the best results. Examples in the literature include a case study of a blind profoundly mentally retarded boy taught to leave an area by a standard fire procedure (Cohen,1984); group designs involving teaching several individuals to dress themselves (Inglesfield and Crisp, 1985), to make a snack (Kayser et al, 1986), to thread a sewing machine (Nettlebeck & Kirby, 1976), to construct bicycle brakes and fishing reels (Koop, Martin, Dicki, & Suthons 1980), to construct dishwasher pumps and lawn mower engines (Zane, Walls & Thvedt,1981) and to assemble circuit boards (Thvedt et al, 1984).

How a subject's aptitude may affect the choice of training is studied by Walls et al (1981). Subjects learned to assemble a bicycle brake, a meat grinder and a carburetor on three successive days by the three training methods in a counterbalanced order. Results showed a treatment by aptitude interaction. Subjects were divided into the fastest learning one-third, the middle learning one-third and the slowest learning one-third. The divisions of thirds were based on the number of trials to criterion. These trials were attempts at sequences or subsequences for chaining methods and the criterion was two correct consecutive trials, without error, within a three-minute time limit per trial. For the fastest learning subject, the whole task training produced a higher percentage of errors than either chaining method. Similar effects were found for slower learning subjects. Middle learning subjects showed less difference between training methods. Based on these results, aptitude should have an effect on choice of training method. It is also possible that other characteristics of the population may be important in choosing a training method.

Normal adult and child populations were also used in studying sequenced behavior. The number of studies, however, is not as large as the number of studies using the mentally disabled population. Examples include teaching adults to dive bomb (Bailey et al, 1980), developing space sextant sighting skills (Powers, 1973) as recorded in the military literature, teaching college students to play basketball as recorded in the sports literature (Chelladurai & Stohart, 1978) and teaching high school graduates to press keys as recorded in the psychology literature (Watters, in press; Weiss, 1978). Studies that involve teaching children a sequence of button pushes are found in the psychology literature (Vaughan, 1985).

The series of experiments to be reported will use an adult population. The intention is to uncover information that will be useful to this "normal adult" population. Further studies then could be developed to determine if this information applies to other populations.

Design Format

The literature contains within-subject and between-subject designs. An example of within-subject design is the multiple baseline crossover design used by Kayser et al (1986) when teaching subjects to make a snack and the within-subject design used by Weiss (1978) to teach a series of button pushes. In the experiment conducted by Kayser et al (1986), each subject received training on the same task using total task training and backward chaining for an individual predetermined number of sessions. Potential sequence effects were decreased by counterbalancing the introduction of treatment across subjects. A within-subject design was used by Weiss (1978) in teaching university students a sequence of button pushes. Ten students were taught four separate six-button sequences, two by forward chaining and two by backward chaining. Subjects were divided into two groups. Forward chaining was given to one group initially and backward chaining was given to the second group first.

A between-subject design was used by Wilcox (1974). Subjects were divided into nine groups (3X3) based on teaching method (forward chaining, backward chaining and whole task training) and length of sequence (short, medium and long). Subjects were taught two tasks: paperfolding and mathematical procedures. Nettlebeck and Kirby (1976) also used a between-subject design. Subjects were randomly assigned to three groups based on the three forms of training procedure. Training procedures consisted of pure-part method, progressive-part method and whole method.

Standard statistic texts such as Keppel (1982) state that a between-subject comparison shows a relative lack of sensitivity in detecting treatment effects when present due to variation between subjects. A within-subject design is more sensitive than a between-subject design as the variability is eliminated. In the following series of experiments each subject will learn by each of the three training methods in a within-subject comparison.

Proficiency Criteria

The proficiency criterion is an arbitrarily defined measure used to determine if a subject has mastered a task. In teaching human sequenced behavior there are two forms of proficiency criteria: a) the criterion used to end training and b) the criterion used to teach a new subsequence in the chaining methods.

The criterion used to end training is usually defined as a predetermined number of consecutive correct performances of the sequence of behaviors.

The criterion used to teach a new subsequence in the chaining methods (both forward and backward) is usually defined as a predetermined number of consecutive correct performances of the subsequences of behaviors. In chaining the sequence is given in subsequences. At the beginning of training, the subsequence consists of one behavior. Performance of this behavior must be mastered before the next behavior can be taught. A criterion must be set to determine when the next subsequence is taught. It may be a set number of consecutive correct performances of this subsequence. A proficiency criterion of two, for example, could be used. In this case, the subject would have to correctly perform the first subsequence (one behavior) twice consecutively before the next behavior is added. The subject would then have to perform correctly and consecutively the second subsequence (two behaviors) twice before the next subsequence is taught. Then the subject would have to perform correctly and consecutively the third subsequence (three behaviors) twice before the next subsequence is taught. This procedure continues until the subject has been taught the last subsequence which is the entire sequence. The proficiency criterion used in learning the entire sequence may, but does not have to be the same as the proficiency criterion used in the chaining procedures to determine when the next subsequence is taught. In the example, if the proficiency criteria are the same for whole sequence and subsequences then the subject must perform the entire sequence two consecutively correct times before he or she is considered to have mastered the sequence.

In most of the studies reviewed the criterion to end training is the same as the criterion to teach a new subsequence. Examples of different criteria range from one perfect trial (Wilcox, 1974) to three (Watters, 1989) to four (Nettlebeck & Kirby, 1976) to five (Deitz et al, 1986; Inglesfield & Crisp, 1985) to six (Kayser et al, 1986; Spooner, 1984). Walls et al (1981) include time by using a criterion of three consecutive correct trials within a three-minute time limit. Weiss (1978), however, used a criterion to teach a new subsequence of one and criterion to end training of ten.

Choice of proficiency criterion may affect results. The criterion used to teach a new subsequence in chaining procedures affects the rate of learning. For example, a high criterion used to teach a new subsequence in chaining procedures will slow the rate of learning (Spooner, 1984).

In our experiments, a criterion to teach a new subsequence of three consecutive correct performances is used. The criterion to end training is the same as the criterion to teach a new subsequence.

Dependent Variables

There is a great variety of dependent variables in the literature. In the following section, three dimensions of measurement recommended by Bellamy, Horner and Inman (1979) and one dimension, included for practicality, will be used to illustrate the variety in variables and problems in measurement. The first is a measure of accuracy. The second is the measure used to determine practicality of training methods. It is called total responses. The third is a measure of time taken to perform the task. The fourth is a measure of how well the task is retained over time.

In measuring accuracy, a problem occurs which involves errors defined as incorrect performances of component behaviors. One kind of error consists of incorrect responses made before a subject has correctly performed the component behavior once. Watters (1989) used the term "random error" to refer to an incorrect performance made before the subject had correctly performed the component behavior. These errors, made before the subject has made a correct response are partly a function of chance or guessing. Another type of error is made after a subject has correctly performed the component behavior once. An error partly due to chance may be considered less relevant in evaluating a training method. To solve this problem, Weiss (1978) used a measure of accuracy, the number of incorrect performances made after a subject has correctly performed the component behavior once. This type of error is important to use in evaluating the effectiveness of a training method, and is referred to as true errors. Total errors for a component behavior consisted of random errors plus true errors. Errors for a sequence of behaviors (either random, true or total, respectively) consisted of the sum of errors (either random, true or total, respectively) for each component behavior.

Bellamy et al (1979) indicated that accuracy only measures the efficacy of a training method not its efficiency. They indicated that even if a training method produces accurate results it may take too long to be of practical use. Similarily, total responses were included because a training method may produce accurate results but take too many total responses to be of practical use.

The second dimension is composed of total responses which involves all performances of a component behavior (both correct and incorrect). Total responses is a poor dependent variable to use to compare training methods because chaining methods inherently require more responses than whole task training. In chaining techniques the subject learns one behavior to a certain criterion, then two behaviors to a certain criterion, then three behaviors and so on. The sequence, for example, may consist of (1) four behaviors; (2) a criterion of three consecutive correct performances to teach a new subsequence and (3) a criterion to end training of three consecutive correct performances of the entire sequence. Assuming the subject makes no errors while performing the chaining procedures, he or she will perform the first subsequence (one behavior) three times for a total of three responses. He or she will then perform the second subsequence (two behaviors) three times for a total of six responses. Then he or she will perform the third subsequence (three behaviors) three times for a total of nine responses. Finally, he or she will perform the final subsequence or sequence (four behaviors) three times for a total of twelve responses. The total number of responses is thirty. In whole task training under similar conditions, the subject performs the sequence (four behaviors) three times. The total number of responses is twelve. Even though the subject has made no errors he will make more total responses by chaining techniques than by whole task training. An attempt to solve this problem resulted in the use of such derived measures as cumulative proportion of responses that are errors (Walls et al, 1981) and percentage of errors which is total errors divided by total number of trials (Deitz et al, 1986). For practical purposes, however, total responses are included to determine the usefulness of a training method.

Examples of measures involving time are (1) total training time, defined as time to learn a task by a specified training technique such as backward chaining or whole task training (Zane et al, 1981); (2) response latency defined as time between correct performance on a component behavior and attempt at performance on the next subsequent component behavior (Deitz et al, 1986); and (3) celeration, defined as the rate of learning in movements per minute (Spooner, 1984).

Measures of retention of the task over a period of time during which no practice takes place involves using the same dependent measures at both acquisition and reacquisition. Nettlebeck & Kirby (1976) used the dependent variables of a) number of trials to criterion (the criterion to end training was four successive correct performances of the entire sequence), b) number of errors, and c) time to criterion (time to learn the task to criterion). One month after having learned a sequence, the subjects attempted the sequence and if errors were made, relearned the task using whole task procedure. To determine how well the task had been retained, the same three measures were taken again. Hur (1986) examined the effectiveness of forward chaining and backward chaining in teaching corsage making skills to moderately and mildly retarded subjects. Retention over time was examined as a measure of maintenance of task.

Weber (1978) examined the effectiveness of forward and backward chaining in teaching educable mentally retarded adults to perform a sequenced motor task. Subjects were retested for retention approximately twenty hours after being instructed. Wilcox (1974) examined retention one week later in teaching university students paperfolding and numerical procedures by forward chaining, backward chaining and whole task training.

In the following series of experiments, all five forms of dependent variables (random errors, true errors, total error, total responses and time) will be determined. For accuracy, true errors are emphasized the most as mentioned earlier. Time and total responses to learn the task by each of the three training methods are measured to determine practicality of training method. Retention of task is not examined in the experiments. All dependent variables are measured and recorded by a computer.

Consequences Following an Incorrect Response

In teaching sequenced behavior, a question emerges regarding the consequences to be arranged following incorrect responses. The situation is fairly simple when a person performs a behavior correctly. Although extrinsic reinforcers could be given, usually the person continues on with the next behavior in the sequence. The situation is more complicated when a person performs the behavior incorrectly. The review of the literature did not reveal any studies comparing the effectiveness of different consequences following incorrect performances of component behaviors in the teaching of sequenced behavior by the three methods of training. Three of the following experiments will address this question. Consequences following errors will include: a) no programmed consequences (no programmed indications that an error has been made), b) programmed consequences (some form of indication that an error has been made), c) prompts (correcting the error), and d) time-out procedure. These consequences are used in conjunction with the three training methods.

The following section describes examples of consequences used in studies on human sequenced behavior. Evaluation of the effect of the different consequences is not possible due to variability in procedures, tasks, subjects, design format, proficiency criteria and dependent variables in studies reviewed. Of the studies discussed in this section, only the animal studies (Boren & Devine,1968; Redd, Sidman & Fletcher, 1974) directly examined the use of consequences resulting from incorrect performances of component behaviors in a sequence of behaviors. Methods of training in animal studies do not include the three training methods described.

No Programmed Consequences

Nettlebeck & Kirby (1976) used no programmed consequences in teaching mentally disabled females to thread a sewing machine. The task was demonstrated once by the experimenter, then carried out once by the subject with guidance by the experimenter. During learning trials, the subject did not receive any guidance or assistance. At the conclusion of each trial, incorrect responses were pointed out and the subject was guided once more through the correct procedure. If no error was made the next trial followed directly.

Programmed Consequences

Watters (1989) used programmed consequences to indicate that an incorrect response had been made. Subjects were made aware that an incorrect response occurred but were given no guidance in correcting the incorrect response. University students were taught a sequence of key presses each preceded by a unique visual symbol on a computer screen. When an error was made the computer emitted a "ZIT" sound and the program waited for the correct response to be made.

Prompts

Prompts are cues given by the trainer to help the learner perform the correct behavior (Walls et al, 1984). A prompt to facilitate performance of correct behaviors may be given (a) before a behavior is performed, or (b) if no response is made, after an incorrect response has been made. Prompts vary from minimal prompts such as verbal instructions to maximal prompts such as physical guidance.

Wilcox (1974) is an example of a study using prompts. The aim of the study was to investigate the effects and interactions of task type (numerical procedures and paper folding), sequence length (short, medium and long) and training method (forward chaining, backward chaining and whole task training). Female university students were randomly assigned to nine groups (3X3) defined by sequence length and training method.

Each subject was taught the two different tasks. For paperfolding, subjects were provided with paper sheets, an instructional book containing diagrams showing the stages of folding and one of three instructional flow charts depending on the chaining strategy to be practised. Subjects used the book to correct their own errors. In the numerical procedures, subjects were provided with an instructional booklet in which they inserted the result of each span of the calculation. A turn of the page revealed the correct answers. Prompts for each task were recorded as references back to respective books. The criterion to teach a new subsequence and end training consisted of one perfect trial (correct performance and no prompts needed from the book).

Weber (1978) used prompts in instructing mentally retarded adults to perform an object assembly task. Each time an error was made, the experimenter said "No, that's not quite right. Let me show you again," and then demonstrated the step once more before the subject tried again.

Walls et al (1981) used help and test trials in teaching object assembly tasks to mentally disabled adults. In help trials, as long as the subject made correct responses, the experimenter did not intervene. When the subject made an error in order of placement, the experimenter said, "No, try this one" and immediately grasped the subject's hand and placed it on the correct part. When the subject made an error in placement of a part, the experimenter said, "No, try it here," and immediately grasped the subject's hand and guided correct placement. Test trials consisted of the subject performing the task unassisted.

The timing of prompts (where in the training procedure they are presented) may be important. Walls et al (1984) taught various object assembly tasks to mentally disabled adults. Training methods consisted of forward chaining and whole task training. A baseline trial was given at initiation of training to ensure that the subject did not know the task. For the first trial in whole task training, subjects were instructed, "This time, watch me and do what I do." The experimenter then modeled placement of the first part, disassembled it, and had the subject match the response. The procedure was then reportec for the second and subsequent parts until the entire task was completed. Timing of prompts consisted of unlimited delay and progressive delay. Unlimited delay of prompts consisted of prompts being given only after an error was made with the subjects given as much time as necessary to respond. Prompts consisted of the experimenter saying "No" and modeling the correct response and then removing the part from the assembly and placing it back on the table. The subject was then required to make the correct response. With progressive delay of prompts, subjects were instructed "Anytime you are sure what comes next you can go ahead before I show you, but if you're not sure, wait for me to help you." On the second trial, the modeling prompt was delayed one second for each part. Timing began after the subject was told to "Begin" for the first part and after the word "Good" for the remaining parts. On the second trial the subject could respond before the prompt but rarely did because the delay was only one second. Before each new trial, the appropriate delay for each of the twelve parts was calculated by the experimenter. If an error occurred, one second was subtracted from the time delay allotted to that part for the next trial. If a correct response occurred before or after a preresponse prompt, one second was added to the time delay for that part on the next trial. If subjects were holding the correct part in their hands when the time elapsed, they were allowed to continue but if subjects were holding an incorrect part when the time elapsed they were stopped and the correct response was prompted. Similar methods were used for prompting in forward chaining except that the first trial consisted of the first part of the apparatus and a part was added only if a trial was completed without error. Other examples of studies using prompts are Kayser et al (1986) and Zane et al (1981) which are described under Guidance and Instruction section.

Time-out

Time-out is a predetermined period of time in which behaviors are not recorded, stimuli are removed and programmed consequences are not given. In some cases of time-out, any response during time-out may increase the duration of the time-out. In teaching a sequence of button pushes, for example, a period of time-out may be programmed when an incorrect button push is made. The antecedent screen stimulus is raised and any responses made during this period are not recorded. Usually there is no teaching and no performing of the sequence of behaviors by the subject during the time-out.

Time-out may or may not be followed by the restarting of training procedure from the beginning of the sequence. The following are examples of two different forms of time-out. Vaughan (1985) used the consequence of a two second buzzer followed by a two second time-out. At the end of the time-out, the subject could try to perform the same component behavior again until it was performed correctly. Any responses produced another two second time-out. The study examined the use of instruction in teaching children a sequence of behaviors (button pushes). Deitz et al (1986) used the consequence of time-out and restarting the sequence. University subjects were presented with a row of graphic characters in the wrong order. They were asked to figure out the correct order. Selections were made by touching the flashing blocks under the characters. Each block was touched one block at a time until all symbols were in correct order. An incorrect response was followed by RF (Response Feedback) and FIR (Feedback for Incorrect Responding). Response Feedback indicated that the computer registered a response. RF resulted in the block changing to an "x" for one second and changing back to a flashing block. With FIR, the trial was immediately terminated.

The screen went blank for two seconds after which the next trial began. The sequence was taught from the beginning and the subject had to attempt the first component behavior in the sequence and continue from the beginning of the sequence.

An example of the use of time-out as a consequence in the animal literature is provided by Boren and Devine (1968). They examined various durations of time-out (one second to four minutes) following errors in the acquisition of a new sequence of behaviors. Monkeys were trained to push three levers from a group of four. The largest number of errors occurred when there was no time-out. Any duration of time-out reduced errors substantially. The function decreased sharply from zero to one second and then appeared asymptotic from one to 240 seconds. Another animal study (Redd et al, 1974) showed that the use of time-out could result in the development of stereotyped errors. After the monkeys had learned the sequence by use of time-out, a new trial resulted in the monkeys making an error. When the sequence was taught so that an incorrect performance of the first component behavior did not produce time-out, monkeys ceased responding. Time-out became a reinforcer for errors.

Explicit Punishers

Punishment is based on "the principle that if in a given situation, somebody does something that is immediately followed by an aversive stimulus, that person is less likely to do the same thing again when she or he encounters a similar situation" (Martin & Pear, 1988 p. 187). Weiss (1978) made subjects lose points for incorrect responding. Weiss taught a sequence of button pushes to university students. They were taught two sequences by forward chaining and two sequences by backward chaining and received five points when making a response without error. Then, upon addition of a second behavior they received five points for performing the two behaviors without error. Then, upon addition of a third behavior they received five points for performing the three behaviors without error. This continued until all six behaviors were performed correctly. At the end of the sequence, they received five points if they performed the sequence without error. If a subject made an error a buzzer sounded and a point was lost. Ten sequences had to be performed without an error before a new sequence was taught. Subjects began the experiment with fifty points and were paid one penny for each three points they earned.

Extinction

Extinction occurs when a behavior is weakened as a result of being emitted without being reinforced. Positive reinforcement is based on "the principle that if in a given situation, somebody does something that is immediately followed by a positive reinforcer, the person is more likely to do the same thing when he or she encounters a similar situation" (Martin et al, 1988, p. 30). In human sequenced behavior, the subject is reinforced for performing a component behavior correctly. This results in an increased probability that the correct behavior wil be performed again. An incorrectly performed component behavior was not reinforced resulting in a decreased probability of an incorrect behavior being performed again.

For example, Kayser et al (1986) taught mentally disabled children to make a snack (peanut butter and crackers). A correct performance of each component behavior was reinforced with a small bite of the snack. Incorrect performances were extinguished because no food was given to eat.

Vaughan(1985) used a similar system in teaching children to push buttons. Correct button pushes resulted in points being given and incorrect button pushes resulted in no points being given. At the end of the session, the child exchanged points accumulated throughout the session for a small toy chosen from the reinforcement box.

The Role of Theory

These series of experiments are undertaken from an operant (ie. radical behaviorism) approach which is particularly associated with Skinner's work. Behavior is defined by Skinner (1938) as "what an organism is doing or more accurately - what it is observed by another organism to be doing. This is not just any action by the organism but the organism acting upon or with the outside world" (Skinner, 1938, p.6). A behavior "is the movement of an organism or of its parts in a frame of reference provided by the organism itself or by various external objects" (Skinner 1938, p.6). Skinner (1938) identified two classes of behaviors, respondent and operant, on the basis of their origin.

The first class of behaviors, respondents, are elicited by specific stimuli. In the environment, an external object or event is traditionally called a "stimulus" and the correlated behavior is called the "response". The observed relation is known as a reflex. Given the stimulus, the response occurs automatically. For example, food in the mouth (unconditioned stimulus) is correlated with a dog salivating (unconditioned response). In respondent conditioning, a neutral stimulus (for example, the sound of rock music) is followed closely in time by the unconditioned stimulus (food in the mouth). Then, the previously neutral stimulus will tend to elicit the response of salivation in the future. If the salivation response was, in fact, conditioned to the sound of rock music, the stimulus-response relationship would be referred to as a conditioned reflex. The stimulus in a conditioned reflex is called a conditioned stimulus (the sound of rock music) and the response is called a conditioned response (dog salivating) (Martin & Pear, 1988).

Skinner maintains that the second class, operant behavior, makes up the majority of behavior (Hill, 1990). Operants do not require eliciting stimuli. They are said to be emitted rather than elicited. This does not mean the behavior is uncaused, but that there are other causes of behavior besides eliciting stimuli. The learning of operant behavior is also called conditioning but it is different from respondent or classical conditioning. Operant conditioning is the same sort of learning described by Thorndike's law of effect (Hill, 1990). If an operant occurs and is followed by reinforcement; probability of reoccurrence increases. For reflexes the reinforcer is an unconditioned stimulus, for operants it is a reward.

When a stimulus sets the occasion for a response which will result in a particular consequence, the stimulus is said to be discriminative. If a response comes under control of this stimulus, the response is called a discriminated operant. Both respondents and discriminative operants involve an antecedent stimulus but the distinction between the two depends on the consequences. A response that depends on the presentation of a stimulus is a member of the respondent class. One that depends on the relations among the three terms - stimulus, response, and consequence - is a member of a discriminated operant class. Discriminated operants are said to be defined by this "three-term contingency" (Skinner, 1984a).

Whereas a respondent is usually an easily identified bit of behavior, it is sometimes less clear where one operant stops and another starts. If a series of operants must occur in a particular sequence to obtain reinforcement, they become organized in a chain. Similarily, reflexes do not usually occur alone either and also become organized in chains.

To further examine this concept of chaining, an example of getting a drink of water will be used. Getting a drink of water involves going to the cupboard, opening the cupboard, taking out a glass, turning on the faucet, filling the glass with water, raising it to the mouth and drinking it. This chain is made up of many operant responses, yet in another sense it functions as a simple operant. The whole chain begins to have the characteristics of a single operant, since the whole chain is the response that is reinforced. If at any point the chain is broken (no glass or the faucet is broken), the whole chain up to that point will undergo extinction (Hill, 1990). However, Skinner (1938) also indicated that a chain of reflexes is not a "chained reflex". The connections between parts are purely mechanical and may be broken at will. Any section of the chain may be elicited in isolation with the same properties which characterize it as part of a total chain.

Skinner (1938) defined a Law of Chaining as "the responses of one reflex may constitute or produce the eliciting or discriminative stimulus of another"(Skinner, 1938, p. 32). A discriminative stimulus is an antecedent event or stimulus which signals that a certain response will be reinforced. Reinforcement increases the probability of a response occuring again under similar circumstances. After an event becomes a discriminative stimulus by being paired with a reinforcer its presence can increase the probability that the response will occur. The stimuli may be proprioceptive, for example, serial action of throwing a ball, or produced externally by a change in position of receptors (for example when an organism moves to the right responding to a visual stimulus).

In chaining, a behavior may function as a discriminative stimulus, behavior and reinforcer. Sulzer-Alzoroff and Mayer (1977) stated, "Each behavior in a chain, then, has a dual stimulus function. Each reinforces the behavior that it follows and each serves as a discriminative stimulus to occasion the behavior that precedes it." (Sulzer-Alzoroff et al ,1977, p.238).

To further clarify how a behavior may function in three different ways, reinforcement will be discussed in the following section. Stimuli whose reinforcing power is biologically determined are called primary reinforcers. The water in our example is a primary reinforcer. Conditioned reinforcers are stimuli that are not originally reinforcing but acquire reinforcing power through association with other reinforcers (Martin & Pear, 1988). For example, in our chain raising the glass full of water to our mouth becomes a conditioned reinforcer because of its association with the primary reinforcer of drinking water.

Backward chaining has been recommended as a technique for human learning because it allows the learner to receive reinforcement numerous times while learning the subsequences of the sequence. Gilbert's (1962a, 1962b) technology of learning called "mathetics" is a systematic approach to the design of learning materials involving sequences of behaviors. It is based on the theoretical framework of operant conditioning. "Mathetics" is based on the concept that reinforcement should be provided to the student as he or she is attempting to learn new material.

In the above example, the response of "drinking water" was reinforcing "the raising of the glass to the mouth" which is also a discriminative stimulus for "drinking water". Thus, in backward chaining the power of the positive reinforcer,"drinking water" is used in each subsequence. For example, subsequence eight is "drinking water"; subsequence seven is "raising of the glass to the mouth, drinking water" and subsequence six is "filling the glass with water, raising of the glass to the mouth, drinking water".

In the following experiments, each discriminated operant consists of a discriminated stimulus (symbol on the screen), response (key press) and consequence. Positive reinforcers are often pleasant and increase the probability of a response. In the following experiment, an example of a positive reinforcer could be the 100% score appearing on the screen. It should be noted that reinforcers may differ with the individual. Chocolate cake is a positive reinforcer for a chocoholic and may act as a punisher for an individual who is allergic to chocolate.

In keeping with the premises of radical behaviorism, this dissertation is basically atheoretical. It uses Skinner's definition of theory which is "any explanation of an observed fact which appeals to events taking place somewhere else, at some other level of observation, described in different terms and measured, if at all, in different dimensions" (Skinner,1984b,p .517).

Skinner (1938) is primarily concerned about using intervening variables such as those found in the theories of connectionism and in the theories of cognitive psychology. Connectionism is the view that learning is the forming and changing of connections (such as stimuli and responses) which are assumed to represent connections in the nervous system. For a connectionist, a response may be any item of behavior, while a stimulus may be any input of energy that tends to affect behavior. The connections, which are a simple kind of intervening variable, are often called habits or stimulus-response bonds (Hill, 1990). Cognitive interpretations are concerned with the cognitions (perceptions, attitudes or beliefs, which are more complex intervening variables) that individuals have about their environment, and with the ways these cognitions determine behavior (Hill, 1990).

Skinner does not argue whether these theories can be useful to science but whether they are necessary. If the answer is no, as he maintains, then the question is why use them as they can be problematic. This is the basis to his argument against theory in the field of learning. Theories - whether connectionist or cognitive - talk about intervening variables. When a behavior is attributed to neural or cognitive events, real or conceptual, scientists are likely to forget that they must still undertake the task of accounting for the neural or mental event. This often results in scientists using theory to answer questions which might be better answered through further empirical study. Skinner argues that "the principal function of learning theory to date has been, not to suggest appropriate research, but to create a false sense of security, an unwarranted satisfaction with the status quo" (Skinner, 1984b, p. 517).

It is claimed that productive research requires a theory otherwise it is aimless and disorganized. Yet a theory that generates research does not prove its value unless the research is valuable. According to Skinner, in psychology, much useless experimentation results from theories because most theories are overthrown and the greater part of the associated research is discarded. The view that productive research requires a theory is supported by psychological texts (Hill, 1990) which base their views on logicians rather than empirical science and describe thinking as involving stages of hypothesis, deduction, experimental test and confirmation. It should be emphasized that when Skinner speaks of theory he is not referring to basic assumptions. He considers certain basic assumptions to be essential to any scientific activity (Skinner, 1984b). This dissertation makes basic assumptions about stimuli, responses and reinforcement.

As illustrated by the examples given in this introduction, the literature in sequenced behavior has such tremendous variation in dependent variables, procedures, tasks, subjects and others that an overarching systematization is not possible. This dissertation presents a series of empirical studies investigating the teaching of sequences of behaviors. In the following experiments, theory as defined by Skinner (1984b) will not be used. However, the research is not aimless and disorganized. It consists of a series of overlapping experiments. The purpose of each experiment is clearly stated without emphasizing intervening variables.

Chapter Two

Experiment 1

This first experiment utilizes three different consequences to be given following an incorrect response in relation to the three training methods of forward chaining, backward chaining, and whole task training.

The first consequence has been standardly used in Watter's (1989; in press) series of experiments. It is an auditory programmed consequence consisting of a "ZIT" sound following an incorrect response. With this arrangement, it is possible for the subject to learn the task without looking at the screen. The second programmed consequence is a visual programmed consequence. The screen border changes color when an incorrect response is made. This could increase the probability that the individual would look at the screen, and screen stimuli, thus producing fewer true errors, total responses, and total responses and less training time. The third consequence is minimal programmed consequence. The individual is made aware that he or she has made an error because the computer does not continue with the program but waits for the individual to make a correct response. This waiting period is also included as part of the other two programmed consequences. The subject has to look to the screen to determine whether the screen stimulus stays the same indicating an incorrect response has been made or whether the stimulus changes or a new subsequence begins indicating a correct response has been made. It is hypothesized that the increased probability of looking at the screen could result in fewer true errors, total responses and training time.

Method

Subjects

Fifty-four subjects (37 female and 17 male) were obtained informally and by classroom recruitment at the University of Ottawa. They were volunteers with a minimum education of grade 12. Ages ranged from 19 to 43 with a mean of 26.9 and median of 27 years.

Apparatus

In the lab the subject sat at one end of a table. A Commodore 64 keyboard was situated on the table in front of and facing the subject. There was a 12 inch (29 cm) diagonal color monitor behind the keyboard. Behind that a cardboard screen blocked the subject's view of the cassette recorder memory, the printer, and the rest of the room. The keyboard was covered by a cardboard mask so that only eight response keys (f,g,h,j,v,b,n,m) were showing. These eight keys, in differing orders, were involved in each of the three sequences taught to each subject. The keys were covered with masking tape so that they could not be identified. A unique visual symbol presented on the monitor screen preceded each key press. The symbols were Commodore graphic characters (eg,"X","%","*") presented in light blue type (6 millimetres high) located at the centre of the screen. The monitor was operating in a blue monochrome mode. In this mode, the screen was blue with a light blue border, 2.5 centimetres wide and the characters were the same color as the border surrounding it. Programs running on the Commodore 64 computer presented the screen symbols in the appropriate order and presented the auditory stimuli. Training of a sequence or subsequence started when the computer emitted a "boing" sound, and a symbol appeared on the screen. The individual's response consisted of a key press. A sequence consisted of eight key presses each preceded by a unique visual symbol. Correct responses, incorrect responses and time to learn the sequence were recorded by the computer. They were printed after each sequence was learned. During the experiment the room was dimly lit by a light in the far corner of the room to eliminate reflections from the computer monitor.

Procedure

The subjects were randomly assigned to three groups based on three forms of consequences resulting from making an incorrect response: auditory programmed consequences, visual programmed consequences and minimal programmed consequences. Auditory programmed consequences consisted of a "ZIT" sound. Visual programmed consequences consisted of the screen border changing colour from light blue to black and back again. The flick of the screen border was of the same duration as the "ZIT" sound. Minimal programmed consequences consisted of no change. In all three conditions, the symbol remained unchanged until the correct response was made. If an incorrect key was held down, auditory or visual programmed consequences occured every 0.46 seconds. For the minimal programmed consequence, holding down the key produced no perceptible effect. Under all three conditions, if an incorrect key was held down (subjects did this very rarely), the computer recorded an error every 0.46 seconds. Correct responses were treated the same under the three conditions: The symbol changed to the next symbol. Instructions to the subject clearly indicated the form of consequences for an incorrect response (see Appendix A).

Each subject learned three separate sequences one by forward chaining, one by backward chaining and one by whole task training. The instructions (see Appendix A) indicated that the task would be taught in parts or all at once. Subjects were not told that the symbols were presented in a forward and backward order. One third of the subjects started by learning a sequence by forward chaining, one third of the subjects started by learning a sequence by backward chaining, and one third of the subjects started by learning a sequence by whole task training. Subsequent training order was randomized. See Appendix C for examples of sequences used.

Both forward and backward chaining involved slowly building up the sequence, starting with a subsequence of one key press preceded by a unique screen symbol; then a subsequence of two and then a subsequence of three until a full sequence of eight keypresses each preceded by a unique screen symbol was learned. Forward chaining began with presentation of the first symbol; then the first symbol, and second symbol; then the first symbol, second symbol, third symbol, and so forth. Backward chaining began with presentation of the last symbol; then the second last symbol and the last symbol; then the third last symbol, second last symbol, and the last symbol and so forth. With each subsequence a criterion of three consecutive errorless performances had to be met before the next key press (preceded by a unique screen symbol) was added. Whole task training consisted of presentation of the first symbol then the second symbol, then the third symbol and so on until all eight symbols had been presented. Because whole task training always involved the entire sequence of eight key presses each preceded by a unique screen symbol, there were no subsequences. For all three training methods, the criterion to end training was three consecutive correct performances of the entire sequence of eight keypresses for all three training methods.

Subjects came individually to the lab. The subject was seated on a chair in front of the keyboard and monitor and the experimenter read the instructions (see Appendix A). After an informed consent was signed the experiment began. The experimenter turned off the main room lights, started the computer and went into the adjoining room, closing the door.

For all training procedures, training of a subsequence or full sequence started with a "boing" sound. Then a screen symbol was presented. The subject responded with a key press. The consequences for an incorrect key press depended upon the treatment group to which the subject was assigned. When the subject had worked to the end of a subsequence or full sequence, the percent score was printed on the screen. When three consecutive correct performances of the entire sequence of eight key presses (each preceded by a unique screen symbol) had been attained, the printer started and the experimenter entered the room and engaged the subject in light conversation while the data were being printed. Then the experimenter started up the program to teach the next sequence and left the room again. At the end of the experiment when the subjects had been taught by the three different training methods, they were asked a series of questions (see Appendix B) examining how they perceived the sequences were taught and the strategies they employed in learning the sequences.

Experimental Design

The experiment had a within-subject component and between-subject component. The within-subject component consisted of the the three training methods: forward chaining, backward chaining, and whole task training. The between-subject component consisted of three forms of consequences given following an incorrect response: auditory programmed consequences, visual programmed consequences, and minimal programmed consequences. Dependent variables included (a) number of true errors (incorrect responses made after the first correct performance of each respective key press), (b) number of random errors (incorrect responses made before the first correct performance of each respective key press), (c) number of total errors (random plus true errors) (d) number of total responses (incorrect plus correct responses) and (e) time to learn sequence to criterion.

Results

Bartlett-Box F test of homogeneity of variance was conducted on each dependent variable. The assumption of homogeneity of variance was invalidated for most dependent variables. Parametric statistics were not used because they are based on the assumption of homogeneity of variance. Nonparametric tests were conducted because these tests make less stringent assumptions about population distributions (Seigel, 1956). See Appendix D for the Bartlett-Box F test of homogeneity of variance for each dependent variable. The Friedman Two-Way analysis of variance was used as an overall test for the within-subject comparison. The Wilcoxan Matched Pairs Signed Ranks test was used for the follow up tests. The Kruskal-Wallis test was used as an overall test for the between-subject comparison. The Mann-Whitney U Test was used for the follow up tests.

An alpha level of .01 was used to determine significant results (Howell, 1989). Due to the large number of comparisons being made, it is possible to have an effect due to chance. A stringent alpha of .01 was used to decrease this possibility and increase the likelihood of finding valid differences between experimental conditions (Howell, 1989).

See Appendix E for means, medians and standard deviations for each dependent variable listed below. See Appendix F for the detailed nonparametric analysis that are summarized below.

In the following discussion, the "ZIT" consequence represents the auditory programmed consequence of "ZIT"sound; the "MIN" consequence represents the minimal programmed consequence and the "SCR" consequence represents the visual programmed consequence of the screen border changing colour.

<u>Dependent Variable - True Errors</u>

Median true errors for sequences learned by each training procedure using the "ZIT" consequence are presented in Figure 1. There were significant differences between the training procedures ($X^2 = 14.2500$, df = 2, p = 0.0003). Whole task training produced more true errors than forward chaining (Z = -3.6582, p= .0003) or backward chaining (z = -2.6783, p = .0074). True errors for forward chaining and backward did not differ significantly.

Median true errors for sequences learned by each training procedure under the "MIN" consequence are presented in Figure 2. For the "MIN" consequence, there were significant differences between training procedures ($X^2 = 13.3616$, df =2, p = .0013). Whole task training produced significantly more true errors than forward chaining (Z = -3.1025, p = .0019) or backward chaining (Z = -2.3269, p = .0200). True errors for forward chaining and backward chaining did not differ significantly.

Median true errors for sequences learned by each training procedure under the "SCR" consequence are presented in Figure 3. The training procedures differed significantly ($X^2 = 14.778$, df = 2, p = .0006). Whole task training produced significantly more true errors than forward chaining (Z = -2.8440, p = .0045). At an alpha of .05, whole task training produced more true errors than backward chaining (Z = -2.4824, p = .0131). These results show the same pattern of whole task training producing more true errors than both chaining methods that was shown with the other two consequences. True errors for forward chaining and backward chaining did not differ significantly.

For the "ZIT" consequence, fourteen out of eighteen subjects produced more true errors in whole task training than both in forward chaining and backward chaining. For the "MIN" consequence, fourteen out of eighteen subjects produced more true errors on whole task training than both forward chaining and backward chaining. For the "SCR" consequence, eleven out of eighteen subjects produced more true errors on whole task training than both chaining methods. In total, thirty-nine out of fifty-four subjects produced more errors using whole task training than each of the chaining methods of forward chaining and backward chaining.

For forward chaining, no significant differences were found in true errors between the groups receiving the three different consequences (X^2 = 6.7666, df =2, p = .0339). For backward chaining, there were no significant differences between the groups receiving the three different consequences (X^2 = 2.5400, df = 2, p = .2808). For whole task training, there were no signficant differences between the groups receiving the three different consequences (X^2 = 1.9365, df = 2, p = .3798).

Dependent Variable - Random Errors

Median random errors for sequences learned by each training procedure under the "ZIT" consequence are found in Figure 4. The training procedures did not differ significantly (X^2 = 6.0278, df = 2, p = .0491).

Median random errors for sequences learned by each training procedure under the "MIN" consequence are found in Figure 5. The training procedures did not differ significantly (X^2 = 8.6944, df =2, p = .0129).

Median random errors for sequences learned by each training procedure under the "SCR" consequence are found in Figure 6. The training procedures did not differ significantly (X^2 = 3.111, df = 2, p = .2111).

For forward chaining, there were no significant differences between the groups receiving the three different consequences (X^2= 1.6793, df = 2, p = .4319). For backward chaining, there were no significant differences between the groups receiving the three different consequences (X^2 = 1.8103, df = 2, p = .4045). For whole task training, there were no significant differences between the groups receiving the three different consequences (X^2 = 7.2923, df =2, p = .0261).

Dependent Variable - Total Errors

Median total errors for sequences learned by each training procedure under the "ZIT" consequence are presented in Figure 7. For the "ZIT" consequence, the training procedures differed significantly (X^2 = 17.4444, df = 2, p = .0002). Whole task training produced significantly more total errors than forward chaining (Z = -3.6582, p = .0003) and backward chaining (Z = -2.7923, p = .0052). Total errors for forward chaining and backward chaining did not differ significantly.

Median total errors for sequences learned by each training procedure under the "MIN" consequence are presented in Figure 8. There were significant differences between training procedures (X^2 = 12.4444, df =2, p = .0020). Whole task training produced more total errors than forward chaining (Z = -3.2227, p = .00013) and backward chaining (Z =-2.6566, p = .0079). Total errors for forward chaining and backward chaining did not differ significantly.

Median total errors for training procedures under the "SCR" consequence are presented in Figure 9. There were significant differences for training procedures (X^2 = 10.111, df =2, p = .0064). Whole task training produced significantly more total errors than forward chaining (Z = -2.5477, p = .0108). No other differences were significant.

For forward chaining, there were no significant differences between the groups receiving the three different consequences (X^2 = 4.6820, df = 2, p = .0962). For backward chaining, there were no significant differences between the groups receiving the three different consequences (X^2 = 3.7024, df = 2, p = .1570). For whole task training, there were no significant differences between the groups receiving the three different consequences (X^2 = 4.5622, df = 2, p = .1022).

Dependent Variable - Total Responses

Median total responses for sequences learned under the "ZIT" consequence are presented in Figure 10. There were significant differences between training procedures (X^2 = 20.1111, df = 2, p < .0000). Whole task training produced significantly fewer total responses than forward chaining (Z = -2.4824, p = .0131) and backward chaining (Z = -2.9396, p = .0033). No other differences were significant.

Median total responses for sequences learned under the "MIN" consequence are presented in Figure 11. There were significant differences between training procedures (X^2 = 12.4444, df = 2, p = .002). Whole task training produced significantly fewer total responses than forward chaining (Z = -2.1122, p = 0.0347) and backward chaining (Z = -2.0033, p = .0451). There was no significant differences between forward chaining and backward chaining.

Median total responses for training procedures under the "SCR" consequence are presented in Figure 12. For the 'SCR' consequence, there were significant differences between training procedures (X^2 = 18.0833, df = 2, p = .0001). Whole task training produced significantly fewer total responses than backward chaining (Z = -2.8961, p = .0038). No other differences were significant.

For forward chaining, there were no significant differences between the groups receiving the three different consequences. (X^2 = 6.7129, df =2, p = .0349). For backward chaining, there were no significant differences between the groups receiving the three different consequences (X^2 = 8.2509, df =2, p = .0162). For whole task training, there were no significant differences between the groups receiving the three different consequences (X^2 = 5.4313, df =2, p = .0661).

Dependent Variable - Time

Median time in seconds to learn the sequence to criterion by the training procedures under the "ZIT" consequence are presented in Figure 13. There were significant differences between training procedures (X^2 = 19.111, df = 2, p = .0001). Whole task training took significantly less time than backward chaining (Z = -2.9832, p = 0.0029). There were no other significant differences.

Median time in seconds to learn the sequence to criterion by the training procedures under the "MIN" consequence are presented in Figure 14. There were significant differences between training procedures (X^2 = 12.3333, df = 2, p = 0.0021). Whole task training took significantly less time than backward chaining (Z = -1.7207, p = .0854). No other differences were significant.

Median time in seconds to learn the sequence to criterion by the training procedures under the "SCR" consequence are presented in Figure 15. There were significant differences between training procedures (X^2 = 21.7778, df = 2, p < .0000). Whole task training took significantly less time than backward chaining (Z = -3.0267, p = 0.0279). Forward chaining took significantly less time than backward chaining (Z = -2.6783, p = 0.0074). No other differences were significant.

For forward chaining, there were no significant differences between the groups receiving the three different consequences (X^2 = 3.0231, p = .2206). For backward chaining, there were no significant differences between the groups receiving the three different consequences (X^2 = 1.7911, p = .4084). For whole task training, there were no significant differences between the groups receiving the three different consequences (X^2 = 1.0188, df= 2, p=.6009).

Summary of Post Experiment Questionnaire Data

See Appendix B for questionnaire and scoring procedures. See Appendix G for post experiment questionnaire data.

The questionnaire data revealed no significant differences between groups for consequences or between training procedures for recall of order of key presses or symbol preceding each respective key press. Results showed that whether subjects were aware of differences in training procedures or not did not affect performance as measured by true errors. True errors were used as the measure of accuracy, as discussed previously, because random errors are due to chance and total errors are the sum of random errors and true errors.

Discussion

In this experiment and the following experiments, the emphasis is on the dependent variable of true errors as a measure of accuracy. This is similar to Weiss (1978). Less emphasis is placed on random errors because they are partially a function of chance and total errors which is the sum of true errors and random errors.

Total responses and time are mentioned for practical interest. For example, even though a particular training method produces few true errors, if it takes a long period of time or a large number of total responses, it may be impractical to use.

The results indicated that none of the consequences (auditory programmed consequence, visual programmed consequence, and minimal programmed consequence) arranged to follow incorrect responses affected performance. Therefore, whether the consequence following an incorrect response affected the subject's probability of looking at the screen did not affect the accuracy or practicality of the training method.

Under all three consequences, forward chaining produced signficantly less true errors than whole task training. For the "ZIT" consequence, both forward and backward chaining produced significantly fewer true errrors than whole task training. For the other consequences (MIN and SCR), although backward chaining did not produce significantly less true errors than whole task training at alpha = .01, it did at alpha = .05. The rank ordering of medians for true errors from least to greatest for all three consequences was forward chaining, backward chaining and whole task training. The evidence indicates that chaining methods produce less true errors than whole task training.

For total responses, as discussed in the introduction, the chaining methods produce a greater number of total responses due to the use of subsequences and criterion to teach a new subsequence which are not used in whole task training. However, in this experiment only backward chaining produced more total responses than whole task training. Forward chaining did not produce significantly more total responses or take more time than whole task training. A possible explanation for the results is that forward chaining produced less true errors than whole task training.

From a practical standpoint, forward chaining seemed the most useful technique because it produced fewer true errors than whole task training, but it took the same number of total responses and time to criterion. The recommendation from a practical standpoint to use backward chaining had less support. Although, there is little difference in true errors produced by the two chaining methods, backward chaining rank ordered greater for true errors than forward chaining for all consequences and took more total responses and time for some consequences than whole task training.

Whole task training was the poorest choice, producing the most true errors. However, from a practical stance, it did take the same amount of time and number of total responses as forward chaining.

Chapter Three

Experiment 2

The following experiment compared two more types of consequences following an error. The first consequence is the standard auditory programmed consequence "ZIT" used in Experiment 1 and Watter's experiments (1989; in press). This was used to replicate the auditory programmed consequence "ZIT" used in experiment 1 and as a comparison to the other consequence used in this experiment. For reference, "ZIT-2" will be used to refer to results found under the auditory programmed consequence used in the second experiment (which is identical to the first experiment) and "ZIT" will be used to refer to the auditory consequence used in the first experiment. In the first experiment, for the auditory programmed consequence, whole task training produced more true errors than each of the chaining methods of forward chaining and backward chaining. The results of Experiment 1 revealed that the three consequences of auditory, visual, and minimal programmed consequences following an incorrect response had minimal effect on the three training procedures of forward chaining, backward chaining, and whole task training. The rank ordering for median true errors for all consequences from least to greatest was forward chaining, backward chaining, and whole task training. Forward chaining and backward chaining, respectively, produced fewer true errors than whole task training.

The second programmed consequence following an incorrect response is the prompt. The prompt programmed consequence consisted of a diagram of the eight buttons on the screen indicating the correct button to press. See the prompt section in the introduction for further explanation on prompts. It could be hypothesized that since this consequence literally tells the subject what key to press that it should improve the learning of sequences compared to the "standard" auditory programmed consequence "ZIT". Therefore, the group receiving the prompt programmed consequence should produce less true errors, and take fewer total responses and less time than the auditory programmed consequence.

Method

Subjects

Thirty-six subjects (11 male and 25 female) were obtained informally and by classroom recruitment at University of Ottawa. The subjects were volunteers with a minimum education of grade 12. Ages ranged from 18 years to 41 years with a mean of 23.6 years and a median of 20 years.

Apparatus

The apparatus was identical to that used in experiment 1.

Procedure

The subjects were randomly assigned to two groups based on two forms of programmed consequences which followed an incorrect response: auditory programmed consequence and a prompt programmed consequence. The auditory programmed consequence was identical to Experiment 1. It consisted of a "Zit" sound and the computer waited until the subject made the correct button press. The prompt programmed consequence consisted of a facsimile of the eight buttons on the screen with the correct button to be pressed flashing and instructions at the top of the screen stating "PUSH THE FLASHING BUTTON". In both programmed consequences, the symbol remained on the screen unchanged until the correct response was made. Each subject learned three sequences: one by forward chaining, one by backward chaining and one by whole task training. The rest of the procedure was similar to Experiment 1. See Appendix A for instructions. See Appendix B for the post experiment questionnaire.

Experimental Design

The experiment had a within-subject component and a between-subject component. The within-subject component compared the three training methods (forward chaining, backward chaining and whole task training). The between-subject component compared the two forms of consequences of prompt programmed consequences and auditory programmed consequence. Dependent variables were (a) true errors (b) random errors (c) total errors (random errors plus true errors) (d) total responses and (e) time to learn sequence to criterion in seconds. These were the same dependent variables used in Experiment 1.

Results

A Bartlett-Box F test of homogeneity of variance was done on each dependent variable (see Appendix H). For most dependent variables under these experimental conditions, the assumption of homogeneity of variance was found to be invalid. Nonparametric tests were conducted because these tests make less stringent assumptions about population distributions (Seigel, 1956). The Friedman Two-way analysis of variance was used as an overall test for the within-subject component. The Wilcoxan Matched Pairs Signed Ranks Test was used for the follow-up tests. The Mann-Whitney U test was used as the overall test for the between-subject comparison.

See Appendix I for means, medians, and standard deviations for the following results. See Appendix J for the details of the nonparametric statistical tests summarized in the following results. A stringent alpha level of .01 was used to determine the significantness of results (Howell, 1989).

In the following discussion, "ZIT-2" refers to results under the visual programmed consequence "ZIT" used in experiment 2 and "PROMPT" refers to the prompt programmed consequence.

Dependent Variable - True Errors

Median true errors for each training procedure under the "ZIT-2" consequence are presented in Figure 16. There were significant differences between training methods (X^2 = 18.0833, df = 2, p = .0001). Whole task training produced more true errors than forward chaining (Z = -3.3094, p = .0009) and backward chaining (Z = -2.6889, p = .0072). Forward chaining produced fewer true errors than backward chaining (Z = -3.1238, p= .0018).

Median true errors for the training procedures under the "PROMPT" consequence are presented in Figure 17. There were significant differences between training methods (X^2 = 10.0278, df =2, p =.0066). Whole task training produced significantly more true errors than forward chaining (Z = -3.0250, p = .0025). Whole task training produced significantly more true errors than backward chaining at alpha = .05 (Z = -2.5563, p =.0106). This is consistent with the pattern of the chaining methods producing less true errors than whole task training established in Experiment 1 and Watters (1989). No other differences were significant.

For the standard auditory consequence "ZIT-2" following an incorrect response, eleven out of eighteen subjects produced fewer true errors on forward chaining and backward chaining, respectively, than whole task training. For the prompt programmed consequence, twelve out of eighteen subjects produced fewer true errors on forward chaining and backward chaining than whole task training. In total, twenty-three out of thirty-six subjects produced fewer true errors on forward chaining and backward chaining than whole task training.

For forward chaining, there were no statistically significant differences between the two groups receiving different consequences ($Z = -.4432$, $p = .6576$). For backward chaining, there were no differences between the two groups receiving different consequences ($Z = -1.1910$ $p = .2337$). For whole task training, there were no differences between the two groups receiving different consequences ($Z = -4122$, $p = .6802$).

Dependent Variable - Random Errors

Median random errors for training procedures under the "ZIT-2" consequence are presented in Figure 18. There were no significant differences between training procedures ($X^2 = 6.3612$, $p = .0416$).

Median random errors for training procedures under the "PROMPT" consequence are presented in Figure 19. There were no significant differences between training procedure ($X^2 = 1.000$, $df = 2$, $p = 0.6065$).

Median random errors for the two groups receiving different consequences for forward chaining were significantly different. The group receiving the "ZIT-2" consequence produced more random errors than the group receiving the "PROMPT" consequence ($Z = -4.1330$, $p < .0000$).

Median random errors for the two groups receiving different consequences for backward chaining were significantly different. The group receiving the "ZIT-2" consequence produced more random errors than the group receiving than the "PROMPT" consequence ($Z = -5.1982$, $p < .0000$).

Median random errors for the two groups receiving different consequences for whole task training were signficantly different. The group receiving the "ZIT-2" consequence produced more random than the group receiving the "PROMPT" consequence ($Z = -5.0997$, $p < .0000$).

Dependent Variable - Total Errors

Median total errors for training procedures under the "ZIT-2" are presented in Figure 20. There were significant differences between training methods ($X^2 = 16.3333$, $df = 2$, $p = .0003$). Whole task training produced more total errors than forward chaining ($Z = -3.4187$, $p = .0006$). There were no other significant differences.

Median total errors for training procedures under the "PROMPT" are presented in Figure 21. There were no significant differences between training methods ($X^2 = 6.0278$, $df = 2$, $p = .0491$)

For forward chaining, the group receiving the "ZIT-2" consequence produced more total errors than the "PROMPT" consequence ($Z = -3.5696$, $p = .0004$). For backward chaining, the "Zit-2" consequence produced more total errors than the "PROMPT" consequence($Z = -4.3839$, $p < .0000$). For whole task training, the group receiving the "ZIT-2" consequence produced more total errors than the than the "PROMPT" consequence ($Z = -2.1059$, $p = .0352$.). (Because the differences found in the two chaining methods are primarily due to differences in random errors, they are not referred to in the discussion.)

Dependent Variable - Total Responses

Median total responses for the training procedures under the "ZIT-2" consequence are presented in Figure 22. There were significant differences between training procedures ($X^2 = 13$, $df = 2$, $p = .0015$). Whole task training produced fewer total responses than forward chaining ($Z = -2.9179$, $p = .0035$) and backward chaining ($Z = -3.0703$, $p = .0021$). Forward chaining and backward chaining did not differ significantly.

Median total responses for the training procedures under the "PROMPT" consequence are presented in Figure 23. There were significant differences for training methods (X^2 = 16.7777, df =2, p=.0002). Whole task training produced significantly less total responses than forward chaining (Z = -3.2445, p = .0012) and backward chaining (Z= -3.1574, p =.0016). Forward chaining and backward chaining did not differ significantly.

For forward chaining, there were no significant differences between groups receiving the two different consequences (Z = -1.7257, p =.0844). For backward chaining, there were no significant differences between groups receiving different consequences (Z = - 1.4243, p =.1544). For whole task training, there were no significant differences between groups receiving different consequences (Z = -0.9182, p =.3585).

Dependent Variable - Time

Median time to criterion in seconds for the training procedures under the "ZIT-2" consequence are presented in Figure 24. There were no significant differences between training procedures (X^2 = 17.4443, df =2, p =.0002). Whole task training took significantly less time than forward chaining (Z = -2.9396, p = .0033) and backward chaining (Z = -3.3752, p =.0007). Forward chaining took significantly less time than backward chaining (Z = -2.9832, p =.0029).

Median time to criterion in seconds for the training procedures under the "PROMPT" consequence are presented in Figure 25. There were no significant differences between training methods (X^2 = 8.1111, df =2, p = .0173).

For forward chaining, there were no significant differences between groups for consequences (Z = -.1266, p = .8993). For backward chaining, there were no significant differences between groups (Z = -.0791, p =.9369). For whole task training, there were no significant differences between groups ($Z = -.0316$, $p = .9748$).

Summary of Post Experiment Questionnaire Data

See Appendix B for post experiment questionnaire. See Appendix K for detailed summary of post experiment data.

The results of the questionnaire showed no significant differences for recall of key order and symbol preceding each respective key press on last sequence taught for training methods. Similarily, there were no significant differences between groups receiving different consequences for recall of key order and symbol preceding each respective key press on last sequence taught. Results showed that subjects' awareness of differences in training procedures did not affect their performance as measured in true errors.

Discussion

There were no significant differences between the prompt programmed consequence and the auditory programmed consequence "ZIT-2" on any of the dependent variables except random errors (which produced significant differences in total errors). The difference in random errors resulted from the fact that as soon as the subject made an incorrect response under the prompt programmed consequence, the computer informed the subject which was the proper key to press. However, under the "ZIT-2" consequence, the subject continued pressing until the correct key was pressed.

The rank ordering for median true errors from least to greatest was forward chaining, backward chaining and whole task training. This confirmed the pattern found in Experiment 1. For the "ZIT-2" consequence, similar results were found to the "ZIT" consequence used in Experiment 1. Results indicated that each of the chaining methods of forward and backward chaining produced less true errors than whole task training.

In this experiment and in Experiment 1, each of the the chaining methods produced more total responses than whole task training. This was not unexpected because of the nature of the methods; when no errors are made, the slow build-up of subsequences in the chaining methods requires more total responses than whole task training. This indicates that chaining methods are poorer practical choices when considering total responses.

The role of time varied between these two experiments. The "ZIT-2" consequence was similar to Experiment 1 because backward chaining took more time than whole task training. Forward chaining took significantly more time than whole task training which was not found in Experiment 1. For the "PROMPT" consequence, there were no significant differences between training methods for time.

Chapter Four

Experiment 3

Time-out is a commonly used consequence following an incorrect performance of a behavior. See introduction for a detailed description of the use of time-out in teaching sequences of behaviors. The following experiment examines the consequence of time-out in relation to the three chaining methods. The time-out period consists of three seconds in which the screen goes blank and no responses are recorded, then the computer programme continues.

Experiments 1 and 2 and the experiments of Watters (1989; in press) clearly showed that under the standard "ZIT" programmed consequence, each of the chaining methods of forward chaining and backward chaining produced fewer true errors than whole task training. Experiments 1 and 2 showed that visual, minimal and prompt programmed consequences following an incorrect response produced a similar pattern of results: 1) rank ordering of medians from least to most was forward chaining, backward chaining and whole task training and 2) chaining methods produced fewer true errors than whole task training (although backward chaining produced fewer true errors than whole task training at an alpha of .05 for minimal, visual, and prompt programmed consequences). In the following experiment, time-out alone is used to determine whether time-out produces similar results to Experiments 1 and 2.

Method

Subjects

Eighteen subjects (14 females and 4 males) were obtained informally and by classroom recruitment at University of Ottawa. Ages ranged from 19 years to 24 years with a median of 20 and a mean of 19.9 years.

Apparatus

The apparatus was identical to that used in Experiment 1.

Procedure

Each subject learned three separate sequences, one by forward chaining, one by backward chaining, and one by whole task training. When the subject made an incorrect response, the screen went blank for three seconds. During this time, no responses were recorded, See Appendix A for instructions. See Appendix B for post-experiment questionnaire.

Experimental Design

The experiment had a within-subject design, with each subject learning by each of the three training methods: forward chaining, backward chaining and whole task training. Dependent variables were (a) true errors (b) random errors (c) total errors (total of random errors plus true errors) (d) total responses and (e) time to learn the sequence to criterion in seconds.

Results

See Appendix L for Bartlett-Box F tests of homogeneity of variance which were conducted on each dependent variable. The assumption of homogeneity of variance was invalidated for most dependent variables. Nonparametric tests were conducted because these tests make less stringent assumptions about population distributions. The Friedman two-way analysis of variance was used as an overall test for the within-subject comparison. The Wilcoxon Matched Pairs Signed Ranks test was used for the follow-up tests. An alpha level of .01 was used to determine significant results (Howell, 1989).

See Appendix M for means, medians and standard deviations for the following data. See Appendix N for nonparametric statistical analysis described below.

Median true errors for sequences learned by each training procedure are presented in Figure 26. There were significant differences between training procedures ($X^2 = 15.0278$, df =2, p = .0005). Whole task training produced more true errors than forward chaining (Z = -3.4794, p = .0005). It should be noted that whole task training produced more true errors than backward chaining (Z = -2.3517, p = .0187) at alpha = .05. No other differences were significant. The pattern of the chaining procedures producing fewer true errors than the whole task training was found in Experiments 1 and 2.

For the time-out consequence, twelve out of eighteen subjects produced fewer true errors on forward and backward chaining respectively than whole task training.

Median random errors for sequences learned by each training procedure are presented in Figure 27. There were no significant differences between training porcedures ($X^2 = 0.2500$, df = 2, p = .8825).

Median total errors for sequences learned be each training procedure are presented in Figure 28. There were no significant differences between the training procedures ($X^2 = 7.5833$, df = 2, p = .0226).

Median total responses for sequences learned by each training procedure are presented in Figure 29. There were significant differences between the three training procedures ($X^2 = 14.7780$, df = 2, p = .0006). Whole task training produced less total responses than backward chaining (Z = 3.0921, p = .0020). No other differences were significant.

Median time to learn the sequence to criterion for sequences learned by each training procedure are presented in Figure 30. The results showed a significant difference between training methods ($X^2 = 12.3334$, $df = 2$, $p = .0001$). Forward chaining took less time than backward chaining ($Z = -2.9832$, $p = .0029$). No other differences were significant.

Summary of Post Experiment Questionnaire Results

See Appendix B for post experiment questionnaire. See Appendix O for post experiment questionnaire data.

The results of the questionnaire showed that the training method used did not affect subjects' recall of order of key press and symbol preceding key press for the last sequence taught. Seventeen out of eighteen noticed a type of chaining method versus whole task training method. Subject's awareness of whether the task was taught by forward chaining or backward chaining did not affect true errors produced.

For time-out period, thirteen individuals stated they used the time-out for covert rehearsal, two used it to think encouraging thoughts and three were frustrated during the time-out period.

Discussion

The results, using the time-out programmed consequence, showed the same pattern as other consequences. For true errors, the rank ordering of medians from least to greatest was forward chaining, backward chaining and whole task training. Once more, forward chaining produced significantly fewer true errors than whole task training. Backward chaining produced significantly less true errors than whole task training at alpha = .05 but not at alpha = .01.

From a practical perspective, for the consequence of time-out, forward chaining appears to be the best training procedure producing fewer true errors but taking the same time and total responses as whole task training.

From a practical stance, backward chaining, although statistically not producing more true errors than forward chaining, did take more time. Backward chaining took more total responses than whole task training.

From a practical stance, whole task training was the least effective, producing more true errors than either chaining methods and taking the same amount of time and number of total responses as forward chaining.

Time-out has commonly been considered a negative punisher (that is, time-out is considered aversive) and results in a decrease in probability of occurrence of the behavior. However, time-out may also be used by some individuals to perform covert behaviors. Covert behavior usually refers to thinking, fantasizing or imagining. Thinking refers to "complete behavior which occurs on so small a scale that it cannot be detected by others." (Skinner, 1974, p. 30). Imagining or fantasizing are "ways of seeing something in the absence of the thing seen, and as presumably a matter of doing what one does when what is seen is present." (Skinner, 1974, p. 86). Any behavior that is private and inferred to be done by a subject is covert.

Covert behavior "has the advantage that we can act without committing ourselves; we can revoke the behavior and try again if private consequences are not reinforcing" (Skinner, 1974, p.114). In playing chess, a person may covertly perform a chess game. He or she may think to move his or her pawn to capture the bishop then realize that his or her opponent could then checkmate him or her. If this had occurred overtly, then the game would have been over. Since he or she thought this, then he or she may think of a better move before overtly performing it. In this experiment, the subject could be privately rehearsing the key presses he knows during the time-out and in this rehearsal eliminate those key presses that were incorrect.

In the informal discussion following the experiment, thirteen out of eighteen individuals reported that they used the time-out period for covert practice, two used it for encouraging thoughts and only three (sixteen percent) found it aversive. Here we see that different individuals react differently to the time-out period. The majority seemed to report using it for covert behaviors.

Chapter Five

Experiment 4

From the previous three experiments, it has been determined that each of the two chaining methods of forward chaining and backward chaining produced fewer true errors than whole task training. This may be due to the systematic nature of introduction of component behaviors in the form of subsequences of the sequence. To test this hypothesis, the following experiment introduces a new chaining method called random chaining which does not involve the systematic introduction of new component behaviors in the form of subsequences of the sequence.

Random chaining consists of gradually learning a sequence in a random order. First, the subject learns a component behavior randomly selected from the sequence to be taught. When this component behavior has been mastered, a second component behavior is randomly selected and the subject learns to perform these two component behaviors together. These two are combined in the sequence order. Sequence order refers to the order of the behaviors in the sequence. In the experiments presented in this thesis, sequence order is an arbitrarily defined fixed order for pushing the eight keys (Appendix C). Sequence order should not be confused with the order that the sequence is taught in training. For example, the initial behavior taught may be the third behavior in the sequence . The first behavior taught is the third behavior according to the sequence order. The second behavior taught may be the fifth behavior according to the sequence order. In this case, the subsequence would be the third behavior followed by the fifth behavior. The next behavior taught is determined randomly and taught in its sequence order in respect to the first two behaviors taught. For example, the third behavior taught may be the second behavior according to sequence order. The third subsequence is second behavior, third behavior, and fifth behavior. Training is continued in this manner until the entire sequence is taught according to the sequence order. The end-product of the forward chaining, backward chaining, and random chaining and whole task training is the same - the sequence.

Method

Subjects

Twenty subjects (12 female and 8 male) were obtained informally and by classroom recruitment at the University of Ottawa. They were volunteers with a minimum education of grade 12. They had not studied behavior chaining. Ages ranged from 19 to 68 years with a mean of 27.4 years and a median of 24 years.

Apparatus

Same as experiment 1.

Procedure

Each subject learned four separate sequences: one by forward chaining, one by backward chaining, one by whole task training and one by random chaining. The instructions (see Appendix A) indicated that the task consisted of a series of keypresses each preceded by a unique symbol on the monitor screen and that the task would be taught sometimes in parts and sometimes all at once. The following changes were made to the instructions in Appendix A to encompass the addition of random chaining: (1) "three sequences" was changed to "four sequences" and (2) "You will learn other sequences a bit at a time, building up slowly, getting one button press correct before going on to the next, then getting two in a row correct before going on to the next, then getting three in a row correct" was changed to "You will learn other sequences a bit at a time, building up slowly, getting one button press correct before going on to the next, then getting two correct before going on to the next, then getting three correct". Subjects were not told that the symbols were presented in a forward, backward and random order.

One quarter of the subjects started learning a sequence by each of the training methods. Subsequent order of the training procedures was randomized.

The rest of the procedure was the same as experiment one.

Experimental Design

The experiment had a within-subject design. Each subject learned four sequences, one by forward chaining, one by backward chaining, one by random chaining, and one by whole task training. Dependent variables were (a) number of true errors (b) number of random errors (c) total number of errors (random plus true errors) (d) total responses and (e) time to learn the sequence to criterion in seconds.

Results

Nonparametric tests were conducted because these tests make less stringent assumptions about population distributions. See Appendix P for Bartlett-Box F test of homogeneity of variance for each dependent variable. The assumption of homogeneity of variance was invalidated for most dependent variables.

The Friedman Two-Way Analysis of Variance was used as an overall test for the within-subject comparison (Seigel, 1956). Follow-up paired comparisons were made using the Wilcoxon Matched Pairs Signed Rank Tests (Seigal,1956). A stringent alpha of .01 was used in determining statistical differences (Howell, 1989).

See Appendix Q for means, medians and standard deviations for each dependent variable and experimental condition. See Appendix R for details of the nonparametric statistical analysis which will be summarized in the following paragraphs.

Median true errors for sequences learned by each training procedure are presented in Figure 31. There were significant differences between the training methods (X^2 = 24.4650, df = 3, p < .0000). Whole task training produced more true errors than forward chaining (Z = -3.8230, p = .0001), backward chaining (Z = -3.0986, p = .0019) and random chaining (Z = -3.0613, p = .0022). No other differences were significant. Fifteen of the twenty subjects produced less true errors on each of the three chaining procedures than on whole task training.

Median random errors for sequences learned by each training procedure are presented in Figure 32. There were significant differences between training procedures (X^2= 12.2550, df =3, p = .0066). Forward chaining produced significantly fewer random errors than backward chaining (Z = -2.7566, p = .0058), and whole task training (Z = -3.2479, p = .0012). No other differences were significant.

Median total errors for sequences learned by each training procedure are presented in Figure 33. There were significant differences between training procedures (X^2 = 27.1950, df =3, p < .0000). Whole task training produced more total errors than forward chaining (Z = -3.9199, p = .0001), backward chaining (Z = -2.8746, p = .0040) and random chaining (Z = -2.7813, p = .0054). Forward chaining produced fewer total errors than backward chaining (Z = -3.1188, p = .0018). No other differences were significant. Sixteen of the twenty subjects produced fewer total errors on each of the three chaining procedures than on whole task training.

Median total responses for sequences learned by each training procedure are presented in Figure 34. There were no significant differences between the training procedures (X^2 = 4.725, df =3, p = .1931).

Median time in seconds for sequences learned by each training method are presented in Figure 35. There were no significant differences between the training procedure (X^2 = 4.3800, df =3, p = .2232).

Summary of Post Experiment Questionnaire Data

See Appendix B for post experiment questionnaire. See Appendix S for detailed summary of post experiment questionnaire data. The results indicated that treatment group did not affect the subjects' recall of the order of keypresses or the symbols which preceded each key press. Similarily, subjects' awareness of differences in how the sequences were trained did not affect the number of true errors made or total errors made. Subjects were generally unable to predict which training method they did best on for true errors. Whether subjects liked the method used or felt the method was comfortable did not seem to be related to which training method they did best on for true errors.

Discussion

All three chaining methods produced fewer true errors than whole task training. The random chaining procedure did not systematically introduce the new component behavior. It follows that it is not just the systematic introduction of new component behaviors in the form of subsequences of the sequence that contributes to the fewer errors in chaining procedures. The following section will detail factors which by themselves or by interaction with other factors may have produced these results.

The following factors may be used in characterizing the three training methods: (1) selection of the component behavior to be taught in the first subsequence (2) selection of additional component behaviors to be taught in the subsequent subsequences (3) ordering of the component behaviors within the subsequences used during training (4) whether the subsequences used during training are subsequences of the sequence (5) whether component behaviors of subsequences are selected with or without replacement from the collection of component behaviors that constitute the sequence to be taught and

(6) the proficiency criteria. A more detailed examination of each factor follows.

Factor One: Selection of the Component Behavior to be Taught in the First Subsequence

The inital component behavior taught can be a specific one from the sequence or randomly selected from the sequence. For example, forward chaining and backward chaining begin with a specific component behavior. The specific component behavior is different in the two training methods. Forward chaining begins with the first component behavior of the sequence and backward chaining begins with the last component behavior of the sequence. For random chaining, the initial component behavior will be selected randomly and may change with each subject. One subject, for example, could begin with the second component behavior of the sequence and another subject could begin with the sixth component behavior of the sequence order.

Factor Two: Selection of Additional Component Behaviors to Taught in the Subsequences

The selection of additional component behaviors can be done in a number of ways. For both forward chaining and backward chaining, the selection of additional component behaviors of the sequence is determined by the sequence order. In forward chaining, as indicated above, the initial component behavior of the sequence taught is the first component behavior of the sequence. When this has been learned, the second component behavior of the sequence is added. When the subject has learned the subsequence of the first and second component behaviors, the third component behavior of the sequence is added. This process is continued until the subject has mastered the entire sequence. In backward chaining, the last component behavior of the sequence is taught initially. When this has been learned, the second last component behavior of the sequence is added. When the subject has learned the subsequence of the second last and last component behaviors, the third last component behavior of the sequence is added. This process is continued until the subject has mastered the entire sequence.

In examples to be used in the following discussion, numbers will be used to represent component behaviors of a sequence. The first component behavior is "1", the second is "2", the third is "3" and so forth. The last component behavior is "8". The entire sequence, in its "sequence order", is then, "1,2,3,4,5,6,7,8".

In random chaining, additional component behaviors of the sequence will be selected randomly. For example, the first subsequence could be "2". The second subsequence could be "2,5". The third subsequence could be "1,2,5".

Factor Three: Ordering of the Component Behaviors within the Subsequences Used during Training

The order of the component behaviors when presented during training can be determined in a number of ways. Following the above example, the first subsequence is "1" in forward chaining. Then the second component behavior taught is placed in sequence order in relation to the first component behavior. The resulting subsequence is "1, 2" not "2,1". Next the third component behavior is placed in sequence order in relation to the other two component behaviors. The third subsequence is "1,2,3" not "1,3,2" or "2,1,3" or "2,3,1" or "3,1,2" or "3,2,1". In backward chaining, the first subsequence is "8". Then the second component behavior taught is placed in sequence order in relation to the first component behavior. The resulting subsequence is "7,8" not "8,7". Next the third component behavior taught is placed in its sequence order in relation to the other two component behaviors. The resulting third subsequence is "6,7,8" not "6,8,7" or "7,6,8" or "7,8,6" or "8,7,6" or "8,6,7". It should be clear then that the resulting subsequences taught in forward and backward chaining are subsequences of the sequence.

In the proposed random chaining procedure, the order of component behaviors when presented during training will be determined by the sequence order. Using the previous example, the first subsequence is "2". The second subsequence is "2,5" not "5,2" because 5 follows 2 in the sequence that is being taught. Then the third subsequence is "1,2,5" not "2,5,1" because 1 precedes 2,5 according to the sequence order.

The end-product of all chaining methods is the sequence.

Factor Four: Whether the Subsequences Used during Training are Subsequences of the Sequence

Component behaviors to be added in the subsequences are selected randomly in random chaining and by sequence order in forward and backward chaining. Therefore, random chaining differs from forward and backward chaining in the subsequences that are formed. Forward and backward chaining use subsequences in training that are subsequences of the sequence whereas random chaining uses subsequences that are not necessarily subsequences of the sequence.

Let us examine, for example, the third subsequence for the three chaining methods. For forward chaining, the third subsequence would be "1,2,3" which is a subsequence of the sequence "1,2,3,4,5,6,7,8" and for backward chaining, the third subsequence would be "6,7,8" which is a subsequence of "1,2,3,4,5,6,7,8". For random chaining the third subsequence could be the subsequence "1,3,8" or "1,4,5" or "5,7,8" which are not subsequences of the sequence "1,2,3,4,5,6,7,8". It is also possible that the random selection and ordering results in "4,5,6" or "3,4,5" which are subsequences of the sequence. But such an outcome is rare and most subsequences in random chaining will not be subsequences of the sequence taught.

Factor Five: Whether Component Behaviors of Subsequences are selected "With" or "Without" Replacement from the Collection of Component Behaviors that Constitute the Sequence

The collection pool from which the first component behavior is selected is the entire sequence. Selection without replacement means that each time a new component behavior is selected from the sequence there is one less component behavior in the collection pool from which the next component behavior is selected. The number of possible component behaviors from which to select decreases as component behaviors are selected.

When the subsequences are taught without replacement then the component behaviors in each subsequence are the same as the prior subsequence with the exception of the new component behavior added. For example, if the first subsequence is "2", then "2" will be in all subsequent subsequences. If the component behavior "5" is added into the second subsequence, then the second subsequence contains "5 and 2" and "2 and 5" will be in all subsequent subsequences. The third subsequence must contain "2 and 5" with the addition of a new component behavior. The component behavior added in to the third subsequence is "1". The resulting third subsequence contains "1 and 5 and 2". "1 and 2 and 5" will be in all subsequent subsequences. Each subsequence (with the exception of the first subsequence) contains all the component behaviors of the previous subsequence and the new component behavior that is added. This process (selection without replacement) is used in both forward, backward and random chaining.

In contrast, selection with replacement means that every component behavior is selected from the entire sequence, There is no decreasing collection as selection continues of component behaviors for subsequences as selection continues. Subsequence one could contain any of the eight component behaviors. This means that "1", "2", "3", "4", "5", "6", "7", and "8" are all possible candidates for the first subsequence. For example, the first subsequence could contain "3". The second subsequence will contain two component behaviors. These two component behaviors may or may not include "3" because all eight component behaviors may be chosen from to form the second subsequence. For example, the second subsequence could contain "1 and 5" or "1 and 3" or "2 and 6" or "4 or 5" or "6 or 5" or "7 or 5" or "8 or 5". The third subsequence may or may not contain 3 or 1 or 5 because any three of the eight component behaviors may be chosen for the third subsequence. The third subsequence could contain "3 and 7 and 1". If the third subsequence was chosen from a sample of the sequence <u>with</u> replacement, subsequence three could be any three component behaviors of the eight in the subsequence and so on.

It should be noted that a subsequence will not contain two or more of the same component behaviors. For example, subsequence two could not be "1,1" or "5,5".

<u>Factor Six: Proficiency Criteria</u>

There are proficiency criteria which must be satisfied at certain stages of the task. In teaching human sequenced behavior there are two forms of proficiency criteria: a) the criterion used to end training and b) the criterion which must be satisfied before teaching a new subsequence in the chaining methods. The criterion used to end training is usually defined as a predetermined number of consecutive correct performances of the entire sequence of behaviors. The criterion to be satisfied to teach a new subsequence in the chaining methods is usually defined as a predetermined number of consecutive correct performances of the current subsequence. Whole task training does not entail a criterion to teach a new subsequence because it is not a gradual training procedure and does not involve subsequences.

In this experiment, forward, backward and random chaining used a criterion of three consecutive correct performances of a subsequence before teaching the next component behavior in this experiment and all four training methods used a criterion to end training of three consecutive correct performances

Whole task training does not entail a criterion to teach a new subsequence because it is not a gradual training program and does not involve subsequences. However it does involve a criterion to end training. Therefore the first five factors do not apply to whole task training.

The results of this experiment clearly indicate that whole task training produced more true errors than all chaining methods. However, no significant differences were found for total responses or time. The roles of the first five factors are unclear because no significant differences among chaining methods were found for true errors, time or total responses. However, differences were found in previous experiments for time and total responses. Clearly, factor six, proficiency criterion to teach a new subsequence is important because it is one of the major differences between chaining methods and whole task training. In the next experiment, the proficiency criterion to teach a new subsequence is examined. It is also possible that the results can produce further information about the other factors.

Chapter Six

Experiment 5

The preceding experiment indicated that the proficiency criteria to teach a new subsequence is important in learning a sequence of behaviors. The effect of various proficiency criterion to be satisfied before teaching a new subsequence in the chaining procedures is examined in this experiment. There is a within-subject component consisting of the four different training methods used in the last experiment: forward chaining, backward chaining, random chaining, and whole task training. The random chaining is identical to the random chaining used in Experiment 4 and was explained in the introduction to Experiment 4. There is a between-subject component which will examine several values of the criterion to teach a new subsequence. One group was programmed to receive a minimal proficiency criterion of one to teach a new subsequence, a second group received a medium criterion (three), and a third group received a large value of six. One was chosen because it is the smallest number of repetitions possible. Three was chosen because it has been used through the previous four experiments. Six was the largest number found in the literature (Kayser et al, 1986; Spooner, 1985).

Method

Subjects

Fifty-four subjects (37 females and 17 males) were obtained informally and by classroom recruitment at the University of Ottawa. They were volunteers with a minimum education of grade 12. They had not studied behavior chaining. Ages ranged from 18 to 48 years with a mean of 23.9 years and median of 24 years.

Apparatus

The apparatus was identical to that used in Experiment 1.

Procedure

Each subject learned four separate sequences; one by forward chaining, one by backward chaining, one by whole task training and one by random chaining. The instructions (see Appendix A) indicated that the task consisted of a series of key presses each preceded by a unique symbol on the monitor screen and that the task would be taught sometimes in parts and sometimes all at once. The instructions in Appendix A contain the following changes to encompass the addition of random chaining: (1) "three sequences" was changed to "four sequences" and (2) "You will learn other sequences a bit at a time, building up slowly, getting one button press correct before going on to the next, then getting two in a row correct before going on to the next, then getting three in a row correct" was changed to "You will learn other sequences a bit at a time, building up slowly, getting one button press correct before going on to the next, then getting two in correct before going on to the next, then getting three correct". The instructions for subjects receiving the auditory programmed consequence were used. Subjects were not told that the symbols were presented in a forward, backward and random order. One quarter of the subjects started learning a sequence by each of the training methods. Subsequent training method order was randomized. Each individual was taught a different randomly ordered sequence as determined by use of random number tables for the random chaining method, however, the final subsequence is the sequence in its natural order.

Subjects were divided into three groups according to the proficiency criterion to teach a new subsequence. For one group, the criterion to teach a new subsequence was one. For the second group, the criterion to teach a new subsequence was three. For the third group, the criterion to teach a new subsequence was six. See Appendix A for instructions. See Appendix B for the post-experiment questionnaire.

The rest of the procedure was the same as used in experiment 1.

Experimental Design

The experiment had a within-subject component. Each subject learned four sequences, one by forward chaining chaining, one by backward chaining, one by random chaining and whole task training. The experiment had also a between-subject component. The subjects were divided into three groups according to proficiency criteria to teach a new subsequence. The proficiency criteria consisted of one, three and six respectively. Dependent variables were (a) true errors (b) random errors (c) total (random plus true errors) (d) total responses and (e) time to learn the sequence to criterion in seconds.

Results

See Appendix T for Bartlett-Box F test of homogeneity of variance for each dependent variable used in the following results. For most dependent variables, the assumption of homogeneity of variance was invalidated.

Nonparametric tests were conducted because these tests make less stringent assumptions about population distributions. The Friedman Two-Way analysis of variance was used as an overall test for the within-subject comparison. Follow-up paired comparisons were made using the Wilcoxon Matched Pairs Signed Rank Tests. See Appendix U for means, medians and standard deviations for each dependent variable. See Appendix V for the nonparametric statistics summarized in the following results. A stringent alpha of .01 was used to determine significant results (Howell, 1989).

Dependent Variable - True Errors

Median true errors for sequences learned by each training procedure for the criterion to teach a new subsequence of one are presented in Figure 36. There were significant differences between training methods (X^2 = 15.7166, p =.0013). Whole task training produced more true errors than forward chaining (Z= -2.9823, p =.0029), backward chaining (Z = -2.0003, p = .0451) and random chaining (Z = -2.6509, p = .0080). No other differences were significant.

Median true errors for sequences learned by each training procedure for criterion to teach a new subsequence of three are presented in Figure 37. There were significant differences between training methods (X^2 = 29.9166, df =3, p < .0000). Whole task training produced more true errors than forward chaining (Z = -3.7236, p =.0002), backward chaining (Z = -3.2663, p = .0011) and random chaining (Z = -3.1792, p =.0015). No other differences were significant.

Median true errors for sequences learned by each training procedure for criterion to teach a new subsequence of six are presented in Figure 38. There were significant differences between training methods. (X^2 = 31.2000, p = .0000). Whole task training produced more true errors than forward chaining (Z=-3.6214, p = .0003), backward chaining (Z= -3.4405, p = .0006) and random chaining (Z = -3.4557, p = .0005). Forward chaining produced significantly fewer true errors than backward chaining (Z = -2.5992, p = .0093) and random chaining (Z = -3.4078, p = .0070). No other differences were significant.

For forward chaining, median true errors for sequences learned under the three different proficiency criteria to teach a new subsequence are presented in Figure 39.

There were significant differences between groups receiving the three different proficiency criteria(X^2 = 9.3565, p = .0093). Subjects in the group using a criterion of one produced more true errors than a group using a criterion of six (Z = -2.9554, p = .0031). There were no other significant differences.

For backward chaining, median true errors for sequences learned under the three proficiency criteria to teach a new subsequence are presented in Figure 40. There were significant differences between groups receiving the three different proficiency criteria (X^2 =12.8198, p = .0016). There was a significant difference between the group using a criterion of one and the group using a criterion of six (Z = -3.3218, p =.0009). There were no other significant differences.

For random chaining, median true errors for sequences learned under the three proficiency criteria to teach a new subsequence are presented in Figure 41. There were no significant differences between groups receiving different criteria (X^2 = 1.7611, p =.4145).

For whole task training, there were no significant differences between groups receiving different criteria (X^2 = .8455, p = .6553).

Dependent Variables - Random Errors

Median random errors for sequences learned by training procedures under the proficiency criterion to teach a new subsequence of one are presented in Figure 42. There were no significant differences for training procedures (X^2 = 6.9166, df =3, p = .0746).

Median random errors for sequences learned by training procedures under criterion to teach a new subsequence of three are presented in Figure 43. For criterion to teach a new subsequence of three, there were no significant differences for training methods (X^2 = 10.9166, p =.0122).

Median random errors for sequences learned by training procedures under criterion to teach a new subsequence of six are presented in Figure 44. There were no signficant differences between training procedures (X^2 = 9.5166 , p = .0232).

For forward chaining, median random errors for sequences taught by the different proficiency criteria to teach a new subsequence are presented in Figure 45. There were no significant differences between groups receiving different criteria (X^2 = 2.5126, df = 2, p = .2847).

For backward chaining, median random errors for sequences taught by the different proficiency criteria to teach a new subsequence are presented in Figure 46. There were no significant differences among groups receiving different criteria (X^2 = 0.2769, df = 2, p =.8707).

For random chaining, median random errors for sequences taught using different criteria to teach a new subseqeunce are presented in Figure 47. There were no significant differences among groups receiving different proficiency criteria (X^2 = 0.5087, df = 2, p= .7754).

For whole task training there were no significant differences among groups receiving different proficiency criteria (X^2 =1.8721, df = 2, p = .3922).

Dependent Variable - Total Errors

Median total errors for sequences learned by each training procedure using criterion to teach a new subsequence of one are presented in Figure 48. There were significant differences between training procedures (X^2 = 12.1500, df = 3, p =.0069). Whole task training produced more total errors than forward chaining (Z = -2.8090, p = .0050). Forward chaining produced fewer total errors than backward chaining (Z = -3.0267, p =.0025). No other differences were significant.

Median total errors for sequences learned by each training procedure using criterion to teach a new subsequence of three are presented in Figure 49. There were significant differences between training procedures (X^2 = 21.2166, df =3, p= .0001). Whole task training produced more true errors than forward chaining(Z = -3.5929, p =.0003), backward chaining(Z = -3.1480, p =.0016) and random chaining (Z = -3.2881, p =.0010). Forward chaining produced significantly fewer total errors than backward chaining (Z = -2.8961, p =.0038).

Median total errors for sequences learned by each training procedure using a criterion to teach a new subsequence of six are presented in Figure 50. There were significant differences between training procedures (X^2 = 25.100, df = 3, p < .0000). Whole task training produced more total errors than forward chaining(Z = -3.6365, p = .0003), backward chaining(Z = -3.2445, p =.0012) and random chaining(Z = -3.6214, p = .0003).

For forward chaining, median total errors for sequences taught by different profiency criteria to teach a new subsequence are presented in Figure 51. There were no significant differences between groups receiving different proficiency criteria for forward chaining(X^2 = 3.1234 , df =2, p = .2098).

For backward chaining, median total errors for sequences taught by different proficiency criteria to teach a new subsequence are presented in Figure 52. There was a significant difference between criterion groups (X^2=10.2551, df = 2, p=.0059) The group using criterion to teach a new subsequence of one produced more total errors than the group using criterion to teach a new subsequence of six (Z =-3.0592, p = .0022). There were no other significant differences.

For random chaining, median total errors taught by different proficiency criteria to teach a new subsequence are presented in Figure 53. There were no significant differences between groups receiving different levels of consequences (X^2 =2.2395, df = 2, p =.3264).

For whole task training, there were no significant differences between groups receiving different proficiency criteria (X^2 =0.7627, df = 2, p= .6829).

Dependent Variable - Total Responses

Median total responses for sequences learned by each training procedure using a criterion of one to teach a new subsequence are presented in Figure 54. There were no significant differences for training procedures (X^2 = 8.8666, df =3, p = .0311).

Median total responses for sequences learned by each training procedure using a proficiency criterion of three to teach a new subsequence are presented in Figure 55. There were significant differences between training procedures (X^2 = 13.5333, df =3 , p =.0036). Whole task training produced significantly fewer total responses than backward chaining (Z = -2.9396, p=.0033) and random chaining (Z = -2.8525, p = .0043). No other differences were significant.

Median total responses for sequences learned by each training procedure using proficiency criterion to teach a new subsequence of six are presented in Figure 56. There were significant differences between training methods (X^2 = 27.9500, df = 3, p = .000). Whole task training produced fewer total responses than forward chaining (Z = -3.3316, p =.0009), backward chaining Z = -3.5929, p = .0003) and random chaining (Z = -3.4187, p = .0006). Forward chaining produced significantly less total responses than random chaining (Z = -3.361, p = .0008).

For forward chaining, total responses for sequences taught by different proficiency criteria to teach a new subsequence are presented in Figure 57. There were significant differences between groups receiving different proficiency criteria (X^2 = 38.0316, df = 3, p < .0000). The subjects receiving a criterion of one produced significantly fewer total responses than subjects receiving a criterion of three (Z = -4.5574, p <.0000) and six (Z = -4.5888, p <.0000). The subjects receiving a criterion of three produced significantly fewer total responses than subjects receiving a criterion of six ($Z = -4.6840$, $p < .0000$).

For backward chaining, total responses for sequences taught using different proficiency criteria to teach a new subsequence are presented in Figure 58. There were significant differences between groups receiving the three different proficiency criteria ($X^2 = 37.5472$, df = 3, $p < .0000$). The group receiving criterion of one produced fewer responses than the group receiving three ($Z = -2.9908$, $p = .0028$) and than the group receiving six ($Z = -5.1327$, $p < .0000$). The group receiving proficiency criterion of three produced fewer total responses than the group receiving six ($Z = 4.8010$, $p < .0000$).

For random chaining, total responses for sequences taught using the three different proficiency criteria to teach a new subsequence are found in Figure 59. There were significant differences between groups receiving the three different proficiency criteria($X^2 = 33.5640$, df = 3, $p < .0000$). The group receiving the proficiency criteria of one produced significantly fewer total responses than the group receiving three($Z = -2.8640$, $p = .0042$) and six ($Z = -5.0945$, $p = .0000$). The group receiving the proficiency criteria of three produced fewer total responses than the group receiving six ($Z = -4.1143$, $p = .0000$).

For whole task training, there were no significant differences between groups receiving different proficiency criteria ($X^2 = 1.2875$, df = 2, $p = .5253$).

Dependent Variable - Time

Median time to learn a sequence to criterion in seconds for sequences learned by each training procedure using a proficiency to teach a new subsequence of one are presented in Figure 60. There were no significant differences for training procedures ($X^2 = 11.1333$, df = 3, $p = .0110$).

Median time to learn a sequence to criterion in seconds for sequences learned by each training procedure using a proficiency criterion to teach a new subsequence of three were presented in Figure 61. There were significant differences for training procedures (X^2 = 14.3833, df =3, p = .0024). Whole task training took significantly less time than forward chaining (Z =-2.8090, p =.0050) and backward chaining (Z = -2.9586, p =.0031) and random chaining (Z = -2.9832, p= .0029).

Median time to learn sequence to criterion in seconds for sequences learned by each training procedure using a proficiency criterion to teach a new subsequence of six are presented in Figure 62. There were significant differences for training methods (X^2 =20.3333, df = 3, p = .0001). Forward chaining took significantly less time than random chaining (Z = -3.4623, p = .0005). Random chaining took significantly more time than whole task training (Z = -2.7654, p = .0057).

For forward chaining, median time to learn sequences using the three different proficiency criteria are presented in Figure 63. There were significant differences between groups receiving different levels of criterion to teach a new subsequence (X^2 = 38.4763, df = 3, p < .0000). The group receiving a proficiency criteria of one took less time than the group receiving a criterion of three (Z = -4.0822, p < .0000) and the groups receiving a criterion of six (Z = -4.6518, p < .0000). The group receiving a criterion of three took less time than the group receiving six(Z = -5.0628, p = .0000).

For backward chaining, median time to learn sequences using the three different proficiency criteria to teach a new subsequence are presented in Figure 64. There were significant differences between groups receiving the three different proficiency criteria(X^2 = 37.5709, df = 2, p < .0000). The group receiving proficiency criterion of one took significantly less time than the group receiving three (Z = -3.4807, p = .0005) and the group receiving criterion of six (Z = -5.0309, p < .0000) took significantly less time than the group receiving the criterion of six (Z = -4.6512, p < .0000).

For random chaining, median time to learn the sequence using the three different proficiency criterion to teach a new subsequence are presented in Figure 65. There were significant differences between groups receiving the three different proficiency criteria(X^2 = 30.9001, df = 2, p < .0000). The groups receiving a proficiency criterion of six took significantly more time than the group receiving a proficiency criterion of one (Z = -5.0309, p < .0000) and the group receiving a proficiency criterion of three (Z = -3.8602, p = .0001). No other differences were significant.

For whole task training, there were no significant differences between groups receiving the different proficiency criteria (X^2 = 0.4130, df =2, p = .8134).

Summary of Post Experiment Questionnaire Results

See Appendix B for post experiment questionnaire. See Appendix W for detailed summary of post experiment data. The results of the questionnaire showed no significant differences for recall of key order and symbol preceding each respective key press for training method or proficiency criteria.

Discussion

For factor six, proficiency criteria, it was clear that a larger value for the proficiency criterion to teach a new subsequence produced fewer true errors for each of the chaining methods of forward and backward chaining. However, practically the larger value was a poor choice, because it took more time and more total responses as compared to smaller values of the proficiency criteria to teach a new subsequence.

For the proficiency criterion to teach a new subsequence of one, each of the chaining methods of forward chaining and random chaining produced fewer true errors than whole task training at alpha = .01. This is the same as Experiment 4 and the groups receiving proficiency criteria to teach a new subsequence of three and six. Backward chaining produced fewer true errors than whole task training at alpha = .05.

This is the same pattern as previously noted of chaining methods producing fewer true errors than whole task training found in Experiments 1, 2, and 3.

For the proficiency criterion to teach a new subsequence of three, the results for true errors were the same as Experiment 4. The chaining methods of forward chaining, backward chaining and random chaining produced fewer true errors than whole task training.

For the proficiency criterion to teach a new subsequence of six, each of the chaining methods of forward chaining and backward chaining produced significantly less true errors than whole task training. This is the same pattern as Experiment 4 and the two other groups receiving the proficiency criteria of one and three. However, results differed between chaining methods which did not occur in the other groups receiving the other two proficiency criteria. Forward chaining produced significantly less true errors than each of backward chaining and random chaining. The rank order of median true errors from least to greatest was forward chaining, backward chaining and random chaining. Backward and random chaining did not differ significantly. At the highest value for the proficiency criterion to teach a new subsequence, it is evident that some factors must interact with the proficiency criterion to teach a new subsequence to proceduce the different results.

For the following discussion, true errors are used as a measure of accuracy, because random errors are partially due to chance and total errors is the sum of random errors and true errors. Total responses and time are not used in this discussion because they were only included to determine the practical usefulness of the training methods.

For factor one, selection of the component behavior to be taught in the first subsequence, the evidence is inconclusive. To refresh the reader, forward chaining teaches the first component behavior according to sequence order, backward chaining teaches the last component behavior, and random chaining teaches a randomly ordered component behavior which differs from subject to subject. There are indications from the results (forward chaining produced less true errors than each of backward chaining and random chaining at a proficiency criterion to teach a new subsequence of six) that choosing the first component behavior in the first subsequence could be advantageous. Whether the last component behavior or a randomly chosen component behavior is taught appears to be irrelevant (backward chaining and random chaining did not produce significantly different true errors).

For factor two, selection of additional component behaviors to be taught in the subsequences, it appears that this factor is fairly uninfluential. Forward chaining and backward chaining use sequence order to determine selection of additional component behaviors and random chaining uses random order. At proficiency criteria to teach a new subsequence of one and three, random chaining produced the same number of true errors as forward chaining and backward chaining. At profiency criteria to teach a new subsequence of six, random chaining produced the same number of true errors as backward chaining but more than forward chaining. Therefore, something differentiates forward chaining from backward chaining and interacts with factor six, proficiency criterion to teach a new subsequence. This could be related to factor one, selection of the component behavior to be taught in the first subsequence.

For factor three, ordering of component behaviors was sequence order and was the same for chaining methods. Therefore this factor was not investigated. In the next experiment, a random order will be investigated to further illuminate the roles of the various factors in the training methods.

For factor four, whether the subsequences taught are subsequences of the sequence does not seem to be an influential factor contributing to the results. For random chaining, the subsequences taught are not subsequences of the sequence. For forward and backward chaining, the subsequences used during training are subsequences of the sequence. Evidence for this conclusion is that backward chaining and random chaining did not produce significantly different true errors at all proficiency criteria.

The fifth factor of whether component behaviors of subsequences are selected with or without replacement from the collection of component behaviors that constitute the sequence has not been investigated. Since the investigation of this factor may supply further evidence to illuminate the roles of the factors, it is investigated in the next experiment.

Chapter Seven

Experiment 6

The following experiment will further investigate the factors examined in Experiment 4. Random-2 Chaining and Random-3 Chaining will be introduced to study these factors.

Random-2 Chaining is similar to Random Chaining described in Experiment 4 except the order that the component behaviors are taught in each subsequence is determined randomly.

To further emphasize how Random-2 Chaining is taught we will use the number example. The first subsequence could be "3". The second subsequence could be "5,3". The third subsequence could be "5,7,3". This differs from random chaining in which the order the of teaching the component behaviors is determined by sequence order. In random chaining, the same example would be "3", "3,5", "3,5,7".

In the random-2 chaining method the individual is learning only one new component behavior in each new subsequence but the order of the component behaviors is changing for each subsequence.

Factor Seven: Addition of One New Component Behavior into Each Subsequence

Forward chaining, backward chaining, random chaining and random-2 chaining have this factor in common. This factor is that each subsequence is composed of the component behaviors of the previous subsequences and involves the addition of only one new component behavior.

For random-3 chaining, the factor of selection with replacement is introduced. Selection, however, is limited within subsequences in that the same component behavior can not appear twice within the same subsequence as discussed in Experiment 4. This results in the subject learning any number of new component behaviors in each subsequence and the order of component behaviors in each subsequence changing constantly. For example, subsequence one could be "3". Then subsequence two could be "4,5" so two new component behaviors are taught. Subsequence three could be "6,8,7" resulting in three new component behaviors being taught. Subsequence four could be "6,8,4,5" resulting in no new component behaviors being taught. Subsequence five could be "3,6,8,2,1" resulting in two new component behaviors being taught. Also, in this example, the component behavior "3" has not been seen since the first subsequence. In the other chaining methods "3" would have been encountered in all prior subsequences.

Random-3 chaining is like random-2 chaining, in that the ordering of the component behaviors within the subsequences is determined randomly. However, random-2 and random-3 chaining differ from forward, backward and random chaining in which ordering of the component behaviors within the subsequences is determined according to sequence order.

Factor Eight: Whether Subsequence Seven is a Subsequence of the Sequence

For random-2 chaining and random-3 chaining, the order of component behaviors in subsequence seven will probably differ greatly from subsequence eight (which is the entire sequence in its correct order). This differs from forward, backward and random chaining. In forward chaining, backward chaining, and random chaining, the seventh subsequence is almost exactly the same as the eighth subsequence, except for the absence of one component behavior. Subsequence seven for forward chaining is "1,2,3,4,5,6,7", for backward chaining it is "2,3,4,5,6,7,8" and for random chaining it could be "1,2,3,5,6,7,8". For random-2 chaining and random-3 chaining, subsequence seven will probably not contain the same order of component behaviors as subsequence eight. For example, it could be "8,5,6,7,4,3,2". This is very different than the original subsequence of "1,2,3,4,5,6,7,8".

Method

Subjects

Twenty subjects (17 female and 3 male) were obtained informally and by classroom recruitment at the University of Ottawa. They were volunteers with a minimum education of grade 12. They had not studied behavior chaining. Ages ranged from 18 years to 32 years with a mean and median of 19 years.

Apparatus

The apparatus was identical to that used in Experiment 1.

Procedure

Each subject learned six separate sequences; one by forward chaining, one by backward chaining, one by random chaining, one by random-2 chaining, one by random-3 chaining and one by whole task training. Random chaining is defined in Experiment 4 and was used in Experiment 4 and 5. Random-2 chaining and random-3 chaining are described in the introduction to this experiment. The instructions in Appendix A contain the following changes to encompass the addition of random chaining methods (random, random-2 and random-3 chaining): (1) "three" sequences was changed to "six" sequences and (2) "you will learn a bit at a time at a time, building up slowly, getting one button press correct before going on to the next, then getting two in a row correct before going on to the next, then getting three in a row correct" was changed to "You will learn other sequences a bit at a time, building up slowly, getting one button press correct before going on to the next, then getting two correct before going on to the next, the getting three correct". The instructions for subjects receiving the auditory programmed response were used. Subjects were not told that the symbols were presented in a forward, backward random, random-2 or random-3 order. One sixth of the subjects started learning a sequence by each of the training methods. Subsequent training method order was randomized. Each individual was taught by use of random number tables for the random chaining method, however, the final subsequence is the sequence in sequence order. See Appendix B for post experiment questionnaire,

The rest of the procedure was the same as Experiment 1.

Experimental Design

The experiment used a within-subject design. Each subject learned six sequences, one by forward chaining, one by backward chaining, one be random chaining, one by random-2 chaining, one by random-3 chaining and one by whole task training. Dependent variables were (a) true errors (b) random errors (c) total errors (d) total responses (e) time to learn the sequence to criterion in seconds.

Results

See Appendix X for the Bartlett-Box F tests of homogeneity of variance for each dependent variable used in the following results. For most dependent variables, the assumption of homogeneity of variance was invalidated. A stringent alpha of .01 was used to determine significant results (Howell, 1989). See Appendix Y for the means, medians and standard deviations for the following results. See Appendix Z for the nonparametric tests summarized in the following results.

Median true errors for sequences learned by each training method are presented in Figure 66. There were significant differences between training procedures (X^2 =

42.1928, df=5, $p < .0000$). Whole task training produced more true errors than forward chaining ($Z = -3.7236$, $p = .0002$), backward chaining ($Z = -3.8639$, $p = .0001$), random chaining ($Z = -3.0921$, $p = .0020$), and random-2 chaining, ($Z = -3.4346$, $p = .0006$). Random-3 chaining produced more true errors than forward chaining ($Z = -3.4405$, $p = .0006$), backward chaining ($Z = -3.6214$, $p = .0003$), random chaining ($Z = -2.6566$, $p = .0079$), and random-2 chaining ($Z = -2.8961$, $p = .0038$). No other differences were significant.

Median random errors for sequences learned by each training method are presented in Figure 67. There were no significant differences between training procedures ($X^2 = 9.9571$, df=5, $p = .0765$).

Median total errors for sequences learned by each training method are presented in Figure 68. There were significant differences for training methods ($X^2 = 30.9142$, df=5, $p < .0000$). Whole task training produced significantly more true errors than forward chaining ($Z = -3.4906$, $p = .0005$), backward chaining ($Z = -3.0267$, $p = .0025$), random chaining ($Z = -2.8170$, $p = .0048$), and random-2 chaining ($Z = -3.1138$, $p = .0018$). Random-3 chaining produced significantly more true errors than forward chaining ($Z = -3.6822$, $p = .0002$), backward chaining ($Z = -2.9306$, $p = .0034$), random chaining ($Z = -2.7440$, $p = .0061$). No other differences were signficant.

Median total responses for sequences learned by each training method are presented in Figure 69. There were significant differences between training procedures ($X^2 = 23.8357$, df =5, $p = .0002$). Whole task produced significantly fewer total responses than backward chaining ($Z = -2.5946$, $p = .0095$), random chaining ($Z = -3.0986$, $p = .0019$), random-2 chaining ($Z = -2.8746$, $p = .0040$) and random-3 chaining ($Z = -3.1733$, $p = .0015$).

Median times for sequences learned by each training method are presented in Figure 70. There were significant differences between training procedures ($X^2 =$

50.2857, df = 5, p = .0000). Whole task training took significantly less time than backward chaining (Z = -2.7813, p = .0054), random chaining (Z = -3.1919, p = .0014), random-2 chaining (Z = -3.2106, p = .0013), and random-3 chaining (Z = -3.6213, p = .0003). Random-3 chaining took significantly more time than forward chaining (Z = -3.8079, p = .0001), backward chaining (Z = -3.7706, p = .0002), and random chaining (Z = -3.2479, p = .0012). Random-2 chaining took significantly more time than forward chaining (Z = -3.3973, p = .0007), and backward chaining (Z = - 2.7066, p = .0068). Forward chaining took significantly less time than random chaining (Z = -3.0610, p = .0022).

Summary of Post Experiment Questionnaire Results

See Appendix B for post experiment questionnaire. See Appendix AA for detailed summary of post experiment data. No differences were found between training procedures for order recall or symbol preceding each respective key press on the last sequence taught.

Discussion

The pattern of forward chaining, backward chaining, and random chaining as well as the new random-2 chaining producing fewer true errors than whole task training has been confirmed in this experiment. However, the new chaining method called random-3 chaining does not follow this pattern. Random-3 chaining produced as many true errors as whole task training. Each of the chaining methods of forward chaining, backward chaining, random chaining, and random-2 chaining produced significantly less true errors than random-3 chaining. Rank ordering of median true errors from least to greatest was forward chaining, backward chaining, random chaining, random-2 chaining, and random-3 chaining.

This experiment does not add any new evidence to enlighten the roles of factor one, selection of the component behavior to be taught in the first subsequence, and factor two, selection of additional component behaviors to be taught in the subsequences.

For factor three, ordering of component behaviors within subsequences, there is evidence to indicate this factor is not influential in teaching sequences. Random-2 chaining consists

of random order of component behaviors within subsequences compared to sequence order in forward chaining, backward and random chaining. No significant differences between these chaining methods were found for true errors.

For factor four, whether subsequences used during training are subsequences of the sequence, the evidence confirms what was indicated in Experiment 5. The role of factor four is minimal. Both random and random-2 chaining teach subsequences that are not subsequences of the sequence. These two chaining methods did not differ from forward and backward chaining which teach subsequences that are subsequences of the sequence.

Factor five, whether component behaviors of subsequences are selected <u>with</u> or <u>without</u> replacement from the collection of component behaviors that constitute the sequence seems to contribute to the effectiveness of the training methods. Random-3 chaining used selection of component behaviors <u>with</u> replacement and it produced more true errors than each of the chaining methods of forward chaining, backward chaining, and random chaining

For factor six, proficiency criteria to teach a new subsequence, it appears that this factor contributes greatly when selection is <u>without</u> replacement and does not contribute greatly when selection is <u>with</u> replacement. The evidence for this conclusion is that random-3 chaining (using selection with replacement) produced similar true errors to whole task training whereas each of the other chaining procedures (using selection without replacement) produced less true errors than whole task training. Random-3 chaining produced more true errors than forward chaining, backward chaining, random chaining, and random-2 chaining.

Factor seven, addition of one new component behavior into each subsequence, seems to contribute greatly to the effectiveness of the training methods. The other four chaining methods have this factor in common but random-3 chaining does not. The evidence indicates that when chaining methods include the addition of one new component behavior into each subsequence that the chaining methods will produce fewer true errors than whole task training.

Factor eight, whether subsequence seven is a subsequence of the sequence, does not appear to contribute greatly as a factor. For random-2 chaining and random-3 chaining, subsequence seven is not likely to be the same as the sequence. However, for forward chaining, backward chaining and random chaining, subsequence seven is likely to be the same. Since random-2 chaining did not differ significantly from forward chaining, backward chaining and random chaining, this indicates that this is not an influential factor.

In practical terms, there were no significant differences for total responses than for the chaining methods. However, forward chaining took significantly less time then each of the three random chaining methods and backward chaining took significantly less time than random-2 chaining and random-3 chaining but not random chaining.

The final chapter discusses the results of all six experiments and make suggestions for future research.

Chapter Eight

Discussion

Refer to Summary Table: Median True Errors for review of results.

Summary of Experiments 1, 2 and 3

The original purpose of this dissertation was to study the three training methods of forward chaining, backward chaining, and whole task training in combination with various consequences following an incorrect response. The first three experiments were guided by this purpose. For all three experiments, the within-subject component consisted of forward chaining, backward chaining and whole task training.

The dependent variable of true errors was used throughout the dissertation and will be used in this discussion as a measure of accuracy because random errors are partly a function of chance, and total errors are the sum of random errors and true errors. Total responses and training time were used throughout the dissertation and will be included in this discussion to determine the practicality of the training methods. For example, a training method may produce few true errors but take too many total responses and/or too much training time to be practical.

The following section will indicate the results for the first three experiments.

True Errors

For true errors, the three experiments produced the following common results; (a) rank order of median true errors from least to most was forward chaining, backward chaining, and whole task training, and (b) whole task training produced significantly more true errors than forward chaining at alpha = .01 and backward chaining at alpha =

.05. The differences between forward chaining and backward chaining were not significant.

Total Responses

For total responses, the three experiments showed that backward chaining produced more total responses than whole task training. Thus, backward chaining is a poor practical choice as a training method. This is particularly true for manual tasks such as training of textile workers in cutting and sewing or training employees in food preparation. In such situations, material waste and training duration can translate into economical and financial loss.

Chaining methods produce more total responses than whole task training when no errors are made. This occurs because chaining methods use subsequences and criterion to teach a new subsequence, whereas whole task training does not. However, the results of the three experiments showed that when few errors were made, forward chaining did not produce more total responses than whole task training. Rank ordering of median total responses from smallest to largest was whole task training, forward chaining, and backward chaining. Forward chaining produced median total responses closer to backward chaining in the rank ordering but did not differ significantly from whole task training or backward chaining.

Time

Rank ordering of median time from least to most was whole task training, forward chaining and backward chaining. Forward chaining was closer to backward chaining in rank ordering but did not differ significantly from either backward chaining and whole task training.

There was a tendency for backward chaining to take more time than whole task training. This is similar to the pattern for total responses and indicates that backward chaining is a poor practical choice as a training method.

Relevant to the following discussion, it should be noted that in all six experiments correctly performed component behaviors were reinforced with (a) the presentation of the next screen stimulus which allowed the subject to learn the next component behavior or (b) at the end of a subsequence of the sequence with the conditioned reinforcement of "100%" printed on the screen.

Experiment 1: Comparison of Auditory Programmed Consequence, Visual Programmed Consequence and Minimal Programmed Consequence

In Experiment 1, the between-subject component consisted of three types of consequences following an incorrect response: 1) the standard auditory programmed consequence which consisted of a "ZIT" sound, 2) visual programmed consequence which consisted of the screen border changing colour from light blue to black and back again and 3) minimal programmed consequence which consisted of no change.

The auditory programmed consequence was used to indicate that an incorrect response had occurred. With this arrangement, it was possible for the subject to learn the task without looking at the screen. This arrangement has its origins in earlier work by Watters (1989; in press) and was used as a standard comparison consequence throughout the dissertation.

The visual programmed consequence was used to increase the probability that the individual would attend to the screen stimuli. Because both error feedback and stimuli were located on the screen, it was hypothesized that increased attendance to the screen would produce fewer true errors, total responses and training time.

The minimal programmed consequence was used as a comparison to the standard auditory programmed consequence and the visual programmed consequence.

The screen stimulus remained on the screen until the subject made the correct response for all consequences. For the minimal programmed consequence, the subject attended to the screen stimulus to determine whether a correct response had been made. If the stimulus changed or a new subsequence began, a correct response had been made. It was hypothesized that since the minimal programmed consequence should increase the probability of looking at the screen, fewer true errors, and total responses and less training time would occur.

The results showed that none of the consequences programmed to follow an incorrect response differentially affected performance. It appears that whether the consequence following an incorrect response affects the subject's probability of looking at the screen or not does not influence the accuracy or practicality of the training methods.

Experiment 2: Comparisons of Prompt Programmed Consequence and Auditory Programmed Consequence

The prompt programmed consequence following an incorrect response was used to indicate to the subject the correct responses. It was hypothesized that this would decrease errors during training. Bellamy et al (1979, p.158) indicated that caution should be used when providing prompts. They suggested that some individuals may find the prompt consequence reinforcing. The effect of the reinforcement would be to increase the probability of incorrect responses being made.

The prompt programmed consequence was compared to the standard auditory programmed consequence. The prompt programmed consequence consisted of an array of buttons appearing on the screen with the one to be pushed flashing, and instructions at the top of the screen stating "Push the flashing button". The auditory programmed consequence was the same as that described earlier.

Other than the effect on random errors, there were no significant differences between the two consequences. The prompt programmed consequence produced fewer random errors than the auditory programmed consequence. Random errors differed due to information conveyed by the consequence. For the standard auditory programmed consequence, the subject made numerous random errors (trial and error responding) trying to guess the correct buttons. For the prompt programmed consequence, the subjects were instructed which was the correct key to press after making one incorrect response (random error).

Experiment 3: Time-out Programmed Consequence

Experiment 3 tested the effect of a three second time-out following an incorrect response during which the screen went blank and responding was not included. This consequence was included to determined the effect of time-out programmed consequence on the established patterns of the dependent variables for the three training methods which were produced in Experiments 1 and 2 and in experiments by Watters (in press; 1989)

Time-out programmed consequences may have been considered aversive and may have been perceived as punishers (Boren & Devine, 1986; Martin & Pear, 1988). It is also possible however that time-out was used by the subject to perform covert behaviors. Based on the post-experiment self-reports, it appeared that subjects used the time-out to perform covert behaviors. Results were similar to the results of the first two experiments. It appears that the time-out programmed consequence does not change the training method pattern revealed in Experiment 1 and 2 (see summary of Experiment 1, 2, and 3 at beginning of discussion).

It is possible that longer time-out periods could produce different results. Veizer (1990) studied the programmed consequence of time-out following an incorrect response.

The within-subject component consisted of forward chaining, backward chaining and whole task training. The between-subject component consisted of comparisons of four groups: one receiving the standard auditory programmed consequence; one receiving the time-out programmed consequence of three seconds; one receiving the time-out programmed consequence of seven seconds and the final group receiving the time-out programmed consequence of twelve seconds.

Results for the three-second time-out were similar to the results of Experiment 3. Whole task training produced significantly more true errors than each of the chaining methods of forward chaining and backward chaining. However, under the seven second and twelve second time-out programmed consequence, there was a decrease in true errors for whole task training. This resulted in no significant differences between each of the three training methods of forward chaining, backward chaining, and whole task training. Post-experimental questionning revealed that the majority of subjects used time-out for covert rehearsal just as occurred in Experiment 3. These results indicated that further exploration into time-out is necessary. For example, subjects could be asked to repeat a verse during time-out to prevent them from performing covert rehearsal during this period. This would help to determine whether covert rehearsal is a factor contributing to the lack of differences between training at seven second and twelve second time-out.

Summary of Experiments 4, 5, and 6

In the first three experiments, chaining methods consistently produced fewer true errors than whole task training for all types of consequences arranged following an incorrect response. It was decided that experiments should be undertaken to examine factors that characterize these three training methods. The goal was to determine which factors contributed to the effectiveness of the chaining methods. Three new types of chaining were developed to examine these factors: random chaining (see description in Experiment 4, Chapter Five), random-2 chaining (see description in Experiment 6, Chapter Seven) and random-3 chaining (see description in Experiment 6, Chapter Seven).

In the last three experiments following an error, the standard auditory programmed consequence was used. Experiment 4 consisted of a within-subject design comparing forward chaining, backward chaining, random chaining and whole task training. In Experiment 5, the within-subject component replicated Experiment 4. The between-subject component in Experiment 6 compared three different proficiency criteria to teach a new subsequence: one errorless performance of the subsequence, three consecutive errorless performances of the subsequence, and six consecutive errorless performances of the subsequence. Experiment 6 consisted of a within-subject design comparing forward chaining, backward chaining, random chaining, random-2 chaining, random-3 chaining, and whole task training.

The following section summarizes the results of Experiments 4, 5, and 6.

True Errors

In Experiments 4 and 5, which used the standard proficiency criterion of three to teach a new subsequence, the results showed that whole task training produced more true errors than each of the three chaining methods of forward chaining, backward chaining, and random chaining. In Experiment 6, these results were duplicated, however, whole task training did not produce more true errors than random-3 chaining. Random-3 chaining produced significantly more true errors than each of the chaining methods of forward chaining, backward chaining, random chaining and random-2 chaining.

For the proficiency criterion of one to teach a new subsequence, whole task training produced more true errors than forward chaining and random chaining at alpha = .01 and backward chaining at alpha = .05.

For the proficiency criterion of six to teach a new subsequence, whole task training produced more true errors than each of the chaining methods of forward chaining, backward chaining and random chaining. Forward chaining produced fewer true errors than each of the chaining methods of backward chaining and random chaining.

Total Responses

For total responses, no clear pattern was found. For the proficiency criterion of three to teach a new subsequence, each of the chaining methods of backward and random chaining produced more total responses than whole task training in Experiment 5 and 6. However, these results were not duplicated in Experiment 4. In this experiment, all four training methods of forward chaining, backward chaining, random chaining and whole task training were indistinguishable in terms of the total responses to learn a sequence of behaviors to criterion. In Experiment 6, random-2 chaining and random-3 chaining produced more total responses than whole task training. These results indicated that random chaining methods could be poor practical choices when total responses are to be considered.

In Experiment 5, increasing the proficiency criterion to teach a new subsequence resulted in an increase in total responses for forward chaining, backward chaining and random chaining.

Time

No clear pattern was found for time. In Experiment 5 and 6, using the proficiency criterion to teach a new subsequence of three, whole task training took significantly less time than backward chaining and random chaining. This was not the pattern found in Experiment 4 in which the four training methods did not differ in time taken to learn a sequence. At criterion to teach a new subsequence of six, forward chaining took significantly less time than random chaining and random chaining took significantly more time than whole task training.

In Experiment 6, whole task training took significantly more time than each of the chaining methods of backward chaining, random chaining, random-2 chaining and random-3 chaining. Random-3 chaining took significantly more time than each of the chaining methods of forward chaining backward chaining, and random chaining. Random-2 chaining took significantly more time than each of the chaining methods of forward chaining and backward chaining. Random chaining took significantly more time than forward chaining.

Generally, each of the forms of random chaining took more time than whole task training. This indicated that all forms of random chaining are poor practical choices when training time is the dependent variable of concern.

Theoretical Application of Results

It has been hypothesized that backward chaining should be the superior method of teaching sequences of behaviors (Gilbert 1962a,b; Martin & Pear, 1988). The results of the six experiments clearly do not support the hypothesis that backward chaining is the superior training method. This hypothesis, however, was based on the assumption that backward chaining is the superior method because it results in terminal reinforcement at each stage of training (Gilbert 1962a,b; Martin & Pear, 1988). These experiments did not disprove or prove this part of the hypothesis because it was not the focus of examination.

In backward chaining, tne final correct response (key press) is taught in the first subsequence. In the six experiments, the final response produced no greater reinforcement than any other correct response taught in the first subsequence of any of the chaining methods. A correct response in the first subsequence resulted in the positive reinforcement of "100%" being presented on the screen and the oportunity to proceed to the next stage in training. This correct response was the final response in backward chaining, the first response in forward chaining, and a random response in any of the random chaining procedures. The person performing the task was unaware of whether the response being taught was the first in the sequence, the last in the sequence, or just a random response.

It is possible that for a task such as drinking water, throwing a basketball, or object assembly, the hypothesis that backward chaining is the superior training method may be correct. In these tasks, the final response does result in a potentially potent reinforcement (a glass of water to drink, the basketball going through the basket, and the production of an assembled object). In contrast to the sequence used in this dissertation, the sequence of getting a glass of water, for example, is very different. The final response of drinking water is very different from the first response of going to the cupboard.

In these experiments, the discriminated operant consisted of a discriminated stimulus (symbol appearing on the screen) followed by a response or component behavior (key press) which was reinforced either by a score of 100% or being allowed to learn the next component behavior. The task consisted of a sequence of eight discriminated operants. The whole sequence began to have the characteristics of a single operant, since the whole sequence was reinforced (that is the task was learned when the entire sequence was learned). This concept was shown quite clearly in the example of getting a glass of water presented in the Introduction. In getting a glass of water, a sequence of behaviors occurs with the whole sequence being reinforced by drinking the glass of water.

However, a sequence of behaviors is not a single operant because the connections between parts (operants) are purely mechanical and can be broken at will (Skinner, 1938, p.32). This hypothesis that connections between parts or operants can be broken at will was supported by the results of Experiments 4, 5, 6. Specifically, the evidence supporting the hypothesis was that the different forms of random chaining (random chaining and random-2 chaining) broke the operants up. These random chaining methods proved as accurate (produced same number of true errors) as each of the other chaining methods of forward chaining, and backward chaining. Each random-3 chaining (which really separated operants and mixed them up in the training) was successfully used to teach the sequence and it produced as accurate results as each of the other chaining methods.

Skinner's (1938) Law of Chaining stated "that the responses or component behavior of one operant may constitute or produce the discriminated stimulus of another" (Skinner, 1938, p.32). It is evident from Experiments 4 and 5 that the response or component behavior of an operant does not necessarily constitute or produce the discriminated stimulus of another. For example, in random chaining and random-2 chaining, the operants were being presented in different orders in each subsequence yet random chaining and random-2 chaining did not differ from forward chaining or backward chaining in the number of true errors produced. The Law of Chaining (Skinner,1938) states that the response of an operant constitutes or produces the discriminative stimulus of another. If this was true, then forward chaining and backward chaining, which gradually build up these relationships, should have produced significantly fewer true errors than random chaining and random-2 chaining. The results showed no significant differences between forward chaining, backward chaining, random chaining, and random-2 chaining.

Factors Involved in Training Methods

The following section will examine factors which may influence the effectiveness of the training methods. As previously explained, the measure of accuracy used in this discussion will be true errors.

Factor One: Selection of the Component Behavior to the Taught in the First Subsequence

Two possibilities are that the component behaviors to be taught in the first subsequence may be the same for each subject or randomly determined and change with each subject. In this section, first and last component behaviors refer to the order of component behaviors in the sequence being taught. Forward chaining teaches the first component behavior, backward chaining teaches the last component behavior, and random chaining teaches a randomly determined component behavior which may be different for each subject. Although the evidence is not conclusive, there are indications that teaching the first component behavior in the first subsequence rather that the last component behavior or a randomly determined component behavior results in more accurate chaining methods. Evidence for the conclusion consists of: (a) at a proficiency criterion of three to teach a new subsequence, the rank ordering of median true errors from least to most was forward chaining, backward chaining, and whole task training; (b) at a proficiency criterion of six to teach a new subsequence, forward chaining produced significantly fewer true errors than each of the chaining methods of backward chaining and random chaining. Results from Watters (in press) indicated that at increased sequence lengths (eight and ten), forward chaining produced significantly fewer true errors than backward chaining. However, for the first three experiments reported above, forward chaining produced fewer, but not significantly fewer, true errors than backward chaining. Thus, the evidence is not as strong as it could be.

Further clarification of this issue will be found in the discussion of the second factor because the first and second factor are related. This first factor will also be discussed again when factor six is discussed as these two factors are related.

Factor Two: Selection of Additional Component Behaviors to be Taught in the Subsequences

The additional component behaviors taught may be chosen by sequence order or random order. In forward chaining and backward chaining, additional component behaviors are selected according to sequence order. In the random chaining procedures, additional component behaviors are selected according to random order. Whether additional component behaviors are selected according to random or sequence order does not appear to be an influential factor in chaining methods. Evidence for this conclusion consists of: (a) in Experiment 4, random chaining (which uses random order to chose additional component behaviors to teach in the subsequence) produced the same number of true errors as forward chaining and backward chaining (which use sequence order); (b) in Experiment 5, at the criteria of one and of three to teach a new subsequence, random chaining produced the same number of true errors as forward chaining and backward chaining; (c) in Experiment 6, random chaining and random -2 chaining produced the same number of true errors as forward chaining and backward chaining. In Experiment 5, under the proficiency criterion of six to teach a new subsequence, only backward chaining did not produce significantly different true errors than random chaining. Since backward chaining uses sequence order and random chaining uses random order, this confirms that factor two was not influential. However, forward chaining produced significantly fewer true errors than random chaining and backward chaining. Evidently, there is something that differentiates forward chaining from backward chaining which interacts with the factor of increasing proficiency criteria. This could be related to factor one, on which all three chaining methods differ. Further research might investigate this at increasing sequence lengths. Watters (in press) showed that increasing sequence length results in backward chaining producing more true errors than forward chaining. It was also shown that increasing the proficiency criterion to teach a new subsequence resulted in forward chaining producing less true errors than backward chaining and random chaining. Therefore, increasing sequence length or increasing the proficiency criterion to teach a new subsequence would assist in studying the factor or factors which contribute to forward chaining being superior to other chaining methods.

Factor Three: Ordering of the Component Behaviors Within the Subsequences Used During Training

Forward, backward and random chaining placed the component behaviors that were selected into the subsequences by sequence order. Random-2 chaining placed the component behaviors that were selected in to the subsequences by random order. No significant differences were found between these four chaining methods in Experiment 6 (which used a criterion of three to teach a new subsequence). It appears that this factor is not influential in teaching subsequences. However, further studies are needed using larger proficiency criterion to teach a new subsequence. In Experiment 5, use of a larger proficiency criterion to teach a new subsequence resulted in significant differences between chaining methods. For a proficiency criterion of six to teach a new subsequence, forward chaining produced significantly fewer true errors than backward chaining and random chaining. Perhaps at a larger proficiency criterion to teach a new subsequence, forward chaining would produce significantly fewer true errors than random chaining and random-2 chaining. Random chaining might even produce less true errors than random-2 chaining. This would indicate that at a larger proficiency criterion to teach a new subsequence that the order the component behaviors are taught within the subsequence may be influential.

Factor Four: Whether the Subsequences Used During Training are Subsequences of the Sequence

In forward chaining and backward chaining, subsequences taught are subsequences of the sequence. In all three forms of random chaining, the subsequences taught are not subsequences of the sequence.

This factor is very important theoretically. Skinner's (1938) Law of Chaining states that a component behavior can only play a dual function of stimulus and reinforcer if it is located next to the component behavior which is either a discriminative stimulus or reinforcer (Skinner, 1938, p.32). However, as in the case in the random sequences, if the subsequences taught are not subsequences of the sequence then the component behaviors are often not located in these positions. Therefore, component behaviors in the random sequences are not playing the dual function of discriminative stimuli and reinforcers. From the following evidence it is shown that for this sequence of behaviors, the component behaviors are not playing this dual function.

In Experiment 6, random chaining and random-2 chaining did not differ significantly from forward chaining and backward chaining for true errors produced. In Experiment 5 and Experiment 6, for criterion of one and three to teach a new subsequence, no significant differences were found among forward chaining, backward chaining, and random chaining. In Experiment 5, for the proficiency criterion of six to teach a new subsequence, each of backward chaining and random chaining produced more true errors than forward chaining. However, backward chaining did not produce significantly more true errors from forward chaining. This evidence further illustrates that whether subsequences used during training are subsequences of the sequence or not is not a very important factor in influencing accuracy of the chaining methods.

Factor Five: Whether Component Behaviors of the Subsequences are selected "With" or "Without" Replacement from the Collection of Component Behaviors That Constitute the Sequence

In Experiment 6, random-3 chaining consisted of selecting component behaviors of its sequence with replacement and all other chaining methods selected component behaviors of their subsequences without replacement. Random-3 chaining produced significantly more true errors than the other chaining methods. In fact, random-3 chaining did not differ significantly from whole task training for true errors produced. This factor appears to be influential in teaching sequences of behaviors. Further research in this area is needed.

Factor Six: Proficiency Criteria

In Experiment 5, it was demonstrated that increasing the proficiency criterion to teach a new subsequence in forward chaining and backward chaining produced fewer true errors. This factor seems to interact with other factors as previously described in the discussion of factors one and two. To review the results at a proficiency criterion of six, each of the chaining methods of backward chaining and random chaining produced more true errors than forward chaining. At each of the proficiency criterion of one and three, there were no significant differences among forward chaining, backward chaining, and random chaining. Future research is needed to investigate random-2 chaining and random-3 chaining at varying proficiency criterion.

Factor Seven: Addition of One New Component Behavior Into Each Subsequence Subsequence

In all chaining methods, except random-3 chaining, only one new component behavior is taught in each subsequence. This results in repetition of component behaviors before a new component behavior is added. In random-3 chaining , this is not the case. A component behavior may for example be taught in the first subsequence and not taught again until the sixth subseqence. A subsequence could consist of a number of component behaviors all being taught for the first time.

This factor seems influential as shown by the results of Experiment 6 in which random-3 chaining produced more true errors than the other chaining methods and produced the same number of true errors as whole task training.

This factor as factor five (sampling with or without replacement) could interact with the proficiency criterion to teach a new subsequence and/or sequence length. Perhaps increasing the proficiency criterion may decrease the influence of factor five(sampling with or without replacement) and factor seven (addition of one new component behavior in each subsequence). The rationale is that with more repetition, the subject may adapt to the new forms of subsequences. The results would be that random-3 chaining and random-2 chaining would produce similar numbers of true errors.

Factor Eight: Subsequence Seven is a Subsequence of the Sequence

For forward chaining, backward chaining and random chaining, the seventh subsequence is a subsequence of the sequence. For random-2 chaining and random-3 chaining, the seventh subsequence is not necessarily a subsequence of the sequence. The evidence found in Experiment 6 indicates that this factor may not be very influential. In Experiment 5, each of the chaining methods of forward chaining, backward chaining and random chaining did not produce significantly different true errors from random-2 chaining. Factor five (sampling with or without replacement) and factor seven (addition of one new component behavior in each subsequent subsequence) seem to contribute to random-3 chaining producing more true errors than each of the other chaining procedures.

Future Research

Once the roles of factors discussed above have been determined for a sequence of key presses using an arbitrarily defined order, then systematic studies should be undertaken to investigate whether these roles are similar for other tasks and populations. In reference to the other headings used in the Introduction, a framework for further investigation of sequences of behaviors is developed in the following section.

Tasks

From the consistent superior performance of forward chaining and backward chaining in the first three experiments, it was determined that the factors which contribute to an effective training procedure to teach a simple sequence of behaviors should be identified and investigated. In the next three experiments, some of the groundwork was undertaken. A natural next step would be to replicate these experiments but with different tasks. If the results differed between these tasks and the simple task, then a conceptual framework would have to be developed to classify tasks and determine what characteristics are important in choosing the best training methods for specific types of tasks.

An example of a possible framework for this undertaking was suggested by Naylor and Briggs (1963). They hypothesized an interaction between task organization, task complexity, and training method. Task organization refers to the nature of the relationships between component behaviors. An example of a highly organized task would be assembly work in which the relationships of parts are important. An example of a low organization task would be a sequence of key presses in which there is little relationship between parts. Task complexity refers to the difficulty in performing the component behaviors. An example of a low complexity component behavior is a button push. A mathematical calculation might be considered a more highly complex component behavior. As reported earlier, Naylor and Briggs' (1963) data supported the hypothesis that for a relatively organized task such as assembly work, whole task training is superior to part schedules (chaining procedures) at all levels of complexity. However, for a relatively unorganized task such as a sequence of key presses, an increase in task complexity will result in part task training being superior to whole task training. The six experiments reported in this dissertation did not provide support for this. They showed that for a relatively unorganized task, chaining procedures (part task training) were superior to whole task training. Unfortunately, Naylor and Briggs (1963) did not define part task training precisely. As shown by the different results produced by the different chaining methods, it is clear that a precise definition of part task training is necessary to refine Naylor and Briggs' (1963) hypothesis. It is recommended that the relationship between task organization, task complexity and the factors discussed above which contribute to the effectiveness of training methods be investigated more systematically.

With Naylor and Briggs' (1963) hypothesis as a framework, a starting point would be to investigate an unorganized, low complexity task such as a sequence of button pushes. This dissertation has begun this groundwork but further experiments should be undertaken to explore this further. The next step could be to increase task complexity to determine whether the factors and relationships determined to be involved in teaching a simple task are relevant to tasks with increasing complexity. Subjects could perform a sequence of eight behaviors consisting of mathematical calculations such as addition, subtraction, multiplication, and division on a computer. The eight component behaviors could consist of (1) 6 times 6 (2) add 24 (3) divide 19 (4) times 200 (5) minus 25 (6) add 1700 (7) divide 15 and (8) minus 17. The first experiments should replicate the six experiments used in the dissertation. If the results differed from those established with the low complexity button pushing task, then it would be clear that tasks must be classified according to task complexity.

The next step could be to replicate the experiments using a task involving increased task organization (such as object assembly). Watters (in press) has shown that increasing sequence length results the three basic training methods. A next step might be to investigate affects the three basic training methods. A next step might be to investigate the sequence length in relation to Naylor and Briggs' (1963) dimensions. As research continues, other dimensions for task classification would be determined.

Everyday tasks such as dressing (Azrin et al, 1976), military tasks such as divebombing (Bailey et al, 1980), sports activities such as basketball (Simek et al, 1988), mathematical computations (Wilcox, 1974), behaviors problems such as the one described in the introduction (Frankel, 1975) and new tasks not yet identified could then be classified along these dimensions. The empirically derived training recommendations could then be made based on this classification.

Subjects

The subjects studied in the six experiments were normal adults with a minimum of grade 12 education. After the programme of research outlined in the previous section was completed, the experiments could be replicated with different subject populations (for example, children, the mentally disabled and people with varying aptitudes for the task). Walls et al (1981) postulated that subjects' aptitude should influence choice of training method. Walls et al (1981) found that for fastest and slowest learning subjects, the whole task training method produced a higher percentage of errors than forward chaining or backward chaining. Middle learning subjects showed less difference between training methods.

Dependent Variables

True errors were used as a measure of accuracy in the six experiments. Time and total responses were used to determine the practicality of the training methods.

For most tasks taught, it is important that the subject is able to perform the task over a period of time. Once a person has been taught to tie his or her shoe, it would be useful if he or she was able to tie the shoe for the rest of his or her life. When a person learns to start a car it would be useful if he or she was able to start the car when needed. This could be the next day or in a week. Future experiments could examine how the factors involved in training methods affect retention of the sequence. It is possible that the factors involved in the best training method to teach the sequence may not be the influential factors involved in retention of sequences. Watters (1990) showed that the sequences learned by whole task training produced fewer errors five days later than those learned by forward chaining and backward chaining. Replication of Watters (1990) should include (a) the three random chaining methods and (b) different proficiency criteria to teach a new subsequence. Watters (1990) hypothesized that whole task training produced better retention due to the similarity between whole task training and the retention test. Both involved performance of the complete sequence. Therefore, by increasing the criterion to end training so that repetition of the entire sequence increases, Watters hypothesized that chaining methods would show greatly improved retention. Finally, experiments using retention could be undertaken to study different task dimensions, different sequence length and different subject populations as previously mentioned.

Experimental Design

The experiments in this dissertation used a within-subject comparison of training methods. For within-subject design there is no assurance that a subject's performance when doing the second or third or whatever sequence is the same as it would have been if he or she had done only one sequence (as would have been the case in a between subject design). Relevant experiments should be replicated using a between subject design which increases variability and would assist in finding more global results.

Proficiency Criteria

From Experiment 5, it is clear that the proficiency criterion to teach a new subsequence is an important factor in teaching sequences of behaviors. The proficiency criterion to end training may also prove relevant as hypothesized by Watters (1990) and explained under the Dependent Variables section. The results from Experiment 5 showed that the larger proficiency criterion to teach a new subsequence of six produced fewer true errors but took more total responses and time to complete. Whether this indicates that a larger proficiency criterion to teach a new subsequence is impractical or not depends on the situation. For example, when teaching individuals with mental disabilities or children with a low tolerance for errors, it would be best to use an accurate method which produces fewer true errors. In teaching a task in an industrial setting where time is important, a smaller proficiency criterion to teach a new subsequence would be the best choice. When teaching a person with motor control problems, decreasing the total responses is important and a method using a smaller proficiency criterion would be optimal.

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Summary Table
Median True Errors

FC - Forward Chaining
BC- Backward Chaining
WT - Whole Task Training
RC - Random Chaining
R2C - Random-2 Chaining
R3C - Random-3 Chaining
ZIT - Auditory Programmed Consequence "Zit" sound
SCR - Visual Programmed Consequence (screen border flashing)
MIN - Minimal Programmed Consequence
TIME-OUT- Time out Programmed Consequence of three seconds
CRT=1 - Proficiency Criterion of One to teach a new subsequence
CRT=3 - Proficiency Criterion of Three to teach a new subsequence
CRT=6 - Proficiency Criterion of Six to teach a new subsequence
____ - represents significant differences
* - significant at alpha = .05
** - signficant at alpha = .01
FC<BC<WT means that forward chaining rank orders less than backward chaining which rank orders less than whole task training for median true errors.
FC<WT** means that forward chaining produces significantly less median true errors than whole task training (alpha =.01).

Summary Table
Median True Errors

Exp 1:	ZIT	SCR	MIN
	FC<BC <WT	FC<BC <WT	FC<BC <WT
	FC<WT**	FC<WT**	FC<WT**
	BC<WT**	BC<WT*	BC<WT**

Exp 2:	ZIT	PRT
	FC<BC <WT	FC<BC <WT
	FC<WT**	FC<WT**
	BC<WT**	BC<WT*

(RANDOM ERRORS)

(for FC, BC, WT)

(ZIT<PRT)**

Exp 3: TIME-OUT

FC<BC <WT
FC<WT**
BC<WT*

Summary Table (cont'd)
Median True Errors

Exp 4
FC<BC<RC <WT
FC<WT**
BC<WT*
RC<WT*

Exp 5
CRT=1
FC<RC<BC <WT
FC<WT**
RC<WT**
BC<WT*

CRT=3
FC<RC<BC <WT
FC<WT**
RC<WT**
BC<WT**

CRIT=6
FC<BC<RC <WT
FC<BC**
FC<RC**
FC<WT**
BC<WT**
RC<WT**

FOR FC, BC:
1>3>6
1>6**

Exp 6
FC<BC<RC<R2C< R3C<WT

FC<R3C**	FC<WT**
BC<R3C**	BC<WT**
RC<R3C**	RC<WT**
R2C<R3C**	R2C<WT**

List of Figures

Figure 1. Experiment 1: Median True Errors for the Zit Consequence as a Function of Training Procedures

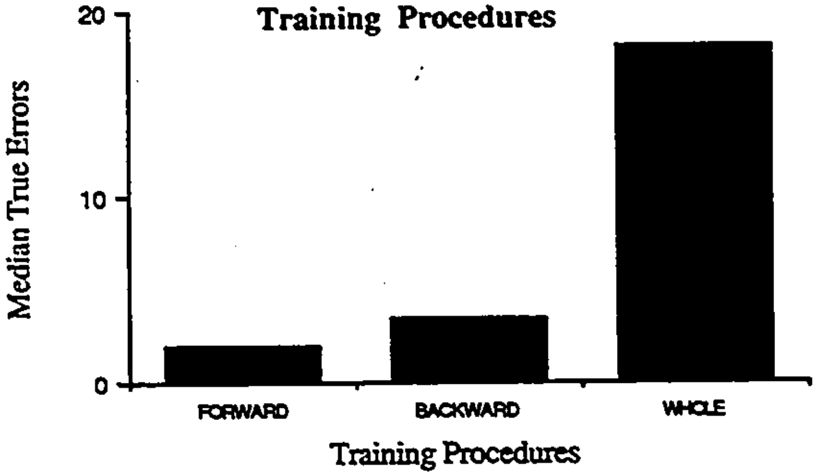


Figure 2. Experiment 1: Median True Errors for the Min Consequence as a Function of Training Procedures

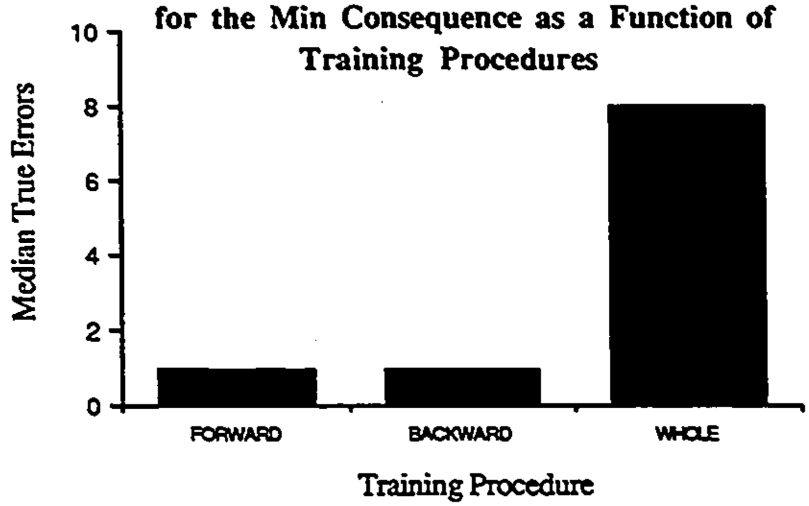
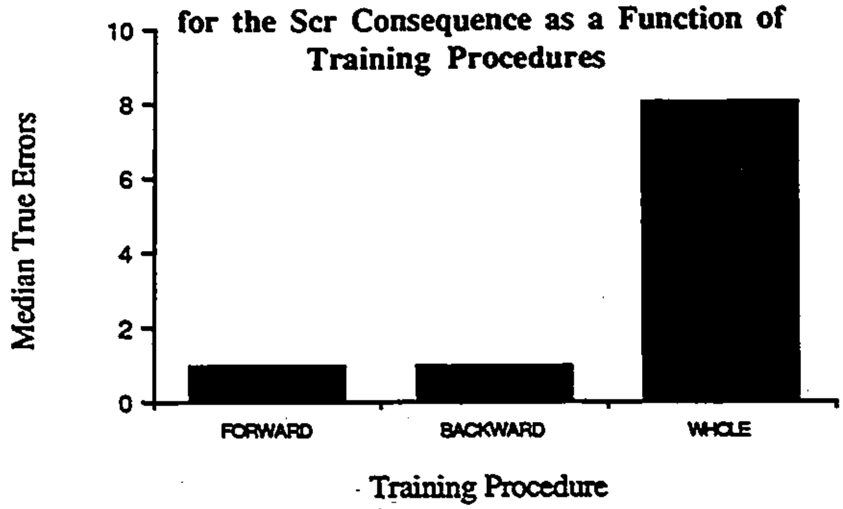


Figure 3. Experiment 1: Median True Errors for the Scr Consequence as a Function of Training Procedures



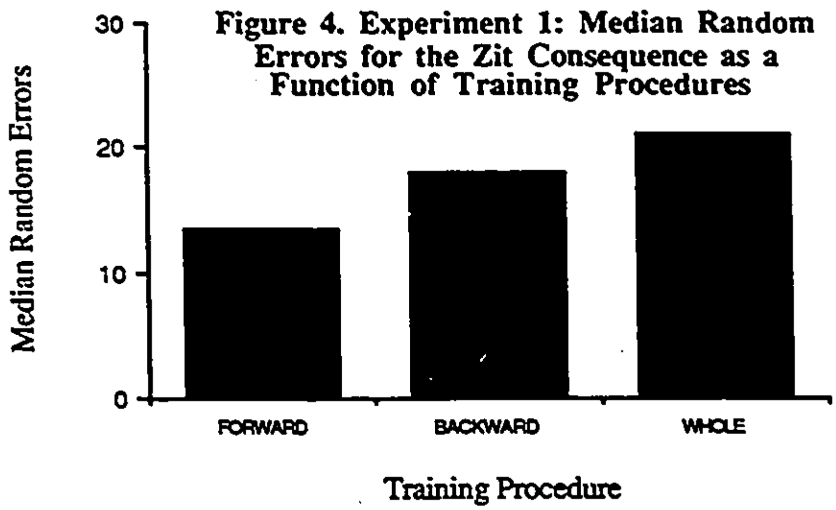


Figure 4. Experiment 1: Median Random Errors for the Zit Consequence as a Function of Training Procedures

Figure 5. Experiment 1: Median Random Errors for the Min Consequence as a Function of Training Procedures

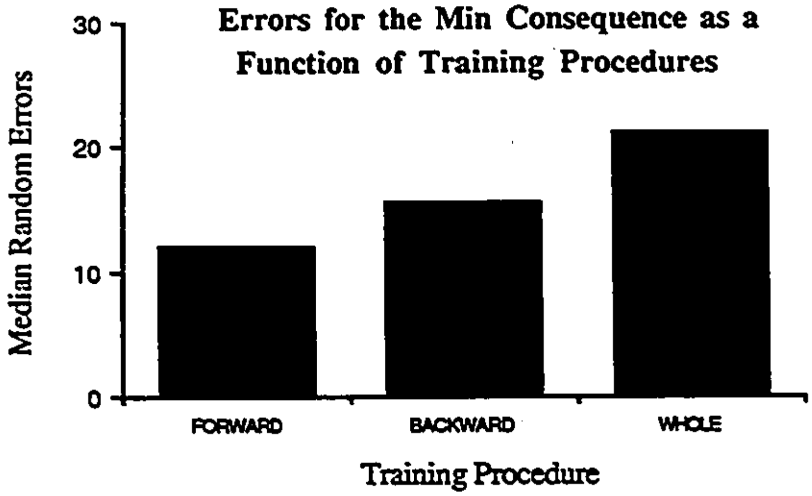


Figure 6. Experiment 1: Median Random Errors for the Scr Consequence as a Function of Training Procedures

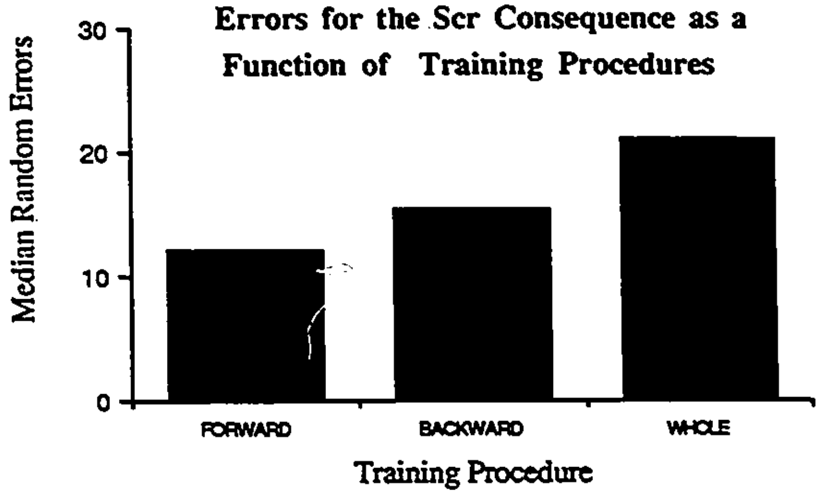


Figure 7. Experiment 1: Median Total Errors for the Zit Consequence as a Function of Training Procedures

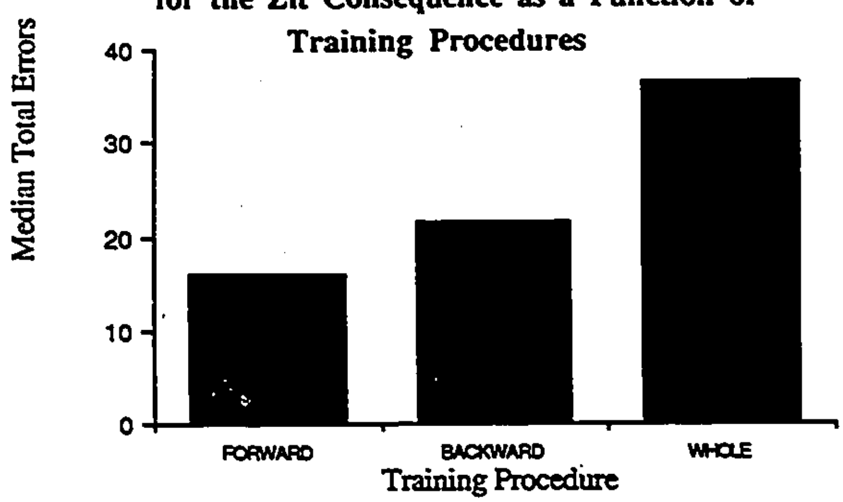


Figure 8. Experiment 1: Median Total Errors for the Min Consequence as a Function of Training Procedures

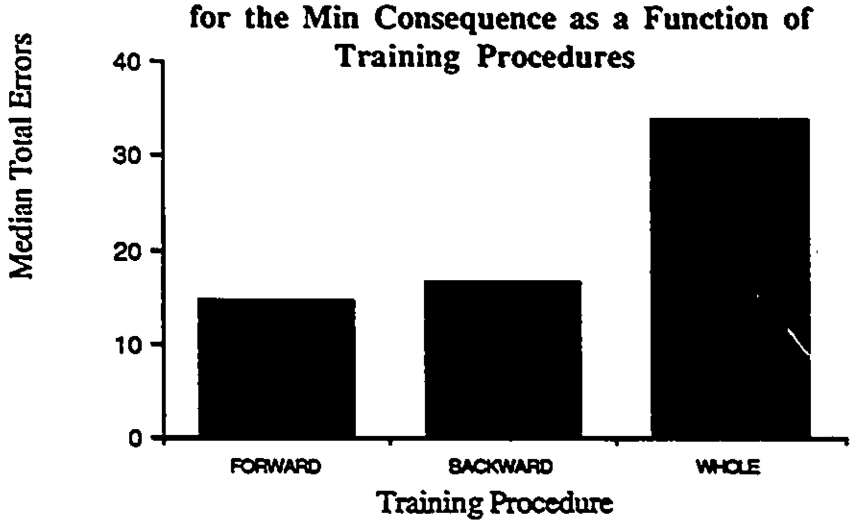


Figure 9. Experiment 1: Median Total Errors for Scr Consequence as a Function of Training Procedures

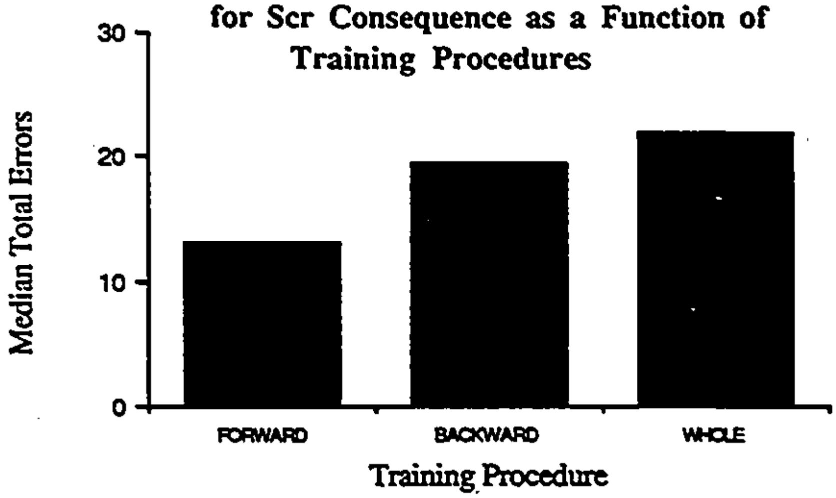


Figure 10. Experiment 1. Median Total Responses for the Zit Consequence as a Function of Training Procedures

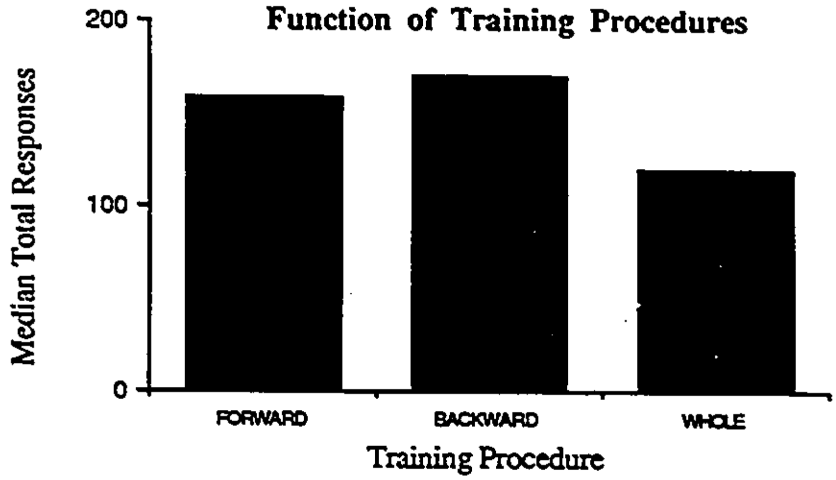


Figure 11. Experiment 1. Median Total Responses for the Min Consequence as a Function of Training Procedures

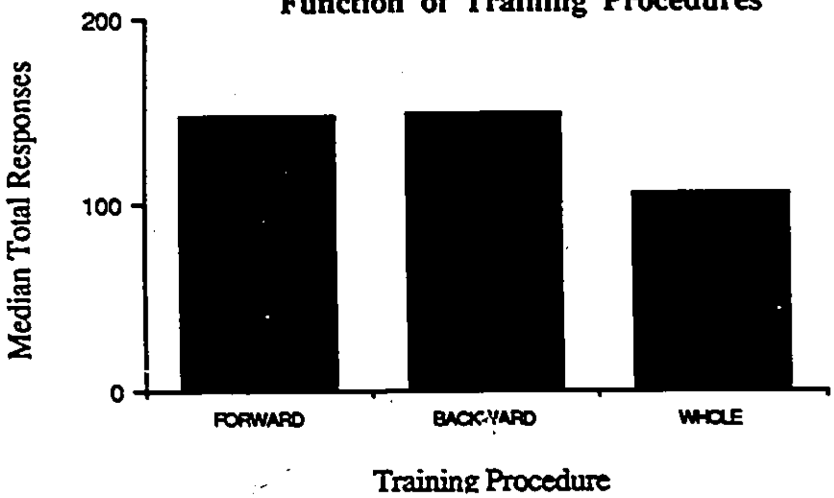


Figure 12. Experiment 1: Median Total Responses for the Scr Consequence as a Function of Training Procedure

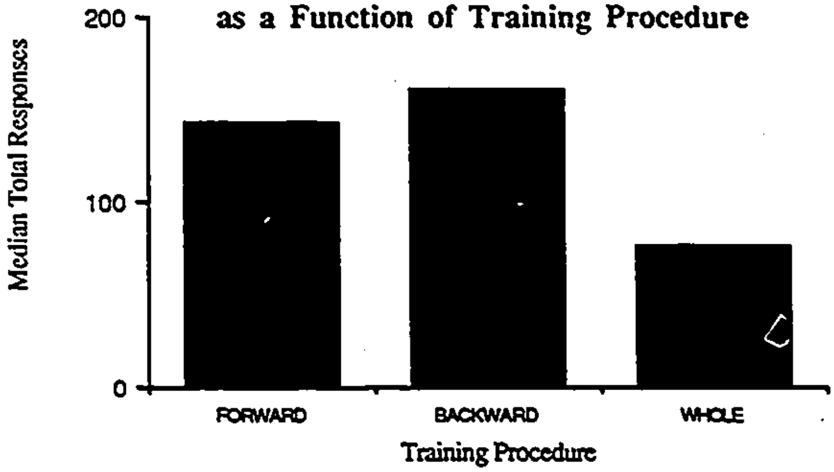


Figure 13. Experiment 1: Median Time for the Zit Consequence as a Function of Training Procedures

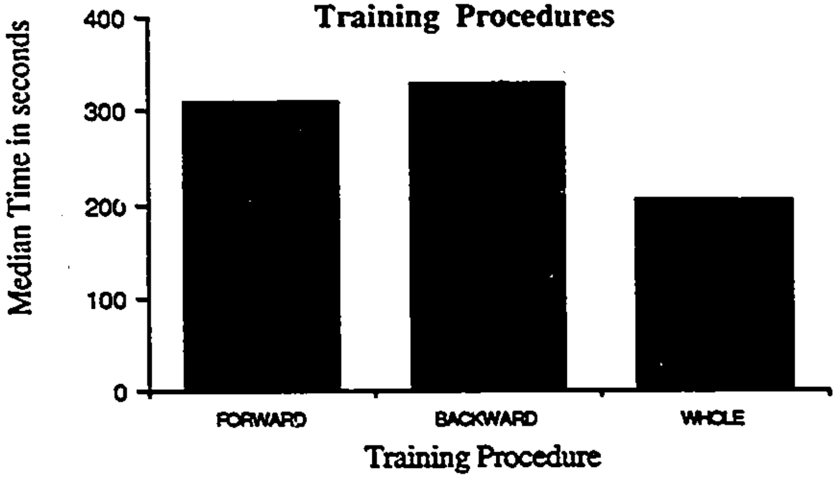


Figure 14. Experiment 1: Median Time for the Min Consequence as a Function of Training Procedures

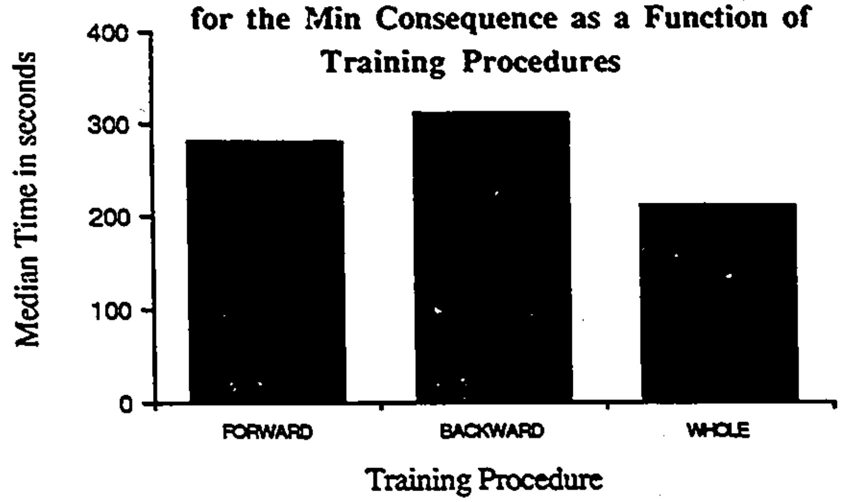


Figure 15. Experiment 1: Median time for the Scr Consequence as a Function of Training Procedures

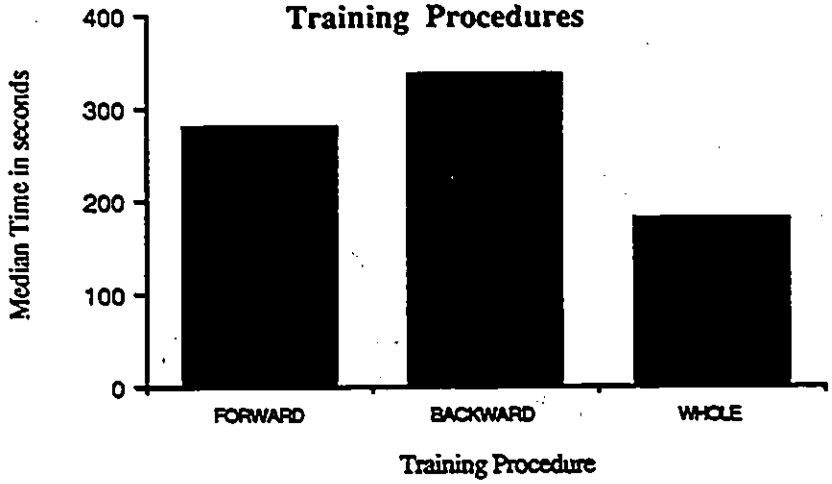


Figure 16. Experiment 2: Median True Errors for the Zit-2 Consequence as a Function of Training Procedures

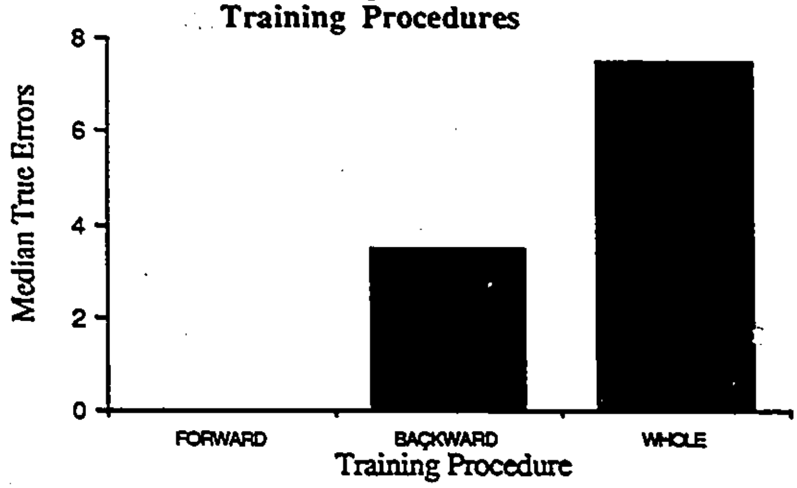


Figure 17. Experiment 2: Median True Errors for the Prompt Consequence as a Function of Training Procedures

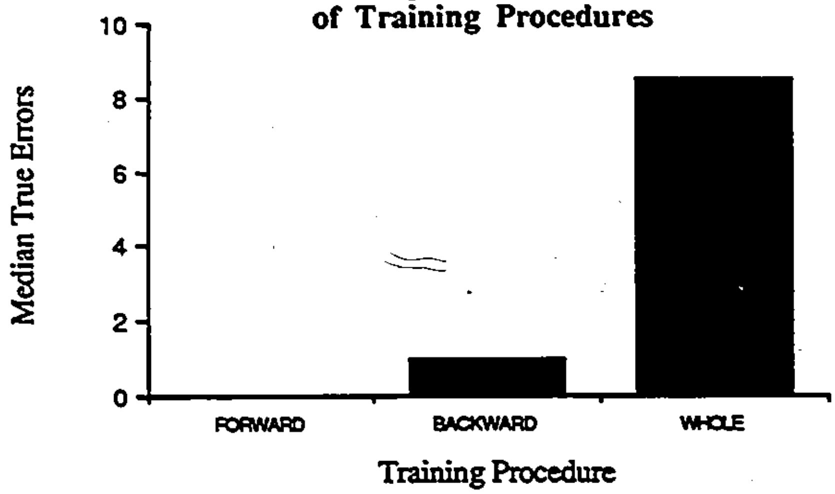


Figure 18. Experiment 2: Median Random Errors for the Zit-2 Consequence as a Function of Training Procedures

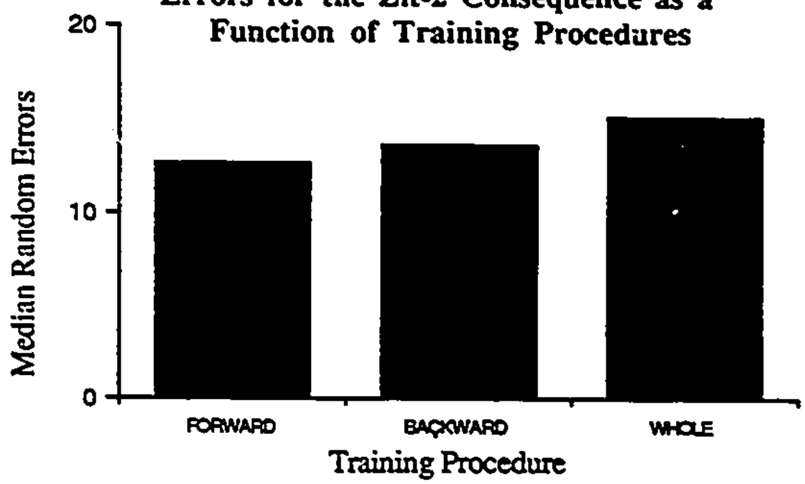
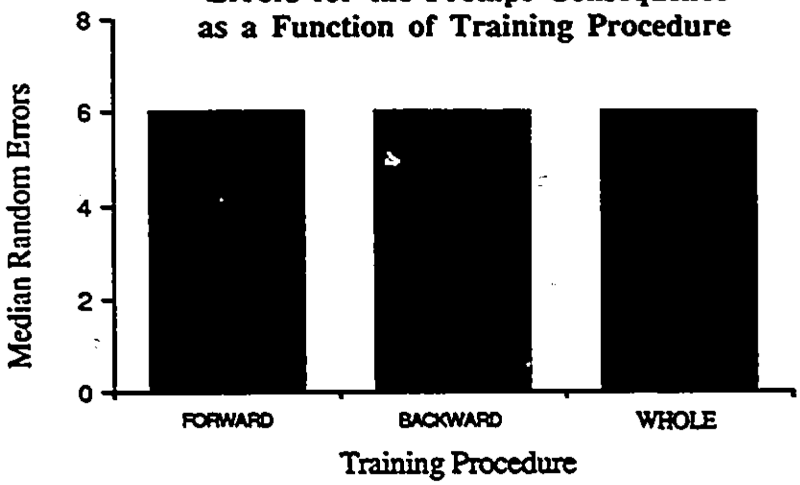


Figure 19. Experiment 2: Median Random Errors for the Prompt Consequence as a Function of Training Procedure



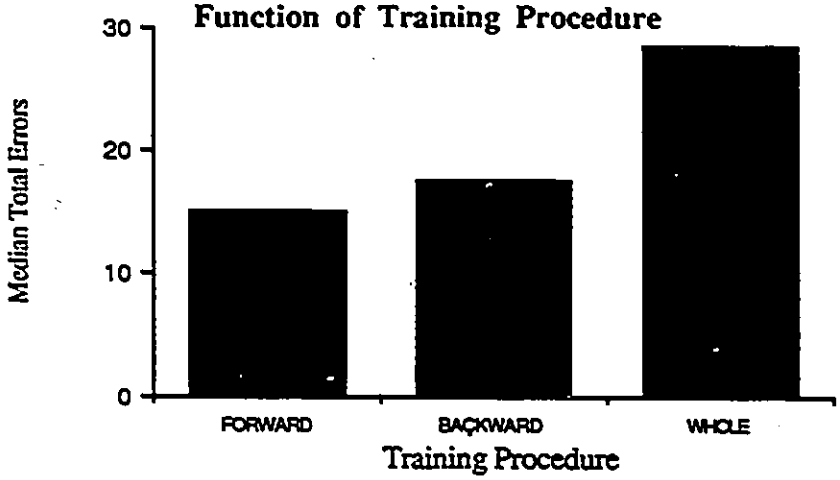


Figure 20. Experiment 2: Median Total Errors for the Zit-2 Consequence as a Function of Training Procedure

Figure 21. Experiment 2: Median Total Errors for the Prompt Consequence as a Function of Training Procedure

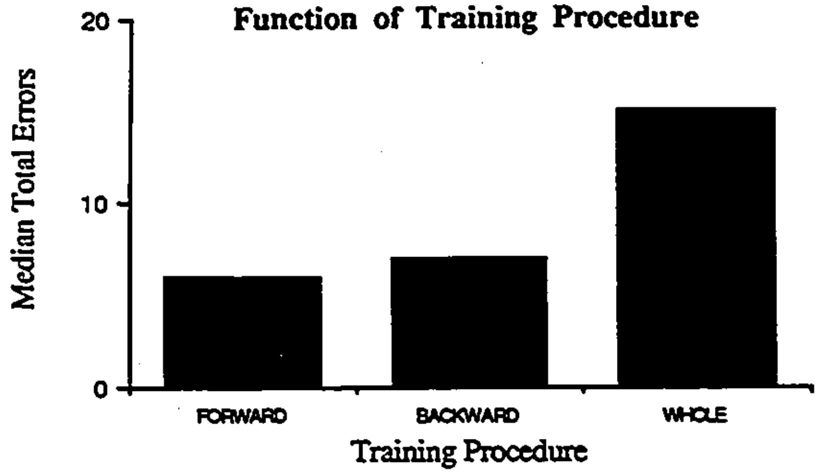


Figure 22. Experiment 2: Median Total Responses for the Zit-2 Consequence as a Function of Training Procedures

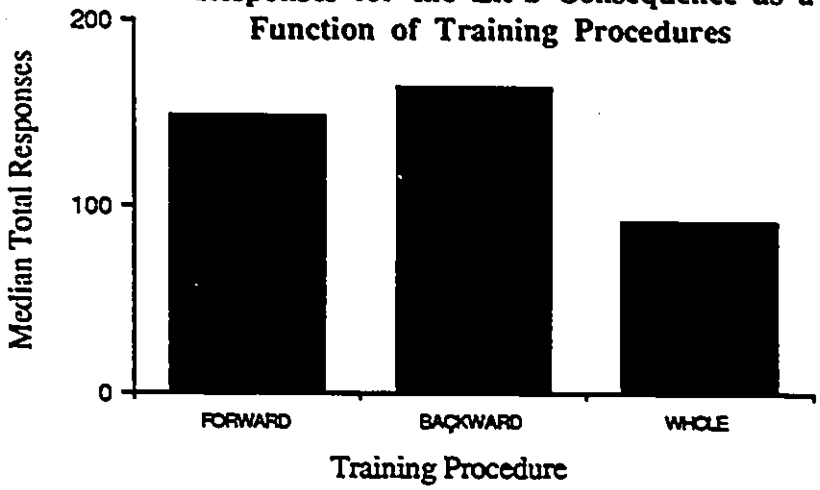


Figure 23. Experiment 2: Median Total Responses for the Prompt Consequence as a Function of Training Procedures

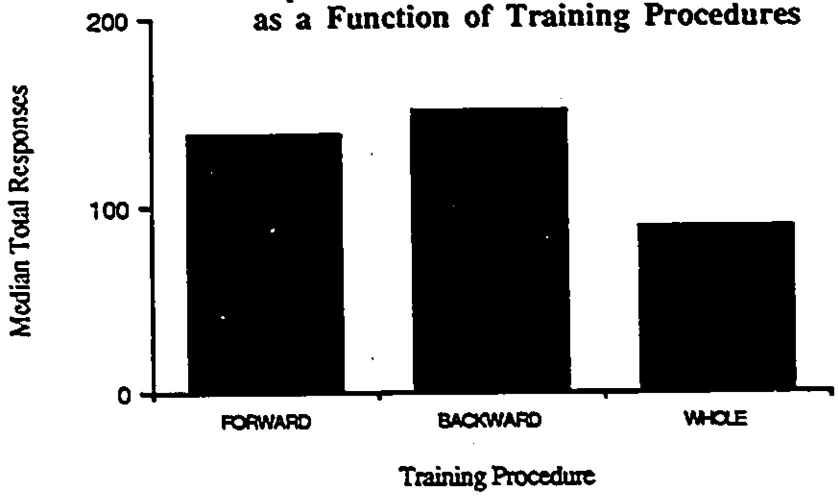


Figure 24. Experiment 2: Median Time for the Zit-2 Consequence as a Function of Training Procedures

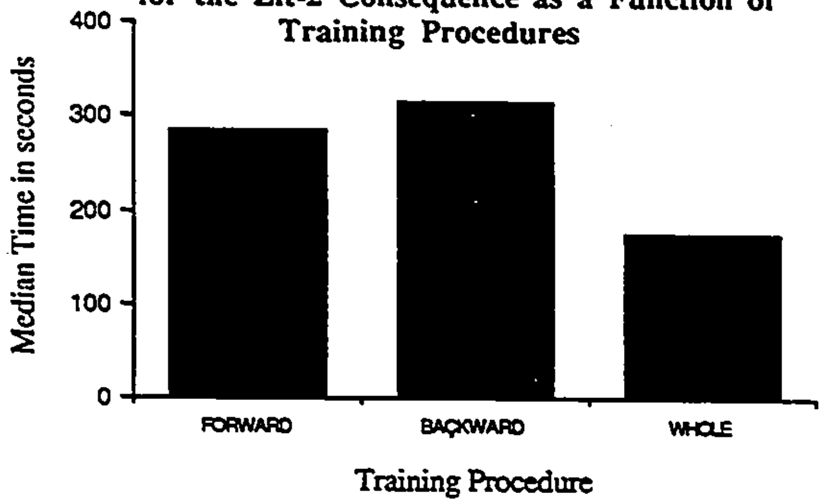


Figure 25. Experiment 2: Median Time for the Prompt Consequence as a Function of Training Procedures

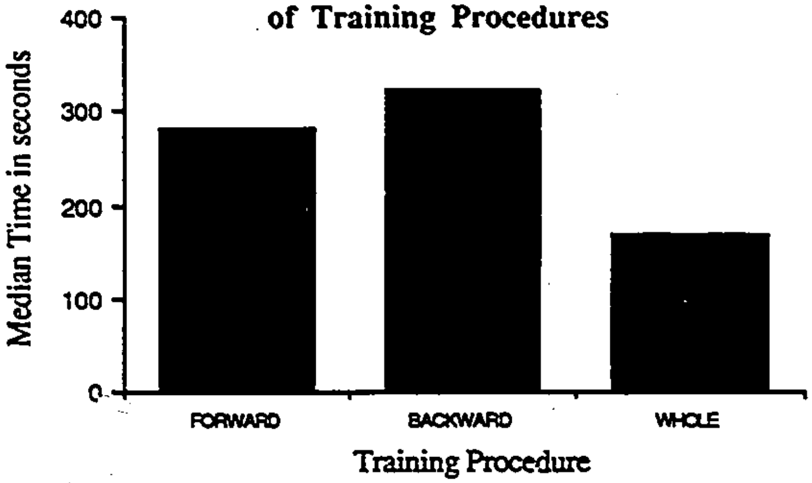


Figure 26. Experiment 3: Median True Errors for the Time-out Consequence as a Function of Training Procedures

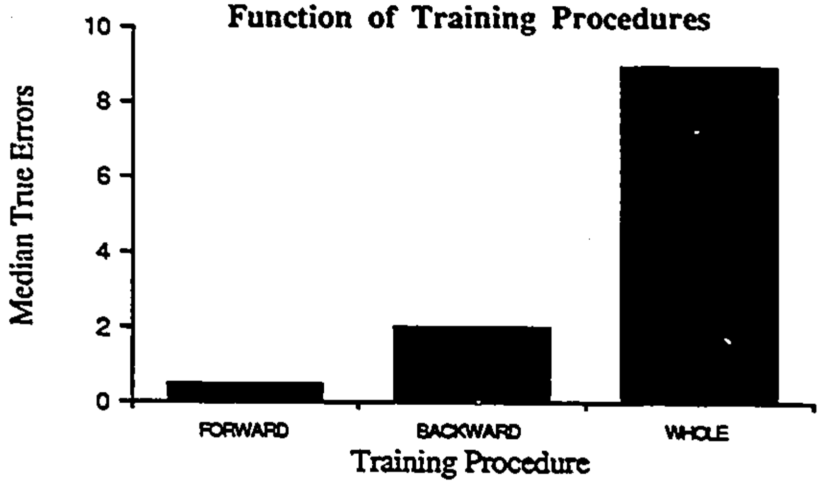


Figure 27. Experiment 3. Median Random Errors for the Time-out Consequence as a Function of Training Procedures

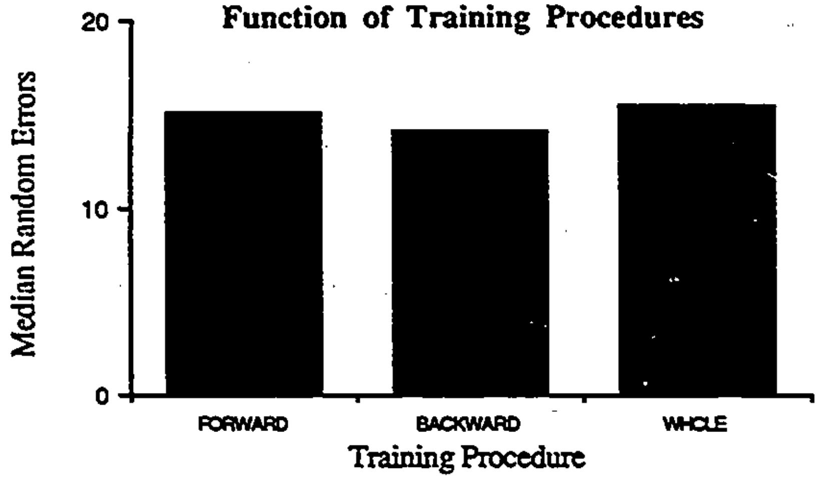
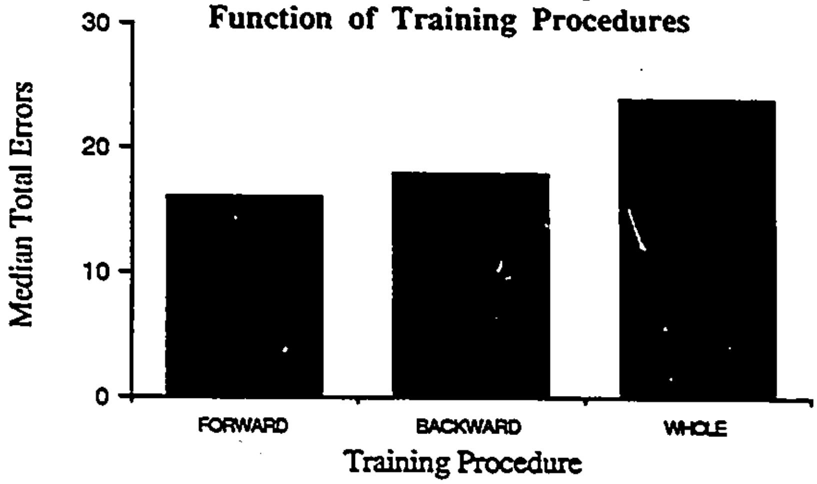


Figure 28. Experiment 3: Median Total Errors for Time-out Consequence as a Function of Training Procedures



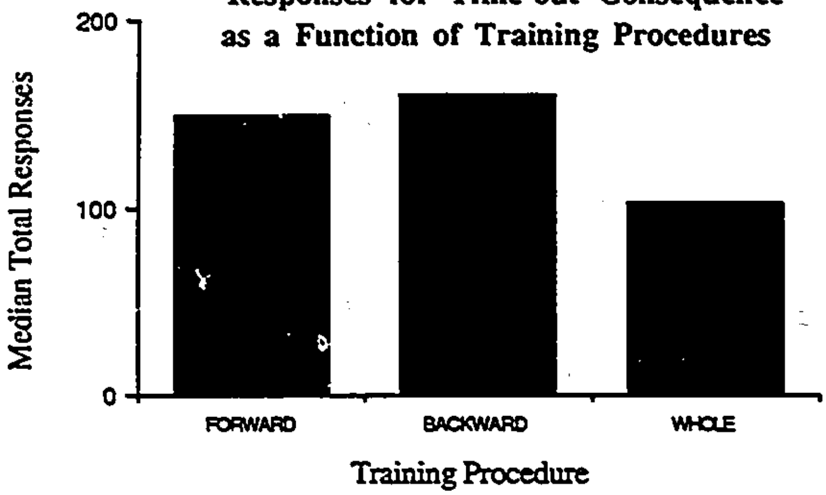


Figure 29. Experiment 3: Median Total Responses for Time-out Consequence as a Function of Training Procedures

Figure 30. Experiment 3: Median Time for Time-out Consequence as a Function of Training Procedures

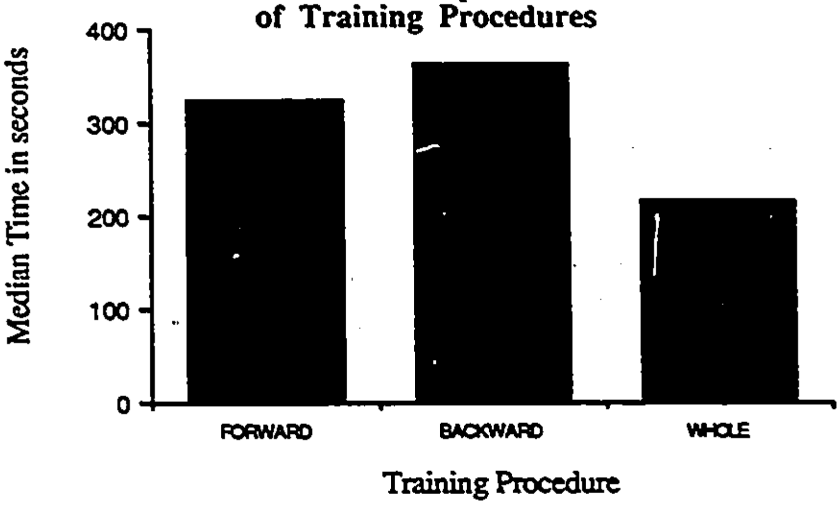


Figure 31. Experiment 4: Median True Errors for Zit-4 Consequence as a Function of Training Procedures

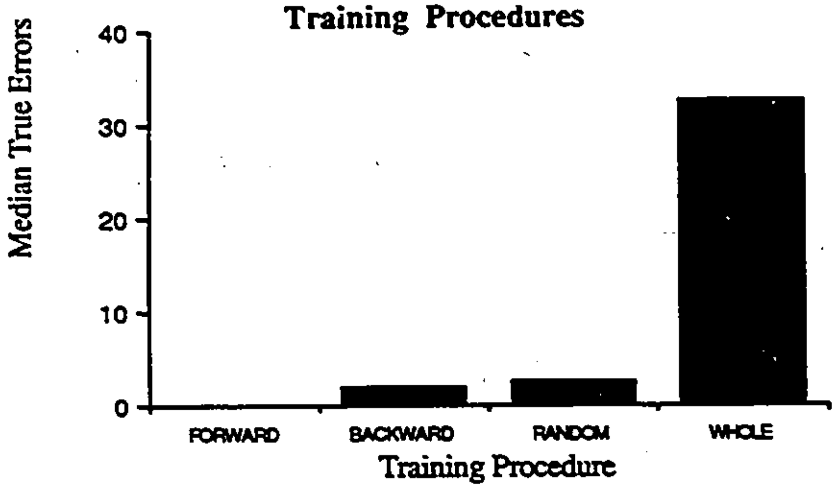


Figure 32. Experiment 4: Median Random Errors for ZIt-4 Consequence as a Function of Training Procedures

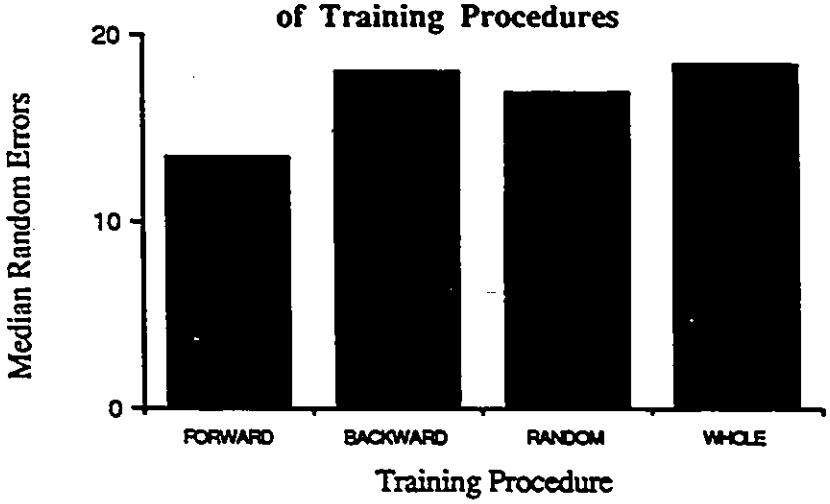


Figure 33. Experiment 4: Median Total Errors for Zit-4 Consequence as a Function of Training Procedures

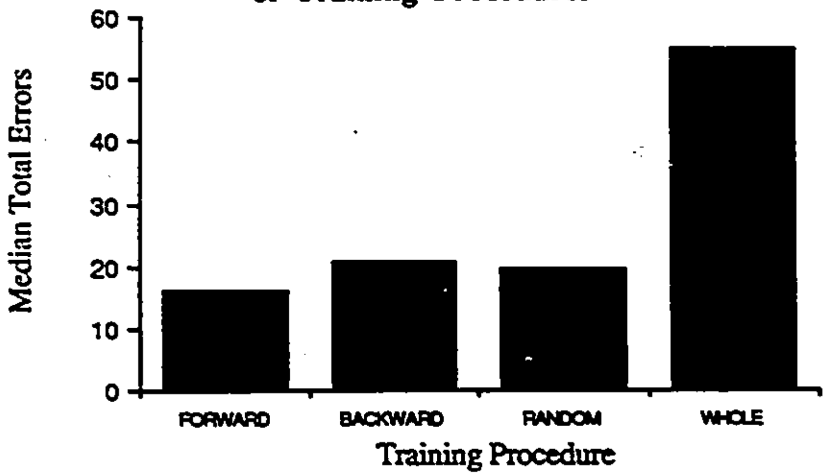


Figure 34. Experiment 4: Median Total Responses for Zit-4 Consequence as a Function of Training Procedures

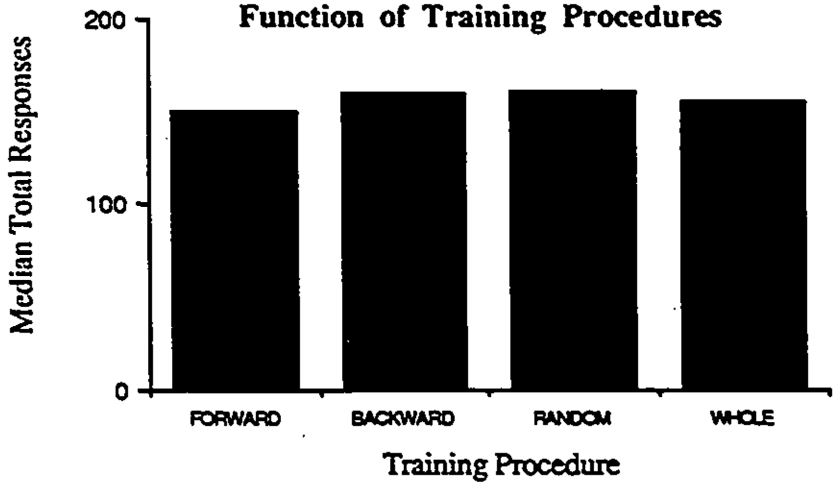


Figure 35. Experiment 4: Median Time for Zit-4 Consequence as a Function of Training Procedures

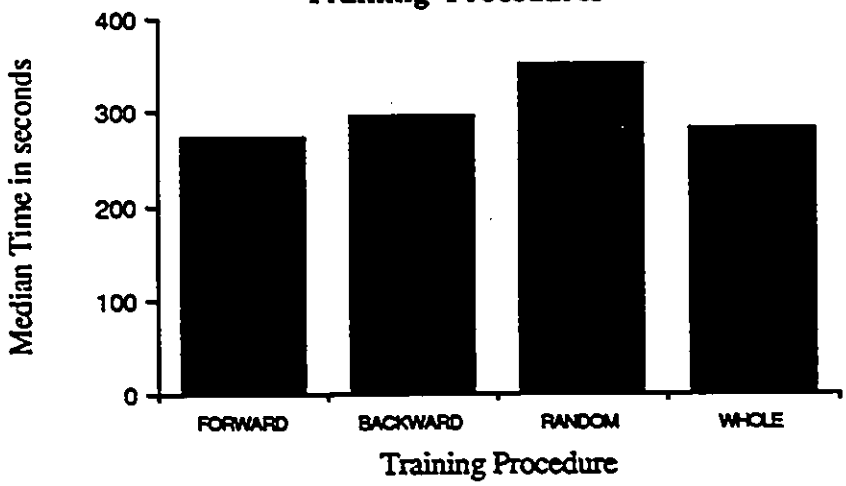


Figure 36. Experiment 5: Median True Errors for the Criterion to Teach A New Subsequence of One as a Function of Training Procedures

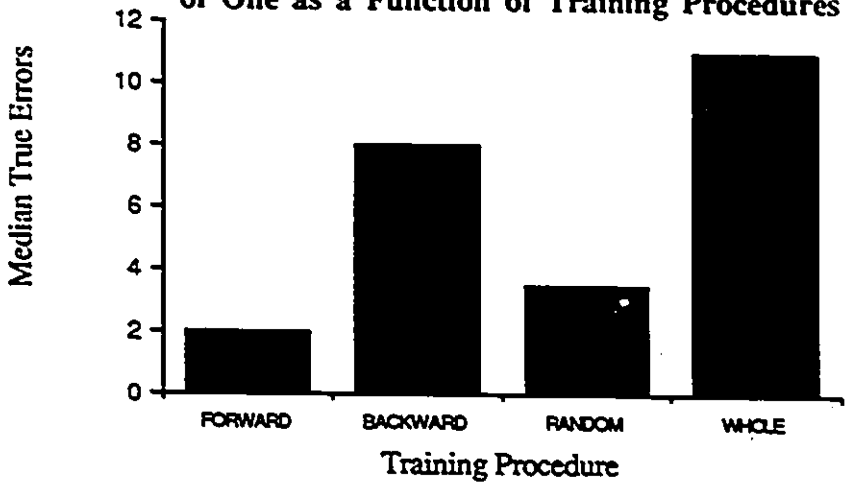


Figure 37. Experiment 5: Median True Errors for the Criterion to Teach a New Subsequence of Three as a Function of Training Procedures

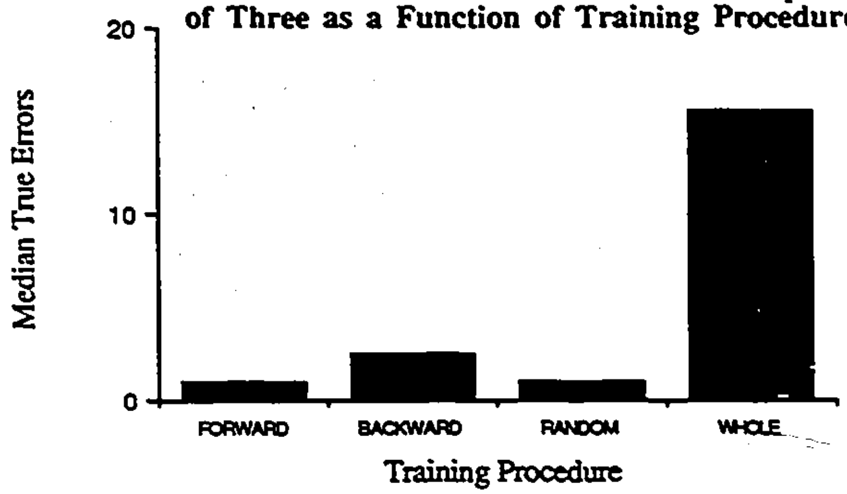


Figure 38. Experiment 5: Median True Errors for the Criterion to Teach a New Subsequence of Six as a Function of Training Procedures

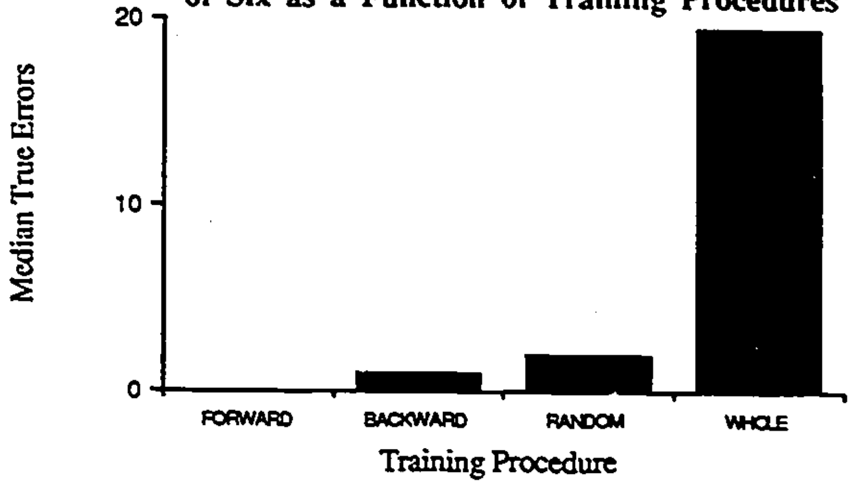


Figure 39. Experiment 5: Median True Errors for Forward Chaining as a Function of Criteria to Teach a New Subsequence

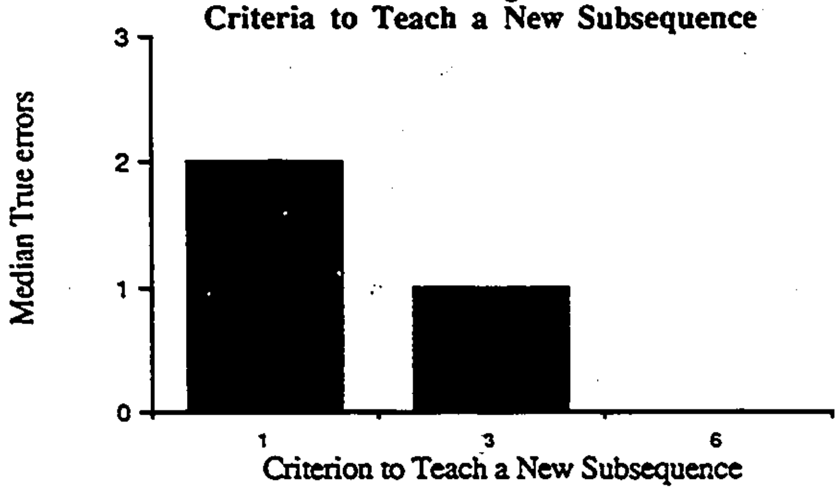


Figure 40. Experiment 5: Median True Errors for Backward Chaining as a Function of Criteria to Teach a New Subsequence

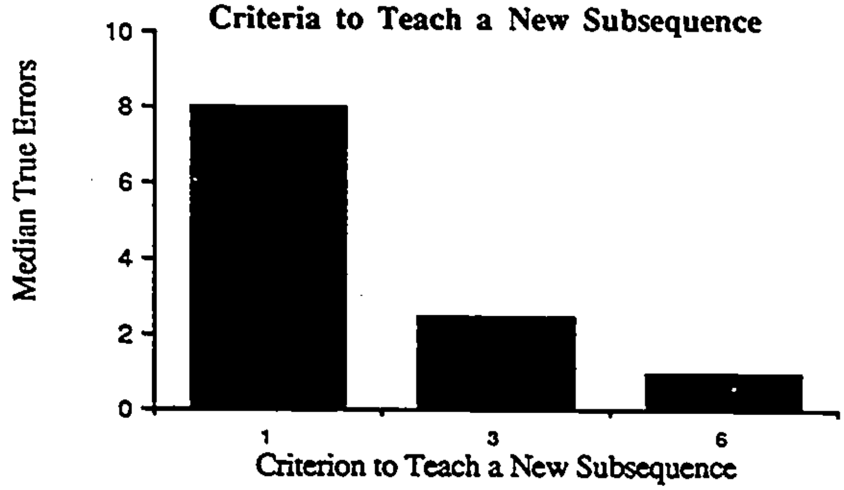


Figure 41. Experiment 5: Median True Errors for Random Chaining as a Function of Criteria to Teach a New Subsequence

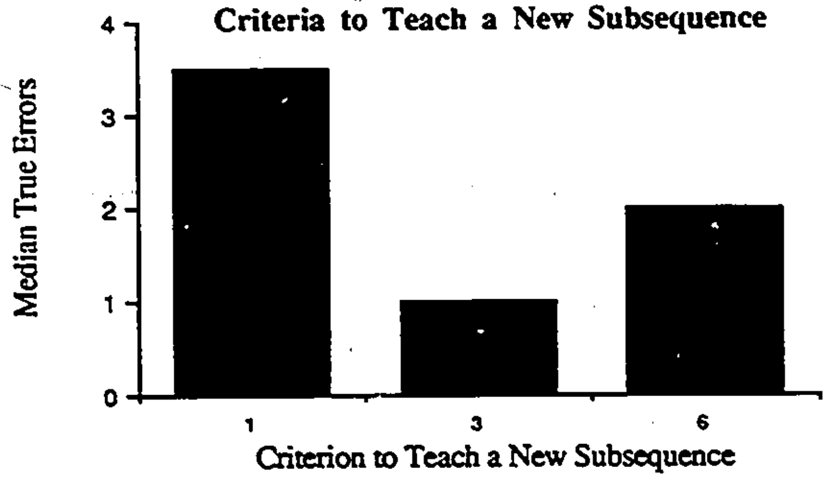


Figure 42. Experiment 5: Median Random Errors for the Criterion to Teach a New Subsequence of One as a Function of Training Procedures

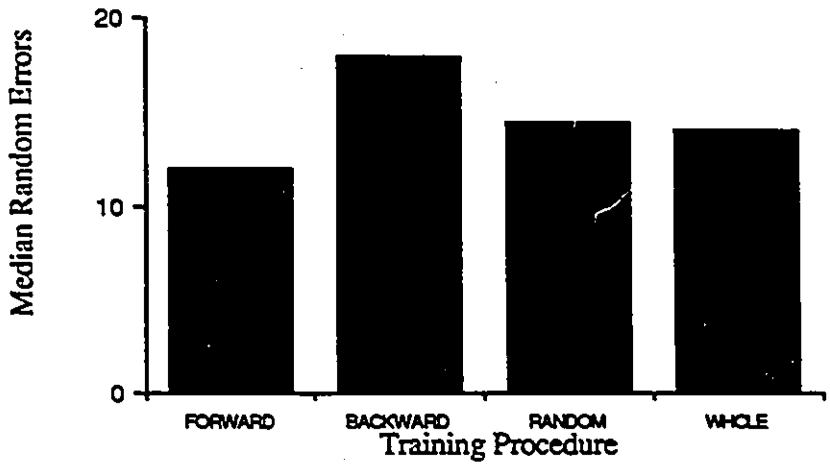


Figure 43. Experiment 5: Median Random Errors for the Criterion to Teach a New Subsequence of Three as a Function of Training Procedures

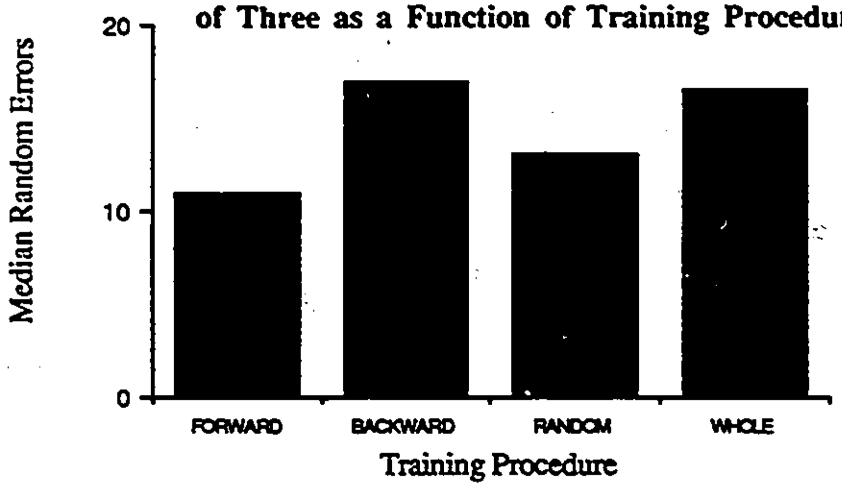


Figure 44. Experiment 5: Median Random Errors for the Criterion to Teach a New Subsequence as a Function of Training Procedures

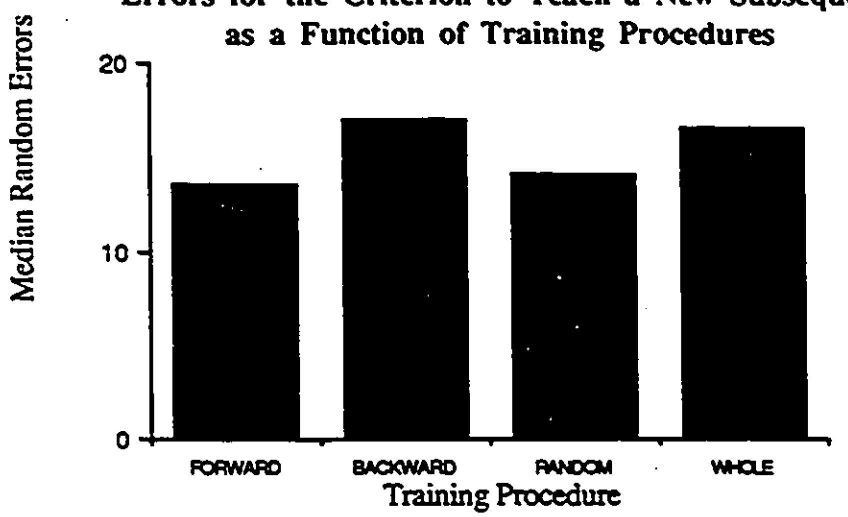


Figure 45. Experiment 5: Median Random Errors for Forward Chaining as a Function of Criteria to Teach a New Subsequence

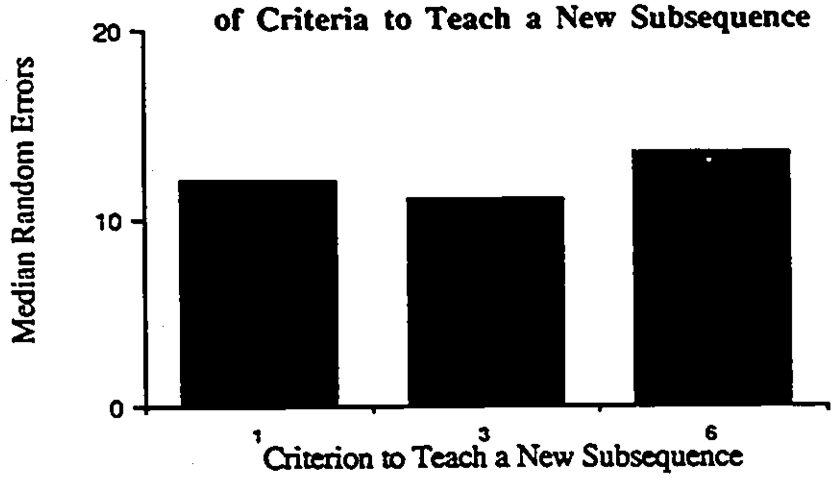


Figure 46. Experiment 5: Median Random Errors for Backward Chaining as a Function of Criteria to Teach a New Subsequence

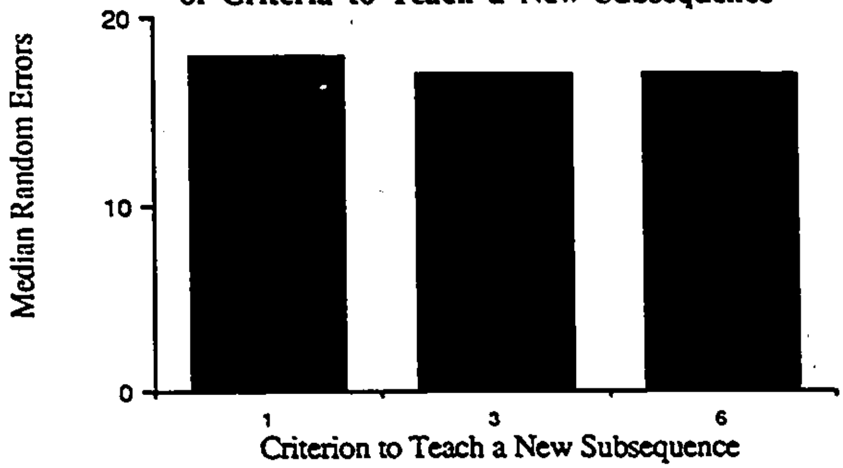


Figure 47. Experiment 5: Median Random Errors for Random Chaining as a Function of Criteria to Teach a New Subsequence

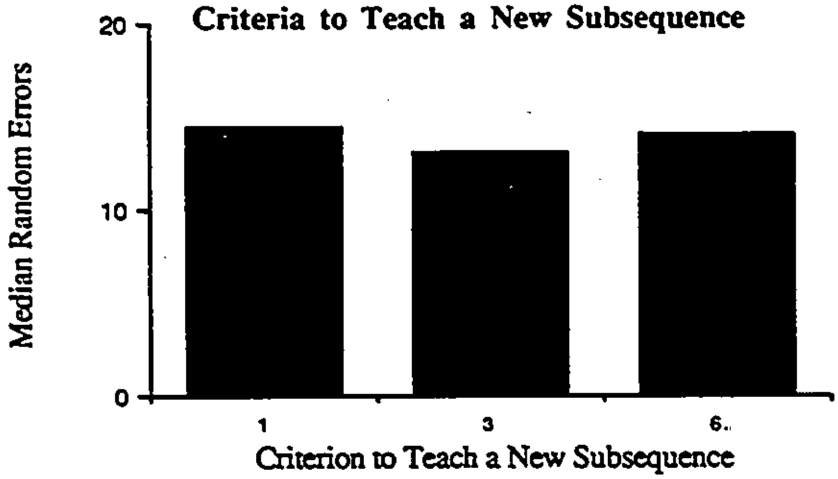


Figure 48. Experiment 5: Median Total Errors for the Criterion to Teach a New Subsequence of One as a Function of Training Procedures

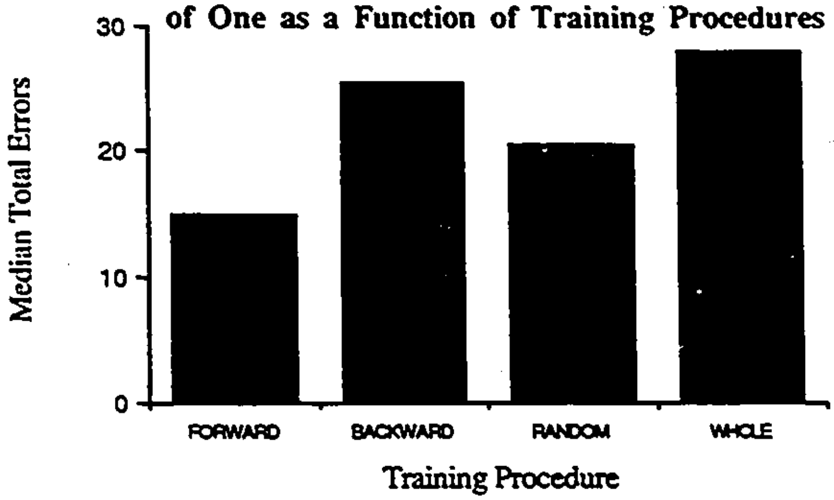


Figure 49. Experiment 5: Median Total Errors for the Criterion to Teach a New Subsequence of Three as a Function of Training Procedures

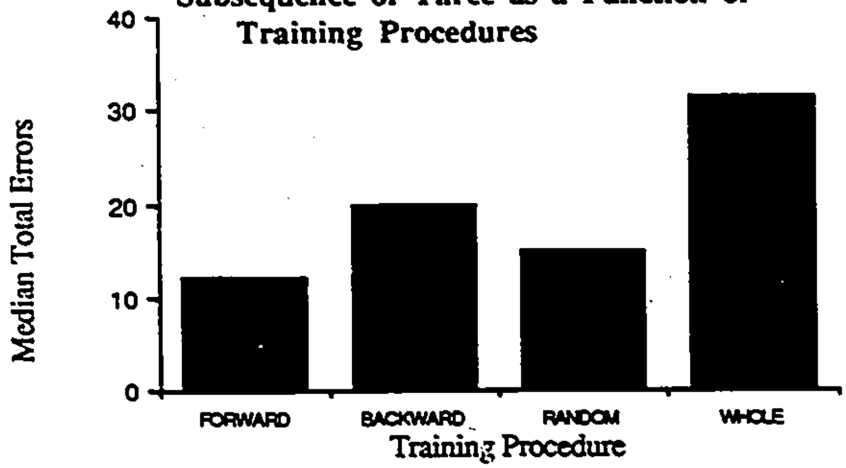


Figure 50. Experiment 5: Median Total Errors for the Criterion to Teach a New Subsequence of Six as a Function of Training Procedures

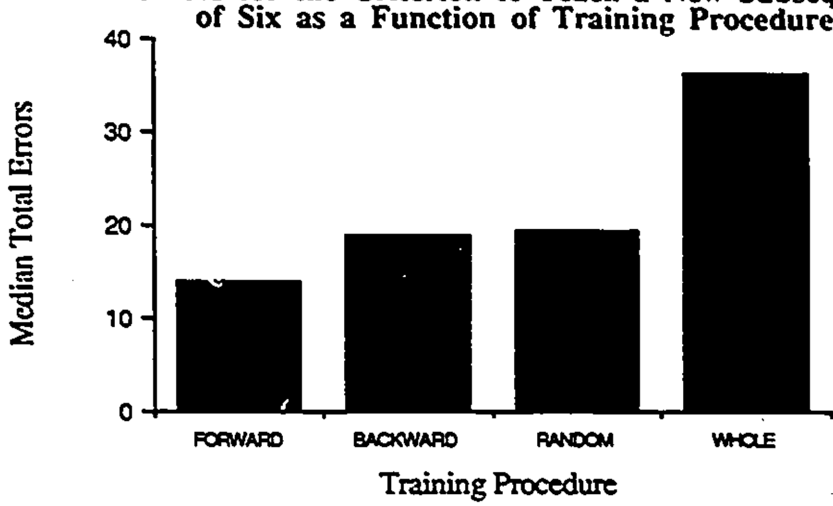


Figure 51. Experiment 5: Median Total Errors for Forward Chaining as a Function of Criteria to Teach a New Subsequence

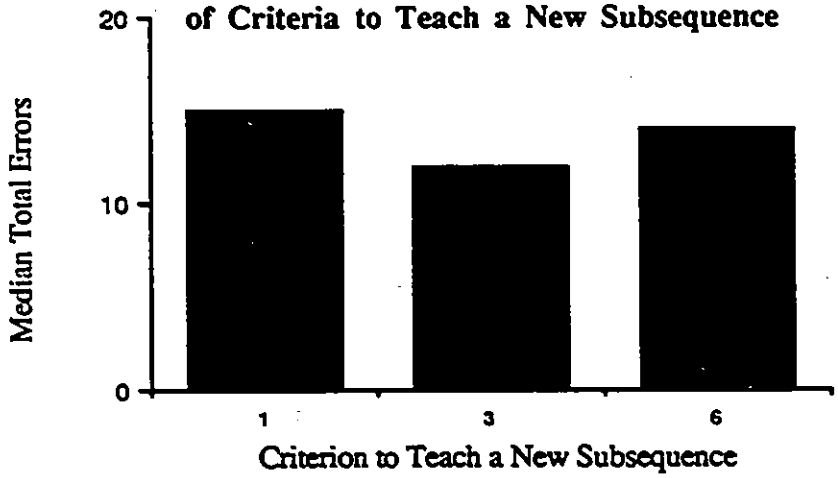


Figure 52. Experiment 5: Median Total Errors for Backward Chaining as a Function of Criteria to Teach a New Subsequence

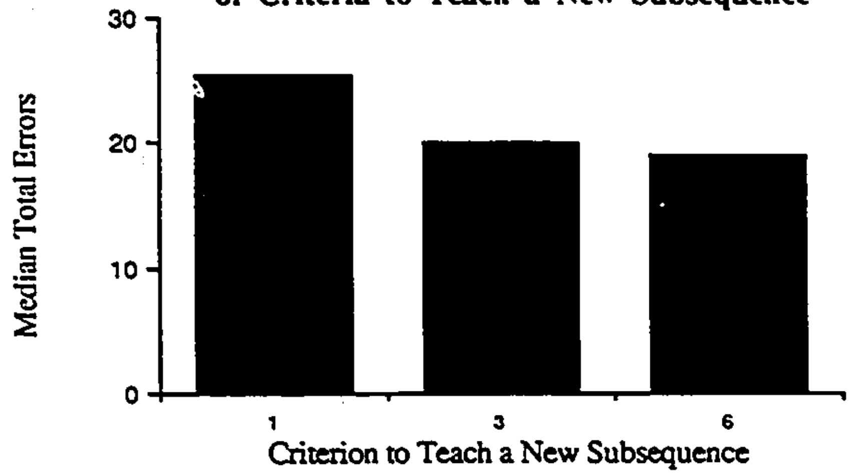


Figure 53. Experiment 5: Median Total Errors for Random Chaining as a Function of Criteria to Teach a New Subsequence

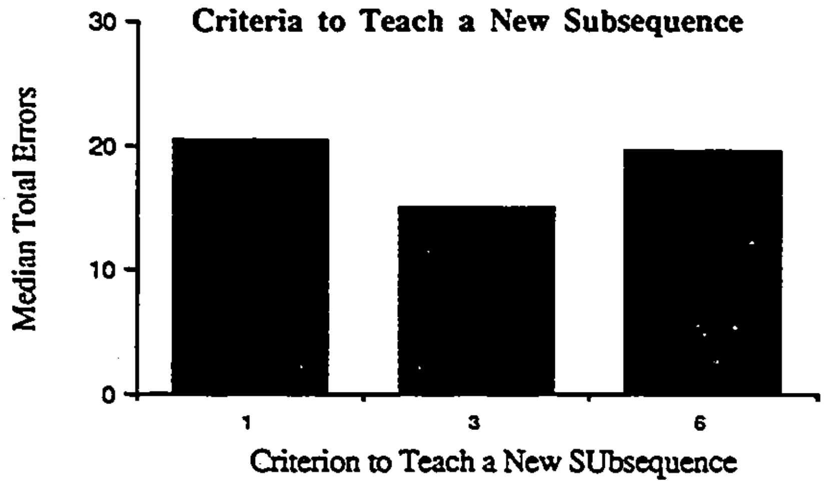


Figure 54. Experiment 5. Median Total Responses for the Criterion to Teach a New Subsequence of One as a Function of Training Procedures

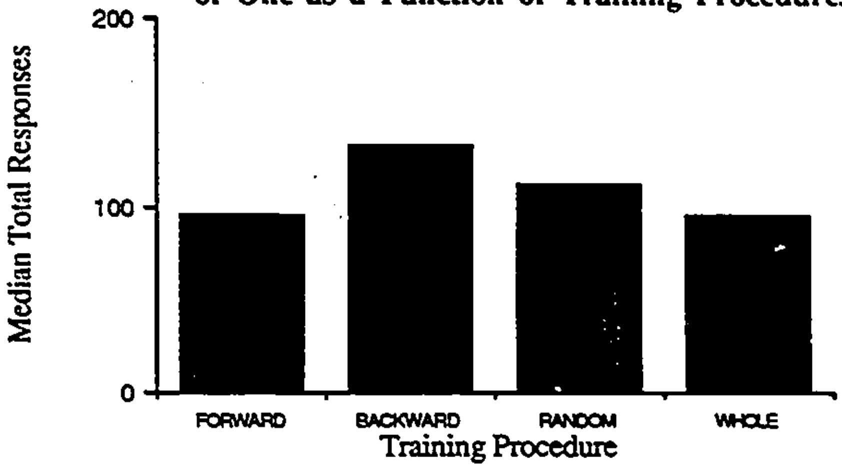


Figure 55. Experiment 5: Median Total Responses for the Criterion to Teach a New Subsequence of Three as a Function of Training Procedures

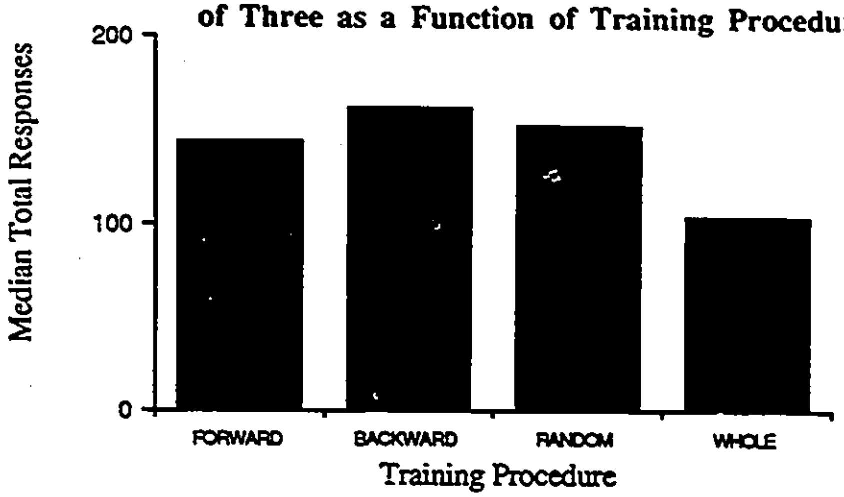


Figure 56. Experiment 5: Median Total Responses for the Criterion to Teach a New Subsequence of Six as a Function of Training Procedures

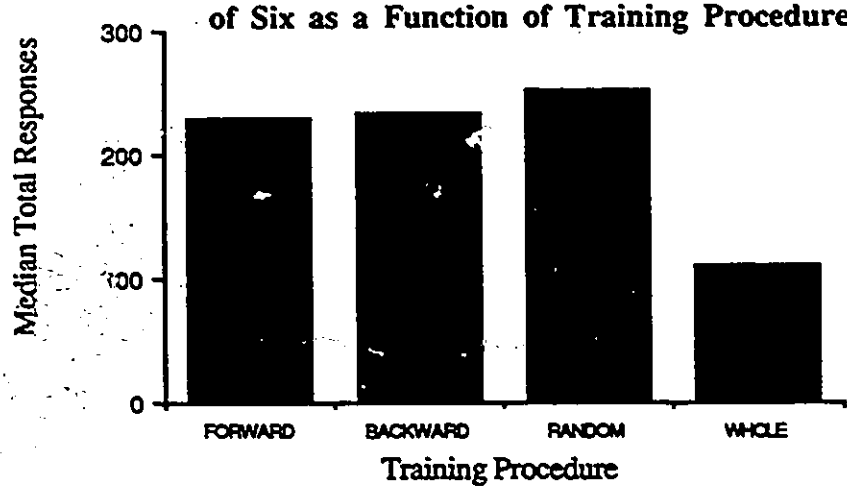
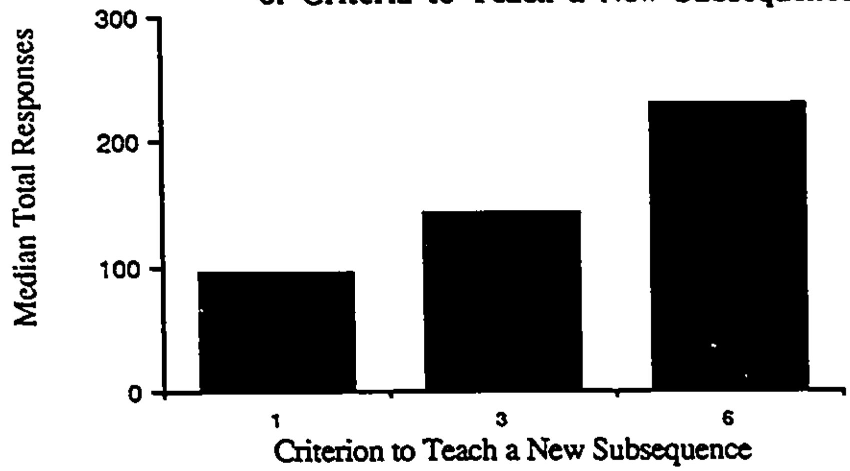


Figure 57. Experiment 5: Median Total Responses for Forward Chaining as a Function of Criteria to Teach a New Subsequence



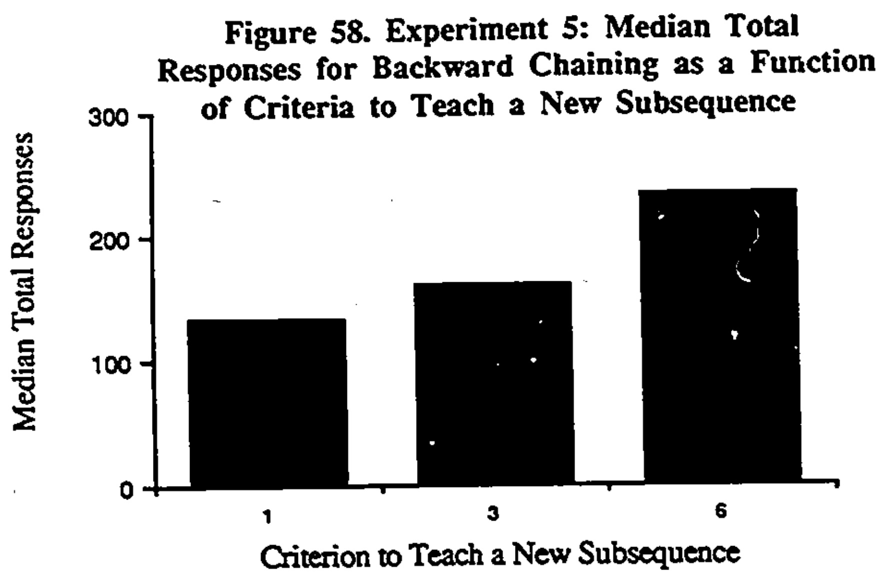


Figure 58. Experiment 5: Median Total Responses for Backward Chaining as a Function of Criteria to Teach a New Subsequence
Median Total Responses
300
200
100
0
1
3
6
Criterion to Teach a New Subsequence

Figure 59. Experiment 5: Median Total Responses for Random Chaining as a Function of Criteria to Teach a New Subsequence

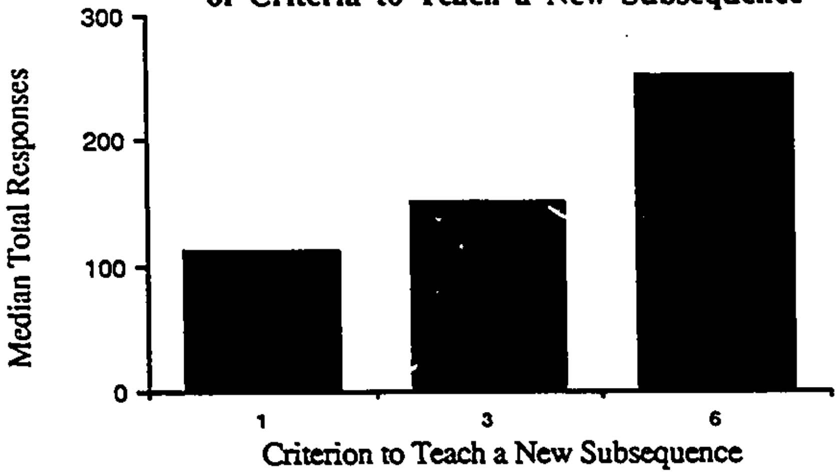


Figure 60. Experiment 5: Median Time for the Criterion to Teach a New Subsequence of One as a Function of Training Procedures

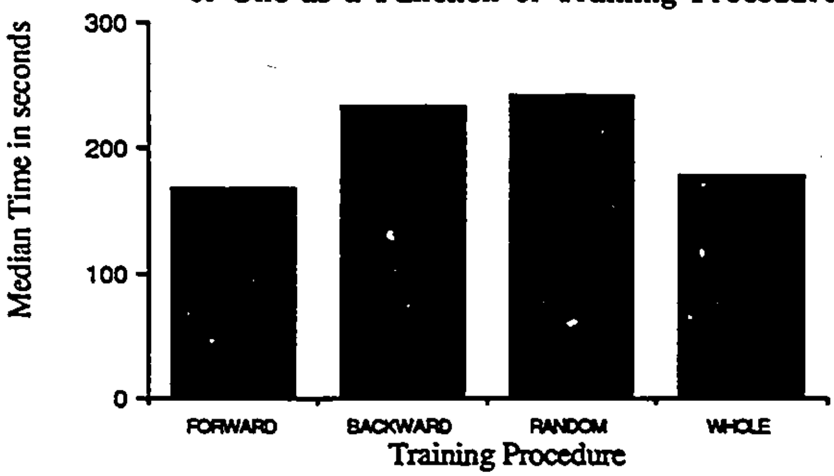


Figure 61. Experiment 5: Median Time for the Criterion to Teach a New Subsequence of Three as a Function of Training Procedures

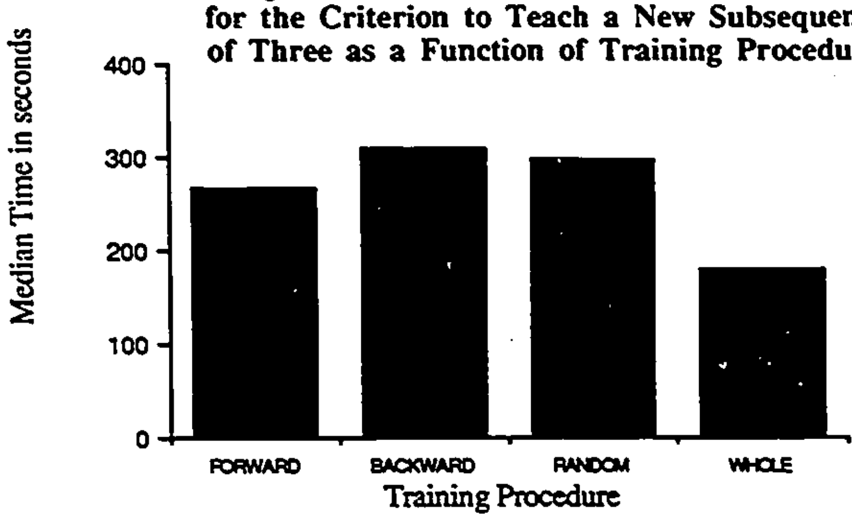


Figure 62. Experiment 5: Median Time for the Criterion to Teach a New Subsequence of Six as a Function of Training Procedures

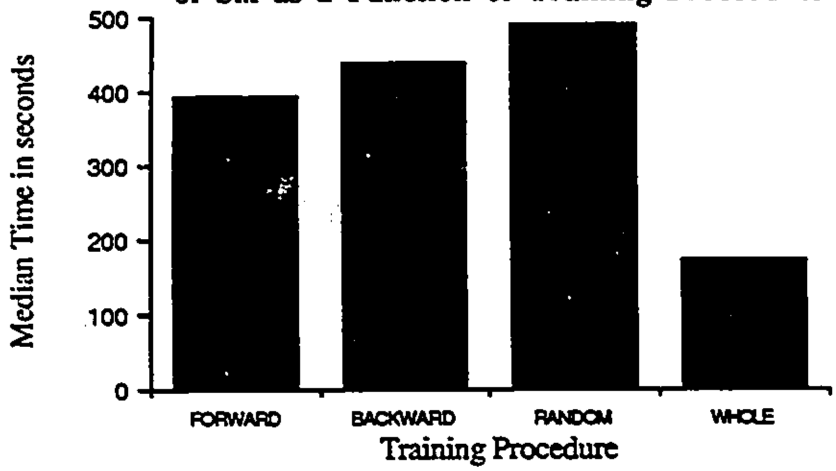


Figure 63. Experiment 5: Median Time for Forward Chaining as a Function of Criteria to Teach a New Subsequence

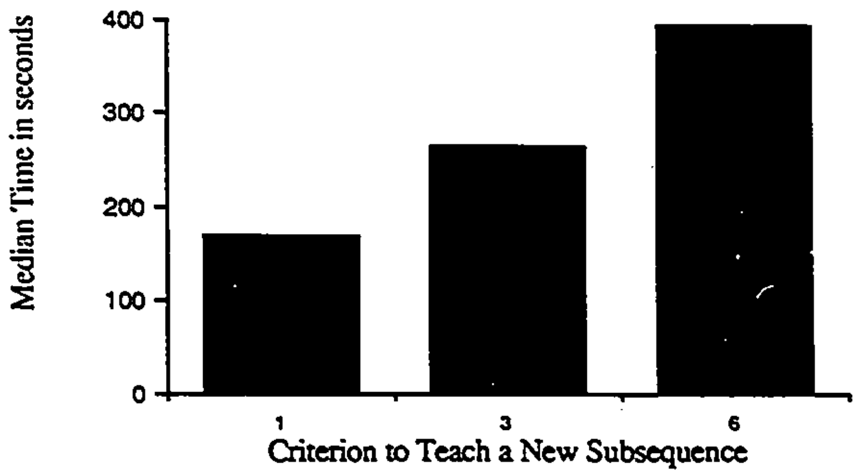


Figure 64. Experiment 5: Median Time for Backward Chaining as a Function of Criteria to Teach a New Subsequence

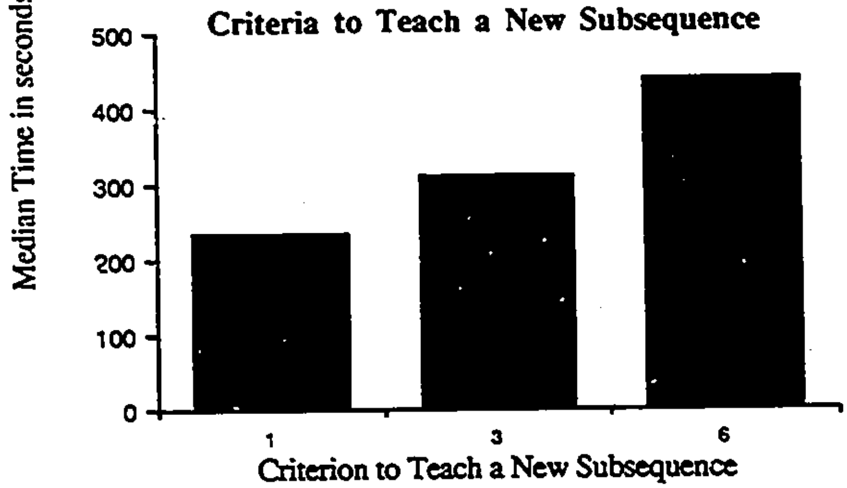


Figure 65. Experiment 5: Median Time for Random Chaining as a Function of Criteria to Teach a New Subsequence

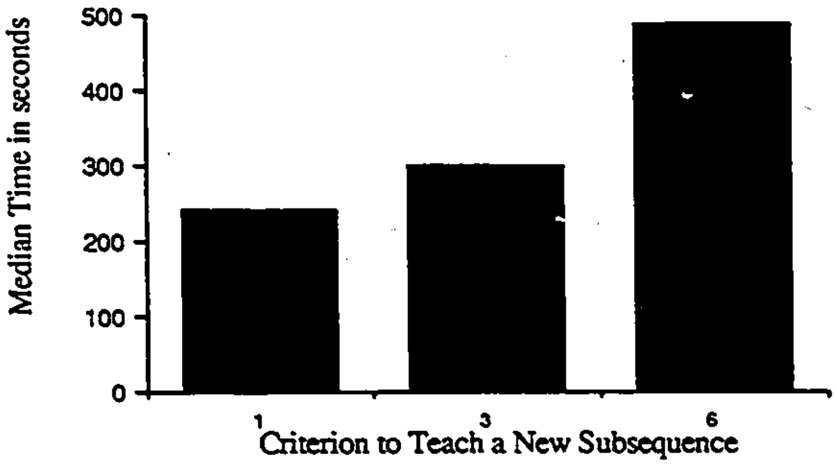


Figure 66. Experiment 6: Median True Errors For the Zit -6 Consequence as a Function of Training Procedures

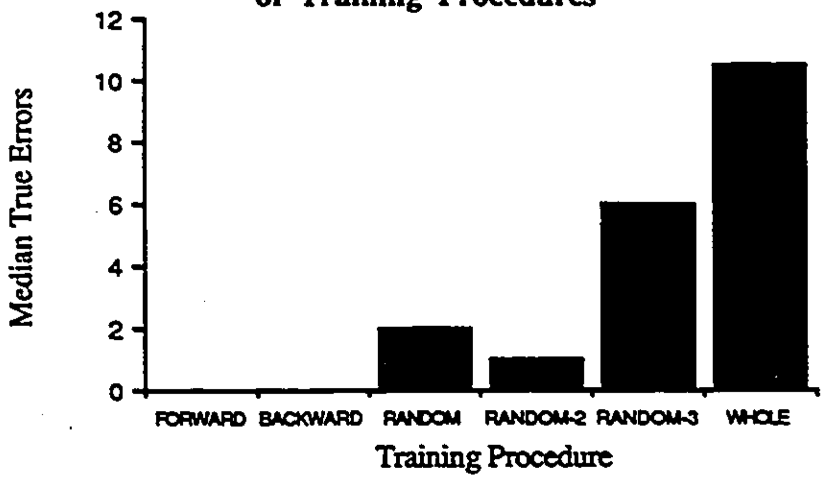


Figure 67. Experiment 6: Median Random Errors for the Zit-6 Consequence as a Function of Training Procedures

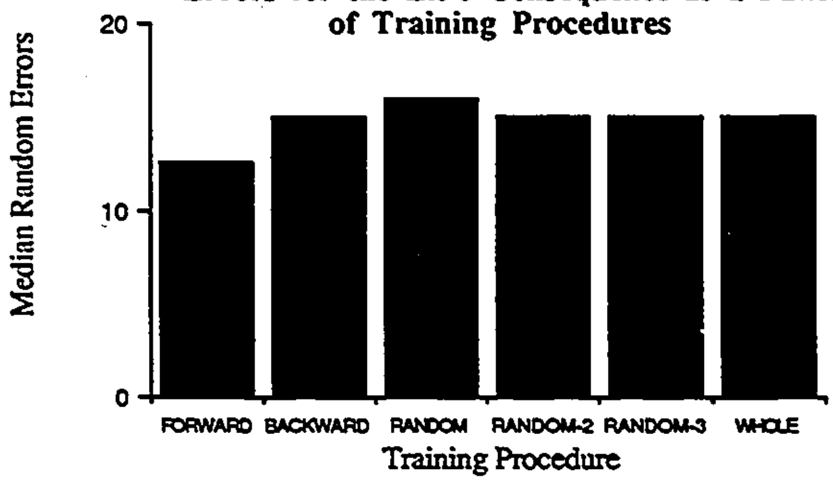


Figure 68. Experiment 6: Median Total Errors for the Zit-6 Consequence as a Function of Training Procedures

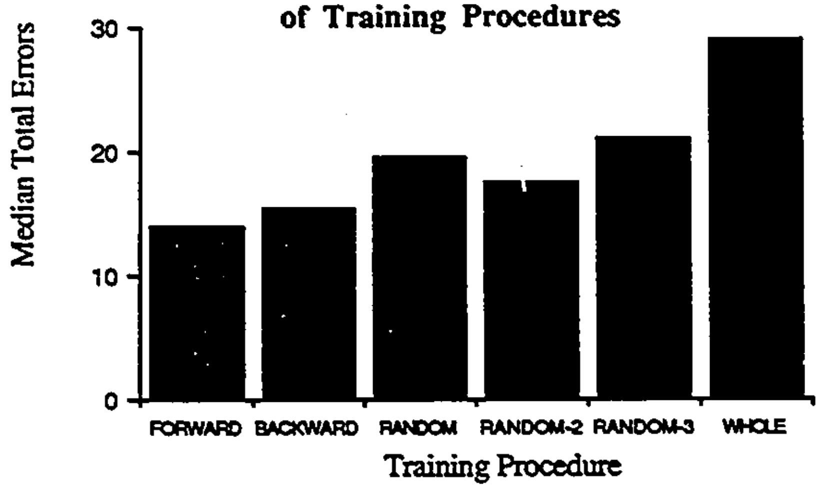


Figure 69. Experiment 6: Median Total Responses for the Zit-6 Consequence as a Function of Training Procedures

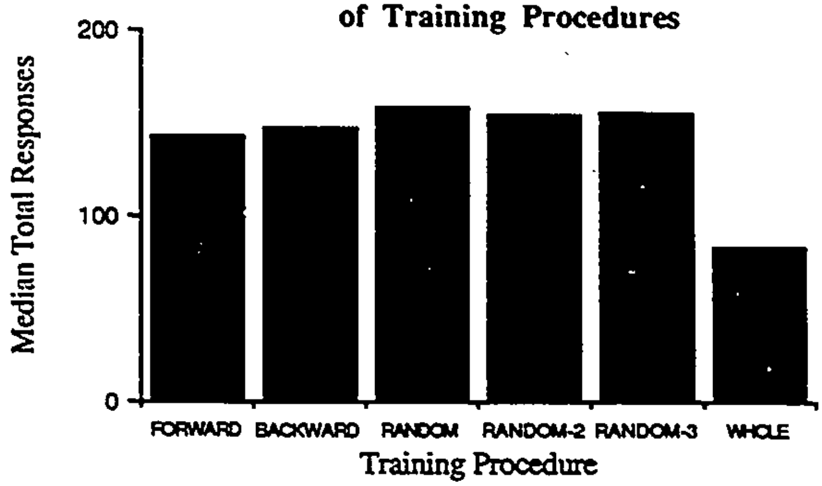
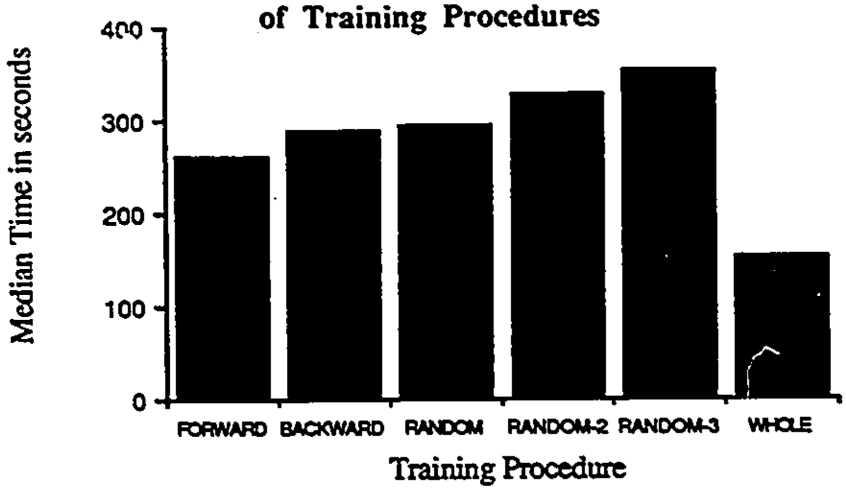


Figure 70. Experiment 6: Median Time for the Zit-6 Consequence as a Function of Training Procedures



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Appendix A

There is no deception involved in this experiment. It is a straight forward experiment to study the learning of sequences of responses. You will learn three separate sequences, each consisting of eight button pushes. You will use these eight buttons(point to the eight on the keyboard). There will be a short break after each sequence.

Before you make each button push a symbol will appear on the screen. Each symbol goes with one particular button. For example a "?" may be the top right button. Remembering which button goes with which symbol may help you to remember the sequence of correct button pushes. Each sequence involves a new set of symbols.

(Read following statements to subjects in groups indicated.)

To be read to subjects receiving auditory prgrammed consequences: "When you press the wrong button there will be a "zit" sound and the computer will wait for you to get it right".

To be read to subjects receiving visual programmmed consequences: When you press the wrong button the screen boarder will change colour and the computer will wait for you to get it right."

To be read to subjects receiving minimal programmmed consequences: "When you press the wrong button the computer will wait for you to get it right:.

To be read to subjects receiving prompts: When you press the wrong button there will be a "zit" sound and instructions on the screen will show you the correct button to push.

To be read to subjects receiving timeout feedback: When you press the wrong button the screen will go blank for 3 seconds. When the screen is blank the computer ignores your button pushes. Once the screen comes back on the computer will wait for you to get it right.

(Continue to read the rest of instructions to all subjects then push "H" and leave the room)

Periodically your percent score since the last score will appear on the screen.

You will learn some sequences all at once. You will learn other sequences a bit at a time, building up slowly, getting one button press correct before going on to the next, then getting two in a row correct before going on, then getting three in a row correct.

Decide on which hand to use and use it throughout the experiment.

Do you have any questions? (if there are any reread the relevant parts of the instructions to the subject - for other questions tell the subject that you will discuss them when the experiment is over.)

Remember at anytime you wish you can stop and leave - (give the consent form for them to read and sign).

I'll be going into this room (point) while you are learning each sequence so that I won't be hanging around making you nervous. I'll come back after you learn each sequence. I'll turn off the overhead lights (turn them off and keep small light on) so you won't be bothered by reflections from the screen.

Remember use only one hand.

(push "H" and leave the room)

Appendix B

Post Experiment Questions

NOTE: The following were used as prompts to guide the experimenter.

1. Give subject a sheet with ordering of buttons and symbols. Subject must (a) put a number indicating order of the button pushes in the sequence of button pushes and (b) in each button put the symbol which preceded it. See prompt sheet.

2. Explain what you just did eg. state method used to teach sequences and technique to learn sequences, any differences between methods etc.

3. Did you use the % scores.

4. Did you find the task boring or interesting?

5. How did you remember the sequences?

-finger position

-key position

-symbol

-early vs. late in learning

-whole vs. gradual task learning

6. Did you assign letters or numbers to the keys to help you remember them?

7.What method seemed the easiest/most natural/most comfortable? Rank order the others.

CONSENT FORM

I have listened to a description of the experiment and I wish to participate. From the description of the experiment I understand that:

(a) The experiment is concerned with the learning of sequences of behavior.

(b) I will be required to learn a sequence of key presses on a computer keyboard.

(c) There is no known discomfort or risk associated with the procedure.

(d) My name will not be used in connection with the analysis or reporting of the data.

(e) The session will last 20 to 40 minutes.

(f) I may, without any necessity of giving an explanation, discontinue my participation at any time and such action will not affect my class marks.

(g) A summary of the results will be available when the study is completed.

DATE: ______________________________

PARTICIPANT'S NAME (PRINTED): ______________________________

PARTICIPANT (SIGNATURE): ______________________________

EXPERIMENTER (SIGNATURE): ______________________________

8. What method did you learn the best with? Rank order the others.

9. What problems did you encounter with a) instructions b) task?

10. If you had to teach this task to someone would you do it the same or differently, then how would you do it differently?

11. Do you know about whole task, forward and backward chaining?

12. What was the criterion used to teach a new subsequence?

13. What training method did you like best? (used in Experiments 2,3,4,5,and 6).

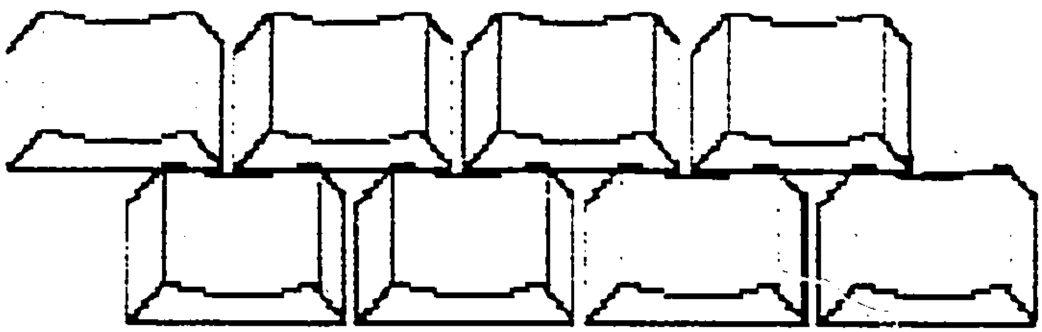
14. How did the time-out period seem? (Experiment 3 only)

15. How did you use the time-out perid? (Experiment 3 only)

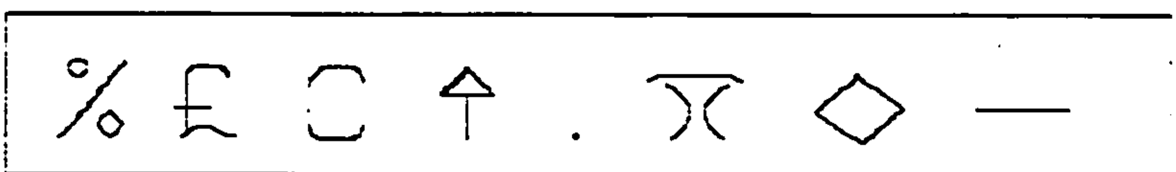
16. What was the optimum proficiency criterion to teach a new subsequence.

Appendix B
(continued)

Question 1 (Handout)
Draw the symbol and the number corresponding to the order you pushed the buttons in the appropriate button drawn below:



Subject is given this sheet of symbols drawn in a random order: (this is an example)



Marking Scheme:

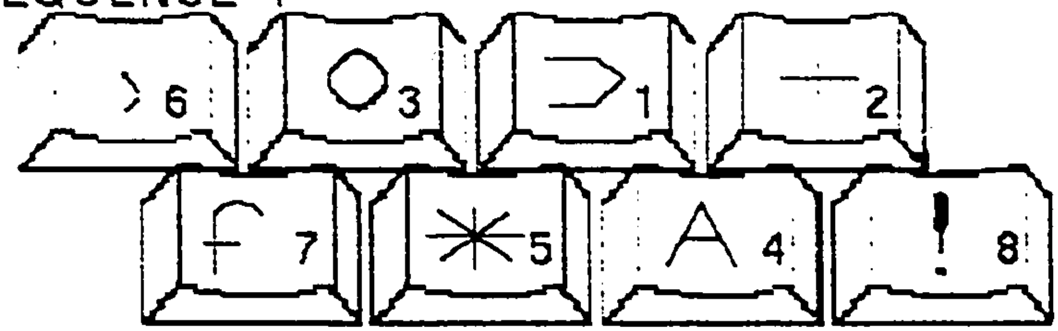
i) Order Recall - 1 mark is given for each correct number in the appropriate button TOTAL: 8

ii) Symbol Recall - 1 mark is given for each correct symbol drawn in the appropriate button TOTAL : 8

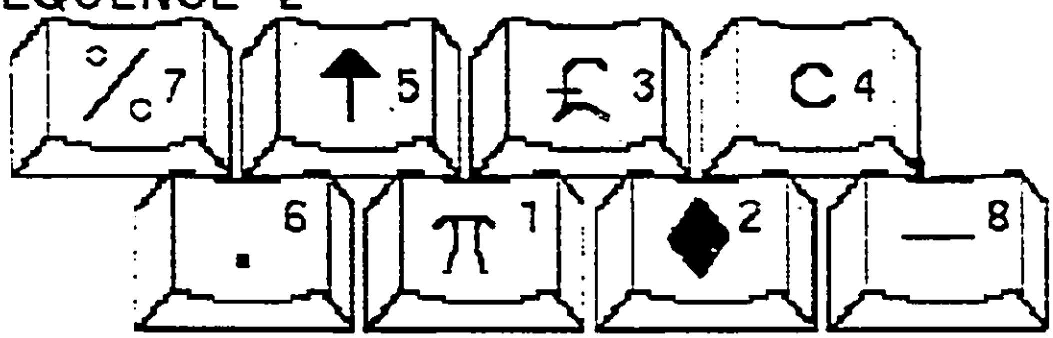
Appendix C
Examples of Sequences

NOTES: The array of squares represents the array of 8 keys used to make the responses. These keys were blank. The symbol shown on each key is the screen symbol which preceeded their keypress. The numbers on the keys represent the order of the symbol-key combination in the sequence.

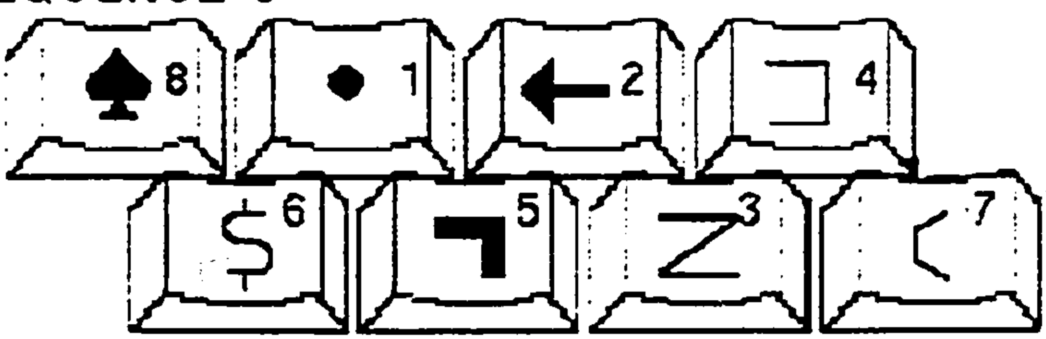
SEQUENCE 1



SEQUENCE 2

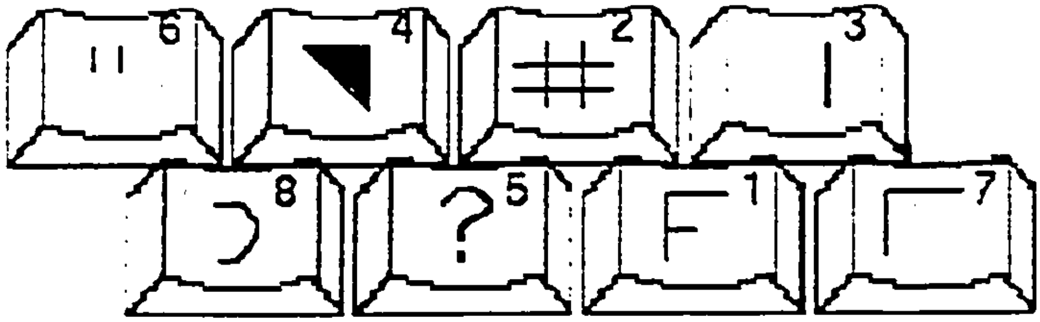


SEQUENCE 3

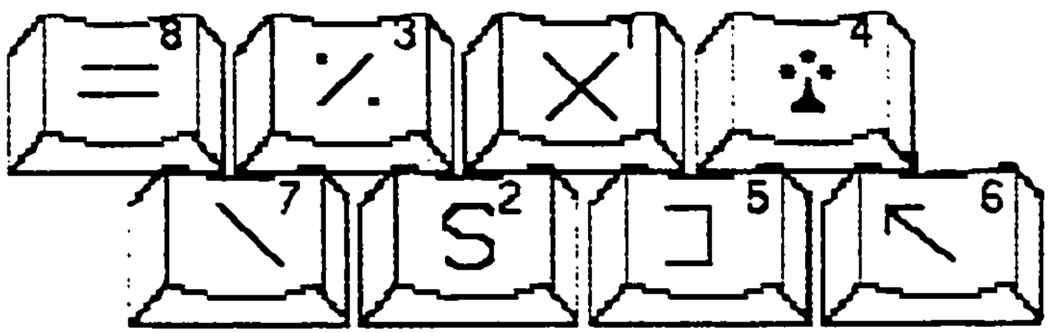


Appendix C
(continued)

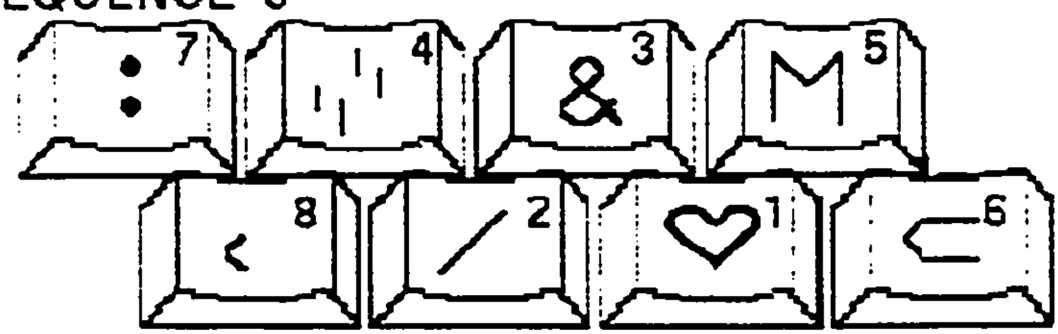
SEQUENCE 4



SEQUENCE 5



SEQUENCE 6



Appendix D

Experiment 1

Bartlett-Box F Test of Homogeneity of Variance

Legend for Appendix D

1 - comparison of consequences using forward chaining

2 - comparison of consequences using backward chaining

3 - comparison of consequences using whole task training

4 - comparison of training procedures for group receiving auditory programmed consequence of "ZIT" sound

5 - comparison of training procedures for group receiving "MIN" programmed consequence

6 - comparison of training procedures for group receiving "SCR" consequence

Training Procedures and Consequences

FC- Forward chaining

BC-Backward chaining

WT-Whole task training

ZIT- Auditory programmed consequence of "ZIT"

MIN- Minimal programmed consequence

SCR-Visual programmed consequence of screen border flashing

Appendix D
(continued)
Experiment 1

Dependent Variable - True Errors

Condition	Bartlett-Box F Test	Probability
1	24.473	.000
2	1.079	.000
3	11.158	.000
4	72.643	.000
5	44.725	.000
6	15.754	.000

Dependent Variable - Random Errors

1	7.915	.000
2	2.439	.088
3	1.129	.323
4	4.283	.014
5	0.477	.621
6	1.998	.136

Appendix D
(continued)
Experiment 1

Dependent Variable - Total Errors

Condition	Bartlett-Box F test	Probability
1	18.046	.000
2	3.638	.026
3	9.832	.000
4	66.606	.000
5	27.521	.000
6	15.884	.000

Dependent Variable - Responses

1	0.933	.394
2	7.199	.001
3	4.757	.009
4	23.576	.000
5	23.343	.000
6	13.436	.000

Appendix D
(continued)
Experiment 1

Dependent Variable - Time in seconds

Condition	Barlett-Box F	Probability
1	2.208	.110
2	10.531	.000
3	1.363	.256
4	12.943	.000
5	6.855	.001
6	5.626	.004

Appendix E
Experiment 1
Means, Medians and Standard Deviations

Legend

Procedure - Training Procedure

FC - Forward chaining

BC - Backward chaining

WT - Whole Task craining

"ZIT" Consequence - Auditory programmed consequence consisting of "ZIT" sound

"MIN" Consequence - Minimal programmed consequence

"SCR" Consequence - Visual programmed consequence consisting of screen border changing color

Appendix E
(continued)
Experiment 1

Dependent Variable - True Errors

"ZIT" Consequence

Procedure	Mean	Median	Standard Deviation
FC	2.6	2.0	3.0
BC	8.3	3.5	9.1
WT	43.2	18.0	99.1

"MIN" Consequence

Procedure	Mean	Median	Standard Deviation
FC	2.6	1.0	4.5
BC	4.4	1.0	8.5
WT	31.0	8.0	51.7

"SCR" Consequence

Procedure	Mean	Median	Standard Deviation
FC	4.6	0.0	15.8
BC	4.7	2.0	6.4
WT	19.9	8.0	29.6

Appendix E
(continued)
Experiment 1

Dependent Variable - Random Errors

"ZIT" Consequence

Procedure	Mean	Median	Standard Deviation
FC	13.8	13.5	3.0
BC	16.9	18.0	4.9
WT	19.6	21.0	6.4

"MIN" Consequence

FC	13.9	12.0	7.7
BC	15.7	15.5	6.5
WT	22.2	21.0	8.3

"SCR" Consequence

FC	12.7	12.5	4.0
BC	15.2	16.0	3.8
WT	15.6	14.0	5.8

Appendix E
(continued)
Experiment 1

Dependent Variable - Total Errors

"ZIT" Consequence

Procedure	Mean	Median	Standard Deviation
FC	16.4	16.0	3.6
BC	23.1	21.5	11.0
WT	62.8	36.5	100.9

"MIN" Consequence

FC	16.6	14.5	9.0
BC	20.1	16.5	13.8
WT	53.2	34.0	53.9

"SCR" Consequence

FC	17.3	13.0	18.4
BC	19.9	19.5	6.9
WT	35.3	22.0	33.1

Appendix E
(continued)
Experiment 1

Dependent Variable -Total Responses

"ZIT" Consequence

Procedure	Mean	Median	Standard Deviation
FC	159.5	158.5	27.4
BC	190.1	170.0	49.7
WT	152.9	119.0	147.0

"MIN" Consequence

FC	156.6	147.5	18.7
BC	155.4	148.5	21.4
WT	123.9	105.0	84.7

"SCR" Consequence

FC	149.4	143.5	25.6
BC	166.1	161.0	24.7
WT	102.0	76.5	73.3

Appendix E
(continued)
Experiment 1

Dependent Variable -Time in seconds

"ZIT" Consequence

Procedure	Mean	Median	Standard Deviation
FC	311.7	310.0	51.1
BC	388.6	327.5	171.9
WT	263.6	203.5	207.6

"MIN" Consequence

FC	291.1	279.5	81.8
BC	323.3	311.0	73.5
WT	256.2	211.0	164.8

"SCR" Consequence

FC	303.1	280.0	83.1
BC	346.8	335.5	61.6
WT	218.8	180.0	138.7

Appendix F

Experiment 1

Nonparametric Statistics

ZIT - Auditory Programmed Consequence

Friedman Two-Way Anova

Mean Rank	Variable	
1.42	TRUEER1	Forward Chaining
1.92	TRUEER2	Backward Chaining
2.67	TRUEER3	Whole Task Training

Cases	Chi-Square	D.F.	Significance
18	14.2500	2	.0008

Wilcoxon Matched-Pairs Signed-Ranks Test

TRUEER1 Forward Chaining
with TRUEER2 Backward Chaining

Mean Rank	Cases		
5.00	6	- Ranks	(TRUEER2 LT TRUEER1)
11.18	11	+ Ranks	(TRUEER2 GT TRUEER1)
	1	Ties	(TRUEER2 EQ TRUEER1)
	18	Total	

Z = -2.2012 2-Tailed P = .0277

Appendix F (cont'd)

Experiment 1

Zit - Auditory Programmed Consequence

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TRUEER1   Forward Chaining
with TRUEER3   Whole Task Training

     Mean Rank    Cases

        1.50          1   - Ranks (TRUEER3 LT TRUEER1)
        9.97         17   + Ranks (TRUEER3 GT TRUEER1)
                      0     Ties  (TRUEER3 EQ TRUEER1)
                     --
                     18     Total

       Z =    -3.6582              2-Tailed P =   .0003
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TRUEER2   Backward Chaining
with TRUEER3   Whole Task Training

     Mean Rank    Cases

        4.80          5   - Ranks (TRUEER3 LT TRUEER2)
       11.31         13   + Ranks (TRUEER3 GT TRUEER2)
                      0     Ties  (TRUEER3 EQ TRUEER2)
                     --
                     18     Total

       Z =    -2.6783              2-Tailed P =   .0074
```

Experiment 1

MIN - Minimal Programmed Consequence

Friedman Two-Way Anova

Mean Rank	Variable	
1.47	TRUEER1	Forward Chaining
1.86	TRUEER2	Backward Chaining
2.67	TRUEER3	Whole Task Training

Cases	Chi-Square	D.F.	Significance
18	13.3611	2	.0013

Wilcoxon Matched-Pairs Signed-Ranks Test

TRUEER1 Forward Chaining
with TRUEER2 Backward Chaining

Mean Rank	Cases		
8.50	4	- Ranks	(TRUEER2 LT TRUEER1)
6.33	9	+ Ranks	(TRUEER2 GT TRUEER1)
	5	Ties	(TRUEER2 EQ TRUEER1)
	18	Total	

Z = -.8037 2-Tailed P = .4216

Experiment 1

MIN - Minimal Programmed Consequence

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TRUEER1    Forward Chaining
with TRUEER3    Whole Task Training

     Mean Rank    Cases

          8.00        1  - Ranks (TRUEER3 LT TRUEER1)
          8.53       15  + Ranks (TRUEER3 GT TRUEER1)
                      2    Ties  (TRUEER3 EQ TRUEER1)
                     --
                     18    Total

        Z =    -3.1025              2-Tailed P =  .0019
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TRUEER2    Backward Chaining
with TRUEER3    Whole Task Training

     Mean Rank    Cases

          7.67        3  - Ranks (TRUEER3 LT TRUEER2)
          8.69       13  + Ranks (TRUEER3 GT TRUEER2)
                      2    Ties  (TRUEER3 EQ TRUEER2)
                     --
                     18    Total

        Z =    -2.3269              2-Tailed P =  .0200
```

Appendix F (cont'd)

Experiment 1

SCR - Visual Programmed Consequence

Friedman Two-Way Anova

Mean Rank	Variable	
1.33	TRUEER1	Forward Chaining
2.06	TRUEER2	Backward Chaining
2.61	TRUEER3	Whole Task Training

Cases	Chi-Square	D.F.	Significance
18	14.7778	2	.0006

Wilcoxon Matched-Pairs Signed-Ranks Test

TRUEER1 Forward Chaining
with TRUEER2 Backward Chaining

Mean Rank	Cases		
10.00	3	- Ranks	(TRUEER2 LT TRUEER1)
8.15	13	+ Ranks	(TRUEER2 GT TRUEER1)
	2	Ties	(TRUEER2 EQ TRUEER1)
	18	Total	

Z = -1.9649 2-Tailed P = .0494

Appendix F (cont'd)

Experiment 1

SCR - Visual Programmed Consequence

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TRUEER1    Forward Chaining
with TRUEER3    Whole Task Training

     Mean Rank     Cases

       13.00          1   - Ranks  (TRUEER3 LT TRUEER1)
        8.20         15   + Ranks  (TRUEER3 GT TRUEER1)
                      2     Ties   (TRUEER3 EQ TRUEER1)
                     --
                     18     Total

       Z =    -2.8440              2-Tailed P =   .0045
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TRUEER2    Backward Chaining
with TRUEER3    Whole Task Training

     Mean Rank     Cases

        5.70          5   - Ranks  (TRUEER3 LT TRUEER2)
       10.96         13   + Ranks  (TRUEER3 GT TRUEER2)
                      0     Ties   (TRUEER3 EQ TRUEER2)
                     --
                     18     Total

       Z =    -2.4824              2-Tailed P =   .0131
```

Experiment 1

Forward Chaining

Kruskal-Wallis 1-Way Anova

```
    TRUERR      True Errors
 by GRP         Consequence

    Mean Rank     Cases

        33.39       18    GRP = 1   ZIT Consequence
        28.56       18    GRP = 2   MIN Consequence
        20.56       18    GRP = 3   SCR Consequence
                    --
                    54    Total

                                                Corrected for ties
        Cases     Chi-Square  Significance    Chi-Square  Significance
           54        6.1104         .0471        6.7666         .0339
```

Mann-Whitney U - Wilcoxon Rank Sum W Test

```
    TRUERR      True Errors
 by GRP         Consequence

    Mean Rank     Cases

        20.19       18  GRP = 1  ZIT Consequence
        16.81       18  GRP = 2  MIN Consequence
                    --
                    36  Total

                                 Exact              Corrected for ties
            U             W    2-Tailed P              Z      2-Tailed P
        131.5         363.5      .3389              -.9908       .3218
```

Experiment 1

Forward Chaining

Mann-Whitney U - Wilcoxon Rank Sum W Test

```
   TRUERR      True Errors
by GRP         Consequence

   Mean Rank     Cases

      22.69         18  GRP = 1  ZIT Consequence
      14.31         18  GRP = 3  SCR Consequence
                    --
                    36  Total

                                   Exact                 Corrected for ties
        U              W        2-Tailed P              Z        2-Tailed P
      86.5           408.5         .0156             -2.5354         .0112
```

Mann-Whitney U - Wilcoxon Rank Sum W Test

```
   TRUERR      True Errors
by GRP         Consequence

   Mean Rank     Cases

      21.25         18  GRP = 2  MIN Consequence
      15.75         18  GRP = 3  SCR Consequence
                    --
                    36  Total

                                   Exact                 Corrected for ties
        U              W        2-Tailed P              Z        2-Tailed P
     112.5           382.5         .1182             -1.7256         .0844
```

Appendix F (cont'd)

Experiment 1

Backward Chaining

Kruskal-Wallis 1-Way Anova

TRUERR True Errors
by GRP Consequence

Mean Rank	Cases		
31.86	18	GRP = 1	ZIT Consequence
23.67	18	GRP = 2	MIN Consequence
26.97	18	GRP = 3	SCR Consequence
	--		
	54	Total	

			Corrected for ties	
Cases	Chi-Square	Significance	Chi-Square	Significance
54	2.4722	.2905	2.5400	.2808

Mann-Whitney U - Wilcoxon Rank Sum W Test

TRUERR True Errors
by GRP Consequence

Mean Rank	Cases		
21.14	18	GRP = 1	ZIT Consequence
15.86	18	GRP = 2	MIN Consequence
	--		
	36	Total	

		Exact	Corrected for ties	
U	W	2-Tailed P	Z	2-Tailed P
114.5	380.5	.1341	-1.5285	.1264

Appendix F (cont'd)

Experiment 1

Backward Chaining

Mann-Whitney U - Wilcoxon Rank Sum W Test

TRUERR True Errors
by GRP Consequence

Mean Rank	Cases	
20.22	18	GRP = 1 ZIT Consequence
16.78	18	GRP = 3 SCR Consequence
	36	Total

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
131.0	364.0	.3389	-.9922	.3211

Mann-Whitney U - Wilcoxon Rank Sum W Test

TRUERR True Errors
by GRP Consequence

Mean Rank	Cases	
17.31	18	GRP = 2 MIN Consequence
19.69	18	GRP = 3 SCR Consequence
	36	Total

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
140.5	311.5	.5010	-.6916	.4892

Appendix F (cont'd)

Experiment 1

Whole Task Training

Kruskal-Wallis 1-Way Anova

TRUERR True Errors
by GRP Consequence

Mean Rank	Cases		
31.56	18	GRP = 1	ZIT Consequence
26.44	18	GRP = 2	MIN Consequence
24.50	18	GRP = 3	SCR Consequence
	--		
	54	Total	

			Corrected for ties	
Cases	Chi-Square	Significance	Chi-Square	Significance
54	1.9318	.3806	1.9365	.3798

Mann-Whitney U - Wilcoxon Rank Sum W Test

TRUERR True Errors
by GRP Consequence

Mean Rank	Cases		
20.00	18	GRP = 1	ZIT Consequence
17.00	18	GRP = 2	MIN Consequence
	36	Total	

		Exact	Corrected for ties	
U	W	2-Tailed P	Z	2-Tailed P
135.0	360.0	.4064	-.8553	.3924

Appendix F (cont'd)

Experiment 1

Whole Task Training

Mann-Whitney U - Wilcoxon Rank Sum W Test

TRUERR True Errors
by GRP Consequence

Mean Rank	Cases		
21.06	18	GRP = 1	ZIT Consequence
15.94	18	GRP = 3	SCR Consequence
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
116.0	379.0	.1516	-1.4569	.1452

Mann-Whitney U - Wilcoxon Rank Sum W Test

TRUERR True Errors
by GRP Consequence

Mean Rank	Cases		
18.94	18	GRP = 2	MIN Consequence
18.06	18	GRP = 3	SCR Consequence
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
154.0	341.0	.8147	-.2535	.7999

Experiment 1

Zit - Auditory Programmed Consequence

Friedman Two-Way Anova

Mean Rank	Variable	
1.56	RANERR1	Forward Chaining
2.08	RANERR2	Backward Chaining
2.36	RANERR3	Whole Task Training

Cases	Chi-Square	D.F.	Significance
18	6.0278	2	.0491

Wilcoxon Matched-Pairs Signed-Ranks Test

RANERR1 Forward Chaining
with RANERR2 Backward Chaining

Mean Rank	Cases		
6.80	5	- Ranks	(RANERR2 LT RANERR1)
10.54	13	+ Ranks	(RANERR2 GT RANERR1)
	0	Ties	(RANERR2 EQ RANERR1)
	18	Total	

Z = -2.2428 2-Tailed P = .0249

Experiment 1

Zit - Auditory Programmed Consequence

Wilcoxon Matched-Pairs Signed-Ranks Test

RANERR1 Forward Chaining
with RANERR3 Whole Task Training

Mean Rank	Cases		
4.00	4	- Ranks	(RANERR3 LT RANERR1)
10.00	12	+ Ranks	(RANERR3 GT RANERR1)
	2	Ties	(RANERR3 EQ RANERR1)
	18	Total	

Z = -2.6889 2-Tailed P = .0072

Wilcoxon Matched-Pairs Signed-Ranks Test

RANERR2 Backward Chaining
with RANERR3 Whole Task Training

Mean Rank	Cases		
8.42	6	- Ranks	(RANERR3 LT RANERR2)
9.32	11	+ Ranks	(RANERR3 GT RANERR2)
	1	Ties	(RANERR3 EQ RANERR2)
	18	Total	

Z = -1.2308 2-Tailed P = .2184

Appendix F (cont'd)

Experiment 1

MIN - Minimal Programmed Consequence

Friedman Two-Way Anova

Mean Rank	Variable	
1.56	RANERR1	Forward Chaining
1.92	RANERR2	Backward Chaining
2.53	RANERR3	Whole Task Training

Cases	Chi-Square	D.F.	Significance
18	8.6944	2	.0129

Wilcoxon Matched-Pairs Signed-Ranks Test

RANERR1 Forward Chaining
with RANERR2 Backward Chaining

Mean Rank	Cases	
8.42	6	- Ranks (RANERR2 LT RANERR1)
9.32	11	+ Ranks (RANERR2 GT RANERR1)
	1	Ties (RANERR2 EQ RANERR1)
	18	Total

Z = -1.2308 2-Tailed P = .2184

Appendix F (cont'd)

Experiment 1

MIN - Minimal Programmed Consequence

Wilcoxon Matched-Pairs Signed-Ranks Test

RANERR1 Forward Chaining
with RANERR3 Whole Task Training

Mean Rank	Cases		
6.83	3	- Ranks	(RANERR3 LT RANERR1)
9.46	14	+ Ranks	(RANERR3 GT RANERR1)
	1	Ties	(RANERR3 EQ RANERR1)
	18	Total	

Z = -2.6509 2-Tailed P = .0080

Wilcoxon Matched-Pairs Signed-Ranks Test

RANERR2 Backward Chaining
with RANERR3 Whole Task Training

Mean Rank	Cases		
5.90	5	- Ranks	(RANERR3 LT RANERR2)
10.88	13	+ Ranks	(RANERR3 GT RANERR2)
	0	Ties	(RANERR3 EQ RANERR2)
	18	Total	

Z = -2.4388 2-Tailed P = .0147

Appendix F (cont'd)

Experiment 1

SCR - Visual Programmed Consequence

Friedman Two-Way Anova

Mean Rank	Variable	
1.67	RANERR1	Forward Chaining
2.22	RANERR2	Backward Chaining
2.11	RANERR3	Whole Task Training

Cases	Chi-Square	D.F.	Significance
18	3.1111	2	.2111

Wilcoxon Matched-Pairs Signed-Ranks Test

RANERR1 Forward Chaining
with RANERR2 Backward Chaining

Mean Rank	Cases	
7.40	5	- Ranks (RANERR2 LT RANERR1)
9.67	12	+ Ranks (RANERR2 GT RANERR1)
	1	Ties (RANERR2 EQ RANERR1)
	18	Total

Z = -1.8699 2-Tailed P = .0615

Appendix F (cont'd)

Experiment 1

SCR - Visual Programmed Consequence

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RANERR1   Forward Chaining
with RANERR3   Whole Task Training

     Mean Rank    Cases

        6.83          6  - Ranks (RANERR3 LT RANERR1)
       10.18         11  + Ranks (RANERR3 GT RANERR1)
                      1    Ties  (RANERR3 EQ RANERR1)
                     --
                     18    Total

        Z =    -1.6805            2-Tailed P =  .0929
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RANERR2   Backward Chaining
with RANERR3   Whole Task Training

     Mean Rank    Cases

        8.00          9  - Ranks (RANERR3 LT RANERR2)
       10.13          8  + Ranks (RANERR3 GT RANERR2)
                      1    Ties  (RANERR3 EQ RANERR2)
                     --
                     18    Total

        Z =     -.2130            2-Tailed P =  .8313
```

Appendix F (cont'd)

Experiment 1

Forward Chaining

Kruskal-Wallis 1-Way Anova

RANERR Random Errors
by GRP Consequence

Mean Rank	Cases		
31.28	18	GRP = 1	ZIT Consequence
26.47	18	GRP = 2	MIN Consequence
24.75	18	GRP = 3	SCR Consequence
	--		
	54	Total	

			Corrected for ties	
Cases	Chi-Square	Significance	Chi-Square	Significance
54	1.6648	.4350	1.6793	.4319

Mann-Whitney U - Wilcoxon Rank Sum W Test

RANERR Random Errors
by GRP Consequence

Mean Rank	Cases		
19.97	18	GRP = 1	ZIT Consequence
17.03	18	GRP = 2	MIN Consequence
	--		
	36	Total	

		Exact	Corrected for ties	
U	W	2-Tailed P	Z	2-Tailed P
135.5	359.5	.4064	-.8420	.3998

Experiment 1

Forward Chaining

Mann-Whitney U - Wilcoxon Rank Sum W Test

```
   RANERR       Random Errors
by GRP          Consequence

   Mean Rank    Cases

      20.81        18  GRP = 1  ZIT Consequence
      16.19        18  GRP = 3  SCR Consequence
                   --
                   36  Total

                                   Exact             Corrected for ties
         U             W        2-Tailed P           Z        2-Tailed P
      120.5          374.5        .1916           -1.3236       .1856
```

Mann-Whitney U - Wilcoxon Rank Sum W Test

```
   RANERR       Random Errors
by GRP          Consequence

   Mean Rank    Cases

      18.94        18  GRP = 2  MIN Consequence
      18.06        18  GRP = 3  SCR Consequence
                   --
                   36  Total

                                   Exact             Corrected for ties
         U             W        2-Tailed P           Z        2-Tailed P
      154.0          341.0        .8147            -.2541       .7994
```

Appendix F (cont'd)

Experiment 1

Backward Chaining

Kruskal-Wallis 1-Way Anova

```
    RANERR      Random Errors
 by GRP         Consequence

    Mean Rank    Cases

       31.56       18    GRP = 1   ZIT Consequence
       25.44       18    GRP = 2   MIN Consequence
       25.50       18    GRP = 3   SCR Consequence
                   --
                   54    Total

                                                 Corrected for ties
       Cases     Chi-Square  Significance    Chi-Square  Significance
          54         1.7944         .4077        1.8103         .4045
```

Mann-Whitney U - Wilcoxon Rank Sum W Test

```
    RANERR      Random Errors
 by GRP         Consequence

    Mean Rank    Cases

       20.50       18   GRP = 1  ZIT Consequence
       16.50       18   GRP = 2  MIN Consequence
                   --
                   36   Total

                                  Exact              Corrected for ties
           U             W     2-Tailed P             Z      2-Tailed P
       126.0         369.0          .2650       -1.1445           .2524
```

Appendix F (cont'd)

Experiment 1

Backward Chaining

Mann-Whitney U - Wilcoxon Rank Sum W Test

	RANERR	Random Errors
by	GRP	Consequence

Mean Rank	Cases		
20.56	18	GRP = 1	ZIT Consequence
16.44	18	GRP = 3	SCR Consequence
	36	Total	

		Exact	Corrected for ties	
U	W	2-Tailed P	Z	2-Tailed P
125.0	370.0	.2516	-1.1764	.2394

Mann-Whitney U - Wilcoxon Rank Sum W Test

	RANERR	Random Errors
by	GRP	Consequence

Mean Rank	Cases		
18.44	18	GRP = 2	MIN Consequence
18.56	18	GRP = 3	SCR Consequence
	36	Total	

		Exact	Corrected for ties	
U	W	2-Tailed P	Z	2-Tailed P
161.0	332.0	.9876	-.0318	.9746

Appendix F (cont'd)

Experiment 1

Whole Task Training

Kruskal-Wallis 1-Way Anova

RANERR   Random Errors
by GRP   Consequence

Mean Rank	Cases		
29.33	18	GRP = 1	ZIT Consequence
33.47	18	GRP = 2	MIN Consequence
19.69	18	GRP = 3	SCR Consequence
	--		
	54	Total	

			Corrected for ties	
Cases	Chi-Square	Significance	Chi-Square	Significance
54	7.2695	.0264	7.2923	.0261

Mann-Whitney U - Wilcoxon Rank Sum W Test

RANERR   Random Errors
by GRP   Consequence

Mean Rank	Cases		
16.83	18	GRP = 1	ZIT Consequence
20.17	18	GRP = 2	MIN Consequence
	--		
	36	Total	

		Exact	Corrected for ties	
U	W	2-Tailed P	Z	2-Tailed P
132.0	303.0	.3551	-.9504	.3419

Appendix F (cont'd)

Experiment 1

Whole Task Training

Mann-Whitney U - Wilcoxon Rank Sum W Test

RANERR Random Errors
by GRP Consequence

Mean Rank	Cases		
22.00	18	GRP = 1	ZIT Consequence
15.00	18	GRP = 3	SCR Consequence
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
99.0	396.0	.0471	-2.0006	.0454

Mann-Whitney U - Wilcoxon Rank Sum W Test

RANERR Random Errors
by GRP Consequence

Mean Rank	Cases		
22.81	18	GRP = 2	MIN Consequence
14.19	18	GRP = 3	SCR Consequence
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
84.5	410.5	.0129	-2.4552	.0141

Appendix F (cont'd)

Experiment 1

Zit - Auditory Programmed Consequence

Friedman Two-Way Anova

Mean Rank	Variable	
1.33	TOTERR1	Forward Chaining
1.94	TOTERR2	Backward Chaining
2.72	TOTERR3	Whole Task Training

Cases	Chi-Square	D.F.	Significance
18	17.4444	2	.0002

Wilcoxon Matched-Pairs Signed-Ranks Test

TOTERR1 Forward Chaining
with TOTERR2 Backward Chaining

Mean Rank	Cases	
5.80	5	- Ranks (TOTERR2 LT TOTERR1)
10.92	13	+ Ranks (TOTERR2 GT TOTERR1)
	0	Ties (TOTERR2 EQ TOTERR1)
	18	Total

Z = -2.4606 2-Tailed P = .0139

Appendix F (cont'd)

Experiment 1

Zit - Auditory Programmed Consequence

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TOTERR1   Forward Chaining
with TOTERR3   Whole Task Training

     Mean Rank    Cases

        1.50          1  - Ranks  (TOTERR3 LT TOTERR1)
        9.97         17  + Ranks  (TOTERR3 GT TOTERR1)
                      0    Ties   (TOTERR3 EQ TOTERR1)
                     --
                     18    Total

        Z =   -3.6582             2-Tailed P =  .0003
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TOTERR2   Backward Chaining
with TOTERR3   Whole Task Training

     Mean Rank    Cases

        4.67          3  - Ranks  (TOTERR3 LT TOTERR2)
        9.38         13  + Ranks  (TOTERR3 GT TOTERR2)
                      2    Ties   (TOTERR3 EQ TOTERR2)
                     --
                     18    Total

        Z =   -2.7923             2-Tailed P =  .0052
```

Appendix F (cont'd)

Experiment 1

MIN - Minimal Programmed Consequence

Friedman Two-Way Anova

Mean Rank	Variable	
1.56	TOTERR1	Forward Chaining
1.78	TOTERR2	Backward Chaining
2.67	TOTERR3	Whole Task Training

Cases	Chi-Square	D.F.	Significance
18	12.4444	2	.0020

Wilcoxon Matched-Pairs Signed-Ranks Test

TOTERR1 Forward Chaining
with TOTERR2 Backward Chaining

Mean Rank	Cases		
8.44	8	- Ranks	(TOTERR2 LT TOTERR1)
10.35	10	+ Ranks	(TOTERR2 GT TOTERR1)
	0	Ties	(TOTERR2 EQ TOTERR1)
	18	Total	

Z = -.7839 2-Tailed P = .4331

Experiment 1

MIN - Minimal Programmed Consequence

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TOTERR1    Forward Chaining
with TOTERR3    Whole Task Training

     Mean Rank    Cases

        5.75          2   - Ranks (TOTERR3 LT TOTERR1)
        9.97         16   + Ranks (TOTERR3 GT TOTERR1)
                      0     Ties  (TOTERR3 EQ TOTERR1)
                     --
                     18     Total

        Z =    -3.2227              2-Tailed P =   .0013
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TOTERR2    Backward Chaining
with TOTERR3    Whole Task Training

     Mean Rank    Cases

        6.13          4   - Ranks (TOTERR3 LT TOTERR2)
       10.46         14   + Ranks (TOTERR3 GT TOTERR2)
                      0     Ties  (TOTERR3 EQ TOTERR2)
                     --
                     18     Total

        Z =    -2.6566              2-Tailed P =   .0079
```

Appendix F (cont'd)

Experiment 1

SCR - Visual Programmed Consequence

Friedman Two-Way Anova

Mean Rank	Variable	
1.39	TOTERR1	Forward Chaining
2.28	TOTERR2	Backward Chaining
2.33	TOTERR3	Whole Task Training

Cases	Chi-Square	D.F.	Significance
18	10.1111	2	.0064

Wilcoxon Matched-Pairs Signed-Ranks Test

TOTERR1 Forward Chaining
with TOTERR2 Backward Chaining

Mean Rank	Cases		
7.13	4	- Ranks	(TOTERR2 LT TOTERR1)
10.18	14	+ Ranks	(TOTERR2 GT TOTERR1)
	0	Ties	(TOTERR2 EQ TOTERR1)
	18	Total	

Z = -2.4824 2-Tailed P = .0131

Experiment 1

SCR - Visual Programmed Consequence

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TOTERR1   Forward Chaining
with TOTERR3   Whole Task Training

     Mean Rank    Cases

        9.00          3   - Ranks (TOTERR3 LT TOTERR1)
        9.60         15   + Ranks (TOTERR3 GT TOTERR1)
                      0     Ties  (TOTERR3 EQ TOTERR1)
                     --
                     18     Total

        Z =    -2.5477            2-Tailed P =   .0108
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TOTERR2   Backward Chaining
with TOTERR3   Whole Task Training

     Mean Rank    Cases

        5.89          9   - Ranks (TOTERR3 LT TOTERR2)
       13.11          9   + Ranks (TOTERR3 GT TOTERR2)
                      0     Ties  (TOTERR3 EQ TOTERR2)
                     --
                     18     Total

        Z =    -1.4154            2-Tailed P =   .1570
```

Appendix F (cont'd)

Experiment 1

Forward Chaining

Kruskal-Wallis 1-Way Anova

TOTERR Total Errors
by GRP Consequence

Mean Rank	Cases		
33.44	18	GRP = 1	ZIT Consequence
26.86	18	GRP = 2	MIN Consequence
22.19	18	GRP = 3	SCR Consequence
	54	Total	

			Corrected for ties	
Cases	Chi-Square	Significance	Chi-Square	Significance
54	4.6468	.0979	4.6820	.0962

Mann-Whitney U - Wilcoxon Rank Sum W Test

TOTERR Total Errors
by GRP Consequence

Mean Rank	Cases		
20.33	18	GRP = 1	ZIT Consequence
16.67	18	GRP = 2	MIN Consequence
	36	Total	

		Exact	Corrected for ties	
U	W	2-Tailed P	Z	2-Tailed P
129.0	366.0	.3079	-1.0490	.2942

Appendix F (cont'd)

Experiment 1

Forward Chaining

Mann-Whitney U - Wilcoxon Rank Sum W Test

```
    TOTERR      Total Errors
by GRP          Consequence

    Mean Rank     Cases

        22.61       18  GRP = 1  ZIT Consequence
        14.39       18  GRP = 3  SCR Consequence
                    --
                    36  Total

                                     Exact            Corrected for ties
        U               W         2-Tailed P            Z        2-Tailed P
      88.0            407.0         .0187           -2.3595        .0183
```

Mann-Whitney U - Wilcoxon Rank Sum W Test

```
    TOTERR      Total Errors
by GRP          Consequence

    Mean Rank     Cases

        19.69       18  GRP = 2  MIN Consequence
        17.31       18  GRP = 3  SCR Consequence
                    --
                    36  Total

                                     Exact            Corrected for ties
        U               W         2-Tailed P            Z        2-Tailed P
      140.5           354.5         .5010            -.6828        .4947
```

Appendix F (cont'd)

Experiment 1

Backward Chaining

Kruskal-Wallis 1-Way Anova

	TOTERR	Total Errors
by	GRP	Consequence

Mean Rank	Cases		
32.36	18	GRP = 1	ZIT Consequence
22.31	18	GRP = 2	MIN Consequence
27.83	18	GRP = 3	SCR Consequence
	—		
	54	Total	

			Corrected for ties	
Cases	Chi-Square	Significance	Chi-Square	Significance
54	3.6890	.1581	3.7024	.1570

Mann-Whitney U - Wilcoxon Rank Sum W Test

	TOTERR	Total Errors
by	GRP	Consequence

Mean Rank	Cases		
21.64	18	GRP = 1	ZIT Consequence
15.36	18	GRP = 2	MIN Consequence
	—		
	36	Total	

		Exact	Corrected for ties	
U	W	2-Tailed P	Z	2-Tailed P
105.5	389.5	.0736	-1.7915	.0732

Experiment 1

Backward Chaining

Mann-Whitney U - Wilcoxon Rank Sum W Test

```
    TOTERR        Total Errors
 by GRP           Consequence

    Mean Rank     Cases

        20.22        18  GRP = 1  ZIT Consequence
        16.78        18  GRP = 3  SCR Consequence
                     --
                     36  Total

                                   Exact                    Corrected for ties
          U              W      2-Tailed P                  Z          2-Tailed P
        131.0          364.0       .3389                -.9822            .3260
```

Mann-Whitney U - Wilcoxon Rank Sum W Test

```
    TOTERR        Total Errors
 by GRP           Consequence

    Mean Rank     Cases

        16.44        18  GRP = 2  MIN Consequence
        20.56        18  GRP = 3  SCR Consequence
                     --
                     36  Total

                                   Exact                    Corrected for ties
          U              W      2-Tailed P                  Z          2-Tailed P
        125.0          296.0       .2516               -1.1740            .2404
```

Appendix F (cont'd)

Experiment 1

Whole Task Training

Kruskal-Wallis 1-Way Anova

TOTERR Total Errors
by GRP Consequence

Mean Rank	Cases		
31.39	18	GRP = 1	ZIT Consequence
30.03	18	GRP = 2	MIN Consequence
21.08	18	GRP = 3	SCR Consequence
	—		
	54	Total	

Cases	Chi-Square	Significance	Corrected for ties Chi-Square	Corrected for ties Significance
54	4.5590	.1023	4.5622	.1022

Mann-Whitney U - Wilcoxon Rank Sum W Test

TOTERR Total Errors
by GRP Consequence

Mean Rank	Cases		
19.00	18	GRP = 1	ZIT Consequence
18.00	18	GRP = 2	MIN Consequence
	—		
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
153.0	342.0	.7906	-.2849	.7757

Appendix F (cont'd)

Experiment 1

Whole Task Training

Mann-Whitney U - Wilcoxon Rank Sum W Test

TOTERR Total Errors
by GRP Consequence

Mean Rank	Cases	
21.89	18	GRP = 1 ZIT Consequence
15.11	18	GRP = 3 SCR Consequence
	36	Total

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
101.0	394.0	.0549	-1.9309	.0535

Mann-Whitney U - Wilcoxon Rank Sum W Test

TOTERR Total Errors
by GRP Consequence

Mean Rank	Cases	
21.53	18	GRP = 2 MIN Consequence
15.47	18	GRP = 3 SCR Consequence
	36	Total

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
107.5	387.5	.0847	-1.7250	.0845

Experiment 1

Zit - Auditory Programmed Consequence

Friedman Two-Way Anova

Mean Rank	Variable	
2.22	RESP1	Forward Chaining
2.61	RESP2	Backward Chaining
1.17	RESP3	Whole Task Training

Cases	Chi-Square	D.F.	Significance
18	20.1111	2	.0000

Wilcoxon Matched-Pairs Signed-Ranks Test

RESP1 Forward Chaining
with RESP2 Backward Chaining

Mean Rank	Cases		
5.17	6	- Ranks	(RESP2 LT RESP1)
11.67	12	+ Ranks	(RESP2 GT RESP1)
	0	Ties	(RESP2 EQ RESP1)
	18	Total	

Z = -2.3735 2-Tailed P = .0176

Appendix F (cont'd)

Experiment 1

Zit - Auditory Programmed Consequence

Wilcoxon Matched-Pairs Signed-Ranks Test

RESP1 Forward Chaining
with RESP3 Whole Task Training

Mean Rank	Cases	
8.91	16	- Ranks (RESP3 LT RESP1)
14.25	2	+ Ranks (RESP3 GT RESP1)
	0	Ties (RESP3 EQ RESP1)
	18	Total

Z = -2.4824 2-Tailed P = .0131

Wilcoxon Matched-Pairs Signed-Ranks Test

RESP2 Backward Chaining
with RESP3 Whole Task Training

Mean Rank	Cases	
9.00	17	- Ranks (RESP3 LT RESP2)
18.00	1	+ Ranks (RESP3 GT RESP2)
	0	Ties (RESP3 EQ RESP2)
	18	Total

Z = -2.9396 2-Tailed P = .0033

Experiment 1

MIN - Minimal Programmed Consequence

Friedman Two-Way Anova

Mean Rank	Variable	
2.22	RESP1	Forward Chaining
2.44	RESP2	Backward Chaining
1.33	RESP3	Whole Task Training

Cases	Chi-Square	D.F.	Significance
18	12.4444	2	.0020

Wilcoxon Matched-Pairs Signed-Ranks Test

RESP1 Forward Chaining
with RESP2 Backward Chaining

Mean Rank	Cases		
10.93	7	- Ranks	(RESP2 LT RESP1)
8.59	11	+ Ranks	(RESP2 GT RESP1)
	0	Ties	(RESP2 EQ RESP1)
	18	Total	

Z = -.3920 2-Tailed P = .6951

Appendix F (cont'd)

Experiment 1

MIN - Minimal Programmed Consequence

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RESP1      Forward Chaining
with RESP3      Whole Task Training

     Mean Rank     Cases

        8.93         15   - Ranks (RESP3 LT RESP1)
       12.33          3   + Ranks (RESP3 GT RESP1)
                      0     Ties  (RESP3 EQ RESP1)
                     --
                     18     Total

         Z =    -2.1122            2-Tailed P =  .0347
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RESP2      Backward Chaining
with RESP3      Whole Task Training

     Mean Rank     Cases

        8.77         15   - Ranks (RESP3 LT RESP2)
       13.17          3   + Ranks (RESP3 GT RESP2)
                      0     Ties  (RESP3 EQ RESP2)
                     --
                     18     Total

         Z =    -2.0033            2-Tailed P =  .0451
```

Experiment 1

SCR - Visual Programmed Consequence

Friedman Two-Way Anova

Mean Rank	Variable	
2.03	RESP1	Forward Chaining
2.69	RESP2	Backward Chaining
1.28	RESP3	Whole Task Training

Cases	Chi-Square	D.F.	Significance
18	18.0833	2	.0001

Wilcoxon Matched-Pairs Signed-Ranks Test

RESP1 Forward Chaining
with RESP2 Backward Chaining

Mean Rank	Cases	
10.67	3	- Ranks (RESP2 LT RESP1)
8.64	14	+ Ranks (RESP2 GT RESP1)
	1	Ties (RESP2 EQ RESP1)
	18	Total

Z = -2.1065 2-Tailed P = .0352

Appendix F (cont'd)

Experiment 1

SCR - Visual Programmed Consequence

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RESP1      Forward Chaining
with RESP3      Whole Task Training

     Mean Rank    Cases

        9.00         15   - Ranks (RESP3 LT RESP1)
       12.00          3   + Ranks (RESP3 GT RESP1)
                      0     Ties  (RESP3 EQ RESP1)
                     --
                     18     Total

        Z =     -2.1557              2-Tailed P =   .0311
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RESP2      Backward Chaining
with RESP3      Whole Task Training

     Mean Rank    Cases

        9.50         16   - Ranks (RESP3 LT RESP2)
        9.50          2   + Ranks (RESP3 GT RESP2)
                      0     Ties  (RESP3 EQ RESP2)
                     --
                     18     Total

        Z =     -2.8961              2-Tailed P =   .0038
```

Experiment 1

Backward Chaining

Kruskal-Wallis 1-Way Anova

RESP
by GRP Consequence

Mean Rank	Cases		
35.11	18	GRP = 1	ZIT Consequence
20.06	18	GRP = 2	MIN Consequence
27.33	18	GRP = 3	SCR Consequence
	--		
	54	Total	

			Corrected for ties	
Cases	Chi-Square	Significance	Chi-Square	Significance
54	8.2456	.0162	8.2509	.0162

Mann-Whitney U - Wilcoxon Rank Sum W Test

RESP
by GRP Consequence

Mean Rank	Cases		
23.39	18	GRP = 1	ZIT Consequence
13.61	18	GRP = 2	MIN Consequence
	36	Total	

		Exact	Corrected for ties	
U	W	2-Tailed P	Z	2-Tailed P
74.0	421.0	.0046	-2.7863	.0053

Experiment 1

Backward Chaining

Mann-Whitney U - Wilcoxon Rank Sum W Test

RESP
by GRP Consequence

Mean Rank	Cases	
21.22	18	GRP = 1 ZIT Consequence
15.78	18	GRP = 3 SCR Consequence
	36	Total

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
113.0	382.0	.1260	-1.5507	.1210

Mann-Whitney U - Wilcoxon Rank Sum W Test

RESP
by GRP Consequence

Mean Rank	Cases	
15.94	18	GRP = 2 MIN Consequence
21.06	18	GRP = 3 SCR Consequence
	36	Total

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
116.0	287.0	.1516	-1.4564	.1453

Appendix F (cont'd)

Experiment 1

Whole Task Training

Kruskal-Wallis 1-Way Anova

RESP
by GRP Consequence

Mean Rank	Cases		
33.25	18	GRP = 1	ZIT Consequence
28.17	18	GRP = 2	MIN Consequence
21.08	18	GRP = 3	SCR Consequence
	--		
	54	Total	

Cases	Chi-Square	Significance	Corrected for ties Chi-Square	Corrected for ties Significance
54	5.4313	.0662	5.4334	.0661

Mann-Whitney U - Wilcoxon Rank Sum W Test

RESP
by GRP Consequence

Mean Rank	Cases		
20.44	18	GRP = 1	ZIT Consequence
16.56	18	GRP = 2	MIN Consequence
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
127.0	368.0	.2788	-1.1076	.2680

Appendix F (cont'd)

Experiment 1

Whole Task Training

Mann-Whitney U - Wilcoxon Rank Sum W Test

RESP
by GRP Consequence

Mean Rank	Cases	
22.31	18	GRP = 1 ZIT Consequence
14.69	18	GRP = 3 SCR Consequence
	36	Total

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
93.5	401.5	.0290	-2.1678	.0302

Mann-Whitney U - Wilcoxon Rank Sum W Test

RESP
by GRP Consequence

Mean Rank	Cases	
21.11	18	GRP = 2 MIN Consequence
15.89	18	GRP = 3 SCR Consequence
	36	Total

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
115.0	380.0	.1427	-1.4873	.1369

Appendix F (cont'd)

Experiment 1

Zit - Auditory Programmed Consequence

Friedman Two-Way Anova

Mean Rank	Variable	
2.11	TIME1	Forward Chaining
2.67	TIME2	Backward Chaining
1.22	TIME3	Whole Task Training

Cases	Chi-Square	D.F.	Significance
18	19.1111	2	.0001

Wilcoxon Matched-Pairs Signed-Ranks Test

TIME1 Forward Chaining
with TIME2 Backward Chaining

Mean Rank	Cases		
7.90	5	- Ranks	(TIME2 LT TIME1)
10.12	13	+ Ranks	(TIME2 GT TIME1)
	0	Ties	(TIME2 EQ TIME1)
	18	Total	

Z = -2.0033 2-Tailed P = .0451

Appendix F (cont'd)

Experiment 1

Zit - Auditory Programmed Consequence

Wilcoxon Matched-Pairs Signed-Ranks Test

TIME1 Forward Chaining
with TIME3 Whole Task Training

Mean Rank	Cases		
9.00	15	- Ranks	(TIME3 LT TIME1)
12.00	3	+ Ranks	(TIME3 GT TIME1)
	0	Ties	(TIME3 EQ TIME1)
	18	Total	

Z = -2.1557 2-Tailed P = .0311

Wilcoxon Matched-Pairs Signed-Ranks Test

TIME2 Backward Chaining
with TIME3 Whole Task Training

Mean Rank	Cases		
9.06	17	- Ranks	(TIME3 LT TIME2)
17.00	1	+ Ranks	(TIME3 GT TIME2)
	0	Ties	(TIME3 EQ TIME2)
	18	Total	

Z = -2.9832 2-Tailed P = .0029

Appendix F (cont'd)

Experiment 1

MIN - Minimal Programmed Consequence

Friedman Two-Way Anova

Mean Rank	Variable	
2.06	TIME1	Forward Chaining
2.56	TIME2	Backward Chaining
1.39	TIME3	Whole Task Training

Cases	Chi-Square	D.F.	Significance
18	12.3333	2	.0021

Wilcoxon Matched-Pairs Signed-Ranks Test

TIME1 Forward Chaining
with TIME2 Backward Chaining

Mean Rank	Cases	
10.40	5	- Ranks (TIME2 LT TIME1)
9.15	13	+ Ranks (TIME2 GT TIME1)
	0	Ties (TIME2 EQ TIME1)
	18	Total

Z = -1.4589 2-Tailed P = .1446

Experiment 1

MIN - Minimal Programmed Consequence

Wilcoxon Matched-Pairs Signed-Ranks Test

TIME1	Forward Chaining
with TIME3	Whole Task Training

Mean Rank	Cases	
8.93	14	- Ranks (TIME3 LT TIME1)
11.50	4	+ Ranks (TIME3 GT TIME1)
	0	Ties (TIME3 EQ TIME1)
	18	Total

Z = -1.7202 2-Tailed P = .0854

Wilcoxon Matched-Pairs Signed-Ranks Test

TIME2	Backward Chaining
with TIME3	Whole Task Training

Mean Rank	Cases	
9.07	15	- Ranks (TIME3 LT TIME2)
11.67	3	+ Ranks (TIME3 GT TIME2)
	0	Ties (TIME3 EQ TIME2)
	18	Total

Z = -2.1993 2-Tailed P = .0279

Appendix F (cont'd)

Experiment 1

SCR - Visual Programmed Consequence

Friedman Two-Way Anova

Mean Rank	Variable	
2.00	TIME1	Forward Chaining
2.78	TIME2	Backward Chaining
1.22	TIME3	Whole Task Training

Cases	Chi-Square	D.F.	Significance
18	21.7778	2	.0000

Wilcoxon Matched-Pairs Signed-Ranks Test

	TIME1	Forward Chaining
with	TIME2	Backward Chaining

Mean Rank	Cases		
12.00	2	- Ranks	(TIME2 LT TIME1)
9.19	16	+ Ranks	(TIME2 GT TIME1)
	0	Ties	(TIME2 EQ TIME1)
	18	Total	

Z = -2.6783 2-Tailed P = .0074

Appendix F (cont'd)

Experiment 1

SCR - Visual Programmed Consequence

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TIME1      Forward Chaining
with TIME3      Whole Task Training

     Mean Rank     Cases

        8.63         16   - Ranks (TIME3 LT TIME1)
       16.50          2   + Ranks (TIME3 GT TIME1)
                      0     Ties  (TIME3 EQ TIME1)
                     --
                     18     Total

        Z =    -2.2864              2-Tailed P =  .0222
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TIME2      Backward Chaining
with TIME3      Whole Task Training

     Mean Rank     Cases

        9.69         16   - Ranks (TIME3 LT TIME2)
        8.00          2   + Ranks (TIME3 GT TIME2)
                      0     Ties  (TIME3 EQ TIME2)
                     --
                     18     Total

        Z =    -3.0267              2-Tailed P =  .0025
```

Experiment 1

Forward Chaining

Kruskal-Wallis 1-Way Anova

TIME by GRP — Time Consequence

Mean Rank	Cases		
32.33	18	GRP = 1	ZIT Consequence
23.28	18	GRP = 2	MIN Consequence
26.89	18	GRP = 3	SCR Consequence
	54	Total	

Cases	Chi-Square	Significance	Corrected for ties Chi-Square	Corrected for ties Significance
54	3.0227	.2206	3.0231	.2206

Mann-Whitney U - Wilcoxon Rank Sum W Test

TIME by GRP — Time Consequence

Mean Rank	Cases		
21.44	18	GRP = 1	ZIT Consequence
15.56	18	GRP = 2	MIN Consequence
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
109.0	386.0	.0971	-1.6772	.0935

Experiment 1

Forward Chaining

Mann-Whitney U - Wilcoxon Rank Sum W Test

TIME by GRP — Time Consequence

Mean Rank	Cases	
20.39	18	GRP = 1 ZIT Consequence
16.61	18	GRP = 3 SCR Consequence
	36	Total

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
128.0	367.0	.2931	-1.0759	.2820

Mann-Whitney U - Wilcoxon Rank Sum W Test

TIME by GRP — Time Consequence

Mean Rank	Cases	
17.22	18	GRP = 2 MIN Consequence
19.78	18	GRP = 3 SCR Consequence
	36	Total

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
139.0	310.0	.4812	-.7277	.4668

Experiment 1

Backward Chaining

Kruskal-Wallis 1-Way Anova

TIME by GRP — Time Consequence

Mean Rank	Cases		
29.14	18	GRP = 1	ZIT Consequence
23.47	18	GRP = 2	MIN Consequence
29.89	18	GRP = 3	SCR Consequence
	54	Total	

Cases	Chi-Square	Significance	Corrected for ties Chi-Square	Corrected for ties Significance
54	1.7902	.4086	1.7911	.4084

Mann-Whitney U - Wilcoxon Rank Sum W Test

TIME by GRP — Time Consequence

Mean Rank	Cases		
20.53	18	GRP = 1	ZIT Consequence
16.47	18	GRP = 2	MIN Consequence
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
125.5	369.5	.2516	-1.1550	.2481

Experiment 1

Backward Chaining

Mann-Whitney U - Wilcoxon Rank Sum W Test

TIME by GRP — Time Consequence

Mean Rank	Cases		
18.11	18	GRP = 1	ZIT Consequence
18.89	18	GRP = 3	SCR Consequence
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
155.0	326.0	.8391	-.2216	.8246

Mann-Whitney U - Wilcoxon Rank Sum W Test

TIME by GRP — Time Consequence

Mean Rank	Cases		
16.50	18	GRP = 2	MIN Consequence
20.50	18	GRP = 3	SCR Consequence
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
126.0	297.0	.2650	-1.1397	.2544

Appendix F (cont'd)

Experiment 1

Whole Task Training

Kruskal-Wallis 1-Way Anova

TIME by GRP — Time Consequence

Mean Rank	Cases		
29.03	18	GRP = 1	ZIT Consequence
29.03	18	GRP = 2	MIN Consequence
24.44	18	GRP = 3	SCR Consequence
	--		
	54	Total	

Cases	Chi-Square	Significance	Corrected for ties Chi-Square	Corrected for ties Significance
54	1.0185	.6009	1.0188	.6009

Mann-Whitney U - Wilcoxon Rank Sum W Test

TIME by GRP — Time Consequence

Mean Rank	Cases		
18.25	18	GRP = 1	ZIT Consequence
18.75	18	GRP = 2	MIN Consequence
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
157.5	328.5	.8882	-.1424	.8868

Appendix F (cont'd)

Experiment 1

Whole Task Training

Mann-Whitney U - Wilcoxon Rank Sum W Test

TIME by GRP — Time Consequence

Mean Rank	Cases	
20.28	18	GRP = 1 ZIT Consequence
16.72	18	GRP = 3 SCR Consequence
	36	Total

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
130.0	365.0	.3231	-1.0125	.3113

Mann-Whitney U - Wilcoxon Rank Sum W Test

TIME by GRP — Time Consequence

Mean Rank	Cases	
19.78	18	GRP = 2 MIN Consequence
17.22	18	GRP = 3 SCR Consequence
	36	Total

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
139.0	356.0	.4812	-.7278	.4667

Appendix G

Experiment 1

Post Experiment Questionnaire Data

The following section summarizes the answers to the questions that each subject was asked after performing the three sequences. (See Appendix B for these questions).

Question 1: Subjects were requested to draw the symbols and numbers in the order that the buttons were pushed. Results were as follows:

i) Forty-seven subjects drew the order of button pushes correctly, three drew six of the eight numbers correctly, one drew seven correctly, one drew two correctly and one drew one correctly, and one drew zero. Subjects were divided into groups according to the method by which the last sequence was taught. There were no significant differences in the accuracy of the order recall among the three groups ($F = 0.8531$, $p = .4321$).

ii) Twenty subjects drew the symbols in the correct buttons, nine subjects drew seven symbols correctly, eight drew six symbols correctly, six drew five symbols correctly, four drew four, five drew three, one drew two, and one drew one. Subjects were divided into groups according to the method by which the last sequence was taught. There were no significant differences in the accuracy of the symbol recall among the groups ($F = 2.2411$, $p = .1160$).

Question 2: Subjects were asked to identify any differences between the three training procedures. Results were as follows:

a) Forty-three subjects reported they noticed a type of chaining technique versus some type of whole task training technique and eleven subjects reported they did not. Subjects were divided into two groups to determine whether awareness of method type affected performance. There were no significant differences for true errors between the three group ($F = 3.2792$, $p = 0.0720$).

b) Twenty-two subjects reported they had noticed a difference between forward and backward chaining and thirty-two subjects did not. There were no significant differences in true errors between awareness of differences between training methods ($F = 1.0747$, $p = 0.3014$).

Question 3: Subjects were asked whether they had used the percent score listed on the screen. Forty-three subjects indicated they had used the percent scores and eleven indicated they had not used them.

Question 4: Subjects were asked whether they found the task boring or reasonably interesting. Forty subjects indicated they found it reasonably interesting, five found it boring, and nine found it so/so.

Question 5: Subjects were asked what strategy they used to learn the task. Twenty-two used key position, three used fingers and symbols, eight used fingers and key positions and ten used symbols and keys and three used keys and eight changed strategy.

Question 6: When asked whether numbers or letters were used to assist in learning the task, one subject indicated numbers were used like telephone numbers.

Question 7: Subjects were asked to rank order the training methods as most comfortable and easy. Results were as follows:

For most comfortable, thirty-three subjects said forward chaining, sixteen said backward chaining, three said whole task training and one said forward chaining or whole task training and one said forward or backward chaining.

For second most comfortable, thirteen subjects said forward chaining, twenty-four said backward chaining, twelve said whole task training and five said nothing.

For third most comfortable, five said forward chaining, fourteen said backward chaining, and thity-five said whole task training.

Question 8: Subjects were asked to rank order which training method they did best on. Results were as follows:

For best, twenty-five reported forward chaining, nineteen reported backward chaining, six reported whole task training, and three reported forward or backward chaining and one reported forward or whole task training.

For second best, eighteen reported forward chaining, twenty-three reported backward chaining, eleven reported whole task training and two reported forward or backward chaining.

For third best, five reported forward chaining, eleven reported backward chaining, and thirty-eight reported whole task training.

Only thirty individuals correctly predicted which training method they rank ordered as doing best, second best, etc.

Questions 9 and 10: Subjects gave general suggestions such as instructions were too long and instructions should be put on screen. One subject suggested that the best training method might depend on the age of the participant.

Question 11: Forty-three subjects indicated they could not define forward and backward chaining and whole task training. Eleven subjects indicated they did have prior knowledge of the training procedures.

Question 12: When asked what the criterion to teach a new subsequence was: twenty-nine said three, three said three or four, three said four, one said three or four or five, one said four or five and three said 3 or 4 and fourteen did not know.

Appendix H
Experiment 2
Bartlett-Box F Test of Homogeneity of Variance

Legend for Appendix H

7 - Comparison of consequences using forward chaining

8 - Comparison of consequences using backward chaining

9 - Comparison of consequences using whole task training

10 - Comparison of training procedures using "ZIT-2" consequence

11 - Comparison of training procedures using "PROMPT" consequence

Training Procedures and Consequences

FC - Forward chaining

BC - Backward chaining

WT - Whole task training

ZIT-2 - Auditory programmed consequence using "ZIT" sound

PROMPT - Prompt programmed consequence

Appendix H
(Continued)
Experiment 2

Dependent Variable - True Errors

Condition	Bartlett-Box F	Probability
7	14.173	.000
8	0.078	.780
9	1.601	.206
10	46.936	.000
11	22.501	.000

Dependent Variables - Random Errors

7	4[illegible]41	.000
8	40.700	.000
9	34.023	.000
10	2.019	.133
11	4.2980	.014

Appendix H
(Continued)
Experiment 2

Dependent Variable - Total Errors

Condition	Bartlett-Box F	Probability
7	0.995	.319
8	3.333	.068
9	1.354	.254
10	20.855	.000
11	22.638	.000

Dependent Variable - Total Responses

7	15.225	.000
8	0.719	.397
9	0.082	.774
10	12.087	.001
11	1.825	.161

Appendix H
(continued)
Experiment 2

Dependent Variable - Time in seconds

Condition	Bartlett-Box F	Probability
7	2.538	.112
8	0.239	.625
9	11.068	.001
10	3.617	.027
11	15.201	.000

Appendix I
Experiment 2
Means, Medians and Standard Deviations

Legend for Appendix I

FC - Forward chaining

BC - Backward chaining

WT - Whole task training

"ZIT-2" Consequence - Auditory programmed consequence consisting of a "ZIT" sound used in Experiment 2

"PROMPT" Consequence - Prompt programmed consequence

Appendix I
(continued)
Experiment 2

Dependent Variable -True Errors

"ZIT-2" Consequence

Procedure	Mean	Median	Standard Deviation
FC	1.1	0.0	1.5
BC	4.1	3.5	4.1
WT	15.3	7.5	22.0

"PROMPT" Consequence

Procedure	Mean	Median	Standard Deviation
FC	1.5	0.0	4.0
BC	2.8	1.0	3.8
WT	14.7	8.5	16.0

Appendix I
(continued)
Experiment 2

Dependent Variable - Random Errors

"ZIT-2" Consequence

Procedure	Mean	Median	Standard Deviation
FC	13.3	12.5	5.7
BC	14.7	13.5	4.8
WT	17.3	15.0	7.4

"PROMPT" Consequence

Procedure	Mean	Median	Standard Deviation
FC	5.8	6.0	0.9
BC	5.9	6.0	0.7
WT	6.0	6.0	1.4

Appendix I
(continued)
Experiment 2

Dependent Variable - Total Errors

"ZIT-2" Consequence

Procedure	Mean	Median	Standard Deviation
FC	14.3	15.0	5.6
BC	18.8	17.5	6.1
WT	32.7	28.5	22.6

"PROMPT" Consequence

Procedure	Mean	Median	Standard Deviation
FC	7.3	6.0	4.4
BC	8.7	7.0	3.9
WT	20.7	15.0	17.0

Appendix I
(continued)
Experiment 2

Dependent Variable -Total Responses

"ZIT-2" Consequence

Procedure	Mean	Median	Standard Deviation
FC	149.9	149.0	14.4
BC	166.2	163.5	23.0
WT	106.4	91.0	48.8

"PROMPT" Consequence

Procedure	Mean	Median	Standard Deviation
FC	150.8	138	40.5
BC	159.1	151	28.4
WT	92.2	88	45.5

Appendix I
(continued)
Experiment 2

Dependent Variable - Time in seconds

"ZIT-2" Consequence

Procedure	Mean	Median	Standard Deviation
FC	290.4	283	46.1
BC	330.9	315.5	56.3
WT	196.5	173	87.1

"PROMPT" Consequence

Procedure	Mean	Median	Standard Deviation
FC	297.5	280	68.6
BC	330.7	321.5	63.5
WT	246.1	138	206.5

Appendix J

Experiment 2

Nonparametric Staticstics

Zit-2 Consequence

Mean Rank	Variable	
1.31	TRUERR1	FORWARD CHAINING
1.97	TRUERR2	BACKWARD CHAINING
2.72	TRUERR3	WHOLE TASK TRAINING

Cases	Chi-Square	D.F.	Significance
18	18.0833	2	.0001

Wilcoxon Matched-Pairs Signed-Ranks Test

TRUERR1 FORWARD CHAINING
with TRUERR2 BACKWARD CHAINING

Mean Rank	Cases	
2.50	2	- Ranks (TRUERR2 LT TRUERR1)
8.85	13	+ Ranks (TRUERR2 GT TRUERR1)
	3	Ties (TRUERR2 EQ TRUERR1)
	18	Total

Z = -3.1238 2-Tailed P = .0018

Appendix J (cont'd)

Experiment 2

Zit-2 Consequence

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TRUERR1   FORWARD CHAINING
with TRUERR3   WHOLE TASK TRAINING

     Mean Rank    Cases

        4.00          1  - Ranks (TRUERR3 LT TRUERR1)
        8.80         15  + Ranks (TRUERR3 GT TRUERR1)
                      2    Ties  (TRUERR3 EQ TRUERR1)
                     --
                     18    Total

       Z =   -3.3094            2-Tailed P =  .0009
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TRUERR2   BACKWARD CHAINING
with TRUERR3   WHOLE TASK TRAINING

     Mean Rank    Cases

        8.00          2  - Ranks (TRUERR3 LT TRUERR2)
        8.57         14  + Ranks (TRUERR3 GT TRUERR2)
                      2    Ties  (TRUERR3 EQ TRUERR2)
                     --
                     18    Total

       Z =   -2.6889            2-Tailed P =  .0072
```

Appendix J (cont'd)

Experiment 2

Nonparametric Statistics

PROMPT Consequence

Friedman Two-Way Anova

Mean Rank	Variable	
1.56	TRUERR1	FORWARD CHAINING
1.86	TRUERR2	BACKWARD CHAINING
2.58	TRUERR3	WHOLE TASK TRAINING

Cases	Chi-Square	D.F.	Significance
18	10.0278	2	.0066

Wilcoxon Matched-Pairs Signed-Ranks Test

TRUERR1 FORWARD CHAINING
with TRUERR2 BACKWARD CHAINING

Mean Rank	Cases	
6.50	5	- Ranks (TRUERR2 LT TRUERR1)
8.06	9	+ Ranks (TRUERR2 GT TRUERR1)
	4	Ties (TRUERR2 EQ TRUERR1)
	18	Total

Z = -1.2555 2-Tailed P = .2093

Appendix J (cont'd)

Experiment 2

PROMPT Consequence

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TRUERR1   FORWARD CHAINING
with TRUERR3   WHOLE TASK TRAINING

     Mean Rank    Cases

        4.75          2   - Ranks (TRUERR3 LT TRUERR1)
        9.04         14   + Ranks (TRUERR3 GT TRUERR1)
                      2     Ties  (TRUERR3 EQ TRUERR1)
                     --
                     18     Total

       Z =   -3.0250              2-Tailed P =  .0025
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TRUERR2   BACKWARD CHAINING
with TRUERR3   WHOLE TASK TRAINING

     Mean Rank    Cases

        5.63          4   - Ranks (TRUERR3 LT TRUERR2)
       10.04         13   + Ranks (TRUERR3 GT TRUERR2)
                      1     Ties  (TRUERR3 EQ TRUERR2)
                     --
                     18     Total

       Z =   -2.5563              2-Tailed P =  .0106
```

Appendix J (cont'd)

Experiment 2

Forward Chaining

Mann-Whitney U - Wilcoxon Rank Sum W Test

```
    TRUERR     TRUE ERRORS
by  GRP        CONSEQUENCES

    Mean Rank    Cases

       19.19        18  GRP = 1  ZIT Consequence
       17.81        18  GRP = 2  PROMPT Consequence
                    --
                    36  Total

                                  Exact              Corrected for ties
         U             W       2-Tailed P             Z        2-Tailed P
       149.5         345.5       .6960             -.4432        .6576
```

Appendix J (cont'd)

Experiment 2

Backward Chaining

Mann-Whitney U - Wilcoxon Rank Sum W Test

TRUERR TRUE ERRORS
by GRP CONSEQUENCES

Mean Rank	Cases		
20.56	18	GRP = 1	ZIT Consequence
16.44	18	GRP = 2	PROMPT Consequence
	36	Total	

		Exact	Corrected for ties	
U	W	2-Tailed P	Z	2-Tailed P
125.0	370.0	.2516	-1.1910	.2337

Appendix J (cont'd)

Experiment 2

Whole Task Training

Mann-Whitney U - Wilcoxon Rank Sum W Test

```
    TRUERR   TRUE ERRORS
 by GRP      CONSEQUENCES

    Mean Rank    Cases

       17.78       18  GRP = 1  ZIT Consequence
       19.22       18  GRP = 2  PROMPT Consequence
                   --
                   36  Total

                              Exact                Corrected for ties
        U              W    2-Tailed P               Z        2-Tailed P
      149.0          320.0    .6960               -.4122         .6802
```

Appendix J (cont'd)

Experiment 2

Zit-2 Consequence

Friedman Two-Way Anova

Mean Rank	Variable	
1.67	RANERR1	FORWARD CHAINING
1.86	RANERR2	BACKWARD CHAINING
2.47	RANERR3	WHOLE TASK TRAINING

Cases	Chi-Square	D.F.	Significance
18	6.3611	2	.0416

Wilcoxon Matched-Pairs Signed-Ranks Test

RANERR1 FORWARD CHAINING
with RANERR2 BACKWARD CHAINING

Mean Rank	Cases	
10.07	7	- Ranks (RANERR2 LT RANERR1)
9.14	11	+ Ranks (RANERR2 GT RANERR1)
	0	Ties (RANERR2 EQ RANERR1)
	18	Total

Z = -.6533 2-Tailed P = .5136

Appendix J

Experiment 2

Zit-2 Consequence

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RANERR1    FORWARD CHAINING
with RANERR3    WHOLE TASK TRAINING

     Mean Rank     Cases

         8.00          5   - Ranks  (RANERR3 LT RANERR1)
        10.08         13   + Ranks  (RANERR3 GT RANERR1)
                       0     Ties   (RANERR3 EQ RANERR1)
                      --
                      18     Total

        Z =    -1.9815              2-Tailed P =   .0475
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RANERR2    BACKWARD CHAINING
with RANERR3    WHOLE TASK TRAINING

     Mean Rank     Cases

        12.00          4   - Ranks  (RANERR3 LT RANERR2)
         8.08         13   + Ranks  (RANERR3 GT RANERR2)
                       1     Ties   (RANERR3 EQ RANERR2)
                      --
                      18     Total

        Z =    -1.3491              2-Tailed P =   .1773
```

Appendix J (cont'd)

Experiment 2

PROMPT Consequence

Friedman Two-Way Anova

Mean Rank	Variable	
1.83	RANERR1	FORWARD CHAINING
2.00	RANERR2	BACKWARD CHAINING
2.17	RANERR3	WHOLE TASK TRAINING

Cases	Chi-Square	D.F.	Significance
18	1.0000	2	.6065

Wilcoxon Matched-Pairs Signed-Ranks Test

RANERR1 FORWARD CHAINING
with RANERR2 BACKWARD CHAINING

Mean Rank	Cases	
7.50	7	- Ranks (RANERR2 LT RANERR1)
8.44	8	+ Ranks (RANERR2 GT RANERR1)
	3	Ties (RANERR2 EQ RANERR1)
	18	Total

Z = -.4260 2-Tailed P = .6701

Appendix J (cont'd)

Experiment 2

PROMPT Consequence

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RANERR1   FORWARD CHAINING
with RANERR3   WHOLE TASK TRAINING

     Mean Rank    Cases

        8.38          4  - Ranks (RANERR3 LT RANERR1)
        6.39          9  + Ranks (RANERR3 GT RANERR1)
                      5    Ties  (RANERR3 EQ RANERR1)
                     --
                     18    Total

       Z =     -.8386            2-Tailed P =  .4017
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RANERR2   BACKWARD CHAINING
with RANERR3   WHOLE TASK TRAINING

     Mean Rank    Cases

        6.83          6  - Ranks (RANERR3 LT RANERR2)
        7.14          7  + Ranks (RANERR3 GT RANERR2)
                      5    Ties  (RANERR3 EQ RANERR2)
                     --
                     18    Total

       Z =     -.3145            2-Tailed P =  .7532
```

Appendix J (cont'd)

Experiment 2

Forward Chaining

Mann-Whitney U - Wilcoxon Rank Sum W Test

```
    RANERR      RANDOM ERRORS
by  GRP         CONSEQUENCES

    Mean Rank    Cases

        25.67       18  GRP = 1  ZIT Consequence
        11.33       18  GRP = 2  PROMPT Consequence
                    --
                    36  Total

                                     Exact          Corrected for ties
          U             W        2-Tailed P           Z      2-Tailed P
        33.0        462.0           .0000       -4.1330          .0000
```

Appendix J (cont'd)

Experiment 2

Backward Chaining

Mann-Whitney U - Wilcoxon Rank Sum W Test

	RANERR	RANDOM ERRORS
by	GRP	CONSEQUENCES

Mean Rank	Cases		
27.50	18	GRP = 1	ZIT Consequence
9.50	18	GRP = 2	PROMPT Consequence
	--		
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
.0	495.0	.0000	-5.1982	.0000

Appendix J (cont'd)

Experiment 2

Whole Task Training

Mann-Whitney U - Wilcoxon Rank Sum W Test

```
    RANERR     RANDOM ERRORS
by  GRP        CONSEQUENCES

    Mean Rank     Cases

       27.42        18   GRP = 1   ZIT Consequence
        9.58        18   GRP = 2   PROMPT Consequence
                    --
                    36   Total

                                 Exact                Corrected for ties
          U            W      2-Tailed P             Z        2-Tailed P
        1.5        493.5         .0000         -5.0997          .0000
```

Experiment 2

Zit-2 Consequence

Friedman Two-Way Anova

Mean Rank	Variable	
1.39	TOTERR1	FORWARD CHAINING
1.89	TOTERR2	BACKWARD CHAINING
2.72	TOTERR3	WHOLE TASK TRAINING

Cases	Chi-Square	D.F.	Significance
18	16.3333	2	.0003

Wilcoxon Matched-Pairs Signed-Ranks Test

TOTERR1 FORWARD CHAINING
with TOTERR2 BACKWARD CHAINING

Mean Rank	Cases		
8.90	5	- Ranks	(TOTERR2 LT TOTERR1)
9.73	13	+ Ranks	(TOTERR2 GT TOTERR1)
	0	Ties	(TOTERR2 EQ TOTERR1)
	18	Total	

Z = -1.7856 2-Tailed P = .0742

Appendix J (cont'd)

Experiment 2

Zit-2 Consequence

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TOTERR1   FORWARD CHAINING
with TOTERR3   WHOLE TASK TRAINING

     Mean Rank     Cases

        3.50          2   - Ranks (TOTERR3 LT TOTERR1)
       10.25         16   + Ranks (TOTERR3 GT TOTERR1)
                      0     Ties  (TOTERR3 EQ TOTERR1)
                     --
                     18     Total

       Z =     -3.4187              2-Tailed P =   .0006
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TOTERR2   BACKWARD CHAINING
with TOTERR3   WHOLE TASK TRAINING

     Mean Rank     Cases

       10.50          3   - Ranks (TOTERR3 LT TOTERR2)
        9.30         15   + Ranks (TOTERR3 GT TOTERR2)
                      0     Ties  (TOTERR3 EQ TOTERR2)
                     --
                     18     Total

       Z =     -2.3517              2-Tailed P =   .0187
```

Appendix J (cont'd)

Experiment 2

PROMPT Consequence

Friedman Two-Way Anova

Mean Rank	Variable	
1.64	TOTERR1	FORWARD CHAINING
1.92	TOTERR2	BACKWARD CHAINING
2.44	TOTERR3	WHOLE TASK TRAINING

Cases	Chi-Square	D.F.	Significance
18	6.0278	2	.0491

Wilcoxon Matched-Pairs Signed-Ranks Test

TOTERR1 FORWARD CHAINING
with TOTERR2 BACKWARD CHAINING

Mean Rank	Cases	
6.42	6	- Ranks (TOTERR2 LT TOTERR1)
9.06	9	+ Ranks (TOTERR2 GT TOTERR1)
	3	Ties (TOTERR2 EQ TOTERR1)
	18	Total

Z = -1.2211 2-Tailed P = .2220

Appendix J (cont'd)

Experiment 2

PROMPT Consequence

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TOTERR1    FORWARD CHAINING
with TOTERR3    WHOLE TASK TRAINING

     Mean Rank     Cases

        5.25           4  - Ranks (TOTERR3 LT TOTERR1)
       10.71          14  + Ranks (TOTERR3 GT TOTERR1)
                       0    Ties  (TOTERR3 EQ TOTERR1)
                      --
                      18    Total

       Z =    -2.8090             2-Tailed P =  .0050
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TOTERR2    BACKWARD CHAINING
with TOTERR3    WHOLE TASK TRAINING

     Mean Rank     Cases

        5.50           6  - Ranks (TOTERR3 LT TOTERR2)
       11.50          12  + Ranks (TOTERR3 GT TOTERR2)
                       0    Ties  (TOTERR3 EQ TOTERR2)
                      --
                      18    Total

       Z =    -2.2864             2-Tailed P =  .0222
```

Experiment 2

Forward Chaining

Mann-Whitney U - Wilcoxon Rank Sum W Test

```
    TOTERR       TOTAL ERRORS
 by GRP          CONSEQUENCES

   Mean Rank    Cases

       24.72       18  GRP = 1  ZIT Consequence
       12.28       18  GRP = 2  PROMPT Consequence
                   --
                   36  Total

                                    Exact                  Corrected for ties
         U               W       2-Tailed P                  Z         2-Tailed P
       50.0           445.0        .0002               -3.5696           .0004
```

Appendix J (cont'd)

Experiment 2

Backward Chaining

Mann-Whitney U - Wilcoxon Rank Sum W Test

```
    TOTERR      TOTAL ERRORS
 by GRP         CONSEQUENCES

    Mean Rank     Cases

        26.17        18  GRP = 1  ZIT Consequence
        10.83        18  GRP = 2  PROMPT Consequence
                     --
                     36  Total

                                  Exact                  Corrected for ties
         U               W     2-Tailed P                 Z       2-Tailed P
        24.0           471.0      .0000               -4.3839        .0000
```

Appendix J (cont'd)

Experiment 2

Whole Task Training

Mann-Whitney U - Wilcoxon Rank Sum W Test

TOTERR TOTAL ERRORS
by GRP CONSEQUENCES

Mean Rank	Cases	
22.19	18	GRP = 1 ZIT Consequence
14.81	18	GRP = 2 PROMPT Consequence
	36	Total

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
95.5	399.5	.0342	-2.1059	.0352

Appendix J (cont'd)

Experiment 2

Zit-2 Consequence

Friedman Two-Way Anova

Mean Rank	Variable	
2.17	RESP1	FORWARD CHAINING
2.50	RESP2	BACKWARD CHAINING
1.33	RESP3	WHOLE TASK TRAINING

Cases	Chi-Square	D.F.	Significance
18	13.0000	2	.0015

Wilcoxon Matched-Pairs Signed-Ranks Test

RESP1 FORWARD CHAINING
with RESP2 BACKWARD CHAINING

Mean Rank	Cases	
6.33	6	- Ranks (RESP2 LT RESP1)
11.08	12	+ Ranks (RESP2 GT RESP1)
	0	Ties (RESP2 EQ RESP1)
	18	Total

Z = -2.0686 2-Tailed P = .0386

Appendix J (cont'd)

Experiment 2

Zit-2 Consequence

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RESP1      FORWARD CHAINING
with RESP3      WHOLE TASK TRAINING

     Mean Rank    Cases

         10.17        15   - Ranks (RESP3 LT RESP1)
          6.17         3   + Ranks (RESP3 GT RESP1)
                       0     Ties  (RESP3 EQ RESP1)
                      --
                      18     Total

         Z =    -2.9179            2-Tailed P =  .0035
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RESP2      BACKWARD CHAINING
with RESP3      WHOLE TASK TRAINING

     Mean Rank    Cases

         10.40        15   - Ranks (RESP3 LT RESP2)
          5.00         3   + Ranks (RESP3 GT RESP2)
                       0     Ties  (RESP3 EQ RESP2)
                      --
                      18     Total

         Z =    -3.0703            2-Tailed P =  .0021
```

Appendix J (cont'd)

Experiment 2

PROMPT Consequence

Friedman Two-Way Anova

Mean Rank	Variable	
2.28	RESP1	FORWARD CHAINING
2.50	RESP2	BACKWARD CHAINING
1.22	RESP3	WHOLE TASK TRAINING

Cases	Chi-Square	D.F.	Significance
18	16.7778	2	.0002

Wilcoxon Matched-Pairs Signed-Ranks Test

RESP1 FORWARD CHAINING
with RESP2 BACKWARD CHAINING

Mean Rank	Cases	
8.50	7	- Ranks (RESP2 LT RESP1)
10.14	11	+ Ranks (RESP2 GT RESP1)
	0	Ties (RESP2 EQ RESP1)
	18	Total

Z = -1.1323 2-Tailed P = .2575

Appendix J (cont'd)

Experiment 2

PROMPT Consequence

```
     Wilcoxon Matched-Pairs Signed-Ranks Test

     RESP1      FORWARD CHAINING
with RESP3      WHOLE TASK TRAINING

     Mean Rank    Cases

       10.00         16  - Ranks (RESP3 LT RESP1)
        5.50          2  + Ranks (RESP3 GT RESP1)
                      0    Ties  (RESP3 EQ RESP1)
                     --
                     18    Total

       Z =    -3.2445            2-Tailed P =  .0012

     Wilcoxon Matched-Pairs Signed-Ranks Test

     RESP2      BACKWARD CHAINING
with RESP3      WHOLE TASK TRAINING

     Mean Rank    Cases

        9.88         16  - Ranks (RESP3 LT RESP2)
        6.50          2  + Ranks (RESP3 GT RESP2)
                      0    Ties  (RESP3 EQ RESP2)
                     --
                     18    Total

       Z =    -3.1574            2-Tailed P =  .0016
```

Appendix J (cont'd)

Experiment 2

Forward Chaining

Mann-Whitney U - Wilcoxon Rank Sum W Test

```
   RESP         RESPONSES
by GRP          CONSEQUENCES

    Mean Rank     Cases

       21.53         18  GRP = 1  ZIT Consequence
       15.47         18  GRP = 2  PROMPT Consequence
                     --
                     36  Total

                                Exact                 Corrected for ties
         U             W     2-Tailed P                 Z       2-Tailed P
       107.5         387.5     .0847                -1.7257       .0844
```

Appendix J (cont'd)

Experiment 2

Backward Chaining

Mann-Whitney U - Wilcoxon Rank Sum W Test

RESP	RESPONSES
by GRP	CONSEQUENCES

Mean Rank	Cases	
21.00	18	GRP = 1 ZIT Consequence
16.00	18	GRP = 2 PROMPT Consequence
	36	Total

		Exact	Corrected for ties	
U	W	2-Tailed P	Z	2-Tailed P
117.0	378.0	.1610	-1.4243	.1544

Appendix J (cont'd)

Experiment 2

Whole Task Training

Mann-Whitney U - Wilcoxon Rank Sum W Test

```
    RESP        RESPONSES
by  GRP         CONSEQUENCES

   Mean Rank    Cases

      20.11       18  GRP = 1  ZIT Consequence
      16.89       18  GRP = 2  PROMPT Consequence
                  --
                  36  Total

                                   Exact                 Corrected for ties
        U              W        2-Tailed P              Z        2-Tailed P
      133.0          362.0        .3717              -.9182        .3585
```

Appendix J (cont'd)

Experiment 2

Zit-2 Consequence

Friedman Two-Way Anova

Mean Rank	Variable	
1.94	TIME1	FORWARD CHAINING
2.72	TIME2	BACKWARD CHAINING
1.33	TIME3	WHOLE TASK TRAINING

Cases	Chi-Square	D.F.	Significance
18	17.4444	2	.0002

Wilcoxon Matched-Pairs Signed-Ranks Test

TIME1 FORWARD CHAINING
with TIME2 BACKWARD CHAINING

Mean Rank	Cases	
5.67	3	- Ranks (TIME2 LT TIME1)
10.27	15	+ Ranks (TIME2 GT TIME1)
	0	Ties (TIME2 EQ TIME1)
	18	Total

Z = -2.9832 2-Tailed P = .0029

Experiment 2

Zit-2 Consequence

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TIME1      FORWARD CHAINING
with TIME3      WHOLE TASK TRAINING

     Mean Rank     Cases

        10.93        14   - Ranks (TIME3 LT TIME1)
         4.50         4   + Ranks (TIME3 GT TIME1)
                      0     Ties  (TIME3 EQ TIME1)
                     --
                     18     Total

        Z =    -2.9396            2-Tailed P =   .0033
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TIME2      BACKWARD CHAINING
with TIME3      WHOLE TASK TRAINING

     Mean Rank     Cases

        10.19        16   - Ranks (TIME3 LT TIME2)
         4.00         2   + Ranks (TIME3 GT TIME2)
                      0     Ties  (TIME3 EQ TIME2)
                     --
                     18     Total

        Z =    -3.3752            2-Tailed P =   .0007
```

Experiment 2

PROMPT Consequence

Friedman Two-Way Anova

Mean Rank	Variable	
2.06	TIME1	FORWARD CHAINING
2.44	TIME2	BACKWARD CHAINING
1.50	TIME3	WHOLE TASK TRAINING

Cases	Chi-Square	D.F.	Significance
18	8.1111	2	.0173

Wilcoxon Matched-Pairs Signed-Ranks Test

TIME1 FORWARD CHAINING
with TIME2 BACKWARD CHAINING

Mean Rank	Cases		
6.33	6	- Ranks	(TIME2 LT TIME1)
11.08	12	+ Ranks	(TIME2 GT TIME1)
	0	Ties	(TIME2 EQ TIME1)
	18	Total	

Z = -2.0686 2-Tailed P = .0386

Experiment 2

PROMPT Consequence

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TIME1      FORWARD CHAINING
with TIME3      WHOLE TASK TRAINING

     Mean Rank     Cases

       9.46          13   - Ranks  (TIME3 LT TIME1)
       9.60           5   + Ranks  (TIME3 GT TIME1)
                      0     Ties   (TIME3 EQ TIME1)
                     --
                     18     Total

        Z =   -1.6331              2-Tailed P =   .1024
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TIME2      BACKWARD CHAINING
with TIME3      WHOLE TASK TRAINING

     Mean Rank     Cases

       8.71          14   - Ranks  (TIME3 LT TIME2)
      12.25           4   + Ranks  (TIME3 GT TIME2)
                      0     Ties   (TIME3 EQ TIME2)
                     --
                     18     Total

        Z =   -1.5896              2-Tailed P =   .1119
```

Appendix J (cont'd)

Experiment 2

Forward Chaining

Mann-Whitney U - Wilcoxon Rank Sum W Test

TIME by GRP — TIME CONSEQUENCES

Mean Rank	Cases	
18.28	18	GRP = 1 ZIT Consequence
18.72	18	GRP = 2 PROMPT Consequence
	36	Total

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
158.0	329.0	.9130	-.1266	.8993

Appendix J (cont'd)

Experiment 2

Backward Chaining

Mann-Whitney U - Wilcoxon Rank Sum W Test

TIME   TIME
by GRP   CONSEQUENCES

Mean Rank	Cases	
18.64	18	GRP = 1 ZIT Consequence
18.36	18	GRP = 2 PROMPT Consequence
	36	Total

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
159.5	335.5	.9378	-.0791	.9369

Appendix J (cont'd)

Experiment 2

Whole Task Training

Mann-Whitney U - Wilcoxon Rank Sum W Test

TIME by GRP — TIME CONSEQUENCES

Mean Rank	Cases	
18.56	18	GRP = 1 ZIT Consequence
18.44	18	GRP = 2 PROMPT Consequence
	36	Total

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
161.0	334.0	.9876	-.0316	.9748

Appendix K

Experiment 2

Post Experiment Questionnaire Data

The following section summarized the answers to the questions asked each subject after performing the four sequences.

Question 1: Subjects were requested to draw the symbols and numbers in the order that the buttons were pushed. Results were as follows:

i) Twenty-two subjects drew the order of button pushes correctly, four drew six of the eight numbers correctly and two drew five correctly, four drew three, one drew one, two drew none and one did not attempt the task. Subjects were divided into groups according to the method by which the last sequence was taught. There were no significant differences in the accuracy of the order recall among the three groups ($F = 2.2563$, $p = 0.1151$).

ii) Fifteen subjects drew the symbols in the correct buttons, eight subjects drew six symbols correctly, one drew five symbols correctly, three drew four symbols correctly, five drew three, one drew two, two drew one symbol correctly and three drew did not attempt the task. Subjects were divided into groups as determined by the method by which the last sequence was taught. There were no significant differences in the accuracy of symbol recall among the three groups ($F = 0.4187$, $p = 0.6602$).

Question 2: Subjects were asked to identify any differences between the three training methods. Results were as follows:

a) Nineteen subjects reported they noticed a type of chaining technique versus some type of whole task training technique and seventeen subjects reported they did not. When subjects were divided into groups based on awareness of chaining methods versus whole task method, differences for true errors were not significant ($F=0.0145$, $p = 0.9044$).

b) Eleven subjects reported they had noticed a difference in order in the chaining techniques of forward, and backward chaining. Twenty-five subjects noticed no differences. Subjects were divided into groups based on awareness of order of chaining methods. There were no significant differences for true errors between groups ($F=0.3100$, $p =0.5788$).

Question 3: Subjects were asked whether they had used the percent score listed on the screen. Twenty-three subjects indicated they had used the percent scores and thirteen indicated they had not.

Question 4: Subjects were asked whether they found the task boring or reasonably interesting. Thirty-two subjects indicated they found it reasonably interesting, and four found it boring.

Question 5: In reference to what strategy subjects used to learn the task, nineteen subjects used key positions, three used fingers and symbols, three used fingers, seven used keys and symbols, three used fingers and symbols and one changed strategy.

Question 6: No subjects assigned letters or numbers to the keys to help them remember them.

Question 7: Subjects were asked to rank order the training methods as most comfortable and easy. Results were as follows:

For most comfortable, twenty subjects said forward chaining, eight said backward chaining, and eight said whole task training.

For second most comfortable, eight subjects said forward chaining, thirteen said backward chaining, five said whole task training, and ten did not reply.

For least most comfortable, three said forward chaining, five said backward chaining, sixteen said whole task training and one said forward and backward chaining and eleven did not reply.

Question 8: Subjects were asked to rank order which training method they did best on. Results were as follows:

For best, nineteen reported forward chaining, ten reported backward chaining, six reported whole task training, and one reported forward or backward chaining.

For second best, five reported forward chaining, sixteen reported backward chaining, three reported whole task training and twelve did not reply.

For third best, four reported forward chaining, one reported backward chaining, and twenty reported whole task training and twelve did not reply.

Only fourteen individuals correctly predicted which training method they rank ordered as doing best, second best, etc.

For question 9 and 10, subjects did not suggest any improvements or ideas.

Question 11: When asked whether the subject had heard of chaining methods and whole task training, thirty-two said no and four said yes.

Question 12: When asked what the criterion to teach a new subsequence was: two said four, twenty-two said three, four said two, one said two or three, one said one and nine did not know.

Question 13: Subjects were asked what training method they liked best. Results were as follows: eleven said forward chaining, seven said backward chaining, sixteen said whole task training, and one said forward chaining or whole task training and one said forward chaining or backward chaining. For only eight individuals, the training method they liked best was what they did best on.

Appendix L
Experiment 3
Bartlett-Box F Test of Homogeneity of Variance

Comparison of Forward Chaining, Backward Chaining and Whole Task Training Under Time-out Consequence

Dependent Variable	Bartlett-Box F	Probability
True Errors	39.5699	.000
Random Errors	1.227	.293
Total Errors	32.550	.000
Total Responses	19.908	.000
Time (in seconds)	22.153	.000

Appendix M
Experiment 3
(using TIME-OUT
Consequence)
Means, Medians and Standard Deviations

Legend

Procedure - Training Procedure

FC - Forward chaining

BC - Backward chaining

WT - Whole task training

Dependent Variable - True Errors

Procedure	Mean	Median	Standard Deviation
FC	1.4	0.5	2.9
BC	4.5	2.0	5.6
WT	20.5	9.0	28.8

Dependent Variable - Random Errors

FC	14.5	15.0	1.1
BC	14.8	14.0	3.5
WT	15.5	15.5	5.1

Dependent Variable - Total Errors

FC	15.9	16.0	4.7
BC	19.3	18.0	6.2
WT	36.0	24.0	31.3

Appendix M
(continued)
Experiment 3

Dependent Variable -Total Responses

Procedure	Mean	Median	Standard Deviation
FC	152.6	149.5	11.5
BC	169.7	160.5	33.9
WT	109.3	102.5	67.9

Dependent Variable -Time in seconds

FC	323.0	326.0	38.6
BC	376.7	363.5	67.8
WT	291.3	216.5	204.6

Appendix N

Experiment 3

TIME-OUT Consequence

```
      Wilcoxon Matched-Pairs Signed-Ranks Test

     TRUEER1   Forward Chaining
with TRUEER3   Whole Task Training


     Mean Rank    Cases

        3.00         1  - Ranks (TRUEER3 LT TRUEER1)
        9.38        16  + Ranks (TRUEER3 GT TRUEER1)
                     1    Ties  (TRUEER3 EQ TRUEER1)
                    --
                    18    Total

       Z =    -3.4794             2-Tailed P =  .0005
```

```
      Wilcoxon Matched-Pairs Signed-Ranks Test

     TRUEER2   Backward Chaining
with TRUEER3   Whole Task Training


     Mean Rank    Cases

        5.25         6  - Ranks (TRUEER3 LT TRUEER2)
       11.63        12  + Ranks (TRUEER3 GT TRUEER2)
                     0    Ties  (TRUEER3 EQ TRUEER2)
                    --
                    18    Total

       Z =    -2.3517             2-Tailed P =  .0187
```

Appendix N

Experiment 3

Nonparametric Statistics

TIME-OUT Consequence

Friedman Two-Way Anova

Mean Rank	Variable	
1.31	TRUEER1	Forward Chaining
2.11	TRUEER2	Backward Chaining
2.58	TRUEER3	Whole Task Training

Cases	Chi-Square	D.F.	Significance
18	15.0278	2	.0005

Wilcoxon Matched-Pairs Signed-Ranks Test

TRUEER1 Forward Chaining
with TRUEER2 Backward Chaining

Mean Rank	Cases		
8.50	2	- Ranks	(TRUEER2 LT TRUEER1)
7.33	12	+ Ranks	(TRUEER2 GT TRUEER1)
	4	Ties	(TRUEER2 EQ TRUEER1)
	18	Total	

Z = -2.2286 2-Tailed P = .0258

Appendix N

Experiment 3

TIME-OUT Consequence

Friedman Two-Way Anova

Mean Rank	Variable	
1.92	RANERR1	Forward Chaining
2.00	RANERR2	Backward Chaining
2.08	RANERR3	Whole Task Training

Cases	Chi-Square	D.F.	Significance
18	.2500	2	.8825

Wilcoxon Matched-Pairs Signed-Ranks Test

RANERR1 Forward Chaining
with RANERR2 Backward Chaining

Mean Rank	Cases		
10.25	8	- Ranks	(RANERR2 LT RANERR1)
8.90	10	+ Ranks	(RANERR2 GT RANERR1)
	0	Ties	(RANERR2 EQ RANERR1)
	18	Total	

Z = -.1524 2-Tailed P = .8789

Appendix N

Experiment 3

TIME-OUT Consequence

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RANERR1    Forward Chaining
with RANERR3    Whole Task Training

     Mean Rank    Cases

        8.44          8  - Ranks  (RANERR3 LT RANERR1)
        9.50          9  + Ranks  (RANERR3 GT RANERR1)
                      1    Ties   (RANERR3 EQ RANERR1)
                     --
                     18    Total

         Z =    -.4260             2-Tailed P =  .6701
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RANERR2    Backward Chaining
with RANERR3    Whole Task Training

     Mean Rank    Cases

        9.63          8  - Ranks  (RANERR3 LT RANERR2)
        9.40         10  + Ranks  (RANERR3 GT RANERR2)
                      0    Ties   (RANERR3 EQ RANERR2)
                     --
                     18    Total

         Z =    -.3702             2-Tailed P =  .7112
```

Appendix N

Experiment 3

TIME-OUT Consequence

Friedman Two-Way Anova

Mean Rank	Variable	
1.56	TOTERR1	Forward Chaining
1.97	TOTERR2	Backward Chaining
2.47	TOTERR3	Whole Task Training

Cases	Chi-Square	D.F.	Significance
18	7.5833	2	.0226

Wilcoxon Matched-Pairs Signed-Ranks Test

TOTERR1 Forward Chaining
with TOTERR2 Backward Chaining

Mean Rank	Cases	
7.67	6	- Ranks (TOTERR2 LT TOTERR1)
10.42	12	+ Ranks (TOTERR2 GT TOTERR1)
	0	Ties (TOTERR2 EQ TOTERR1)
	18	Total

Z = -1.7202 2-Tailed P = .0854

Appendix N

Experiment 3

TIME-OUT Consequence

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TOTERR1    Forward Chaining
with TOTERR3    Whole Task Training

     Mean Rank    Cases

       6.00          4   - Ranks  (TOTERR3 LT TOTERR1)
      10.50         14   + Ranks  (TOTERR3 GT TOTERR1)
                     0     Ties   (TOTERR3 EQ TOTERR1)
                    --
                    18     Total

        Z =   -2.6783              2-Tailed P =  .0074
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TOTERR2    Backward Chaining
with TOTERR3    Whole Task Training

     Mean Rank    Cases

       6.80          5   - Ranks  (TOTERR3 LT TOTERR2)
       9.92         12   + Ranks  (TOTERR3 GT TOTERR2)
                     1     Ties   (TOTERR3 EQ TOTERR2)
                    --
                    18     Total

        Z =   -2.0119              2-Tailed P =  .0442
```

Appendix N

Experiment 3

TIME-OUT Consequence

Friedman Two-Way Anova

Mean Rank	Variable	
2.06	RESP1	Forward Chaining
2.61	RESP2	Backward Chaining
1.33	RESP3	Whole Task Training

Cases	Chi-Square	D.F.	Significance
18	14.7778	2	.0006

Wilcoxon Matched-Pairs Signed-Ranks Test

RESP1 Forward Chaining
with RESP2 Backward Chaining

Mean Rank	Cases		
8.63	4	- Ranks	(RESP2 LT RESP1)
9.75	14	+ Ranks	(RESP2 GT RESP1)
	0	Ties	(RESP2 EQ RESP1)
	18	Total	

Z = -2.2211 2-Tailed P = .0263

Appendix N

Experiment 3

TIME-OUT Consequence

Wilcoxon Matched-Pairs Signed-Ranks Test

RESP1 with RESP3 — Forward Chaining / Whole Task Training

Mean Rank	Cases		
8.73	15	- Ranks	(RESP3 LT RESP1)
13.33	3	+ Ranks	(RESP3 GT RESP1)
	0	Ties	(RESP3 EQ RESP1)
	18	Total	

Z = -1.9815 2-Tailed P = .0475

Wilcoxon Matched-Pairs Signed-Ranks Test

RESP2 with RESP3 — Backward Chaining / Whole Task Training

Mean Rank	Cases		
10.43	15	- Ranks	(RESP3 LT RESP2)
4.83	3	+ Ranks	(RESP3 GT RESP2)
	0	Ties	(RESP3 EQ RESP2)
	18	Total	

Z = -3.0921 2-Tailed P = .0020

Appendix N

Experiment 3

TIME-OUT Consequence

Friedman Two-Way Anova

Mean Rank	Variable	
1.94	TIME1	Forward Chaining
2.61	TIME2	Backward Chaining
1.44	TIME3	Whole Task Training

Cases	Chi-Square	D.F.	Significance
18	12.3333	2	.0021

Wilcoxon Matched-Pairs Signed-Ranks Test

TIME1 Forward Chaining
with TIME2 Backward Chaining

Mean Rank	Cases	
4.25	4	- Ranks (TIME2 LT TIME1)
11.00	14	+ Ranks (TIME2 GT TIME1)
	0	Ties (TIME2 EQ TIME1)
	18	Total

Z = -2.9832 2-Tailed P = .0029

Appendix N

Experiment 3

TIME-OUT Consequence

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TIME1      Forward Chaining
with TIME3      Whole Task Training

     Mean Rank    Cases

        8.92        13   - Ranks  (TIME3 LT TIME1)
       11.00         5   + Ranks  (TIME3 GT TIME1)
                     0     Ties   (TIME3 EQ TIME1)
                    --
                    18     Total

        Z =    -1.3283             2-Tailed P =  .1841
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TIME2      Backward Chaining
with TIME3      Whole Task Training

     Mean Rank    Cases

        8.53        15   - Ranks  (TIME3 LT TIME2)
       14.33         3   + Ranks  (TIME3 GT TIME2)
                     0     Ties   (TIME3 EQ TIME2)
                    --
                    18     Total

        Z =    -1.8509             2-Tailed P =  .0642
```

Appendix O

Experiment 3

Post Experiment Questionnaire Data

The following section summarizes the answers to the questions asked each subject after performing the four sequences.

Question 1: Subjects were requested to draw the symbols and numbers in the order that the buttons were pushed in the respective buttons. Results were as follows:

i) Thirteen subjects drew the order of button pushes correctly, three drew six of the eight numbers correctly, one drew five and one drew two correctly. Subjects were divided into groups according to the method by which the last sequence was taught. There were no significant differences in the accuracy of order recall among the three groups ($F = 0.1724$, $p = 0.8433$).

ii) Six subjects drew the symbols in the correct buttons, one subject drew six symbols correctly, two drew five symbols correctly, seven drew four symbols correctly, and two drew two symbols correctly. Subjects were divided into groups according to the method by which the last sequence was taught by. There were no significant differences in the accuracy of symbol recall among the three groups ($F= 0.1621$, $p =0.8518$).

Question 2: Subjects were asked to identify any differences between the four training methods. Results were as follows:

a) Seventeen subjects reported they noticed a type of chaining technique versus some type of whole task training technique and one subject reported no differences.

Subjects were divided into two groups to determine whether awareness of method type affected performance. No statistical tests were run on the data because only one subject did not recognize a difference between chaining methods and whole task training.

b) Eleven subjects reported they had noticed a difference in order in the chaining techniques of forward, and backward chaining. Seven subjects reported noticing no differences. Subjects were divided into groups based on reported awareness of differences in order. No statistical differences for true errors were found between groups ($F(1,18) = 0.4289$, $p = 0.5154$).

Question 3: Subjects were asked whether they had paid attention to the percent score listed on the screen. Twelve subjects indicated they had paid attention to the percent scores and six indicated they had not used them.

Question 4: Subjects were asked whether they found the task boring or reasonably interesting. Twelve indicated they found it reasonably interesting, four found it boring, one found it so/so and one reported it being reasonably interesting except forward and backward chaining.

Question 5: In reference to what strategy subjects used to learn the task; four used keys, three used keys and symbols, one used fingers and symbols, one used fingers and keys, three used finger position and six subjects changed strategies.

Question 6: None of the subjects indicated they used numbers or letters to learn the sequence for question 6.

Question 7: Subjects were asked to rank order the training methods as most comfortable and easy. Results were as follows:

For most comfortable, six subjects said backward chaining, seven said forward chaining, two said whole task training and three said forward or backward chaining.

For second most comfortable, six subjects said forward chaining, six said backward chaining, and four said whole task training.

For third most comfortable, two said forward chaining, four said backward chaining, and twelve said whole task training.

Question 8: Subjects were asked to rank order which training method they did best on. Results were as follows:

Twelve individuals performed best according to true errors produced with the training procedure they found the most comfortable.

For best, nine reported forward chaining, six reported backward chaining, and three reported whole task training.

For second best, nine reported forward chaining, six reported backward chaining, and three reported whole task training.

For third best, two reported forward chaining, four reported backward chaining, and twelve reported whole task training.

Only four individuals correctly predicted which training method they rank ordered as doing best, second best, etc.

For question 9 and 11, one subject suggested time-out was too long.

Question 12: when asked what the criterion to teach a new subsequence was: five said three, five said three or four, three said four, one said two or three and four said they did not know.

Question 13: Subjects were asked what training method they liked best. Results were as follows: five said forward chaining, four said backward chaining, five said whole task training, two said forward or backward chaining and two said forward chaining or whole task training. For only nine individuals, the training method they liked best was what they did best on.

Question 14: When asked how the time-out period seemed, eight said long, five said no comment, three said ok and one said alright and one said too short.

Question 15: When asked what how they used the time-out, thirteen individuals stated they used it for rehearsal, two used it for encouraging thoughts and three were frustrated during the time-out period.

Appendix P
Experiment 4
Bartlett-Box F Test of Homogeneity of Variance

Comparison of Forward Chaining, Backward Chaining, Random Chaining and Whole Task Training

Dependent Variable	Bartlett-Box F	Probability
True Errors	37.029	.000
Random Errors	2.398	.066
Total Errors	28.323	.000
Total Responses	16.228	.000
Time (in seconds)	7.214	.000

Appendix Q
Experiment 4
Means, Medians and Standard Deviations

Legend

Procedure - Training Procedure

FC - Forward chaining

BC - Backward chaining

RC - Random chaining

WT- Whole task training

Dependent Variable - True Errors

Procedure	Mean	Median	Standard Deviation
FC	2.0	0.0	3.4
BC	8.6	2.0	19.9
RC	7.1	3.0	8.3
WT	41.4	32.5	49.8

Dependent Variable - Random Errors

FC	13.5	13.5	4.4
BC	17.5	18.0	4.2
RC	16.0	17.0	7.0
WT	19.2	18.5	6.3

Dependent Variable - Total Errors

FC	15.5	15.0	5.6
BC	26.0	20.5	21.3
RC	23.2	20.0	13.3
WT	60.4	54.5	54.5

Appendix Q
(continued)
Experiment 4

Dependent Variable -Total Responses

Procedure	Mean	Median	Standard Deviation
FC	153.7	150.0	18.7
BC	177.7	159.5	50.2
RC	173.3	162.0	31.31
WT	157.6	156.0	94.6

Dependent Variable -Time in seconds

FC	295.8	272.5	67.6
BC	352.8	295.5	191.1
RC	365.1	351.5	98.0
WT	288.9	280.5	158.1

Experiment 4

Friedman Two-Way Anova

Mean Rank	Variable	
1.77	TRUERR1	FORWARD CHAINING TRUE ERRORS
2.15	TRUERR2	BACKWARD CHAINING TRUE ERRORS
3.67	TRUERR3	WHOLE TASK TRAINING TRUE ERRORS
2.40	TRUERR4	RANDOM CHAINING TRUE ERRORS

Cases	Chi-Square	D.F.	Significance
20	24.4650	3	.0000

Wilcoxon Matched-Pairs Signed-Ranks Test

TRUERR1 FORWARD CHAINING TRUE ERRORS
with TRUERR2 BACKWARD CHAINING TRUE ERRORS

Mean Rank	Cases	
7.64	7	- Ranks (TRUERR2 LT TRUERR1)
10.68	11	+ Ranks (TRUERR2 GT TRUERR1)
	2	Ties (TRUERR2 EQ TRUERR1)
	20	Total

Z = -1.3936 2-Tailed P = .1634

Experiment 4

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TRUERR1   FORWARD CHAINING TRUE ERRORS
with TRUERR3   WHOLE TASK TRAINING TRUE ERRORS

     Mean Rank    Cases

         .00          0   - Ranks (TRUERR3 LT TRUERR1)
       10.00         19   + Ranks (TRUERR3 GT TRUERR1)
                      1     Ties  (TRUERR3 EQ TRUERR1)
                     --
                     20     Total

         Z =   -3.8230              2-Tailed P =   .0001
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TRUERR1   FORWARD CHAINING TRUE ERRORS
with TRUERR4   RANDOM CHAINING TRUE ERRORS

     Mean Rank    Cases

        6.00          5   - Ranks (TRUERR4 LT TRUERR1)
        9.64         11   + Ranks (TRUERR4 GT TRUERR1)
                      4     Ties  (TRUERR4 EQ TRUERR1)
                     --
                     20     Total

         Z =   -1.9649              2-Tailed P =   .0494
```

Experiment 4

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TRUERR2   BACKWARD CHAINING TRUE ERRORS
with TRUERR3   WHOLE TASK TRAINING TRUE ERRORS

     Mean Rank    Cases

        11.00         2  - Ranks (TRUERR3 LT TRUERR2)
        10.44        18  + Ranks (TRUERR3 GT TRUERR2)
                      0    Ties  (TRUERR3 EQ TRUERR2)
                     --
                     20    Total

        Z =   -3.0986             2-Tailed P =  .0019
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TRUERR2   BACKWARD CHAINING TRUE ERRORS
with TRUERR4   RANDOM CHAINING TRUE ERRORS

     Mean Rank    Cases

         8.42         6  - Ranks (TRUERR4 LT TRUERR2)
         6.81         8  + Ranks (TRUERR4 GT TRUERR2)
                      6    Ties  (TRUERR4 EQ TRUERR2)
                     --
                     20    Total

        Z =    -.1256             2-Tailed P =  .9001
```

Experiment 4

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TRUERR3   WHOLE TASK TRAINING TRUE ERRORS
with TRUERR4   RANDOM CHAINING TRUE ERRORS

     Mean Rank    Cases

       11.69        16  - Ranks (TRUERR4 LT TRUERR3)
        5.75         4  + Ranks (TRUERR4 GT TRUERR3)
                     0    Ties  (TRUERR4 EQ TRUERR3)
                    --
                    20    Total

       Z =    -3.0613          2-Tailed P =  .0022
```

Experiment 4

Friedman Two-Way Anova

Mean Rank	Variable	
1.67	RANERR1	FORWARD CHAINING RANDOM ERRORS
2.80	RANERR2	BACKWARD CHAINING RANDOM ERRORS
3.00	RANERR3	WHOLE TASK RANDOM ERRORS
2.52	RANERR4	RANDOM CHAINING RANDOM ERRORS

Cases	Chi-Square	D.F.	Significance
20	12.2550	3	.0066

Wilcoxon Matched-Pairs Signed-Ranks Test

RANERR1 FORWARD CHAINING RANDOM ERRORS
with RANERR2 BACKWARD CHAINING RANDOM ERRORS

Mean Rank	Cases		
5.30	5	- Ranks	(RANERR2 LT RANERR1)
11.68	14	+ Ranks	(RANERR2 GT RANERR1)
	1	Ties	(RANERR2 EQ RANERR1)
	20	Total	

Z = -2.7566 2-Tailed P = .0058

Experiment 4

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RANERR1   FORWARD CHAINING RANDOM ERRORS
with RANERR3   WHOLE TASK RANDOM ERRORS

     Mean Rank    Cases

       6.00         3   - Ranks (RANERR3 LT RANERR1)
      11.29        17   + Ranks (RANERR3 GT RANERR1)
                    0     Ties  (RANERR3 EQ RANERR1)
                   --
                   20     Total

      Z =    -3.2479             2-Tailed P =   .0012
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RANERR1   FORWARD CHAINING RANDOM ERRORS
with RANERR4   RANDOM CHAINING RANDOM ERRORS

     Mean Rank    Cases

      12.50         4   - Ranks (RANERR4 LT RANERR1)
       8.64        14   + Ranks (RANERR4 GT RANERR1)
                    2     Ties  (RANERR4 EQ RANERR1)
                   --
                   20     Total

      Z =    -1.5460             2-Tailed P =   .1221
```

Experiment 4

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RANERR2   BACKWARD CHAINING RANDOM ERRORS
with RANERR3   WHOLE TASK RANDOM ERRORS

     Mean Rank    Cases

        7.38         8  - Ranks (RANERR3 LT RANERR2)
       10.44         9  + Ranks (RANERR3 GT RANERR2)
                     3    Ties  (RANERR3 EQ RANERR2)
                    --
                    20    Total

     Z =    -.8284              2-Tailed P =  .4074
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RANERR2   BACKWARD CHAINING RANDOM ERRORS
with RANERR4   RANDOM CHAINING RANDOM ERRORS

     Mean Rank    Cases

        9.23        11  - Ranks (RANERR4 LT RANERR2)
        9.93         7  + Ranks (RANERR4 GT RANERR2)
                     2    Ties  (RANERR4 EQ RANERR2)
                    --
                    20    Total

     Z =    -.6968              2-Tailed P =  .4859
```

Experiment 4

Wilcoxon Matched-Pairs Signed-Ranks Test

RANERR3 WHOLE TASK RANDOM ERRORS
with RANERR4 RANDOM CHAINING RANDOM ERRORS

Mean Rank	Cases	
10.54	12	- Ranks (RANERR4 LT RANERR3)
9.07	7	+ Ranks (RANERR4 GT RANERR3)
	1	Ties (RANERR4 EQ RANERR3)
	20	Total

Z = -1.2676 2-Tailed P = .2049

Experiment 4

Friedman Two-Way Anova

Mean Rank	Variable	
1.42	TOTERR1	FORWARD CHAINING TOTAL ERRORS
2.57	TOTERR2	BACKWARD CHAINING TOTAL ERRORS
3.55	TOTERR3	WHOLE TASK TRAINING TOTAL ERRORS
2.45	TOTERR4	RANDOM CHAINING TOTAL ERRORS

Cases	Chi-Square	D.F.	Significance
20	27.1950	3	.0000

Wilcoxon Matched-Pairs Signed-Ranks Test

TOTERR1 FORWARD CHAINING TOTAL ERRORS
with TOTERR2 BACKWARD CHAINING TOTAL ERRORS

Mean Rank	Cases	
4.38	4	- Ranks (TOTERR2 LT TOTERR1)
11.50	15	+ Ranks (TOTERR2 GT TOTERR1)
	1	Ties (TOTERR2 EQ TOTERR1)
	20	Total

Z = -3.1188 2-Tailed P = .0018

Experiment 4

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TOTERR1   FORWARD CHAINING TOTAL ERRORS
with TOTERR3   WHOLE TASK TRAINING TOTAL ERRORS


     Mean Rank    Cases

         .00          0  - Ranks (TOTERR3 LT TOTERR1)
       10.50         20  + Ranks (TOTERR3 GT TOTERR1)
                      0    Ties  (TOTERR3 EQ TOTERR1)
                     --
                     20    Total

       Z =    -3.9199              2-Tailed P =   .0001
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TOTERR1   FORWARD CHAINING TOTAL ERRORS
with TOTERR4   RANDOM CHAINING TOTAL ERRORS


     Mean Rank    Cases

        9.63          4  - Ranks (TOTERR4 LT TOTERR1)
       10.72         16  + Ranks (TOTERR4 GT TOTERR1)
                      0    Ties  (TOTERR4 EQ TOTERR1)
                     --
                     20    Total

       Z =    -2.4826              2-Tailed P =   .0130
```

Experiment 4

Wilcoxon Matched-Pairs Signed-Ranks Test

TOTERR2 BACKWARD CHAINING TOTAL ERRORS
with TOTERR3 WHOLE TASK TRAINING TOTAL ERRORS

Mean Rank	Cases		
7.00	4	- Ranks	(TOTERR3 LT TOTERR2)
11.38	16	+ Ranks	(TOTERR3 GT TOTERR2)
	0	Ties	(TOTERR3 EQ TOTERR2)
	20	Total	

Z = -2.8746 2-Tailed P = .0040

Wilcoxon Matched-Pairs Signed-Ranks Test

TOTERR2 BACKWARD CHAINING TOTAL ERRORS
with TOTERR4 RANDOM CHAINING TOTAL ERRORS

Mean Rank	Cases		
9.79	12	- Ranks	(TOTERR4 LT TOTERR2)
11.56	8	+ Ranks	(TOTERR4 GT TOTERR2)
	0	Ties	(TOTERR4 EQ TOTERR2)
	20	Total	

Z = -.4667 2-Tailed P = .6407

Experiment 4

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TOTERR3   WHOLE TASK TRAINING TOTAL ERRORS
with TOTERR4   RANDOM CHAINING TOTAL ERRORS

     Mean Rank    Cases

       11.97        15  - Ranks (TOTERR4 LT TOTERR3)
        6.10         5  + Ranks (TOTERR4 GT TOTERR3)
                     0    Ties  (TOTERR4 EQ TOTERR3)
                    --
                    20    Total

       Z =   -2.7813              2-Tailed P =  .0054
```

Experiment 4

Friedman Two-Way Anova

Mean Rank	Variable	
2.07	RESP1	FORWARD CHAINING RESPONSES
2.90	RESP2	BACKWARD CHAINING RESPONSES
2.35	RESP3	WHOLE TASK TRAINING RESPONSES
2.67	RESP4	RANDOM CHAINING RESPONSES

Cases	Chi-Square	D.F.	Significance
20	4.7250	3	.1931

Wilcoxon Matched-Pairs Signed-Ranks Test

RESP1 FORWARD CHAINING RESPONSES
with RESP2 BACKWARD CHAINING RESPONSES

Mean Rank	Cases		
6.67	6	- Ranks	(RESP2 LT RESP1)
12.14	14	+ Ranks	(RESP2 GT RESP1)
	0	Ties	(RESP2 EQ RESP1)
	20	Total	

Z = -2.4266 2-Tailed P = .0152

Experiment 4

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RESP1     FORWARD CHAINING RESPONSES
with RESP3     WHOLE TASK TRAINING RESPONSES

     Mean Rank    Cases

         11.90       10  - Ranks (RESP3 LT RESP1)
          9.10       10  + Ranks (RESP3 GT RESP1)
                      0    Ties  (RESP3 EQ RESP1)
                     --
                     20    Total

        Z =    -.5227             2-Tailed P =  .6012
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RESP1     FORWARD CHAINING RESPONSES
with RESP4     RANDOM CHAINING RESPONSES

     Mean Rank    Cases

          8.20        5  - Ranks (RESP4 LT RESP1)
         10.64       14  + Ranks (RESP4 GT RESP1)
                      1    Ties  (RESP4 EQ RESP1)
                     --
                     20    Total

        Z =   -2.1731             2-Tailed P =  .0298
```

Experiment 4

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RESP2       BACKWARD CHAINING RESPONSES
with RESP3       WHOLE TASK TRAINING RESPONSES

     Mean Rank     Cases

       10.65         13   - Ranks (RESP3 LT RESP2)
       10.21          7   + Ranks (RESP3 GT RESP2)
                      0     Ties  (RESP3 EQ RESP2)
                     --
                     20     Total

       Z =    -1.2506              2-Tailed P =   .2111
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RESP2       BACKWARD CHAINING RESPONSES
with RESP4       RANDOM CHAINING RESPONSES

     Mean Rank     Cases

       10.23         11   - Ranks (RESP4 LT RESP2)
       10.83          9   + Ranks (RESP4 GT RESP2)
                      0     Ties  (RESP4 EQ RESP2)
                     --
                     20     Total

       Z =     -.2800              2-Tailed P =   .7795
```

Experiment 4

Wilcoxon Matched-Pairs Signed-Ranks Test

RESP3	WHOLE TASK TRAINING RESPONSES
with RESP4	RANDOM CHAINING RESPONSES

Mean Rank	Cases		
8.45	10	- Ranks	(RESP4 LT RESP3)
12.55	10	+ Ranks	(RESP4 GT RESP3)
	0	Ties	(RESP4 EQ RESP3)
	20	Total	

Z = -.7653 2-Tailed P = .4441

Experiment 4

Friedman Two-Way Anova

Mean Rank	Variable	
2.25	TIME1	FORWARD CHAINING TIME
2.60	TIME2	BACKWARD CHAINING TIME
2.20	TIME3	WHOLE TASK TIME
2.95	TIME4	RANDOM CHAINING TIME

Cases	Chi-Square	D.F.	Significance
20	4.3800	3	.2232

Wilcoxon Matched-Pairs Signed-Ranks Test

TIME1 FORWARD CHAINING TIME
with TIME2 BACKWARD CHAINING TIME

Mean Rank	Cases	
8.63	8	- Ranks (TIME2 LT TIME1)
11.75	12	+ Ranks (TIME2 GT TIME1)
	0	Ties (TIME2 EQ TIME1)
	20	Total

Z = -1.3440 2-Tailed P = .1790

Experiment 4

Wilcoxon Matched-Pairs Signed-Ranks Test

TIME1	FORWARD CHAINING TIME
with TIME3	WHOLE TASK TIME

Mean Rank	Cases	
10.38	12	- Ranks (TIME3 LT TIME1)
10.69	8	+ Ranks (TIME3 GT TIME1)
	0	Ties (TIME3 EQ TIME1)
	20	Total

Z = -.7280 2-Tailed P = .4666

Wilcoxon Matched-Pairs Signed-Ranks Test

TIME1	FORWARD CHAINING TIME
with TIME4	RANDOM CHAINING TIME

Mean Rank	Cases	
6.60	5	- Ranks (TIME4 LT TIME1)
11.80	15	+ Ranks (TIME4 GT TIME1)
	0	Ties (TIME4 EQ TIME1)
	20	Total

Z = -2.6880 2-Tailed P = .0072

Experiment 4

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TIME2     BACKWARD CHAINING TIME
with TIME3     WHOLE TASK TIME

     Mean Rank    Cases

       12.32        11  - Ranks (TIME3 LT TIME2)
        8.28         9  + Ranks (TIME3 GT TIME2)
                     0    Ties  (TIME3 EQ TIME2)
                    --
                    20    Total

       Z =    -1.1386            2-Tailed P =   .2549
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TIME2     BACKWARD CHAINING TIME
with TIME4     RANDOM CHAINING TIME

     Mean Rank    Cases

        8.56         9  - Ranks (TIME4 LT TIME2)
       12.09        11  + Ranks (TIME4 GT TIME2)
                     0    Ties  (TIME4 EQ TIME2)
                    --
                    20    Total

       Z =    -1.0453            2-Tailed P =   .2959
```

Experiment 4

- Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TIME3      WHOLE TASK TIME
with TIME4      RANDOM CHAINING TIME

     Mean Rank    Cases

        8.43          7   - Ranks  (TIME4 LT TIME3)
       11.62         13   + Ranks  (TIME4 GT TIME3)
                      0     Ties   (TIME4 EQ TIME3)
                     --
                     20     Total

       Z =    -1.7173              2-Tailed P =   .0859
```

Appendix S

Experiment 4

Post Experiment Questionnaire Data

The following section summarizes the answers to the questions that each subject was asked after performing the four sequences. (See Appendix B for these questions).

Question 1: Subjects were requested to draw the symbols and numbers in the order that the buttons were pushed. Results were as follows:

i) Sixteen subjects drew the order of the button pushes correctly, three drew six of the eight numbers correctly and one drew two correctly. Subjects were divided into four groups according to which method was used to teach the last sequence. There were no significant differences in the accuracy of order recall among the three groups ($F = 0.9436$, $p = .4428$).

ii)Eleven subjects drew the symbols in the correct buttons, one drew seven correctly, four subjects drew six symbols correctly, one drew four symbols correctly, two drew five symbols correctly, and one did not even attempt to draw the symbols indicating he could not remember any of them. Subjects were divided into groups according to the method by which the last sequence was taught. There were no significant differences in the accuracy of the order recall among the three groups ($F = 0.3510$, $p = .7890$).

Question 2: Subjects were asked to identify any differences between the four training methods. Results were as follows:

a) Twelve subjects reported they noticed a type of chaining technique versus some type of whole task training technique and eight subjects reported they did not. Subjects were divided into two groups according to the method by which the last sequence was taught. There were no significant differences in the accuracy of the symbol recall among the three groups ($F = 0.1471$, $p = 0.7023$).

b) Six subjects reported they had noticed a difference in order in the chaining techniques of forward, backward and random. Five subjects reported they noticed a random order but not a backward order and two reported they noticed a backward order but not random. Seven subjects reported they had not noticed any difference. Subjects were divided into groups based on awareness of differences between training methods. There were no statistical differences in true errors between groups ($F = 0.1471$, $p = 0.7023$). No signficant differences in true errors were determined for awareness of random order ($F = 0.3198$, $p = 0.5733$) or backward order ($F = 0.4003$, $p = 0.5288$).

Question 3: Subjects were asked whether they used the percent scores listed on the screen. Fourteen subjects indicated they had used percent scores, two indicated they used them a little and four indicated they had not used them.

Question 4: Subjects were asked whether they found the task boring or reasonably interesting. Sixteen subjects indicated they found it reasonably interesting, two found it boring, one found it so/so and one reported it as being reasonably interesting except forward and backward chaining.

Question 5: Subjects were asked what strategy they used to learn the task. Six subjects used key positions, two used fingers and symbols, five used fingers and symbols with keys and five used symbols and keys. One subject used musical notes like a piano and one used visual memory. No other methods were used in reference to question 6.

Question 7: Subjects were asked to rank order the training methods as most comfortable and easy. Results were as follows:

For most comfortable, ten subjects said backward chaining, six said forward chaining, one said whole task training and two said random chaining and one subject did not reply.

For second most comfortable, seven subjects said forward chaining, six said backward chaining, three said whole task training and three said random chaining and one did not reply.

For third most comfortable, one said forward chaining, two said backward chaining, five said whole task training and nine said random chaining and three subjects did not reply.

For least comfortable, two said forward chaining, two said backward chaining, eight said whole task training and five said random chaining. and three subjects did not reply.

For nine subjects, the training method they found most comfortable was the training method they did best on for true errors.

For question 8: Subjects were asked to rank order which training method they did best on. Results were as follows:

For best, ten reported forward chaining, five reported backward chaining, two reported whole task training, and three reported randomc chaining.

For second best, four reported forward chaining, seven reported backward chaining, three reported whole task training and six reported random chaining.

For third best, four reported forward chaining, four reported backward chaining, five reported whole task training and six reported random chaining and one subject did not reply.

For least best, one reported forward chaining, four reported backward chaining, ten reported whole task training and four reported random chaining and one did not reply.

Only four individuals correctly predicted which training method they rank ordered as doing best, second best, etc.

Question 11: All subjects did not know the training methods prior to doing the experiment.

Question 12: When asked what the criterion to teach a new subsequence was: five subjects said three, two said three or four, four said four, one said five and eight said they did not know.

Question 13: Subjects were asked what training method they liked best. Results were as follows: four said forward chaining, three said backward chaining, five said whole task training, four said random chaining, two said forward and random chaining and two said chaining methods. For only six individuals, the training method they liked best was what they did best on.

Appendix T
Experiment 5
Bartlett-Box F Test of Homogeneity of Variance

Legend For Appendix T

12 - comparison of criteria to teach a new subsequence using forward chaining

13 - comparison of criteria to teach a new subsequence using backward chaining

14 - comparisons of criterions to teach a new subsequence using random chaining

15 - comparisons of criterions to teach a new subsequence using whole task training

16 - comparisons of training procedures using a criterion to teach a new subsequence of one

17 - comparisons of training procedures using a criterion to teach a new subsequence of three

18 - comparisons of training procedures using a criterion to teach a new subsequence of six

Appendix T
(continued)
Experiment 5

Dependent Variable - True Errors

Condition	Barlett-Box F	Probability
12	32.847	.000
13	9.367	.000
14	5.161	.006
15	3.626	.026
16	18.044	.000
17	16.270	.000
18	60.486	.000

Dependent Variable - Random Errors

12	.652	.521
13	.569	.566
14	3.871	.021
15	4.472	.012
16	3.794	.01
17	1.873	.132
18	4.218	.000

Appendix T
(continued)
Experiment 5

Dependent Variable - Total Errors

Condition	Bartlett-Box F	Probability
12	3.412	.033
13	2.05	.129
14	2.147	.117
15	3.758	.024
16	18.351	.000
17	10.799	.000
18	33.363	.000

Dependent Variable - Total Responses

12	4.906	.007
13	2.599	.075
14	4.52	.011
15	1.475	.229
16	5.339	.001
17	4.275	.005
18	11.607	.000

Appendix T
(continued)
Experiment 5

Dependent Variable - Time in seconds

Condition	Bartlett-Box F	Probability
12	3.876	.021
13	2.799	.061
14	0.800	.449
15	8.952	.000
16	6.048	.000
17	6.023	.000
18	16.341	.000

Appendix U
Experiment 5
Means, Medians and Standard Deviations

Legend

Procedure - Training procedure

FC - Forward chaining

BC - Backward chaining

RC - Random chaining

WT - Whole task training

Criterion = 1 - Criterion to teach a new sequence of 1

Criterion = 3 - Criterion to teach a new sequence of 3

Criterion = 6 - Criterion to teach a new suquence of 6

Appendix U
(continued)
Experiment 5

Dependent Variable -True Errors

Criterion = 1

Procedure	Mean	Median	Standard Deviation
FC	4.5	2.0	8.0
BC	11.7	8.0	10.9
RC	7.67	3.5	8.9
WT	28.1	11.0	34.5

Criterion = 3

FC	1.9	1.0	6.6
BC	4.3	2.5	4.2
RC	6.6	1.0	7.0
WT	21.5	15.5	19.1

Criterion = 6

FC	.3	0	0.6
BC	2.9	1.0	4.7
RC	4.9	2.0	5.7
WT	34.6	19.5	36.3

Appendix U
(continued)
Experiment 5

Dependent Variable - Random Errors

Criterion = 1

Procedure	Mean	Median	Standard Deviation
FC	13.2	12.0	4.1
BC	17.1	18.0	4.9
RC	14.2	14.5	3.5
WT	16.9	14.0	7.4

Criterion = 3

FC	11.6	11.0	4.1
BC	16.3	17.0	5.4
RC	14.3	13.0	6.9
WT	16.9	16.5	4.3

Criterion = 6

FC	13.6	13.5	5.2
BC	16.2	17.0	4.1
RC	14.7	14.0	5.9
WT	20.7	16.5	9.4

Appendix U
(continued)
Experiment 5

Dependent Variable - Total Errors

Criterion = 1

Procedure	Mean	Median	Standard Deviation
FC	17.7	15.0	9.5
BC	28.8	25.5	10.4
RC	22.0	20.5	9.9
WT	44.9	28.0	38.2

Criterion = 3

FC	13.5	12.0	5.8
BC	20.6	20.0	7.9
RC	19.7	15.0	14.2
WT	38.4	31.5	21.8

Criterion = 6

FC	13.9	14.0	5.3
BC	19.2	19.0	6.3
RC	19.6	19.5	8.9
WT	55.2	36.5	43.3

Appendix U
(continued)
Experiment 5

Dependent Variable - Total Responses

Criterion =1

Procedure	Mean	Median	Standard Deviation
FC	106.7	95.5	43.1
BC	137.3	132.5	31.6
RC	124.6	111.5	40.0
WT	122.3	95.5	77.6

Criterion = 3

FC	152.8	143.5	25.6
BC	169.9	161.0	28.8
RC	169.0	151.5	50.8
WT	121.3	103.0	52.1

Criterion = 6

FC	233.8	230.0	20.8
BC	256.1	233.0	47.9
RC	256.7	252.0	23.5
WT	139.7	110	75.4

Appendix U
(continued)
Experiment 5

Dependent - Time in seconds

Criterion = 1

Procedure	Mean	Median	Standard Deviation
FC	194.0	168.0	83.4
BC	248.1	234.5	59.3
RC	246.9	241.5	87.9
WT	236.8	178.0	160.2

Criterion = 3

FC	279.8	265.5	41.0
BC	317.1	309.5	53.7
RC	332.2	298.5	105.3
WT	212.5	180.0	94.4

Criterion = 6

FC	426.9	393.5	67.9
BC	471.6	439.5	91.3
RC	509.8	490.0	77.4
WT	303.4	191.5	278.3

Appendix V

Experiment 5

Nonparametric Statistics

Criterion = 1

Friedman Two-Way Anova

Mean Rank	Variable	
1.67	TRUERR1	TRUE ERRORS - FORWARD CHAINING
2.81	TRUERR2	TRUE ERRORS - BACKWARD CHAINING
2.25	TRUERR3	TRUE ERRORS - RANDOM CHAINING
3.28	TRUERR4	TRUE ERRORS - WHOLE TASK TRAINING

Cases	Chi-Square	D.F.	Significance
18	15.7166	3	.0013

Wilcoxon Matched-Pairs Signed-Ranks Test

TRUERR1 TRUE ERRORS - FORWARD CHAINING
with TRUERR2 TRUE ERRORS - BACKWARD CHAINING

Mean Rank	Cases	
9.00	3	- Ranks (TRUERR2 LT TRUERR1)
9.60	15	+ Ranks (TRUERR2 GT TRUERR1)
	0	Ties (TRUERR2 EQ TRUERR1)
	18	Total

Z = -2.5477 2-Tailed P = .0108

Appendix V (cont'd)

Experiment 5

Criterion = 1

```
          Wilcoxon Matched-Pairs Signed-Ranks Test

     TRUERR1    TRUE ERRORS - FORWARD CHAINING
with TRUERR3    TRUE ERRORS - RANDOM CHAINING

     Mean Rank    Cases

        8.25         6  - Ranks (TRUERR3 LT TRUERR1)
        9.41        11  + Ranks (TRUERR3 GT TRUERR1)
                     1    Ties  (TRUERR3 EQ TRUERR1)
                    --
                    18    Total

        Z =   -1.2781             2-Tailed P =  .2012


          Wilcoxon Matched-Pairs Signed-Ranks Test

     TRUERR1    TRUE ERRORS - FORWARD CHAINING
with TRUERR4    TRUE ERRORS - WHOLE TASK TRAINING

     Mean Rank    Cases

        6.75         2  - Ranks (TRUERR4 LT TRUERR1)
        9.30        15  + Ranks (TRUERR4 GT TRUERR1)
                     1    Ties  (TRUERR4 EQ TRUERR1)
                    --
                    18    Total

        Z =   -2.9823             2-Tailed P =  .0029
```

Appendix V (cont'd)

Experiment 5

Criterion = 1

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TRUERR2   TRUE ERRORS - BACKWARD CHAINING
with TRUERR3   TRUE ERRORS - RANDOM CHAINING

     Mean Rank    Cases

        9.75        10  - Ranks (TRUERR3 LT TRUERR2)
        7.93         7  + Ranks (TRUERR3 GT TRUERR2)
                     1    Ties  (TRUERR3 EQ TRUERR2)
                    --
                    18    Total

        Z =     -.9941            2-Tailed P =  .3202
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TRUERR2   TRUE ERRORS - BACKWARD CHAINING
with TRUERR4   TRUE ERRORS - WHOLE TASK TRAINING

     Mean Rank    Cases

        5.64         7  - Ranks (TRUERR4 LT TRUERR2)
       11.95        11  + Ranks (TRUERR4 GT TRUERR2)
                     0    Ties  (TRUERR4 EQ TRUERR2)
                    --
                    18    Total

        Z =    -2.0033            2-Tailed P =  .0451
```

Appendix V (cont'd)

Experiment 5

Criterion = 1

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TRUERR3   TRUE ERRORS - RANDOM CHAINING
with TRUERR4   TRUE ERRORS - WHOLE TASK TRAINING

     Mean Rank    Cases

        6.83         3  - Ranks (TRUERR4 LT TRUERR3)
        9.46        14  + Ranks (TRUERR4 GT TRUERR3)
                     1    Ties  (TRUERR4 EQ TRUERR3)
                    --
                    18    Total

        Z =    -2.6509           2-Tailed P =  .0080
```

Appendix V (cont'd)

Experiment 5

Criterion = 3

Friedman Two-Way Anova

Mean Rank	Variable	
1.64	TRUERR1	TRUE ERRORS - FORWARD CHAINING
2.53	TRUERR2	TRUE ERRORS - BACKWARD CHAINING
2.00	TRUERR3	TRUE ERRORS - RANDOM CHAINING
3.83	TRUERR4	TRUE ERRORS - WHOLE TASK TRAINING

Cases	Chi-Square	D.F.	Significance
18	29.9166	3	.0000

Wilcoxon Matched-Pairs Signed-Ranks Test

TRUERR1 TRUE ERRORS - FORWARD CHAINING
with TRUERR2 TRUE ERRORS - BACKWARD CHAINING

Mean Rank	Cases	
7.75	4	- Ranks (TRUERR2 LT TRUERR1)
8.75	12	+ Ranks (TRUERR2 GT TRUERR1)
	2	Ties (TRUERR2 EQ TRUERR1)
	18	Total

Z = -1.9132 2-Tailed P = .0557

Appendix V (cont'd)

Experiment 5

Criterion = 3

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TRUERR1   TRUE ERRORS - FORWARD CHAINING
with TRUERR3   TRUE ERRORS - RANDOM CHAINING

     Mean Rank    Cases

        6.75          4   - Ranks (TRUERR3 LT TRUERR1)
        7.11          9   + Ranks (TRUERR3 GT TRUERR1)
                      5     Ties  (TRUERR3 EQ TRUERR1)
                     --
                     18     Total

        Z =    -1.2929              2-Tailed P =  .1961
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TRUERR1   TRUE ERRORS - FORWARD CHAINING
with TRUERR4   TRUE ERRORS - WHOLE TASK TRAINING

     Mean Rank    Cases

         .00          0   - Ranks (TRUERR4 LT TRUERR1)
        9.50         18   + Ranks (TRUERR4 GT TRUERR1)
                      0     Ties  (TRUERR4 EQ TRUERR1)
                     --
                     18     Total

        Z =    -3.7236              2-Tailed P =  .0002
```

Appendix V (cont'd)

Experiment 5

Criterion = 3

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TRUERR2   TRUE ERRORS - BACKWARD CHAINING
with TRUERR3   TRUE ERRORS - RANDOM CHAINING

     Mean Rank     Cases

        7.63          12   - Ranks  (TRUERR3 LT TRUERR2)
       12.30           5   + Ranks  (TRUERR3 GT TRUERR2)
                       1     Ties   (TRUERR3 EQ TRUERR2)
                      --
                      18     Total

        Z =     -.7101              2-Tailed P =   .4777
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TRUERR2   TRUE ERRORS - BACKWARD CHAINING
with TRUERR4   TRUE ERRORS - WHOLE TASK TRAINING

     Mean Rank     Cases

        5.25           2   - Ranks  (TRUERR4 LT TRUERR2)
       10.03          16   + Ranks  (TRUERR4 GT TRUERR2)
                       0     Ties   (TRUERR4 EQ TRUERR2)
                      --
                      18     Total

        Z =    -3.2663              2-Tailed P =   .0011
```

Appendix V (cont'd)

Experiment 5

Criterion = 3

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TRUERR3   TRUE ERRORS - RANDOM CHAINING
with TRUERR4   TRUE ERRORS - WHOLE TASK TRAINING

   Mean Rank     Cases

     12.50          1   - Ranks  (TRUERR4 LT TRUERR3)
      9.32         17   + Ranks  (TRUERR4 GT TRUERR3)
                    0     Ties   (TRUERR4 EQ TRUERR3)
                   --
                   18     Total

     Z =    -3.1792                2-Tailed P =  .0015
```

Appendix V

Criterion = 6

Experiment 5

Friedman Two-Way Anova

Mean Rank	Variable	
1.39	TRUERR1	TRUE ERRORS - FORWARD CHAINING
2.17	TRUERR2	TRUE ERRORS - BACKWARD CHAINING
2.72	TRUERR3	TRUE ERRORS - RANDOM CHAINING
3.72	TRUERR4	TRUE ERRORS - WHOLE TASK TRAINING

Cases	Chi-Square	D.F.	Significance
18	31.2000	3	.0000

Wilcoxon Matched-Pairs Signed-Ranks Test

TRUERR1 TRUE ERRORS - FORWARD CHAINING
with TRUERR2 TRUE ERRORS - BACKWARD CHAINING

Mean Rank	Cases		
2.00	1	- Ranks	(TRUERR2 LT TRUERR1)
5.89	9	+ Ranks	(TRUERR2 GT TRUERR1)
	8	Ties	(TRUERR2 EQ TRUERR1)
	18	Total	

Z = -2.5992 2-Tailed P = .0093

Appendix V (cont'd)

Criterion = 6

Experiment 5

```
         Wilcoxon Matched-Pairs Signed-Ranks Test

      TRUERR1    TRUE ERRORS - FORWARD CHAINING
 with TRUERR3    TRUE ERRORS - RANDOM CHAINING

      Mean Rank     Cases

           .00          0   - Ranks  (TRUERR3 LT TRUERR1)
          8.00         15   + Ranks  (TRUERR3 GT TRUERR1)
                        3     Ties   (TRUERR3 EQ TRUERR1)
                       --
                       18     Total

         Z =    -3.4078              2-Tailed P =   .0007
```

```
         Wilcoxon Matched-Pairs Signed-Ranks Test

      TRUERR1    TRUE ERRORS - FORWARD CHAINING
 with TRUERR4    TRUE ERRORS - WHOLE TASK TRAINING

      Mean Rank     Cases

           .00          0   - Ranks  (TRUERR4 LT TRUERR1)
          9.00         17   + Ranks  (TRUERR4 GT TRUERR1)
                        1     Ties   (TRUERR4 EQ TRUERR1)
                       --
                       18     Total

         Z =    -3.6214              2-Tailed P =   .0003
```

Appendix V (cont'd)

Criterion = 6

Experiment 5

```
        Wilcoxon Matched-Pairs Signed-Ranks Test

     TRUERR2   TRUE ERRORS - BACKWARD CHAINING
with TRUERR3   TRUE ERRORS - RANDOM CHAINING

     Mean Rank    Cases

        6.33         3  - Ranks (TRUERR3 LT TRUERR2)
        7.82        11  + Ranks (TRUERR3 GT TRUERR2)
                     4    Ties  (TRUERR3 EQ TRUERR2)
                    --
                    18    Total

     Z =    -2.1030               2-Tailed P =   .0355


        Wilcoxon Matched-Pairs Signed-Ranks Test

     TRUERR2   TRUE ERRORS - BACKWARD CHAINING
with TRUERR4   TRUE ERRORS - WHOLE TASK TRAINING

     Mean Rank    Cases

        2.17         3  - Ranks (TRUERR4 LT TRUERR2)
       10.97        15  + Ranks (TRUERR4 GT TRUERR2)
                     0    Ties  (TRUERR4 EQ TRUERR2)
                    --
                    18    Total

     Z =    -3.4405               2-Tailed P =   .0006
```

Appendix V (cont'd)

Criterion = 6

Experiment 5

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TRUERR3   TRUE ERRORS - RANDOM CHAINING
with TRUERR4   TRUE ERRORS - WHOLE TASK TRAINING

  Mean Rank     Cases

     3.50          1  - Ranks (TRUERR4 LT TRUERR3)
     9.34         16  + Ranks (TRUERR4 GT TRUERR3)
                   1    Ties  (TRUERR4 EQ TRUERR3)
                  --
                  18    Total

     Z =    -3.4557             2-Tailed P =  .0005
```

Appendix V (cont'd)

Experiment 5

Forward Chaining

Kruskal-Wallis 1-Way Anova

TRUERR TRUE ERRORS
by REP

Mean Rank	Cases		
34.75	18	CRI = 1	ONE Criterion
27.89	18	CRI = 2	THREE Criterion
19.86	18	CRI = 3	SIX Crtierion
	--		
	54	Total	

			Corrected for ties	
Cases	Chi-Square	Significance	Chi-Square	Significance
54	8.0775	.0176	9.3565	.0093

Mann-Whitney U - Wilcoxon Rank Sum W Test

TRUERR TRUE ERRORS
by REP

Mean Rank	Cases		
20.97	18	CRI = 1	ONE Criterion
16.03	18	CRI = 2	THREE Criterion
	--		
	36	Total	

		Exact	Corrected for ties	
U	W	2-Tailed P	Z	2-Tailed P
117.5	377.5	.1610	-1.4613	.1439

Experiment 5

Forward Chaining

Mann-Whitney U - Wilcoxon Rank Sum W Test

TRUERR TRUE ERRORS
by REP

Mean Rank	Cases		
23.28	18	CRI = 1	ONE Criterion
13.72	18	CRI = 3	SIX Criterion
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	2-Tailed P
76.0	419.0	.0058	-2.9554	.0031

Mann-Whitney U - Wilcoxon Rank Sum W Test

TRUERR TRUE ERRORS
by REP

Mean Rank	Cases		
21.36	18	CRI = 2	THREE Criterion
15.64	18	CRI = 3	SIX Criterion
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	2-Tailed P
110.5	384.5	.1038	-1.8444	.0651

Experiment 5

Backward Chaining

Kruskal-Wallis 1-Way Anova

TRUERR TRUE ERRORS
by REP

Mean Rank	Cases		
37.56	18	CRI = 1	ONE Criterion
25.78	18	CRI = 2	THREE Criterion
19.17	18	CRI = 3	SIX Criterion
	54	Total	

			Corrected for ties	
Cases	Chi-Square	Significance	Chi-Square	Significance
54	12.6200	.0018	12.8198	.0016

Mann-Whitney U - Wilcoxon Rank Sum W Test

TRUERR TRUE ERRORS
by REP

Mean Rank	Cases		
22.78	18	CRI = 1	ONE Criterion
14.22	18	CRI = 2	THREE Criterion
	36	Total	

		Exact	Corrected for ties	
U	W	2-Tailed P	Z	2-Tailed P
85.0	410.0	.0142	-2.4447	.0145

Appendix V (cont'd)

Experiment 5

Backward Chaining

Mann-Whitney U - Wilcoxon Rank Sum W Test

TRUERR TRUE ERRORS
by REP

Mean Rank	Cases		
24.28	18	CRI = 1	ONE Criterion
12.72	18	CRI = 3	SIX Criterion
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
58.0	437.0	.0007	-3.3218	.0009

Mann-Whitney U - Wilcoxon Rank Sum W Test

TRUERR TRUE ERRORS
by REP

Mean Rank	Cases		
21.06	18	CRI = 2	THREE Criterion
15.94	18	CRI = 3	SIX Criterion
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
116.0	379.0	.1516	-1.4830	.1381

Appendix V (cont'd)

Experiment 5

Random Chaining

Kruskal-Wallis 1-Way Anova

TRUERR TRUE ERRORS
by REP

Mean Rank	Cases		
30.69	18	CRI = 1	ONE Criterion
23.86	18	CRI = 2	THREE Criterion
27.94	18	CRI = 3	SIX Criterion
	--		
	54	Total	

			Corrected for ties	
Cases	Chi-Square	Significance	Chi-Square	Significance
54	1.7195	.4233	1.7611	.4145

Mann-Whitney U - Wilcoxon Rank Sum W Test

TRUERR TRUE ERRORS
by REP

Mean Rank	Cases		
20.61	18	CRI = 1	ONE Criterion
16.39	18	CRI = 2	THREE Criterion
	--		
	36	Total	

		Exact	Corrected for ties	
U	W	2-Tailed P	Z	2-Tailed P
124.0	371.0	.2387	-1.2227	.2214

Appendix V (cont'd)

Experiment 5

Random Chaining

Mann-Whitney U - Wilcoxon Rank Sum W Test

TRUERR TRUE ERRORS
by REP

Mean Rank	Cases		
19.58	18	CRI = 1	ONE Criterion
17.42	18	CRI = 3	SIX Criterion
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	2-Tailed P
142.5	352.5	.5418	-.6213	.5344

Mann-Whitney U - Wilcoxon Rank Sum W Test

TRUERR TRUE ERRORS
by REP

Mean Rank	Cases		
16.97	18	REP = 2	THREE Criterion
20.03	18	REP = 3	SIX Criterion
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	2-Tailed P
134.5	305.5	.3888	-.8834	.3770

Appendix V

Experiment 5

Whole Task Training

Kruskal-Wallis 1-Way Anova

TRUERR TRUE ERRORS
by REP

Mean Rank	Cases		
25.42	18	REP = 1	ONE REPETITION
26.94	18	REP = 2	THREE REPETITIONS
30.14	18	REP = 3	SIX REPETITION
	--		
	54	Total	

			Corrected for ties	
Cases	Chi-Square	Significance	Chi-Square	Significance
54	.8446	.6556	.8455	.6553

Mann-Whitney U - Wilcoxon Rank Sum W Test

TRUERR TRUE ERRORS
by REP

Mean Rank	Cases		
17.81	18	REP = 1	ONE REPETITION
19.19	18	REP = 2	THREE REPETITIONS
	36	Total	

		Exact	Corrected for ties	
U	W	2-Tailed P	Z	2-Tailed P
149.5	320.5	.6960	-.3960	.6921

Appendix V

Experiment 5

Whole Task Training

Mann-Whitney U - Wilcoxon Rank Sum W Test

TRUERR TRUE ERRORS
by REP

Mean Rank	Cases	
17.11	18	REP = 1 ONE REPETITION
19.89	18	REP = 3 SIX REPETITION
	--	
	36	Total

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
137.0	308.0	.4430	-.7914	.4287

Mann-Whitney U - Wilcoxon Rank Sum W Test

TRUERR TRUE ERRORS
by REP

Mean Rank	Cases	
17.25	18	REP = 2 THREE REPETITIONS
19.75	18	REP = 3 SIX REPETITION
	--	
	36	Total

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
139.5	310.5	.4812	-.7121	.4764

Appendix V (cont'd)

Experiment 5

Criterion = 1

Fricdman Two-Way Anova

Mean Rank	Variable	
1.92	RANERR1	RANDOM ERRORS - FORWARD CHAINING
3.00	RANERR2	RANDOM ERRORS - BACKWARD CHAINING
2.39	RANERR3	RANDOM ERRORS - RANDOM CHAINING
2.69	RANERR4	RANDOM ERRORS - WHOLE TASK TRAINING

Cases	Chi-Square	D.F.	Significance
18	6.9166	3	.0746

Wilcoxon Matched-Pairs Signed-Ranks Test

RANERR1 RANDOM ERRORS - FORWARD CHAINING
with RANERR2 RANDOM ERRORS - BACKWARD CHAINING

Mean Rank	Cases		
8.50	4	- Ranks	(RANERR2 LT RANERR1)
9.79	14	+ Ranks	(RANERR2 GT RANERR1)
	0	Ties	(RANERR2 EQ RANERR1)
	18	Total	

Z = -2.2428 2-Tailed P = .0249

Appendix V (cont'd)

Experiment 5

Criterion = 1

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RANERR1   RANDOM ERRORS - FORWARD CHAINING
with RANERR3   RANDOM ERRORS - RANDOM CHAINING

     Mean Rank    Cases

       11.10         5   - Ranks  (RANERR3 LT RANERR1)
        8.88        13   + Ranks  (RANERR3 GT RANERR1)
                     0     Ties   (RANERR3 EQ RANERR1)
                    --
                    18     Total

       Z =    -1.3065             2-Tailed P =   .1914
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RANERR1   RANDOM ERRORS - FORWARD CHAINING
with RANERR4   RANDOM ERRORS - WHOLE TASK TRAINING

     Mean Rank    Cases

        6.43         7   - Ranks  (RANERR4 LT RANERR1)
       10.80        10   + Ranks  (RANERR4 GT RANERR1)
                     1     Ties   (RANERR4 EQ RANERR1)
                    --
                    18     Total

       Z =    -1.4911             2-Tailed P =   .1359
```

Appendix V (cont'd)

Experiment 5

Criterion = 1

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RANERR2   RANDOM ERRORS - BACKWARD CHAINING
with RANERR3   RANDOM ERRORS - RANDOM CHAINING

     Mean Rank    Cases

        9.81         13   - Ranks  (RANERR3 LT RANERR2)
        8.70          5   + Ranks  (RANERR3 GT RANERR2)
                      0     Ties   (RANERR3 EQ RANERR2)
                     --
                     18     Total

      Z =     -1.8291              2-Tailed P =   .0674
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RANERR2   RANDOM ERRORS - BACKWARD CHAINING
with RANERR4   RANDOM ERRORS - WHOLE TASK TRAINING

     Mean Rank    Cases

        8.69          8   - Ranks  (RANERR4 LT RANERR2)
        8.31          8   + Ranks  (RANERR4 GT RANERR2)
                      2     Ties   (RANERR4 EQ RANERR2)
                     --
                     18     Total

      Z =      -.0776              2-Tailed P =   .9382
```

Appendix V (cont'd)

Experiment 5

Criterion = 1

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RANERR3    RANDOM ERRORS - RANDOM CHAINING
with RANERR4    RANDOM ERRORS - WHOLE TASK TRAINING

     Mean Rank    Cases

         7.71         7  - Ranks (RANERR4 LT RANERR3)
        10.64        11  + Ranks (RANERR4 GT RANERR3)
                      0    Ties  (RANERR4 EQ RANERR3)
                     --
                     18    Total

        Z =    -1.3718              2-Tailed P =   .1701
```

Appendix V (cont'd)

Experiment 5

Criterion = 3

Friedman Two-Way Anova

Mean Rank	Variable	
1.78	RANERR1	RANDOM ERRORS - FORWARD CHAINING
2.83	RANERR2	RANDOM ERRORS - BACKWARD CHAINING
2.31	RANERR3	RANDOM ERRORS - RANDOM CHAINING
3.08	RANERR4	RANDOM ERRORS - WHOLE TASK TRAINING

Cases	Chi-Square	D.F.	Significance
18	10.9166	3	.0122

Wilcoxon Matched-Pairs Signed-Ranks Test

RANERR1 RANDOM ERRORS - FORWARD CHAINING
with RANERR2 RANDOM ERRORS - BACKWARD CHAINING

Mean Rank	Cases	
7.00	4	- Ranks (RANERR2 LT RANERR1)
10.21	14	+ Ranks (RANERR2 GT RANERR1)
	0	Ties (RANERR2 EQ RANERR1)
	18	Total

Z = -2.5041 2-Tailed P = .0123

Appendix V (cont'd)

Experiment 5

Criterion = 3

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RANERR1    RANDOM ERRORS - FORWARD CHAINING
with RANERR3    RANDOM ERRORS - RANDOM CHAINING

     Mean Rank     Cases

        6.75          6  - Ranks (RANERR3 LT RANERR1)
        9.55         10  + Ranks (RANERR3 GT RANERR1)
                      2    Ties  (RANERR3 EQ RANERR1)
                     --
                     18    Total

     Z =    -1.4220               2-Tailed P =   .1550
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RANERR1    RANDOM ERRORS - FORWARD CHAINING
with RANERR4    RANDOM ERRORS - WHOLE TASK TRAINING

     Mean Rank     Cases

        8.33          3  - Ranks (RANERR4 LT RANERR1)
        9.73         15  + Ranks (RANERR4 GT RANERR1)
                      0    Ties  (RANERR4 EQ RANERR1)
                     --
                     18    Total

     Z =    -2.6348               2-Tailed P =   .0084
```

Appendix V (cont'd)

Experiment 5

Criterion = 3

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RANERR2    RANDOM ERRORS - BACKWARD CHAINING
with RANERR3    RANDOM ERRORS - RANDOM CHAINING

     Mean Rank    Cases

       10.30        10  - Ranks (RANERR3 LT RANERR2)
        7.14         7  + Ranks (RANERR3 GT RANERR2)
                     1    Ties  (RANERR3 EQ RANERR2)
                    --
                    18    Total

       Z =    -1.2545             2-Tailed P =  .2097
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RANERR2    RANDOM ERRORS - BACKWARD CHAINING
with RANERR4    RANDOM ERRORS - WHOLE TASK TRAINING

     Mean Rank    Cases

        8.31         8  - Ranks (RANERR4 LT RANERR2)
        9.61         9  + Ranks (RANERR4 GT RANERR2)
                     1    Ties  (RANERR4 EQ RANERR2)
                    --
                    18    Total

       Z =     -.4734             2-Tailed P =  .6359
```

Appendix V (cont'd)

Experiment 5

Criterion = 3

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RANERR3    RANDOM ERRORS - RANDOM CHAINING
with RANERR4    RANDOM ERRORS - WHOLE TASK TRAINING

     Mean Rank    Cases

        7.30          5   - Ranks  (RANERR4 LT RANERR3)
       10.35         13   + Ranks  (RANERR4 GT RANERR3)
                      0     Ties   (RANERR4 EQ RANERR3)
                     --
                     18     Total

       Z =   -2.1340              2-Tailed P =   .0328
```

Appendix V (cont'd)

Criterion = 6

Experiment 5

Friedman Two-Way Anova

Mean Rank	Variable	
1.92	RANERR1	RANDOM ERRORS - FORWARD CHAINING
2.50	RANERR2	RANDOM ERRORS - BACKWARD CHAINING
2.36	RANERR3	RANDOM ERRORS - RANDOM CHAINING
3.22	RANERR4	RANDOM ERRORS - WHOLE TASK TRAINING

Cases	Chi-Square	D.F.	Significance
18	9.5166	3	.0232

Wilcoxon Matched-Pairs Signed-Ranks Test

RANERR1 RANDOM ERRORS - FORWARD CHAINING
with RANERR2 RANDOM ERRORS - BACKWARD CHAINING

Mean Rank	Cases	
5.50	6	- Ranks (RANERR2 LT RANERR1)
9.67	9	+ Ranks (RANERR2 GT RANERR1)
	3	Ties (RANERR2 EQ RANERR1)
	18	Total

Z = -1.5335 2-Tailed P = .1252

Appendix V (cont'd)

Criterion = 6

Experiment 5

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RANERR1   RANDOM ERRORS - FORWARD CHAINING
with RANERR3   RANDOM ERRORS - RANDOM CHAINING

     Mean Rank    Cases

       11.50          5   - Ranks  (RANERR3 LT RANERR1)
        7.96         12   + Ranks  (RANERR3 GT RANERR1)
                      1     Ties   (RANERR3 EQ RANERR1)
                     --
                     18     Total

     Z =     -.8994               2-Tailed P =  .3684
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RANERR1   RANDOM ERRORS - FORWARD CHAINING
with RANERR4   RANDOM ERRORS - WHOLE TASK TRAINING

     Mean Rank    Cases

        6.83          3   - Ranks  (RANERR4 LT RANERR1)
        9.46         14   + Ranks  (RANERR4 GT RANERR1)
                      1     Ties   (RANERR4 EQ RANERR1)
                     --
                     18     Total

     Z =    -2.6509               2-Tailed P =  .0080
```

Appendix V (cont'd)

Criterion = 6

Experiment 5

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RANERR2   RANDOM ERRORS - BACKWARD CHAINING
with RANERR3   RANDOM ERRORS - RANDOM CHAINING

     Mean Rank    Cases

       10.05        10  - Ranks (RANERR3 LT RANERR2)
        7.50         7  + Ranks (RANERR3 GT RANERR2)
                     1    Ties  (RANERR3 EQ RANERR2)
                    --
                    18    Total

       Z =   -1.1361              2-Tailed P =  .2559
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RANERR2   RANDOM ERRORS - BACKWARD CHAINING
with RANERR4   RANDOM ERRORS - WHOLE TASK TRAINING

     Mean Rank    Cases

        8.00         6  - Ranks (RANERR4 LT RANERR2)
       10.25        12  + Ranks (RANERR4 GT RANERR2)
                     0    Ties  (RANERR4 EQ RANERR2)
                    --
                    18    Total

       Z =   -1.6331              2-Tailed P =  .1024
```

Appendix V (cont'd)

Criterion = 6

Experiment 5

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RANERR3   RANDOM ERRORS - RANDOM CHAINING
with RANERR4   RANDOM ERRORS - WHOLE TASK TRAINING

   Mean Rank    Cases

       6.63         4   - Ranks (RANERR4 LT RANERR3)
       9.73        13   + Ranks (RANERR4 GT RANERR3)
                    1     Ties  (RANERR4 EQ RANERR3)
                   --
                   18     Total

     Z =    -2.3669             2-Tailed P =   .0179
```

Appendix V (cont'd)

Experiment 5

Forward Chaining

Kruskal-Wallis 1-Way Anova

RANERR RANDOM ERRORS
by REP

Mean Rank	Cases		
29.86	18	CRI = 1	ONE Criterion
22.72	18	CRI = 2	THREE Criterion
29.92	18	CRI = 3	SIX Criterion
	54	Total	

			Corrected for ties	
Cases	Chi-Square	Significance	Chi-Square	Significance
54	2.4903	.2879	2.5126	.2847

Mann-Whitney U - Wilcoxon Rank Sum W Test

RANERR RANDOM ERRORS
by REP

Mean Rank	Cases		
20.97	18	CRI = 1	ONE Criterion
16.03	18	CRI = 2	THREE Criterion
	36	Total	

		Exact	Corrected for ties	
U	W	2-Tailed P	Z	2-Tailed P
117.5	377.5	.1610	-1.4154	.1569

Experiment 5

Forward Chaining

Mann-Whitney U - Wilcoxon Rank Sum W Test

RANERR RANDOM ERRORS
by REP

Mean Rank	Cases		
16.19	18	CRI = 2	THREE Criterion
20.81	18	CRI = 3	SIX Criterion
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
120.5	291.5	.1916	-1.3189	.1872

Mann-Whitney U - Wilcoxon Rank Sum W Test

RANERR RANDOM ERRORS
by REP

Mean Rank	Cases		
16.19	18	CRI = 2	THREE Criterion
20.81	18	CRI = 3	SIX Criterion
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
120.5	291.5	.1916	-1.3189	.1872

Appendix V (cont'd)

Experiment 5

Backward Chaining

Kruskal-Wallis 1-Way Anova

RANERR RANDOM ERRORS
by REP

Mean Rank	Cases		
29.06	18	CRI = 1	ONE Crterion
27.00	18	CRI = 2	THREE Criterion
26.44	18	CRI = 3	SIX Criterion
	54	Total	

			Corrected for ties	
Cases	Chi-Square	Significance	Chi-Square	Significance
54	.2752	.8714	.2769	.8707

Mann-Whitney U - Wilcoxon Rank Sum W Test

RANERR RANDOM ERRORS
by REP

Mean Rank	Cases		
19.14	18	CRI = 1	ONE Criterion
17.86	18	CRI = 2	THREE Criterion
	36	Total	

		Exact	Corrected for ties	
U	W	2-Tailed P	Z	2-Tailed P
150.5	344.5	.7193	-.3647	.7153

Appendix V (cont'd)

Experiment 5

Backward Chaining

Mann-Whitney U - Wilcoxon Rank Sum W Test

RANERR RANDOM ERRORS
by REP

Mean Rank	Cases	
19.42	18	REP = 1 ONE REPETITION
17.58	18	REP = 3 SIX REPETITION
	36	Total

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
145.5	349.5	.6059	-.5240	.6003

Mean Rank Cases

Mann-Whitney U - Wilcoxon Rank Sum W Test

RANERR RANDOM ERRORS
by REP

Mean Rank	Cases	
18.64	18	CRI = 2 THREE Criterion
18.36	18	CRI = 3 SIX Criterion
	36	Total

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
159.5	335.5	.9378	-.0795	.9367

Experiment 5

Random Chaining

Kruskal-Wallis 1-Way Anova

RANERR RANDOM ERRORS
by REP

Mean Rank	Cases		
27.89	18	CRI = 1	ONE Criterion
25.47	18	CRI = 2	THREE Criterion
29.14	18	CRI = 3	SIX Criterion
	--		
	54	Total	

			Corrected for ties	
Cases	Chi-Square	Significance	Chi-Square	Significance
54	.5054	.7767	.5087	.7754

Mann-Whitney U - Wilcoxon Rank Sum W Test

RANERR RANDOM ERRORS
by REP

Mean Rank	Cases		
19.39	18	CRI = 1	ONE Criterion
17.61	18	CRI = 2	THREE Criterion
	36	Total	

		Exact	Corrected for ties	
U	W	2-Tailed P	Z	2-Tailed P
146.0	349.0	.6279	-.5085	.6111

Experiment 5

Random Chaining

Mann-Whitney U - Wilcoxon Rank Sum W Test

RANERR RANDOM ERRORS
by REP

Mean Rank	Cases		
18.00	18	REP = 1	ONE REPETITION
19.00	18	REP = 3	SIX REPETITION
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	2-Tailed P
153.0	324.0	.7906	-.2859	.7750

Mann-Whitney U - Wilcoxon Rank Sum W Test

RANERR RANDOM ERRORS
by REP

Mean Rank	Cases		
17.36	18	CRI = 2	THREE Criterion
19.64	18	CRI = 3	SIX Criterion
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	2-Tailed P
141.5	312.5	.5212	-.6507	.5152

Appendix V (cont'd)

Experiment 5

Random Chaining

Mann-Whitney U - Wilcoxon Rank Sum W Test

RANERR RANDOM ERRORS
by REP

Mean Rank	Cases		
17.36	18	CRI = 2	THREE Criterion
19.64	18	CRI = 3	SIX Criterion
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
141.5	312.5	.5212	-.6507	.5152

Mann-Whitney U - Wilcoxon Rank Sum W Test

RANERR RANDOM ERRORS
by REP

Mean Rank	Cases		
17.36	18	CRI = 2	THREE Criterion
19.64	18	CRI = 3	SIX Criterion
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
141.5	312.5	.5212	-.6507	.5152

Appendix V

Experiment 5

Whole Task Training

Kruskal-Wallis 1-Way Anova

RANERR RANDOM ERRORS
by REP

Mean Rank	Cases		
24.69	18	REP = 1	ONE REPETITION
26.28	18	REP = 2	THREE REPETITIONS
31.53	18	REP = 3	SIX REPETITION
	--		
	54	Total	

Cases	Chi-Square	Significance	Corrected for ties Chi-Square	Corrected for ties Significance
54	1.8609	.3944	1.8721	.3922

Mann-Whitney U - Wilcoxon Rank Sum W Test

RANERR RANDOM ERRORS
by REP

Mean Rank	Cases		
18.03	18	REP = 1	ONE REPETITION
18.97	18	REP = 2	THREE REPETITIONS
	--		
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
153.5	324.5	.7906	-.2701	.7871

Appendix V

Experiment 5

Whole Task Training

Mann-Whitney U - Wilcoxon Rank Sum W Test

RANERR RANDOM ERRORS
by REP

Mean Rank	Cases		
16.17	18	REP = 1	ONE REPETITION
20.83	18	REP = 3	SIX REPETITION
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	2-Tailed P
120.0	291.0	.1916	-1.3347	.1820

Mann-Whitney U - Wilcoxon Rank Sum W Test

RANERR RANDOM ERRORS
by REP

Mean Rank	Cases		
16.81	18	REP = 2	THREE REPETITIONS
20.19	18	REP = 3	SIX REPETITION
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	2-Tailed P
131.5	302.5	.3389	-.9672	.3334

Appendix V (cont'd)

Experiment 5

Criterion = 1

Friedman Two-Way Anova

Mean Rank	Variable	
1.75	TOTERR1	TOTAL ERRORS - FORWARD CHAINING
3.00	TOTERR2	TOTAL ERRORS - BACKWARD CHAINING
2.25	TOTERR3	TOTAL ERRORS - RANDOM CHAINING
3.00	TOTERR4	TOTAL ERRORS - WHOLE TASK TRAINING

Cases	Chi-Square	D.F.	Significance
18	12.1500	3	.0069

Wilcoxon Matched-Pairs Signed-Ranks Test

TOTERR1 TOTAL ERRORS - FORWARD CHAINING
with TOTERR2 TOTAL ERRORS - BACKWARD CHAINING

Mean Rank	Cases		
5.33	3	- Ranks	(TOTERR2 LT TOTERR1)
10.33	15	+ Ranks	(TOTERR2 GT TOTERR1)
	0	Ties	(TOTERR2 EQ TOTERR1)
	18	Total	

Z = -3.0267 2-Tailed P = .0025

Appendix V (cont'd)

Experiment 5

Criterion = 1

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TOTERR1   TOTAL ERRORS - FORWARD CHAINING
with TOTERR3   TOTAL ERRORS - RANDOM CHAINING

     Mean Rank    Cases

        9.00         5  - Ranks (TOTERR3 LT TOTERR1)
        9.00        12  + Ranks (TOTERR3 GT TOTERR1)
                     1    Ties  (TOTERR3 EQ TOTERR1)
                    --
                    18    Total

       Z =   -1.4911            2-Tailed P =  .1359
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TOTERR1   TOTAL ERRORS - FORWARD CHAINING
with TOTERR4   TOTAL ERRORS - WHOLE TASK TRAINING

     Mean Rank    Cases

        4.20         5  - Ranks (TOTERR4 LT TOTERR1)
       11.54        13  + Ranks (TOTERR4 GT TOTERR1)
                     0    Ties  (TOTERR4 EQ TOTERR1)
                    --
                    18    Total

       Z =   -2.8090            2-Tailed P =  .0050
```

Appendix V (cont'd)

Experiment 5

Criterion = 1

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TOTERR2    TOTAL ERRORS - BACKWARD CHAINING
with TOTERR3    TOTAL ERRORS - RANDOM CHAINING

     Mean Rank    Cases

        8.79         12  - Ranks (TOTERR3 LT TOTERR2)
        7.63          4  + Ranks (TOTERR3 GT TOTERR2)
                      2    Ties  (TOTERR3 EQ TOTERR2)
                     --
                     18    Total

     Z =    -1.9391               2-Tailed P =   .0525
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TOTERR2    TOTAL ERRORS - BACKWARD CHAINING
with TOTERR4    TOTAL ERRORS - WHOLE TASK TRAINING

     Mean Rank    Cases

        7.19          8  - Ranks (TOTERR4 LT TOTERR2)
       11.35         10  + Ranks (TOTERR4 GT TOTERR2)
                      0    Ties  (TOTERR4 EQ TOTERR2)
                     --
                     18    Total

     Z =    -1.2194               2-Tailed P =   .2227
```

Appendix V (cont'd)

Experiment 5

Criterion = 1

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TOTERR3   TOTAL ERRORS - RANDOM CHAINING
with TOTERR4   TOTAL ERRORS - WHOLE TASK TRAINING

     Mean Rank    Cases

        6.50         5   - Ranks (TOTERR4 LT TOTERR3)
       10.65        13   + Ranks (TOTERR4 GT TOTERR3)
                     0     Ties  (TOTERR4 EQ TOTERR3)
                    --
                    18     Total

       Z =    -2.3082            2-Tailed P =   .0210
```

Appendix V (cont'd)

Experiment 5

Criterion = 3

Friedman Two-Way Anova

Mean Rank	Variable	
1.83	TOTERR1	TOTAL ERRORS - FORWARD CHAINING
2.50	TOTERR2	TOTAL ERRORS - BACKWARD CHAINING
2.03	TOTERR3	TOTAL ERRORS - RANDOM CHAINING
3.64	TOTERR4	TOTAL ERRORS - WHOLE TASK TRAINING

Cases	Chi-Square	D.F.	Significance
18	21.2166	3	.0001

Wilcoxon Matched-Pairs Signed-Ranks Test

TOTERR1 TOTAL ERRORS - FORWARD CHAINING
with TOTERR2 TOTAL ERRORS - BACKWARD CHAINING

Mean Rank	Cases		
4.75	4	- Ranks	(TOTERR2 LT TOTERR1)
10.86	14	+ Ranks	(TOTERR2 GT TOTERR1)
	0	Ties	(TOTERR2 EQ TOTERR1)
	18	Total	

Z = -2.8961 2-Tailed P = .0038

Appendix V (cont'd)

Experiment 5

Criterion = 3

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TOTERR1    TOTAL ERRORS - FORWARD CHAINING
with TOTERR3    TOTAL ERRORS - RANDOM CHAINING

     Mean Rank    Cases

       6.94          9  - Ranks (TOTERR3 LT TOTERR1)
      12.06          9  + Ranks (TOTERR3 GT TOTERR1)
                     0    Ties  (TOTERR3 EQ TOTERR1)
                    --
                    18    Total

        Z =    -1.0017             2-Tailed P =   .3165
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TOTERR1    TOTAL ERRORS - FORWARD CHAINING
with TOTERR4    TOTAL ERRORS - WHOLE TASK TRAINING

     Mean Rank    Cases

       1.50          2  - Ranks (TOTERR4 LT TOTERR1)
      10.50         16  + Ranks (TOTERR4 GT TOTERR1)
                     0    Ties  (TOTERR4 EQ TOTERR1)
                    --
                    18    Total

        Z =    -3.5929             2-Tailed P =   .0003
```

Appendix V (cont'd)

Experiment 5

Criterion = 3

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TOTERR2   TOTAL ERRORS - BACKWARD CHAINING
with TOTERR3   TOTAL ERRORS - RANDOM CHAINING

     Mean Rank    Cases

        9.15        10  - Ranks (TOTERR3 LT TOTERR2)
        8.79         7  + Ranks (TOTERR3 GT TOTERR2)
                     1    Ties  (TOTERR3 EQ TOTERR2)
                    --
                    18    Total

     Z =    -.7101             2-Tailed P =  .4777
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TOTERR2   TOTAL ERRORS - BACKWARD CHAINING
with TOTERR4   TOTAL ERRORS - WHOLE TASK TRAINING

     Mean Rank    Cases

        5.00         2  - Ranks (TOTERR4 LT TOTERR2)
        9.53        15  + Ranks (TOTERR4 GT TOTERR2)
                     1    Ties  (TOTERR4 EQ TOTERR2)
                    --
                    18    Total

     Z =   -3.1480             2-Tailed P =  .0016
```

Appendix V (cont'd)

Experiment 5

Criterion = 3

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TOTERR3    TOTAL ERRORS - RANDOM CHAINING
with TOTERR4    TOTAL ERRORS - WHOLE TASK TRAINING

     Mean Rank     Cases

        5.00          2   - Ranks  (TOTERR4 LT TOTERR3)
       10.06         16   + Ranks  (TOTERR4 GT TOTERR3)
                      0     Ties   (TOTERR4 EQ TOTERR3)
                     --
                     18     Total

       Z =    -3.2881             2-Tailed P =   .0010
```

Appendix V (cont'd)

Criterion = 6

Experiment 5

Friedman Two-Way Anova

Mean Rank	Variable	
1.69	TOTERR1	TOTAL ERRORS - FORWARD CHAINING
2.36	TOTERR2	TOTAL ERRORS - BACKWARD CHAINING
2.19	TOTERR3	TOTAL ERRORS - RANDOM CHAINING
3.75	TOTERR4	TOTAL ERRORS - WHOLE TASK TRAINING

Cases	Chi-Square	D.F.	Significance
18	25.1000	3	.0000

Wilcoxon Matched-Pairs Signed-Ranks Test

TOTERR1 TOTAL ERRORS - FORWARD CHAINING
with TOTERR2 TOTAL ERRORS - BACKWARD CHAINING

Mean Rank	Cases	
4.50	6	- Ranks (TOTERR2 LT TOTERR1)
11.45	11	+ Ranks (TOTERR2 GT TOTERR1)
	1	Ties (TOTERR2 EQ TOTERR1)
	18	Total

Z = -2.3432 2-Tailed P = .0191

Appendix V (cont'd)

Criterion = 6

Experiment 5

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TOTERR1   TOTAL ERRORS - FORWARD CHAINING
with TOTERR3   TOTAL ERRORS - RANDOM CHAINING

     Mean Rank    Cases

        7.10         5  - Ranks (TOTERR3 LT TOTERR1)
       10.42        13  + Ranks (TOTERR3 GT TOTERR1)
                     0    Ties  (TOTERR3 EQ TOTERR1)
                    --
                    18    Total

       Z =   -2.1775             2-Tailed P =  .0294
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TOTERR1   TOTAL ERRORS - FORWARD CHAINING
with TOTERR4   TOTAL ERRORS - WHOLE TASK TRAINING

     Mean Rank    Cases

        2.00         1  - Ranks (TOTERR4 LT TOTERR1)
        9.94        17  + Ranks (TOTERR4 GT TOTERR1)
                     0    Ties  (TOTERR4 EQ TOTERR1)
                    --
                    18    Total

       Z =   -3.6365             2-Tailed P =  .0003
```

Appendix V (cont'd)

Criterion = 6

Experiment 5

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TOTERR2   TOTAL ERRORS - BACKWARD CHAINING
with TOTERR3   TOTAL ERRORS - RANDOM CHAINING

   Mean Rank     Cases

      9.05         10   - Ranks  (TOTERR3 LT TOTERR2)
     10.06          8   + Ranks  (TOTERR3 GT TOTERR2)
                    0     Ties   (TOTERR3 EQ TOTERR2)
                   --
                   18     Total

     Z =      -.2178            2-Tailed P =   .8276
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TOTERR2   TOTAL ERRORS - BACKWARD CHAINING
with TOTERR4   TOTAL ERRORS - WHOLE TASK TRAINING

   Mean Rank     Cases

      3.67          3   - Ranks  (TOTERR4 LT TOTERR2)
     10.67         15   + Ranks  (TOTERR4 GT TOTERR2)
                    0     Ties   (TOTERR4 EQ TOTERR2)
                   --
                   18     Total

     Z =     -3.2445            2-Tailed P =   .0012
```

Appendix V (cont'd)

Criterion = 6

Experiment 5

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TOTERR3   TOTAL ERRORS - RANDOM CHAINING
with TOTERR4   TOTAL ERRORS - WHOLE TASK TRAINING

     Mean Rank    Cases

          .00         0   - Ranks (TOTERR4 LT TOTERR3)
         9.00        17   + Ranks (TOTERR4 GT TOTERR3)
                      1     Ties  (TOTERR4 EQ TOTERR3)
                     --
                     18     Total

        Z =   -3.6214             2-Tailed P =   .0003
```

Appendix V (cont'd)

Experiment 5

Forward Chaining

Kruskal-Wallis 1-Way Anova

TOTERR TOTAL ERRORS
by REP

Mean Rank	Cases		
32.67	18	CRI = 1	ONE Criterion
23.78	18	CRI = 2	THREE Criterion
26.06	18	CRI = 3	SIX Criterion
	54	Total	

Cases	Chi-Square	Significance	Corrected for ties Chi-Square	Corrected for ties Significance
54	3.1008	.2122	3.1234	.2098

Mann-Whitney U - Wilcoxon Rank Sum W Test

TOTERR TOTAL ERRORS
by REP

Mean Rank	Cases		
21.47	18	CRI = 1	ONE Criterion
15.53	18	CRI = 2	THREE Criterion
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
108.5	386.5	.0907	-1.7009	.0890

Appendix V (cont'd)

Experiment 5

Forward Chaining

Mann-Whitney U - Wilcoxon Rank Sum W Test

```
     TOTERR     TOTAL ERRORS
by REP

     Mean Rank      Cases

        20.69          18   CRI = 1  ONE Criterion
        16.31          18   CRI = 3  SIX Criterion
                       --
                       36   Total

                                   Exact                    Corrected for ties
           U             W      2-Tailed P                  Z        2-Tailed P
        122.5          372.5       .2143              -1.2551           .2094
```

Mann-Whitney U - Wilcoxon Rank Sum W Test

```
     TOTERR     TOTAL ERRORS
by REP

     Mean Rank      Cases

        17.75          18   CRI = 2  THREE Criterion
        19.25          18   CRI = 3  SIX Criterion
                       --
                       36   Total

                                   Exact                    Corrected for ties
           U             W      2-Tailed P                  Z        2-Tailed P
        148.5          319.5       .6730               -.4286           .6682
```

Appendix V (cont'd)

Experiment 5

Backward Chaining

Kruskal-Wallis 1-Way Anova

TOTERR TOTAL ERRORS
by REP

Mean Rank	Cases		
36.92	18	CRI = 1	ONE Criterion
24.72	18	CRI = 2	THREE Criterion
20.86	18	CRI = 3	SIX Criterion
	—		
	54	Total	

Cases	Chi-Square	Significance	Corrected for ties Chi-Square	Corrected for ties Significance
54	10.2156	.0060	10.2551	.0059

Mann-Whitney U - Wilcoxon Rank Sum W Test

TOTERR TOTAL ERRORS
by REP

Mean Rank	Cases		
22.56	18	CRI = 1	ONE Criterion
14.44	18	CRI = 2	THREE Criterion
	—		
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
89.0	406.0	.0205	-2.3144	.0206

Appendix V (cont'd)

Experiment 5

Backward Chaining

Mann-Whitney U - Wilcoxon Rank Sum W Test

TOTERR TOTAL ERRORS
by REP

Mean Rank	Cases	
23.86	18	Cri = 1 ONE Criterion
13.14	18	Cri = 3 SIX Criterion
	36	Total

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
65.5	429.5	.0016	-3.0592	.0022

Mann-Whitney U - Wilcoxon Rank Sum W Test

TOTERR TOTAL ERRORS
by REP

Mean Rank	Cases	
19.78	18	CRI = 2 THREE Criterion
17.22	18	CRI = 3 SIX Criterion
	36	Total

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
139.0	356.0	.4812	-.7306	.4650

Appendix V (cont'd)

Experiment 5

Random Chaining

Kruskal-Wallis 1-Way Anova

TOTERR TOTAL ERRORS
by REP

Mean Rank	Cases		
31.33	18	CRI = 1	ONE Criterion
23.50	18	CRI = 2	THREE Criterion
27.67	18	CRI = 3	SIX Criterion
	--		
	54	Total	

			Corrected for ties	
Cases	Chi-Square	Significance	Chi-Square	Significance
54	2.2343	.3272	2.2395	.3264

Mann-Whitney U - Wilcoxon Rank Sum W Test

TOTERR TOTAL ERRORS
by REP

Mean Rank	Cases		
21.08	18	CRI = 1	ONE Criterion
15.92	18	CRI = 2	THREE Criterion
	--		
	36	Total	

		Exact	Corrected for ties	
U	W	2-Tailed P	Z	2-Tailed P
115.5	379.5	.1427	-1.4731	.1407

Appendix V (cont'd)

Experiment 5

Random Chaining

Mann-Whitney U - Wilcoxon Rank Sum W Test

TOTERR TOTAL ERRORS
by REP

Mean Rank	Cases		
19.75	18	CRI = 1	ONE Criterion
17.25	18	CRI = 3	SIX Criterion
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
139.5	355.5	.4812	-.7131	.4758

Mann-Whitney U - Wilcoxon Rank Sum W Test

TOTERR TOTAL ERRORS
by REP

Mean Rank	Cases		
17.08	18	CRI = 2	THREE Criterion
19.92	18	CRI = 3	SIX Criterion
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
136.5	307.5	.4245	-.8076	.4193

Appendix V

Experiment 5

Whole Task Training

Kruskal-Wallis 1-Way Anova

TOTERR TOTAL ERRORS
by REP

Mean Rank	Cases		
25.64	18	REP = 1	ONE REPETITION
26.81	18	REP = 2	THREE REPETITIONS
30.06	18	REP = 3	SIX REPETITION
	--		
	54	Total	

			Corrected for ties	
Cases	Chi-Square	Significance	Chi-Square	Significance
54	.7620	.6832	.7627	.6829

Appendix V

Experiment 5

Whole Task Training

Mann-Whitney U - Wilcoxon Rank Sum W Test

```
    TOTERR     TOTAL ERRORS
by  REP

   Mean Rank    Cases

       17.92        18  REP = 1  ONE REPETITION
       19.08        18  REP = 2  THREE REPETITIONS
                    --
                    36  Total

                                  Exact                  Corrected for ties
         U             W      2-Tailed P                 Z       2-Tailed P
       151.5         322.5        .7428             -.3323           .7396
```

Appendix V

Experiment 5

Whole Task Training

Mann-Whitney U - Wilcoxon Rank Sum W Test

TOTERR TOTAL ERRORS
by REP

Mean Rank	Cases		
17.22	18	REP = 1	ONE REPETITION
19.78	18	REP = 3	SIX REPETITION
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
139.0	310.0	.4812	-.7284	.4663

Mann-Whitney U - Wilcoxon Rank Sum W Test

TOTERR TOTAL ERRORS
by REP

Mean Rank	Cases		
17.22	18	REP = 2	THREE REPETITIONS
19.78	18	REP = 3	SIX REPETITION
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
139.0	310.0	.4812	-.7282	.4665

Appendix V

Experiment 5

Whole Task Training

Kruskal-Wallis 1-Way Anova

RESP RESPONSES
by REP

Mean Rank	Cases		
24.36	18	REP = 1	ONE REPETITION
27.86	18	REP = 2	THREE REPETITIONS
30.28	18	REP = 3	SIX REPETITION
	54	Total	

			Corrected for ties	
Cases	Chi-Square	Significance	Chi-Square	Significance
54	1.2872	.5254	1.2875	.5253

Mann-Whitney U - Wilcoxon Rank Sum W Test

RESP RESPONSES
by REP

Mean Rank	Cases		
17.14	18	REP = 1	ONE REPETITION
19.86	18	REP = 2	THREE REPETITIONS
	36	Total	

		Exact	Corrected for ties	
U	W	2-Tailed P	Z	2-Tailed P
137.5	308.5	.4430	-.7753	.4381

Appendix V

Experiment 5

Whole Task Training

Mann-Whitney U - Wilcoxon Rank Sum W Test

TOTERR TOTAL ERRORS
by REP

Mean Rank	Cases		
17.22	18	REP = 1	ONE REPETITION
19.78	18	REP = 3	SIX REPETITION
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
139.0	310.0	.4812	-.7284	.4663

Mann-Whitney U - Wilcoxon Rank Sum W Test

TOTERR TOTAL ERRORS
by REP

Mean Rank	Cases		
17.22	18	REP = 2	THREE REPETITIONS
19.78	18	REP = 3	SIX REPETITION
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
139.0	310.0	.4812	-.7282	.4665

Appendix V (cont'd)

Experiment 5

Criterion = 1

Friedman Two-Way Anova

Mean Rank	Variable	
2.11	RESP1	RESPONSES - FORWARD CHAINING
3.17	RESP2	RESPONSES - BACKWARD CHAINING
2.67	RESP3	RESPONSES - RANDOM CHAINING
2.06	RESP4	RESPONSES - WHOLE TASK TRAINING

Cases	Chi-Square	D.F.	Significance
18	8.8666	3	.0311

Wilcoxon Matched-Pairs Signed-Ranks Test

RESP1 RESPONSES - FORWARD CHAINING
with RESP2 RESPONSES - BACKWARD CHAINING

Mean Rank	Cases		
5.88	4	- Ranks	(RESP2 LT RESP1)
10.54	14	+ Ranks	(RESP2 GT RESP1)
	0	Ties	(RESP2 EQ RESP1)
	18	Total	

Z = -2.7001 2-Tailed P = .0069

Appendix V (cont'd)

Experiment 5

Criterion = 1

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RESP1      RESPONSES - FORWARD CHAINING
with RESP3      RESPONSES - RANDOM CHAINING

     Mean Rank    Cases

        6.14         7   - Ranks (RESP3 LT RESP1)
       11.64        11   + Ranks (RESP3 GT RESP1)
                     0     Ties  (RESP3 EQ RESP1)
                    --
                    18     Total

       Z =    -1.8509              2-Tailed P =  .0642
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RESP1      RESPONSES - FORWARD CHAINING
with RESP4      RESPONSES - WHOLE TASK TRAINING

     Mean Rank    Cases

        9.00         9   - Ranks (RESP4 LT RESP1)
       10.00         9   + Ranks (RESP4 GT RESP1)
                     0     Ties  (RESP4 EQ RESP1)
                    --
                    18     Total

       Z =     -.1960              2-Tailed P =  .8446
```

Appendix V (cont'd)

Experiment 5

Criterion = 1

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RESP2      RESPONSES - BACKWARD CHAINING
with RESP3      RESPONSES - RANDOM CHAINING

     Mean Rank     Cases

       11.45         11    - Ranks  (RESP3 LT RESP2)
        6.43          7    + Ranks  (RESP3 GT RESP2)
                      0      Ties   (RESP3 EQ RESP2)
                     --
                     18      Total

       Z =     -1.7638                2-Tailed P =  .0778
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RESP2      RESPONSES - BACKWARD CHAINING
with RESP4      RESPONSES - WHOLE TASK TRAINING

     Mean Rank     Cases

        7.50         14    - Ranks  (RESP4 LT RESP2)
       16.50          4    + Ranks  (RESP4 GT RESP2)
                      0      Ties   (RESP4 EQ RESP2)
                     --
                     18      Total

       Z =      -.8492                2-Tailed P =  .3958
```

Appendix V (cont'd)

Experiment 5

Criterion = 1

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RESP3      RESPONSES - RANDOM CHAINING
with RESP4      RESPONSES - WHOLE TASK TRAINING

     Mean Rank    Cases

        8.63        12   - Ranks (RESP4 LT RESP3)
       11.25         6   + Ranks (RESP4 GT RESP3)
                     0     Ties  (RESP4 EQ RESP3)
                    --
                    18     Total

        Z =    -.7839             2-Tailed P =  .4331
```

Appendix V (cont'd)

Experiment 5

Criterion = 3

Friedman Two-Way Anova

Mean Rank	Variable	
2.44	RESP1	RESPONSES - FORWARD CHAINING
3.06	RESP2	RESPONSES - BACKWARD CHAINING
2.89	RESP3	RESPONSES - RANDOM CHAINING
1.61	RESP4	RESPONSES - WHOLE TASK TRAINING

Cases	Chi-Square	D.F.	Significance
18	13.5333	3	.0036

Wilcoxon Matched-Pairs Signed-Ranks Test

RESP1 RESPONSES - FORWARD CHAINING
with RESP2 RESPONSES - BACKWARD CHAINING

Mean Rank	Cases	
6.75	6	- Ranks (RESP2 LT RESP1)
10.88	12	+ Ranks (RESP2 GT RESP1)
	0	Ties (RESP2 EQ RESP1)
	18	Total

Z = -1.9598 2-Tailed P = .0500

Appendix V (cont'd)

Experiment 5

Criterion = 3

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RESP1       RESPONSES - FORWARD CHAINING
with RESP3       RESPONSES - RANDOM CHAINING

     Mean Rank     Cases

       10.25          6   - Ranks  (RESP3 LT RESP1)
        9.13         12   + Ranks  (RESP3 GT RESP1)
                      0     Ties   (RESP3 EQ RESP1)
                     --
                     18     Total

       Z =     -1.0452              2-Tailed P =  .2959
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RESP1       RESPONSES - FORWARD CHAINING
with RESP4       RESPONSES - WHOLE TASK TRAINING

     Mean Rank     Cases

        9.93         14   - Ranks  (RESP4 LT RESP1)
        8.00          4   + Ranks  (RESP4 GT RESP1)
                      0     Ties   (RESP4 EQ RESP1)
                     --
                     18     Total

       Z =     -2.3299              2-Tailed P =  .0198
```

Appendix V (cont'd)

Experiment 5

Criterion = 3

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RESP2       RESPONSES - BACKWARD CHAINING
with RESP3       RESPONSES - RANDOM CHAINING

     Mean Rank    Cases

        9.45        11   - Ranks (RESP3 LT RESP2)
        9.57         7   + Ranks (RESP3 GT RESP2)
                     0     Ties  (RESP3 EQ RESP2)
                    --
                    18     Total

       Z =    -.8057            2-Tailed P =  .4204
```

Appendix V (cont'd)

Experiment 5

Criterion = 3

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RESP2      RESPONSES - BACKWARD CHAINING
with RESP4      RESPONSES - WHOLE TASK TRAINING

Mean Rank    Cases

  10.93        14   - Ranks (RESP4 LT RESP2)
   4.50         4   + Ranks (RESP4 GT RESP2)
                0     Ties  (RESP4 EQ RESP2)
               --
               18     Total

Z =    -2.9396            2-Tailed P =   .0033
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RESP3      RESPONSES - RANDOM CHAINING
with RESP4      RESPONSES - WHOLE TASK TRAINING

Mean Rank    Cases

  10.07        15   - Ranks (RESP4 LT RESP3)
   6.67         3   + Ranks (RESP4 GT RESP3)
                0     Ties  (RESP4 EQ RESP3)
               --
               18     Total

Z =    -2.8525            2-Tailed P =   .0043
```

Appendix V (cont'd)

Criterion = 6

Experiment 5

Friedman Two-Way Anova

Mean Rank	Variable	
2.19	RESP1	RESPONSES - FORWARD CHAINING
3.11	RESP2	RESPONSES - BACKWARD CHAINING
3.36	RESP3	RESPONSES - RANDOM CHAINING
1.33	RESP4	RESPONSES - WHOLE TASK TRAINING

Cases	Chi-Square	D.F.	Significance
18	27.7500	3	.0000

Wilcoxon Matched-Pairs Signed-Ranks Test

RESP1 RESPONSES - FORWARD CHAINING
with RESP3 RESPONSES - RANDOM CHAINING

Mean Rank	Cases	
5.50	1	- Ranks (RESP3 LT RESP1)
9.22	16	+ Ranks (RESP3 GT RESP1)
	1	Ties (RESP3 EQ RESP1)
	18	Total

Z = -3.3610 2-Tailed P = .0008

Appendix V (cont'd)

Criterion = 6

Experiment 5

```
          Wilcoxon Matched-Pairs Signed-Ranks Test

     RESP1      RESPONSES - FORWARD CHAINING
with RESP4      RESPONSES - WHOLE TASK TRAINING

     Mean Rank    Cases

        10.13        16  - Ranks (RESP4 LT RESP1)
         4.50         2  + Ranks (RESP4 GT RESP1)
                      0    Ties  (RESP4 EQ RESP1)
                     --
                     18    Total

        Z =    -3.3316              2-Tailed P =  .0009


          Wilcoxon Matched-Pairs Signed-Ranks Test

     RESP2      RESPONSES - BACKWARD CHAINING
with RESP3      RESPONSES - RANDOM CHAINING

     Mean Rank    Cases

         8.06         8  - Ranks (RESP3 LT RESP2)
        10.65        10  + Ranks (RESP3 GT RESP2)
                      0    Ties  (RESP3 EQ RESP2)
                     --
                     18    Total

        Z =     -.9146              2-Tailed P =  .3604
```

Appendix V (cont'd)

Criterion = 6

Experiment 5

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RESP2      RESPONSES - BACKWARD CHAINING
with RESP4      RESPONSES - WHOLE TASK TRAINING

     Mean Rank    Cases

       10.50        16   - Ranks (RESP4 LT RESP2)
        1.50         2   + Ranks (RESP4 GT RESP2)
                     0     Ties  (RESP4 EQ RESP2)
                    --
                    18     Total

       Z =    -3.5929            2-Tailed P =   .0003
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RESP3      RESPONSES - RANDOM CHAINING
with RESP4      RESPONSES - WHOLE TASK TRAINING

     Mean Rank    Cases

       10.25        16   - Ranks (RESP4 LT RESP3)
        3.50         2   + Ranks (RESP4 GT RESP3)
                     0     Ties  (RESP4 EQ RESP3)
                    --
                    18     Total

       Z =    -3.4187            2-Tailed P =   .0006
```

Appendix V (cont'd)

Experiment 5

Forward Chaining

Kruskal-Wallis 1-Way Anova

RESP RESPONSES
by REP

Mean Rank	Cases		
11.44	18	CRI = 1	ONE Criterion
27.28	18	CRI = 2	THREE Criterion
43.78	18	CRI = 3	SIX Criterion
	54	Total	

			Corrected for ties	
Cases	Chi-Square	Significance	Chi-Square	Significance
54	38.0215	.0000	38.0316	.0000

Mann-Whitney U - Wilcoxon Rank Sum W Test

RESP RESPONSES
by REP

Mean Rank	Cases		
10.50	18	CRI = 1	ONE Criterion
26.50	18	CRI = 2	THREE Criterion
	36	Total	

		Exact	Corrected for ties	
U	W	2-Tailed P	Z	2-Tailed P
18.0	189.0	.0000	-4.5574	.0000

Appendix V (cont'd)

Experiment 5

Forward Chaining

Mann-Whitney U - Wilcoxon Rank Sum W Test

```
    RESP      RESPONSES
by  REP

    Mean Rank    Cases

      10.44        18   CRI = 1  ONE Criterion
      26.56        18   CRI = 3  SIX Criterion
                   --
                   36   Total

                              Exact                Corrected for ties
        U            W      2-Tailed P            Z        2-Tailed P
      17.0         188.0      .0000            -4.5888        .0000
```

Mann-Whitney U - Wilcoxon Rank Sum W Test

```
    RESP      RESPONSES
by  REP

    Mean Rank    Cases

      10.28        18   CRI = 2  THREE Criterion
      26.72        18   CRI = 3  SIX Criterion
                   --
                   36   Total

                              Exact                Corrected for ties
        U            W      2-Tailed P            Z        2-Tailed P
      14.0         185.0      .0000            -4.6840        .0000
```

Appendix V (cont'd)

Experiment 5

Backward Chaining

Kruskal-Wallis 1-Way Anova

RESP RESPONSES
by REP

Mean Rank	Cases		
13.25	18	CRI = 1	ONE Criterion
24.33	18	CRI = 2	THREE Criterion
44.92	18	CRI = 3	SIX Criterion
	54	Total	

Cases	Chi-Square	Significance	Corrected for ties Chi-Square	Corrected for ties Significance
54	37.5585	.0000	37.5972	.0000

Mann-Whitney U - Wilcoxon Rank Sum W Test

RESP RESPONSES
by REP

Mean Rank	Cases		
13.25	18	CRI = 1	ONE Criterion
23.75	18	CRI = 2	THREE Criterion
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
67.5	238.5	.0021	-2.9908	.0028

Appendix V (cont'd)

Experiment 5

Backward Chaining

Mann-Whitney U - Wilcoxon Rank Sum W Test

RESP RESPONSES
by REP

Mean Rank	Cases	
9.50	18	CRI = 1 ONE Criterion
27.50	18	CRI = 3 SIX Criterion
	36	Total

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
.0	171.0	.0000	-5.1327	.0000

Mann-Whitney U - Wilcoxon Rank Sum W Test

RESP RESPONSES
by REP

Mean Rank	Cases	
10.08	18	CRI = 2 THREE Criterion
26.92	18	CRi = 3 SIX Criterion
	36	Total

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
10.5	181.5	.0000	-4.8010	.0000

Appendix V (cont'd)

Experiment 5

Random Chaining

Kruskal-Wallis 1-Way Anova

RESP RESPONSES
by REP

Mean Rank	Cases		
13.53	18	CRI = 1	ONE Criterion
25.31	18	CRI = 2	THREE Criterion
43.67	18	CRI = 3	SIX Criterion
	--		
	54	Total	

Cases	Chi-Square	Significance	Corrected for ties Chi-Square	Corrected for ties Significance
54	33.5563	.0000	33.5640	.0000

Mann-Whitney U - Wilcoxon Rank Sum W Test

RESP RESPONSES
by REP

Mean Rank	Cases		
13.47	18	CRI = 1	ONE Criterion
23.53	18	CRI = 2	THREE Criterion
	--		
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
71.5	242.5	.0033	-2.8640	.0042

Appendix V (cont'd)

Experiment 5

Random Chaining

Mann-Whitney U - Wilcoxon Rank Sum W Test

RESP RESPONSES
by REP

Mean Rank	Cases	
9.56	18	CRI = 1 ONE Criterion
27.44	18	CRI = 3 SIX Criterion
	36	Total

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
1.0	172.0	.0000	-5.0945	.0000

Mann-Whitney U - Wilcoxon Rank Sum W Test

RESP RESPONSES
by REP

Mean Rank	Cases	
11.28	18	CRI = 2 THREE Criterion
25.72	18	CRI = 3 SIX Criterion
	36	Total

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
32.0	203.0	.0000	-4.1143	.0000

Appendix V

Experiment 5

Whole Task Training

Kruskal-Wallis 1-Way Anova

RESP RESPONSES
by REP

Mean Rank	Cases		
24.36	18	REP = 1	ONE REPETITION
27.86	18	REP = 2	THREE REPETITIONS
30.28	18	REP = 3	SIX REPETITION
	--		
	54	Total	

Cases	Chi-Square	Significance	Corrected for ties Chi-Square	Corrected for ties Significance
54	1.2872	.5254	1.2875	.5253

Mann-Whitney U - Wilcoxon Rank Sum W Test

RESP RESPONSES
by REP

Mean Rank	Cases		
17.14	18	REP = 1	ONE REPETITION
19.86	18	REP = 2	THREE REPETITIONS
	--		
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
137.5	308.5	.4430	-.7753	.4381

Appendix V

Experiment 5

Whole Task Training

Mann-Whitney U - Wilcoxon Rank Sum W Test

RESP RESPONSES
by REP

Mean Rank	Cases		
16.72	18	REP = 1	ONE REPETITION
20.28	18	REP = 3	SIX REPETITION
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
130.0	301.0	.3231	-1.0126	.3112

Mann-Whitney U - Wilcoxon Rank Sum W Test

RESP RESPONSES
by REP

Mean Rank	Cases		
17.50	18	REP = 2	THREE REPETITIONS
19.50	18	REP = 3	SIX REPETITION
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
144.0	315.0	.5841	-.5696	.5689

Appendix V (cont'd)

Experiment 5

Criterion = 1

Friedman Two-Way Anova

Mean Rank	Variable	
1.94	TIME1	TIME - FORWARD CHAINING
3.11	TIME2	TIME - BACKWARD CHAINING
2.89	TIME3	TIME - RANDOM CHAINING
2.06	TIME4	TIME - WHOLE TASK TRAINING

Cases	Chi-Square	D.F.	Significance
18	11.1333	3	.0110

Wilcoxon Matched-Pairs Signed-Ranks Test

TIME1 TIME - FORWARD CHAINING
with TIME2 TIME - BACKWARD CHAINING

Mean Rank	Cases	
8.67	3	- Ranks (TIME2 LT TIME1)
9.67	15	+ Ranks (TIME2 GT TIME1)
	0	Ties (TIME2 EQ TIME1)
	18	Total

Z = -2.5912 2-Tailed P = .0096

Appendix V (cont'd)

Experiment 5

Criterion = 1

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TIME1      TIME - FORWARD CHAINING
with TIME3      TIME - RANDOM CHAINING

     Mean Rank    Cases

        9.25          4   - Ranks  (TIME3 LT TIME1)
        9.57         14   + Ranks  (TIME3 GT TIME1)
                      0     Ties   (TIME3 EQ TIME1)
                     --
                     18     Total

        Z =    -2.1122              2-Tailed P =   .0347
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TIME1      TIME - FORWARD CHAINING
with TIME4      TIME - WHOLE TASK TRAINING

     Mean Rank    Cases

        6.90         10   - Ranks  (TIME4 LT TIME1)
       12.75          8   + Ranks  (TIME4 GT TIME1)
                      0     Ties   (TIME4 EQ TIME1)
                     --
                     18     Total

        Z =     -.7186              2-Tailed P =   .4724
```

Appendix V (cont'd)

Experiment 5

Criterion = 1

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TIME2      TIME - BACKWARD CHAINING
with TIME3      TIME - RANDOM CHAINING

     Mean Rank     Cases

       7.73          11   - Ranks  (TIME3 LT TIME2)
      12.29           7   + Ranks  (TIME3 GT TIME2)
                      0     Ties   (TIME3 EQ TIME2)
                     --
                     18     Total

       Z =    -.0218              2-Tailed P =  .9826
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TIME2      TIME - BACKWARD CHAINING
with TIME4      TIME - WHOLE TASK TRAINING

     Mean Rank     Cases

       8.42          12   - Ranks  (TIME4 LT TIME2)
      11.67           6   + Ranks  (TIME4 GT TIME2)
                      0     Ties   (TIME4 EQ TIME2)
                     --
                     18     Total

       Z =    -.6750              2-Tailed P =  .4997
```

Appendix V (cont'd)

Experiment 5

Criterion = 1

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TIME3      TIME - RANDOM CHAINING
with TIME4      TIME - WHOLE TASK TRAINING

     Mean Rank    Cases

         8.08        13  - Ranks (TIME4 LT TIME3)
        13.20         5  + Ranks (TIME4 GT TIME3)
                      0    Ties  (TIME4 EQ TIME3)
                     --
                     18    Total

        Z =     -.8492             2-Tailed P =  .3958
```

Appendix V (cont'd)

Experiment 5

Criterion = 3

Friedman Two-Way Anova

Mean Rank	Variable	
2.61	TIME1	TIME - FORWARD CHAINING
2.97	TIME2	TIME - BACKWARD CHAINING
2.89	TIME3	TIME - RANDOM CHAINING
1.53	TIME4	TIME - WHOLE TASK TRAINING

Cases	Chi-Square	D.F.	Significance
18	14.3833	3	.0024

Wilcoxon Matched-Pairs Signed-Ranks Test

TIME1 TIME - FORWARD CHAINING
with TIME2 TIME - BACKWARD CHAINING

Mean Rank	Cases	
6.64	7	- Ranks (TIME2 LT TIME1)
11.32	11	+ Ranks (TIME2 GT TIME1)
	0	Ties (TIME2 EQ TIME1)
	18	Total

Z = -1.6985 2-Tailed P = .0894

Appendix V (cont'd)

Experiment 5

Criterion = 3

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TIME1      TIME - FORWARD CHAINING
with TIME3      TIME - RANDOM CHAINING

     Mean Rank    Cases

        6.75          8   - Ranks (TIME3 LT TIME1)
       11.70         10   + Ranks (TIME3 GT TIME1)
                      0     Ties  (TIME3 EQ TIME1)
                     --
                     18     Total

       Z =    -1.3718             2-Tailed P =   .1701
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TIME1      TIME - FORWARD CHAINING
with TIME4      TIME - WHOLE TASK TRAINING

     Mean Rank    Cases

       10.71         14   - Ranks (TIME4 LT TIME1)
        5.25          4   + Ranks (TIME4 GT TIME1)
                      0     Ties  (TIME4 EQ TIME1)
                     --
                     18     Total

       Z =    -2.8090             2-Tailed P =   .0050
```

Appendix V (cont'd)

Experiment 5

Criterion = 3

Wilcoxon Matched-Pairs Signed-Ranks Test

	TIME2	TIME - BACKWARD CHAINING
with	TIME3	TIME - RANDOM CHAINING

Mean Rank	Cases		
9.80	10	- Ranks	(TIME3 LT TIME2)
9.13	8	+ Ranks	(TIME3 GT TIME2)
	0	Ties	(TIME3 EQ TIME2)
	18	Total	

Z = -.5444 2-Tailed P = .58629

Wilcoxon Matched-Pairs Signed-Ranks Test

	TIME2	TIME - BACKWARD CHAINING
with	TIME4	TIME - WHOLE TASK TRAINING

Mean Rank	Cases		
9.93	14	- Ranks	(TIME4 LT TIME2)
4.67	3	+ Ranks	(TIME4 GT TIME2)
	1	Ties	(TIME4 EQ TIME2)
	18	Total	

Z = -2.9586 2-Tailed P = .0031

Appendix V (cont'd)

Experiment 5

Criterion = 3

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TIME3      TIME - RANDOM CHAINING
with TIME4      TIME - WHOLE TASK TRAINING

     Mean Rank    Cases

          9.63       16   - Ranks (TIME4 LT TIME3)
          8.50        2   + Ranks (TIME4 GT TIME3)
                      0     Ties  (TIME4 EQ TIME3)
                     --
                     18     Total

       Z =    -2.9832               2-Tailed P =  .0029
```

Appendix V (cont'd)

Criterion - 6

Experiment 5

Friedman Two-Way Anova

Mean Rank	Variable	
2.11	TIME1	TIME - FORWARD CHAINING
2.89	TIME2	TIME - BACKWARD CHAINING
3.39	TIME3	TIME - RANDOM CHAINING
1.61	TIME4	TIME - WHOLE TASK TRAINING

Cases	Chi-Square	D.F.	Significance
18	20.3333	3	.0001

Wilcoxon Matched-Pairs Signed-Ranks Test

TIME1 TIME - FORWARD CHAINING
with TIME2 TIME - BACKWARD CHAINING

Mean Rank	Cases		
6.40	5	- Ranks	(TIME2 LT TIME1)
10.69	13	+ Ranks	(TIME2 GT TIME1)
	0	Ties	(TIME2 EQ TIME1)
	18	Total	

Z = -2.3299 2-Tailed P = .0198

Appendix V (cont'd)

Criterion = 6

Experiment 5

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TIME1      TIME - FORWARD CHAINING
with TIME3      TIME - RANDOM CHAINING

     Mean Rank     Cases

        3.00          2   - Ranks  (TIME3 LT TIME1)
       10.31         16   + Ranks  (TIME3 GT TIME1)
                      0     Ties   (TIME3 EQ TIME1)
                     --
                     18     Total

        Z =    -3.4623               2-Tailed P =   .0005
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TIME1      TIME - FORWARD CHAINING
with TIME4      TIME - WHOLE TASK TRAINING

     Mean Rank     Cases

       10.85         13   - Ranks  (TIME4 LT TIME1)
        6.00          5   + Ranks  (TIME4 GT TIME1)
                      0     Ties   (TIME4 EQ TIME1)
                     --
                     18     Total

        Z =    -2.4170               2-Tailed P =   .0156
```

Appendix V (cont'd)

Criterion = 6

Experiment 5

```
        Wilcoxon Matched-Pairs Signed-Ranks Test

     TIME2      TIME - BACKWARD CHAINING
with TIME3      TIME - RANDOM CHAINING

     Mean Rank    Cases

        5.67          6  - Ranks  (TIME3 LT TIME2)
       11.42         12  + Ranks  (TIME3 GT TIME2)
                      0    Ties   (TIME3 EQ TIME2)
                     --
                     18    Total

        Z =    -2.2428              2-Tailed P =   .0249


        Wilcoxon Matched-Pairs Signed-Ranks Test

     TIME2      TIME - BACKWARD CHAINING
with TIME4      TIME - WHOLE TASK TRAINING

     Mean Rank    Cases

        9.60         15  - Ranks  (TIME4 LT TIME2)
        9.00  [illegible]  + Ranks  (TIME4 GT TIME2)
              [illegible]    Ties   (TIME4 EQ TIME2)

              [illegible]    Total

        Z =    -[illegible]         2-Tailed P =   .0108
```

Appendix V (cont'd)

Criterion = 6

Experiment 5

Wilcoxon Matched-Pairs Signed-Ranks Test

	TIME3	TIME - RANDOM CHAINING
with	TIME4	TIME - WHOLE TASK TRAINING

Mean Rank	Cases		
9.93	15	- Ranks	(TIME4 LT TIME3)
7.33	3	+ Ranks	(TIME4 GT TIME3)
	0	Ties	(TIME4 EQ TIME3)
	18	Total	

Z = -2.7654 2-Tailed P = .0057

Appendix V (cont'd)

Experiment 5

Forward Chaining

Kruskal-Wallis 1-Way Anova

TIME TIME
by REP

Mean Rank	Cases		
12.17	18	CRI = 1	ONE Criterion
25.78	18	CRI = 2	THREE Criterion
44.56	18	CRI = 3	SIX Criterion
	54	Total	

			Corrected for ties	
Cases	Chi-Square	Significance	Chi-Square	Significance
54	38.4704	.0000	38.4763	.0000

Mann-Whitney U - Wilcoxon Rank Sum W Test

TIME TIME
by REP

Mean Rank	Cases		
11.33	18	CRI = 1	ONE Criterion
25.67	18	CRI = 2	THREE Criterion
	36	Total	

		Exact	Corrected for ties	
U	W	2-Tailed P	Z	2-Tailed P
33.0	204.0	.0000	-4.0822	.0000

Appendix V (cont'd)

Experiment 5

Forward Chaining

Mann-Whitney U - Wilcoxon Rank Sum W Test

```
    TIME       TIME
by  REP

    Mean Rank      Cases

        10.33         18  CRI = 1  ONE Criterion
        26.67         18  CRI = 3  SIX Criterion
                      --
                      36  Total

                                   Exact                   Corrected for ties
          U              W       2-Tailed P                Z          2-Tailed P
        15.0           186.0       .0000               -4.6518          .0000
```

Mann-Whitney U - Wilcoxon Rank Sum W Test

```
    TIME       TIME
by  REP

    Mean Rank      Cases

         9.61         18  CRI = 2  THREE Criterion
        27.39         18  CRI = 3  SIX Criterion
                      --
                      36  Total

                                   Exact                   Corrected for ties
          U              W       2-Tailed P                Z          2-Tailed P
         2.0           173.0       .0000               -5.0628          .0000
```

Appendix V (cont'd)

Experiment 5

Backward Chaining

Kruskal-Wallis 1-Way Anova

TIME TIME
by REP

Mean Rank	Cases		
12.56	18	CRI = 1	ONE Criterion
25.44	18	CRI = 2	THREE Criterion
44.50	18	CRI = 3	SIX Criterion
	54	Total	

			Corrected for ties	
Cases	Chi-Square	Significance	Chi-Square	Significance
54	37.5681	.0000	37.5709	.0000

Mann-Whitney U - Wilcoxon Rank Sum W Test

TIME TIME
by REP

Mean Rank	Cases		
12.39	18	CRI = 1	ONE Criterion
24.61	18	CRI = 2	THREE Criterion
	36	Total	

		Exact	Corrected for ties	
U	W	2-Tailed P	Z	2-Tailed P
52.0	223.0	.0003	-3.4807	.0005

Appendix V (cont'd)

Experiment 5

Backward Chaining

Mann-Whitney U - Wilcoxon Rank Sum W Test

TIME TIME
by REP

Mean Rank	Cases		
9.67	18	CRI = 1	ONE Criterion
27.33	18	CRI = 3	SIX Criterion
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
3.0	174.0	.0000	-5.0309	.0000

Mann-Whitney U - Wilcoxon Rank Sum W Test

TIME TIME
by REP

Mean Rank	Cases		
10.33	18	CRI = 2	THREE Criterion
26.67	18	CRI = 3	SIX Criterion
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	Corrected for ties 2-Tailed P
15.0	186.0	.0000	-4.6512	.0000

Appendix V (cont'd)

Experiment 5

Random Chaining

Kruskal-Wallis 1-Way Anova

TIME TIME
by REP

Mean Rank	Cases		
14.25	18	CRI = 1	ONE Criterion
25.14	18	CRI = 2	THREE Criterion
43.11	18	CRI = 3	SIX Criterion
	--		
	54	Total	

			Corrected for ties	
Cases	Chi-Square	Significance	Chi-Square	Significance
54	30.8977	.0000	30.9001	.0000

Mann-Whitney U - Wilcoxon Rank Sum W Test

TIME TIME
by REP

Mean Rank	Cases		
14.08	18	CRI = 1	ONE Crterion
22.92	18	CRI = 2	THREE Criterion
	--		
	36	Total	

		Exact	Corrected for ties	
U	W	2-Tailed P	Z	2-Tailed P
82.5	253.5	.0106	-2.5154	.0119

Appendix V (cont'd)

Experiment 5

Random Chaining

Mann-Whitney U - Wilcoxon Rank Sum W Test

TIME by REP TIME

Mean Rank	Cases		
9.67	18	CRI = 1	ONE Criterion
27.33	18	CRI = 3	SIX CriterionN
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	2-Tailed P
3.0	174.0	.0000	-5.0309	.0000

Mann-Whitney U - Wilcoxon Rank Sum W Test

TIME by REP TIME

Mean Rank	Cases		
11.72	18	CRI = 2	THREE Criterion
25.28	18	Cri = 3	SIX Criterion
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	2-Tailed P
40.0	211.0	.0000	-3.8602	.0001

Appendix V

Experiment 5

Whole Task Training

Kruskal-Wallis 1-Way Anova

```
    TIME       TIME
by  REP

    Mean Rank    Cases

       26.58       18    REP = 1   ONE REPETITION
       26.47       18    REP = 2   THREE REPETITIONS
       29.44       18    REP = 3   SIX REPETITION
                   --
                   54    Total

                                                 Corrected for ties
       Cases     Chi-Square  Significance    Chi-Square  Significance
          54         .4129         .8135         .4130         .8134
```

Mann-Whitney U - Wilcoxon Rank Sum W Test

```
    TIME       TIME
by  REP

    Mean Rank    Cases

       18.44       18   REP = 1   ONE REPETITION
       18.56       18   REP = 2   THREE REPETITIONS
                   --
                   36   Total

                               Exact                  Corrected for ties
          U            W    2-Tailed P                  Z      2-Tailed P
      161.0        332.0       .9876               -.0316           .9748
```

Appendix V

Experiment 5

Whole Task Training

Mann-Whitney U - Wilcoxon Rank Sum W Test

TIME TIME
by REP

Mean Rank	Cases		
17.64	18	REP = 1	ONE REPETITION
19.36	18	REP = 3	SIX REPETITION
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	2-Tailed P
146.5	317.5	.6279	-.4905	.6238

Mann-Whitney U - Wilcoxon Rank Sum W Test

TIME TIME
by REP

Mean Rank	Cases		
17.42	18	REP = 2	THREE REPETITIONS
19.58	18	REP = 3	SIX REPETITION
	36	Total	

U	W	Exact 2-Tailed P	Corrected for ties Z	2-Tailed P
142.5	313.5	.5418	-.6170	.5372

Appendix W

Experiment 5

Post Experiment Questionnaire Data

The following section summarizes the answers to the questions asked each subject after performing the four sequences.

Question 1: Subjects were requested to draw the symbols and numbers in the order that the buttons were pushed. Results were as follows:

i)For criterion of one to teach a new subsequence, twelve subjects drew the order correctly (four backward, three forward, two random and three whole), three drew six correctly (two backward, one random), one drew five correctly (random), two drew three correctly (forward). For criterion of three to teach a new subsequence, twelve drew the order correctly (four forward, three backward, three random and two whole) one drew six correctly (backward), two drew five correctly (random), one drew three (whole) and two drew none correctly (backward). For criterion of six to teach a new subsequence, sixteen drew the order correctly (four forward, six backward, three random, three whole), two drew six correctly (random). Subjects were divided into groups according to which criteria the last sequence was taught. There was no significant differences in the accuracy of order recall among the three groups ($F(2,51) = .3365$, $p = .7169$). Subjects were divided into groups according to the training procedure by which the last sequence was taught. There was no significant differences in the accuracy of order recall among the three groups ($F(3,50) = .7081$, $p = 0.5517$).

ii)For criterion of one to teach a new subsequence, eleven subjects drew the symbols in the correct button (two forward, four backward, three random, two whole) three drew six (one backward, one random, one whole) one drew five (backward), one drew three (forward) and one drew two (random) and one drew none. For criterion of three to teach a new subsequence, twelve drew eight correctly (one forward, four backward, five random, and two whole), four drew six correctly (three forward and one whole), one drew two (backward) and one drew zero correctly (backward). For criterion of six to teach a new subsequence, twelve drew eight correctly (one forward, five backward, five random, and one whole), one drew six (forward), one drew five (backward), one drew four (forward), one drew three (forward), one drew two (whole) and one drew one (backward). Subjects were divided into groups according to the training procedure by which the last sequence was taught. No significant differences were found for symbol recall between groups ($F(2,51)=.3056$, $p=.7380$).

Question 2: Subjects were asked to identify any differences between the four training methods. Results were as follows:

a) Thirty-three subjects reported they noticed a type of chaining technique versus some type of whole task training technique and twenty-one subjects reported they did not. For the group using a criterion of one to teach a new subsequence, ten reported a difference and eight did not; for criterion of twelve to teach a new subsequence, twelve reported a difference and six did not; for criterion of six to teach a new subsequence, eleven reported they observed a difference and seven subjects reported they did not. Subjects were divided into two groups to determine whether awareness of procedure type affected performance. The dependent variable of true errors was used. Nonparametric statistics were used, because the homogeneity of variance assumption was invalidated (Bartlett Box $F = 44.016$, $p = 0.000$). According to the Mann -Whitney U test, there were no significant differences between groups ($z = 01.6042$, $p = .1087$).

b) Fifteen subjects reported they had noticed a difference in order in the chaining techniques of forward, backward and random. Thirteen subjects reported they noticed a random order but not a backward order and two reported they noticed a backward order but not random, one noticed a little difference and three noticed the order changed and twenty did reported they had not noticed any difference. For the group with a criterion to teach a new subsequence of one, seven reported a difference in order, three reported a backward order but not a random order, three reported a random order but not a backward order and five reported no difference in order. For the group with a criterion to teach a new subsequence of three, six reported they observed the differences in order, one reported a backward order, three reported a random order but not a backward order and seven did not not report a difference in order and one reported an awareness of differences in order. For the group with a criterion to teach a new subsequence of six, six reported differences in order, six reported random order not backward order and six did not report a difference in order. For true errors, when subjects were divided into groups as determined by awareness of order, no significant differences were determined ($F = 1.6468$, $= 0.2008$). No significant differences were determined for awareness of random order ($F = 0.3198$, $p = 0.5733$) or backward order ($F = 0.4003$, $p = 0.5288$).

Question 3: Subjects were asked whether they had used the percent score listed on the screen. Thirty-nine subjects indicated they had used percent scores, five indicated they used them a little, one used it for the last sequence, one used it for the first sequence and eight did not use them.

Question 4: Subjects were asked whether they found the task boring or reasonably interesting. Forty-six subjects reported they found it reasonably interesting, six found it boring(all six were in the group useing a criterion of six repetitions)ng , one found it reasonably interesting then boring at the end and one found it frustrating.

Question 5: In reference to what strategy subjects used to learn the task, thirteen used a combination, nineteen used keys and symbols, thirteen used keys only, six used fingers and symbol, one used fingers only, one used a guitar association and one used musical associations. For subjects in the group using a criterion of one to teach a new subsequence, six used a combination, three used keys and symbols, five used keys, two used fingers and symbols, one used fingers and one used a guitar association. For subjects in the group using a criterion of three to teach a new subsequence, four used a combination, nine used keys and symbols, three used keys and two used fingers and symbols. For subjects in the groups using a criterion of six to teach a new subsequence, three used a combination, seven used keys and symbols five used keys and two used fingers and symbols and one used music association.

Question 6: None of the subjects indicated they assigned letters or numbers to the keys to help them remember them

Question 7: Subjects were asked to rank order the training methods as most comfortable and easy. (In the following, repetition refers to using a chaining method). The results were:

For most comfortable for criterion to teach a new subsequence of one; ten said forward, four said backward and two said random and two said whole task.

For second most comfortable; five said forward, five said backward four said whole task and two said random and two said chaining method.

For third most comfortable, five said forward chaining, eight said backward chaining, two said whole task training, one random chaining and two said chaining method.

For least comfortable, none said forward chaining, two said said backward chaining, eight said whole task training and six said random chaining and two said none.

For most comfortable for criterion to teach a new sequence of three; six said forward, six said backward and four said whole task training and two said random.

For second most comfortable, five said forward, five said backward, six said whole task and one said random and one said chaining method.

For third most comfortable, two said forward, six said backward three said whole and seven said random.

For least comfortable, three said forward, one said backward five said whole and eight said random and one said chaining method.

For most comfortable for criterion of six to teach a new subsequence; eight said forward, four said backward, two said whole task, two said random, and two did not know.

For second most comfortable, four said forward, seven said backward, three said whole, and two said random and two said none.

For third most comfortable, two said forward, three said backward, one said whole task and nine said random and three said none.

For least comfortable, one said forward, three said backward, twelve said whole, and one said random and one did not know.

Question 8: Subjects were asked to rank order which training method they did best on. Results were as follows:

For best criterion to teach a new subsequence of one, eleven said forward, one said backward, four reported whole, and two reported random chaining.

For second best, ten reported forward, one reported backward chaining, five reported whole and two reported random.

For third best, four reported forward, eight reported backward, three reported whole and three reported random.

For least best, none reported forward chaining, six reported backward chaining, seven reported whole task training and five reported random chaining.

For best on criterion to teach a new subsequence of three; eleven reported forward, one reported backward, two reported random and three reported whole and one did not know.

For second best, eleven reported forward, none reported backward three reported whole and three reported random and one said none.

For third best, four reported forward, six reported backward, one reported whole and six reported random and reported chaining.

For least best, one reported forward, one reported backward twelve reported whole and three reported random and one reported backward.

For best on criterion to teach a new subsequence of six; nine reported forward, three reported backward, two reported whole and three reported random and one said chaining.

For second best, ten reported forward, two reported backward, two reported whole, three reported random and one reported chaining method.

For third best, five reported forward, three reported backward, one reported whole and eight reported random and one reported chaining.

For least best, none reported forward, one reported backward, thirteen reported whole and three reported random and one said chaining.

Only two individuals correctly predicted which training method they rank ordered as doing best, second best, etc.

Question 9 and 11, subjects thought too many repetitions seemed boring and others thought a "lot was a good idea".

Question 12: Subjects were asked what the criterion to teach a new subsequence was. The results were for the criterion to teach a new subsequence of one: four said one, three said two, three said two or three, three said two, two said no, one said one or two; and two said I do not know; for the criterion to teach a new subsequence of three: one said one, one said two or three, eight said three, three said no, one said three or four, and four said four; and for the criterion to teach a new subsequence of six: two said three, four said no three said four, one said four or five, and three said six, one said three, and one said two or three, and one said five to ten, and one said five, and one said greater than five.

Question 13: Subjects were asked what training method they liked best. Results were as follows: eight said forward chaining, five said backward chaining, seventeen said whole task training, seventeen said random chaining, one said forward or backward chaining, four did not know and two said chaining methods. For only twelve individuals, the training method they liked best was what they did best on.

Question 16: Subjects were asked which was the optimum criterion used to teach a new subsequence. The results are as follows: (1) For criterion to teach a new subsequence of one, one subject indicated the optimum criterion was one, five indicated three, six indicated three or six and six indicated five. (2) For criterion to teach a new subsequence of three, two subjects indicated the criterion was one, twelve indicated three and three indicated six, and one indicated a one for himself and six for others. (3) For criterion to teach a new subsequence of six; ten indicated three, one indicated three and seven indicated six. For all groups, half (28) indicated that three was the optimum number and fourteen indicated six was an optimum number and seven indicated three or six was optimum. Only three individuals indicated that one was an optimum number.

Appendix X

Experiment 6

Bartlett-Box F Test of Homogeneity of Variance

Comparison of Forward Chaining, Backward Chaining, Random Chaining, Random-2 Chaining, Random-3 Chaining and Whole Task Training

Dependent Variables	Bartlett-Box F	Probability
True Errors	31.937	.000
Random Errors	3.407	.005
Total Errors	25.234	.000
Total Responses	12.610	.000
Time (in seconds)	11.542	.000

Appendix Y
Experiment 6
Means, Medians and Standard Deviations

Legend

FC - Forward Chaining

BC - Backward Chaining

RC - Random Chaining

R2C - Random-2 Chaining

R3C - Random-3 Chaining

WT - Whole Task Training

Appendix Y
(continued)
Experiment 6

Dependent Variable - True Errors

Procedure	Mean	Median	Standard Deviation
FC	1.3	0.0	2.5
BC	1.4	0.0	3.3
RC	3.5	2.0	4.5
R2C	2.5	1.0	3.3
R3C	10.0	6.0	10.9
WT	22.0	10.5	25.2

Dependent Variable - Random Errors

Procedure	Mean	Median	Standard Deviation
FC	12.7	12.5	4.7
BC	15.5	15.0	3.9
RC	15.3	16.0	5.4
R2C	14.7	15.0	3.7
R3C	16.0	15.0	3.4
WT	17.4	15.0	7.4

Dependent Variable - Total Errors

Procedure	Mean	Median	Standard Deviation
FC	13.6	14.0	4.7
BC	16.9	15.5	5.3
RC	18.8	19.5	6.3
R2C	17.1	17.5	3.9
R3C	26.0	21.0	11.5
WT	39.4	29.0	29.1

Appendix Y
(continued)
Experiment 6

Dependent Variable -Total Responses

Procedure	Mean	Median	Standard Deviation
FC	150.8	143.0	22.3
BC	151.4	147.5	16.9
RC	161.8	158.5	22.1
R2C	158.9	154.5	16.4
R3C	180.6	155.0	58.0
WT	109.0	84.0	56.0

Dependent Variable -Time in seconds

FC	275.7	262.0	42.7
BC	292.7	287.5	38.3
RC	324.2	293.5	70.6
R2C	331.1	327.5	33.7
R3C	406.0	351.5	122.3
WT	192.4	152	119.5

Appendix Z

Nonparametric Statistics

Experiment 6

Friedman Two-Way Anova

Mean Rank	Variable	
2.27	TRUERR1	TRUE ERRORS - FORWARD CHAINING
2.20	TRUERR2	TRUE ERRORS - BACKWARD CHAINING
3.45	TRUERR3	TRUE ERRORS - RANDOM CHAINING
3.25	TRUERR4	TRUE ERRORS - RANDOM-2 CHAINING
4.65	TRUERR5	TRUE ERRORS - RANDOM-3 CHAINING
5.17	TRUERR6	TRUE ERRORS - WHOLE TASK TRAINING

Cases	Chi-Square	D.F.	Significance
20	42.1928	5	.0000

Wilcoxon Matched-Pairs Signed-Ranks Test

TRUERR1 TRUE ERRORS - FORWARD CHAINING
with TRUERR2 TRUE ERRORS - BACKWARD CHAINING

Mean Rank	Cases	
7.92	6	- Ranks (TRUERR2 LT TRUERR1)
7.19	8	+ Ranks (TRUERR2 GT TRUERR1)
	6	Ties (TRUERR2 EQ TRUERR1)
	20	Total

Z = -.3139 2-Tailed P = .7536

Appendix 2 (cont'd)

Experiment 6

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TRUERR1   TRUE ERRORS - FORWARD CHAINING
with TRUERR3   TRUE ERRORS - RANDOM CHAINING

     Mean Rank    Cases

        6.50          5  - Ranks (TRUERR3 LT TRUERR1)
        9.41         11  + Ranks (TRUERR3 GT TRUERR1)
                      4    Ties  (TRUERR3 EQ TRUERR1)
                     --
                     20    Total

        Z =   -1.8357             2-Tailed P =  .0664
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TRUERR1   TRUE ERRORS - FORWARD CHAINING
with TRUERR4   TRUE ERRORS - RANDOM-2 CHAINING

     Mean Rank    Cases

        9.00          4  - Ranks (TRUERR4 LT TRUERR1)
        7.64         11  + Ranks (TRUERR4 GT TRUERR1)
                      5    Ties  (TRUERR4 EQ TRUERR1)
                     --
                     20    Total

        Z =   -1.3631             2-Tailed P =  .1728
```

Experiment 6

Wilcoxon Matched-Pairs Signed-Ranks Test

TRUERR1 TRUE ERRORS - FORWARD CHAINING
with TRUERR5 TRUE ERRORS - RANDOM-3 CHAINING

Mean Rank	Cases		
6.50	1	- Ranks	(TRUERR5 LT TRUERR1)
9.68	17	+ Ranks	(TRUERR5 GT TRUERR1)
	2	Ties	(TRUERR5 EQ TRUERR1)
	20	Total	

Z = -3.4405 2-Tailed P = .0006

Wilcoxon Matched-Pairs Signed-Ranks Test

TRUERR1 TRUE ERRORS - FORWARD CHAINING
with TRUERR6 TRUE ERRORS - WHOLE TASK TRAINING

Mean Rank	Cases		
.00	0	- Ranks	(TRUERR6 LT TRUERR1)
9.50	18	+ Ranks	(TRUERR6 GT TRUERR1)
	2	Ties	(TRUERR6 EQ TRUERR1)
	20	Total	

Z = -3.7236 2-Tailed P = .0002

Experiment 6

Wilcoxon Matched-Pairs Signed-Ranks Test

TRUERR2 TRUE ERRORS - BACKWARD CHAINING
with TRUERR3 TRUE ERRORS - RANDOM CHAINING

Mean Rank	Cases		
8.75	2	- Ranks	(TRUERR3 LT TRUERR2)
6.68	11	+ Ranks	(TRUERR3 GT TRUERR2)
	7	Ties	(TRUERR3 EQ TRUERR2)
	20	Total	

Z = -1.9568   2-Tailed P = .0504

Wilcoxon Matched-Pairs Signed-Ranks Test

TRUERR2 TRUE ERRORS - BACKWARD CHAINING
with TRUERR4 TRUE ERRORS - RANDOM-2 CHAINING

Mean Rank	Cases		
9.00	2	- Ranks	(TRUERR4 LT TRUERR2)
7.25	12	+ Ranks	(TRUERR4 GT TRUERR2)
	6	Ties	(TRUERR4 EQ TRUERR2)
	20	Total	

Z = -2.1658   2-Tailed P = .0303

Appendix 2 (cont'd)

Experiment 6

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TRUERR2   TRUE ERRORS - BACKWARD CHAINING
with TRUERR5   TRUE ERRORS - RANDOM-3 CHAINING

     Mean Rank    Cases

           .00        0   - Ranks  (TRUERR5 LT TRUERR2)
          9.00       17   + Ranks  (TRUERR5 GT TRUERR2)
                      3     Ties   (TRUERR5 EQ TRUERR2)
                     --
                     20     Total

        Z =    -3.6214              2-Tailed P =  .0003
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TRUERR2   TRUE ERRORS - BACKWARD CHAINING
with TRUERR6   TRUE ERRORS - WHOLE TASK TRAINING

     Mean Rank    Cases

          1.50        1   - Ranks  (TRUERR6 LT TRUERR2)
         10.97       19   + Ranks  (TRUERR6 GT TRUERR2)
                      0     Ties   (TRUERR6 EQ TRUERR2)
                     --
                     20     Total

        Z =    -3.8639              2-Tailed P =  .0001
```

Experiment 6

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TRUERR3   TRUE ERRORS - RANDOM CHAINING
with TRUERR4   TRUE ERRORS - RANDOM-2 CHAINING

     Mean Rank     Cases

        9.85          10   - Ranks (TRUERR4 LT TRUERR3)
        7.79           7   + Ranks (TRUERR4 GT TRUERR3)
                       3     Ties  (TRUERR4 EQ TRUERR3)
                      --
                      20     Total

        Z =    -1.0414               2-Tailed P =  .2977
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TRUERR3   TRUE ERRORS - RANDOM CHAINING
with TRUERR5   TRUE ERRORS - RANDOM-3 CHAINING

     Mean Rank     Cases

        4.90           5   - Ranks (TRUERR5 LT TRUERR3)
       11.27          13   + Ranks (TRUERR5 GT TRUERR3)
                       2     Ties  (TRUERR5 EQ TRUERR3)
                      --
                      20     Total

        Z =    -2.6566               2-Tailed P =  .0079
```

Appendix Z (cont'd)

Experiment 6

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TRUERR3    TRUE ERRORS - RANDOM CHAINING
with TRUERR6    TRUE ERRORS - WHOLE TASK TRAINING

     Mean Rank    Cases

        4.83          3   - Ranks  (TRUERR6 LT TRUERR3)
       10.43         15   + Ranks  (TRUERR6 GT TRUERR3)
                      2     Ties   (TRUERR6 EQ TRUERR3)
                     --
                     20     Total

        Z =    -3.0921              2-Tailed P =   .0020
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TRUERR4    TRUE ERRORS - RANDOM-2 CHAINING
with TRUERR5    TRUE ERRORS - RANDOM-3 CHAINING

     Mean Rank    Cases

        4.75          4   - Ranks  (TRUERR5 LT TRUERR4)
       10.86         14   + Ranks  (TRUERR5 GT TRUERR4)
                      2     Ties   (TRUERR5 EQ TRUERR4)
                     --
                     20     Total

        Z =    -2.8961              2-Tailed P =   .0038
```

Appendix 2 (cont'd)

Experiment 6

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TRUERR4   TRUE ERRORS - RANDOM-2 CHAINING
with TRUERR6   TRUE ERRORS - WHOLE TASK TRAINING

     Mean Rank    Cases

        4.33          3  - Ranks (TRUERR6 LT TRUERR4)
       11.59         17  + Ranks (TRUERR6 GT TRUERR4)
                      0    Ties  (TRUERR6 EQ TRUERR4)
                     --
                     20    Total

        Z =    -3.4346            2-Tailed P =   .0006
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TRUERR5   TRUE ERRORS - RANDOM-3 CHAINING
with TRUERR6   TRUE ERRORS - WHOLE TASK TRAINING

     Mean Rank    Cases

        7.07          7  - Ranks (TRUERR6 LT TRUERR5)
       11.71         12  + Ranks (TRUERR6 GT TRUERR5)
                      1    Ties  (TRUERR6 EQ TRUERR5)
                     --
                     20    Total

        Z =    -1.8310            2-Tailed P =   .0671
```

Appendix Z (cont'd)

Experiment 6

Friedman Two Way Anova

Mean Rank	Variable	
2.47	RANERR1	RANDOM ERRORS - FORWARD CHAINING
3.42	RANERR2	RANDOM ERRORS - BACKWARD CHAINING
3.85	RANERR3	RANDOM ERRORS - RANDOM CHAINING
3.27	RANERR4	RANDOM ERRORS - RANDOM-2 CHAINING
4.13	RANERR5	RANDOM ERRORS - RANDOM-3 CHAINING
3.85	RANERR6	RANDOM ERRORS - WHOLE TASK TRAINING

Cases	Chi-Square	D.F.	Significance
20	9.9571	5	.0765

Wilcoxon Matched-Pairs Signed-Ranks Test

RANERR1 RANDOM ERRORS - FORWARD CHAINING
with RANERR2 RANDOM ERRORS - BACKWARD CHAINING

Mean Rank	Cases	
8.42	6	- Ranks (RANERR2 LT RANERR1)
11.39	14	+ Ranks (RANERR2 GT RANERR1)
	0	Ties (RANERR2 EQ RANERR1)
	20	Total

Z = -2.0346 2-Tailed P = .0419

Appendix 2 (cont'd)

Experiment 6

Wilcoxon Matched-Pairs Signed-Ranks Test

RANERR1 RANDOM ERRORS - FORWARD CHAINING
with RANERR3 RANDOM ERRORS - RANDOM CHAINING

Mean Rank	Cases		
7.36	7	- Ranks	(RANERR3 LT RANERR1)
11.54	12	+ Ranks	(RANERR3 GT RANERR1)
	1	Ties	(RANERR3 EQ RANERR1)
	20	Total	

Z = -1.7505 2-Tailed P = .0800

Wilcoxon Matched-Pairs Signed-Ranks Test

RANERR1 RANDOM ERRORS - FORWARD CHAINING
with RANERR4 RANDOM ERRORS - RANDOM-2 CHAINING

Mean Rank	Cases		
11.30	5	- Ranks	(RANERR4 LT RANERR1)
9.54	14	+ Ranks	(RANERR4 GT RANERR1)
	1	Ties	(RANERR4 EQ RANERR1)
	20	Total	

Z = -1.5493 2-Tailed P = .1213

Appendix Z (cont'd)

Experiment 6

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RANERR1    RANDOM ERRORS - FORWARD CHAINING
with RANERR5    RANDOM ERRORS - RANDOM-3 CHAINING

     Mean Rank     Cases

        7.17           3   - Ranks (RANERR5 LT RANERR1)
        9.39          14   + Ranks (RANERR5 GT RANERR1)
                       3     Ties  (RANERR5 EQ RANERR1)
                      --
                      20     Total

        Z =    -2.6036              2-Tailed P =   .0092
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RANERR1    RANDOM ERRORS - FORWARD CHAINING
with RANERR6    RANDOM ERRORS - WHOLE TASK TRAINING

     Mean Rank     Cases

        6.20           5   - Ranks (RANERR6 LT RANERR1)
       10.77          13   + Ranks (RANERR6 GT RANERR1)
                       2     Ties  (RANERR6 EQ RANERR1)
                      --
                      20     Total

        Z =    -2.3735              2-Tailed P =   .0176
```

Experiment 6

```
        Wilcoxon Matched-Pairs Signed-Ranks Test

     RANERR2    RANDOM ERRORS - BACKWARD CHAINING
with RANERR3    RANDOM ERRORS - RANDOM CHAINING

     Mean Rank     Cases

       11.80          5   - Ranks (RANERR3 LT RANERR2)
        7.83         12   + Ranks (RANERR3 GT RANERR2)
                      3     Ties  (RANERR3 EQ RANERR2)
                     --
                     20     Total

       Z =      -.8284              2-Tailed P =   .4074
```

```
        Wilcoxon Matched-Pairs Signed-Ranks Test

     RANERR2    RANDOM ERRORS - BACKWARD CHAINING
with RANERR4    RANDOM ERRORS - RANDOM-2 CHAINING

     Mean Rank     Cases

        8.86         11   - Ranks (RANERR4 LT RANERR2)
       10.50          7   + Ranks (RANERR4 GT RANERR2)
                      2     Ties  (RANERR4 EQ RANERR2)
                     --
                     20     Total

       Z =      -.5226              2-Tailed P =   .6012
```

Appendix 2 (cont'd)

Experiment 6

```
          Wilcoxon Matched-Pairs Signed-Ranks Test

     RANERR2    RANDOM ERRORS - BACKWARD CHAINING
with RANERR5    RANDOM ERRORS - RANDOM-3 CHAINING

     Mean Rank    Cases

        12.00         7  - Ranks (RANERR5 LT RANERR2)
         8.83        12  + Ranks (RANERR5 GT RANERR2)
                      1    Ties  (RANERR5 EQ RANERR2)
                     --
                     20    Total

        Z =     -.4427             2-Tailed P =  .6580

          Wilcoxon Matched-Pairs Signed-Ranks Test

     RANERR2    RANDOM ERRORS - BACKWARD CHAINING
with RANERR6    RANDOM ERRORS - WHOLE TASK TRAINING

     Mean Rank    Cases

         9.69         8  - Ranks (RANERR6 LT RANERR2)
        10.23        11  + Ranks (RANERR6 GT RANERR2)
                      1    Ties  (RANERR6 EQ RANERR2)
                     --
                     20    Total

        Z =     -.7042             2-Tailed P =  .4813
```

Experiment 6

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RANERR3   RANDOM ERRORS - RANDOM CHAINING
with RANERR4   RANDOM ERRORS - RANDOM-2 CHAINING

   Mean Rank    Cases

      8.81         13  - Ranks (RANERR4 LT RANERR3)
     13.64          7  + Ranks (RANERR4 GT RANERR3)
                    0    Ties  (RANERR4 EQ RANERR3)
                   --
                   20    Total

      Z =     -.3547            2-Tailed P =   .7228
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RANERR3   RANDOM ERRORS - RANDOM CHAINING
with RANERR5   RANDOM ERRORS - RANDOM-3 CHAINING

   Mean Rank    Cases

      9.64          7  - Ranks (RANERR5 LT RANERR3)
      8.55         10  + Ranks (RANERR5 GT RANERR3)
                    3    Ties  (RANERR5 EQ RANERR3)
                   --
                   20    Total

      Z =     -.4260            2-Tailed P =   .6701
```

Appendix 2 (cont'd)

Experiment 6

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RANERR3    RANDOM ERRORS - RANDOM CHAINING
with RANERR6    RANDOM ERRORS - WHOLE TASK TRAINING

     Mean Rank      Cases

        8.67           9   - Ranks  (RANERR6 LT RANERR3)
       11.20          10   + Ranks  (RANERR6 GT RANERR3)
                       1     Ties   (RANERR6 EQ RANERR3)
                      --
                      20     Total

        Z =      -.6841            2-Tailed P =   .4939
```

0Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RANERR4    RANDOM ERRORS - RANDOM-2 CHAINING
with RANERR5    RANDOM ERRORS - RANDOM-3 CHAINING

     Mean Rank      Cases

        8.86           7   - Ranks  (RANERR5 LT RANERR4)
        9.91          11   + Ranks  (RANERR5 GT RANERR4)
                       2     Ties   (RANERR5 EQ RANERR4)
                      --
                      20     Total

        Z =     -1.0234            2-Tailed P =   .3061
```

Experiment 6

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RANERR4    RANDOM ERRORS - RANDOM-2 CHAINING
with RANERR6    RANDOM ERRORS - WHOLE TASK TRAINING

     Mean Rank    Cases

        9.44          8  - Ranks (RANERR6 LT RANERR4)
       11.21         12  + Ranks (RANERR6 GT RANERR4)
                      0    Ties  (RANERR6 EQ RANERR4)
                     --
                     20    Total

       Z =    -1.1013              2-Tailed P =  .2708
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RANERR5    RANDOM ERRORS - RANDOM-3 CHAINING
with RANERR6    RANDOM ERRORS - WHOLE TASK TRAINING

     Mean Rank    Cases

        9.14         11  - Ranks (RANERR6 LT RANERR5)
       12.17          9  + Ranks (RANERR6 GT RANERR5)
                      0    Ties  (RANERR6 EQ RANERR5)
                     --
                     20    Total

       Z =     -.1680              2-Tailed P =  .8666
```

Appendix 2 (cont'd)

Experiment 6

Friedman Two-Way Anova

Mean Rank	Variable	
2.02	TOTERR1	TOTAL ERRORS - FORWARD CHAINING
2.92	TOTERR2	TOTAL ERRORS - BACKWARD CHAINING
3.63	TOTERR3	TOTAL ERRORS - RANDOM CHAINING
3.10	TOTERR4	TOTAL ERRORS - RANDOM-2 CHAINING
4.55	TOTERR5	TOTAL ERRORS - RANDOM-3 CHAINING
4.77	TOTERR6	TOTAL ERRORS - WHOLE TASK TRAINING

Cases	Chi-Square	D.F.	Significance
20	30.9142	5	.0000

Wilcoxon Matched-Pairs Signed-Ranks Test

TOTERR1 TOTAL ERRORS - FORWARD CHAINING
with TOTERR2 TOTAL ERRORS - BACKWARD CHAINING

Mean Rank	Cases		
7.67	6	- Ranks	(TOTERR2 LT TOTERR1)
11.08	13	+ Ranks	(TOTERR2 GT TOTERR1)
	1	Ties	(TOTERR2 EQ TOTERR1)
	20	Total	

Z = -1.9719 2-Tailed P = .0486

Appendix Z (cont'd)

Experiment 6

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TOTERR1   TOTAL ERRORS - FORWARD CHAINING
with TOTERR3   TOTAL ERRORS - RANDOM CHAINING

    Mean Rank    Cases

       7.50         5  - Ranks (TOTERR3 LT TOTERR1)
      11.50        15  + Ranks (TOTERR3 GT TOTERR1)
                    0    Ties  (TOTERR3 EQ TOTERR1)
                   --
                   20    Total

       Z =    -2.5200             2-Tailed P =   .0117
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TOTERR1   TOTAL ERRORS - FORWARD CHAINING
with TOTERR4   TOTAL ERRORS - RANDOM-2 CHAINING

    Mean Rank    Cases

       8.60         5  - Ranks (TOTERR4 LT TOTERR1)
      10.50        14  + Ranks (TOTERR4 GT TOTERR1)
                    1    Ties  (TOTERR4 EQ TOTERR1)
                   --
                   20    Total

       Z =    -2.0926             2-Tailed P =   .0364
```

Experiment 6

```
        Wilcoxon Matched-Pairs Signed-Ranks Test

     TOTERR1    TOTAL ERRORS - FORWARD CHAINING
with TOTERR5    TOTAL ERRORS - RANDOM-3 CHAINING

     Mean Rank    Cases

        3.50         1  - Ranks (TOTERR5 LT TOTERR1)
       10.36        18  + Ranks (TOTERR5 GT TOTERR1)
                     1    Ties  (TOTERR5 EQ TOTERR1)
                    --
                    20    Total

       Z =    -3.6822              2-Tailed P =  .0002
```

```
        Wilcoxon Matched-Pairs Signed-Ranks Test

     TOTERR1    TOTAL ERRORS - FORWARD CHAINING
with TOTERR6    TOTAL ERRORS - WHOLE TASK TRAINING

     Mean Rank    Cases

        5.75         2  - Ranks (TOTERR6 LT TOTERR1)
       11.03        18  + Ranks (TOTERR6 GT TOTERR1)
                     0    Ties  (TOTERR6 EQ TOTERR1)
                    --
                    20    Total

       Z =    -3.4906              2-Tailed P =  .0005
```

Appendix Z (cont'd)

Experiment 6

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TOTERR2   TOTAL ERRORS - BACKWARD CHAINING
with TOTERR3   TOTAL ERRORS - RANDOM CHAINING

     Mean Rank    Cases

       13.00          5   - Ranks (TOTERR3 LT TOTERR2)
        8.93         14   + Ranks (TOTERR3 GT TOTERR2)
                      1     Ties  (TOTERR3 EQ TOTERR2)
                     --
                     20     Total

        Z =    -1.2073            2-Tailed P =   .2273
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TOTERR2   TOTAL ERRORS - BACKWARD CHAINING
with TOTERR4   TOTAL ERRORS - RANDOM-2 CHAINING

     Mean Rank    Cases

        9.17          9   - Ranks (TOTERR4 LT TOTERR2)
       10.75         10   + Ranks (TOTERR4 GT TOTERR2)
                      1     Ties  (TOTERR4 EQ TOTERR2)
                     --
                     20     Total

        Z =     -.5030            2-Tailed P =   .6149
```

Appendix 2 (cont'd)

Experiment 6

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TOTERR2   TOTAL ERRORS - BACKWARD CHAINING
with TOTERR5   TOTAL ERRORS - RANDOM-3 CHAINING

     Mean Rank    Cases

        5.30        5  - Ranks (TOTERR5 LT TOTERR2)
       12.23       15  + Ranks (TOTERR5 GT TOTERR2)
                    0    Ties  (TOTERR5 EQ TOTERR2)
                   --
                   20    Total

       Z =    -2.9306             2-Tailed P =  .0034
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TOTERR2   TOTAL ERRORS - BACKWARD CHAINING
with TOTERR6   TOTAL ERRORS - WHOLE TASK TRAINING

     Mean Rank    Cases

        4.00        4  - Ranks (TOTERR6 LT TOTERR2)
       11.07       14  + Ranks (TOTERR6 GT TOTERR2)
                    2    Ties  (TOTERR6 EQ TOTERR2)
                   --
                   20    Total

       Z =    -3.0267             2-Tailed P =  .0025
```

Appendix Z (cont'd)

Experiment 6

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TOTERR3   TOTAL ERRORS - RANDOM CHAINING
with TOTERR4   TOTAL ERRORS - RANDOM-2 CHAINING

     Mean Rank    Cases

        9.42        12   - Ranks (TOTERR4 LT TOTERR3)
       11.00         7   + Ranks (TOTERR4 GT TOTERR3)
                     1     Ties  (TOTERR4 EQ TOTERR3)
                    --
                    20     Total

        Z =    -.7244              2-Tailed P =  .4688
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TOTERR3   TOTAL ERRORS - RANDOM CHAINING
with TOTERR5   TOTAL ERRORS - RANDOM-3 CHAINING

     Mean Rank    Cases

        6.30         5   - Ranks (TOTERR5 LT TOTERR3)
       11.90        15   + Ranks (TOTERR5 GT TOTERR3)
                     0     Ties  (TOTERR5 EQ TOTERR3)
                    --
                    20     Total

        Z =   -2.7440              2-Tailed P =  .0061
```

Appendix Z (cont'd)

Experiment 6

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TOTERR3   TOTAL ERRORS - RANDOM CHAINING
with TOTERR6   TOTAL ERRORS - WHOLE TASK TRAINING

     Mean Rank    Cases

        5.00         5  - Ranks (TOTERR6 LT TOTERR3)
       11.79        14  + Ranks (TOTERR6 GT TOTERR3)
                     1    Ties  (TOTERR6 EQ TOTERR3)
                    --
                    20    Total

       Z =    -2.8170            2-Tailed P =  .0048
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TOTERR4   TOTAL ERRORS - RANDOM-2 CHAINING
with TOTERR5   TOTAL ERRORS - RANDOM-3 CHAINING

     Mean Rank    Cases

        6.50         5  - Ranks (TOTERR5 LT TOTERR4)
       11.25        14  + Ranks (TOTERR5 GT TOTERR4)
                     1    Ties  (TOTERR5 EQ TOTERR4)
                    --
                    20    Total

       Z =    -2.5151            2-Tailed P =  .0119
```

Appendix 2 (cont'd)

Experiment 6

```
            Wilcoxon Matched-Pairs Signed-Ranks Test

     TOTERR4   TOTAL ERRORS - RANDOM-2 CHAINING
with TOTERR6   TOTAL ERRORS - WHOLE TASK TRAINING

     Mean Rank    Cases

        4.67         3  - Ranks (TOTERR6 LT TOTERR4)
       10.47        15  + Ranks (TOTERR6 GT TOTERR4)
                     2    Ties  (TOTERR6 EQ TOTERR4)
                    --
                    20    Total

       Z =   -3.1138             2-Tailed P =  .0018

            Wilcoxon Matched-Pairs Signed-Ranks Test

     TOTERR5   TOTAL ERRORS - RANDOM-3 CHAINING
with TOTERR6   TOTAL ERRORS - WHOLE TASK TRAINING

     Mean Rank    Cases

        8.63         8  - Ranks (TOTERR6 LT TOTERR5)
       11.75        12  + Ranks (TOTERR6 GT TOTERR5)
                     0    Ties  (TOTERR6 EQ TOTERR5)
                    --
                    20    Total

       Z =   -1.3440             2-Tailed P =  .1790
```

Appendix 2 (cont'd)

Experiment 6

Friedman Two-Way Anova

Mean Rank	Variable	
3.02	RESP1	RESPONSES - FORWARD CHAINING
3.27	RESP2	RESPONSES - BACKWARD CHAINING
4.35	RESP3	RESPONSES - RANDOM CHAINING
4.10	RESP4	RESPONSES - RANDOM-2 CHAINING
4.25	RESP5	RESPONSES - RANDOM-3 CHAINING
2.00	RESP6	RESPONSES - WHOLE TASK TRAINING

Cases	Chi-Square	D.F.	Significance
20	23.8357	5	.0002

Wilcoxon Matched-Pairs Signed-Ranks Test

RESP1 RESPONSES - FORWARD CHAINING
with RESP2 RESPONSES - BACKWARD CHAINING

Mean Rank	Cases	
12.93	7	- Ranks (RESP2 LT RESP1)
9.19	13	+ Ranks (RESP2 GT RESP1)
	0	Ties (RESP2 EQ RESP1)
	20	Total

Z = -.5413 2-Tailed P = .5883

Appendix 2 (cont'd)

Experiment 6

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RESP1      RESPONSES - FORWARD CHAINING
with RESP3      RESPONSES - RANDOM CHAINING

     Mean Rank     Cases

       11.08           6   - Ranks  (RESP3 LT RESP1)
       10.25          14   + Ranks  (RESP3 GT RESP1)
                       0     Ties   (RESP3 EQ RESP1)
                      --
                      20     Total

       Z =    -1.4373              2-Tailed P =   .1506
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RESP1      RESPONSES - FORWARD CHAINING
with RESP4      RESPONSES - RANDOM-2 CHAINING

     Mean Rank     Cases

        9.00           7   - Ranks  (RESP4 LT RESP1)
       11.31          13   + Ranks  (RESP4 GT RESP1)
                       0     Ties   (RESP4 EQ RESP1)
                      --
                      20     Total

       Z =    -1.5680              2-Tailed P =   .1169
```

Appendix Z (cont'd)

Experiment 6

```
        Wilcoxon Matched-Pairs Signed-Ranks Test

     RESP1      RESPONSES - FORWARD CHAINING
with RESP5      RESPONSES - RANDOM-3 CHAINING

     Mean Rank    Cases

        9.00         4   - Ranks (RESP5 LT RESP1)
       10.27        15   + Ranks (RESP5 GT RESP1)
                     1     Ties  (RESP5 EQ RESP1)
                    --
                    20     Total

       Z =    -2.3743             2-Tailed P =  .0176


        Wilcoxon Matched-Pairs Signed-Ranks Test

     RESP1      RESPONSES - FORWARD CHAINING
with RESP6      RESPONSES - WHOLE TASK TRAINING

     Mean Rank    Cases

       10.66        16   - Ranks (RESP6 LT RESP1)
        9.88         4   + Ranks (RESP6 GT RESP1)
                     0     Ties  (RESP6 EQ RESP1)
                    --
                    20     Total

       Z =    -2.4453             2-Tailed P =  .0145
```

Experiment 6

```
        Wilcoxon Matched-Pairs Signed-Ranks Test

     RESP1       RESPONSES - FORWARD CHAINING
with RESP5       RESPONSES - RANDOM-3 CHAINING

     Mean Rank    Cases

        9.00          4   - Ranks  (RESP5 LT RESP1)
       10.27         15   + Ranks  (RESP5 GT RESP1)
                      1     Ties   (RESP5 EQ RESP1)
                     --
                     20     Total

       Z =    -2.3743              2-Tailed P =   .0176


        Wilcoxon Matched-Pairs Signed-Ranks Test

     RESP1       RESPONSES - FORWARD CHAINING
with RESP6       RESPONSES - WHOLE TASK TRAINING

     Mean Rank    Cases

       10.66         16   - Ranks  (RESP6 LT RESP1)
        9.88          4   + Ranks  (RESP6 GT RESP1)
                      0     Ties   (RESP6 EQ RESP1)
                     --
                     20     Total

       Z =    -2.4453              2-Tailed P =   .0145
```

Appendix Z (cont'd)

Experiment 6

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RESP2       RESPONSES - BACKWARD CHAINING
with RESP3       RESPONSES - RANDOM CHAINING

     Mean Rank    Cases

       11.10         5   - Ranks (RESP3 LT RESP2)
        9.61        14   + Ranks (RESP3 GT RESP2)
                     1     Ties  (RESP3 EQ RESP2)
                    --
                    20     Total

       Z =   -1.5896              2-Tailed P =  .1119
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RESP2       RESPONSES - BACKWARD CHAINING
with RESP4       RESPONSES - RANDOM-2 CHAINING

     Mean Rank    Cases

        9.25         4   - Ranks (RESP4 LT RESP2)
       10.20        15   + Ranks (RESP4 GT RESP2)
                     1     Ties  (RESP4 EQ RESP2)
                    --
                    20     Total

       Z =   -2.3340              2-Tailed P =  .0196
```

Appendix 2 (cont'd)

Experiment 6

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RESP2      RESPONSES - BACKWARD CHAINING
with RESP5      RESPONSES - RANDOM-3 CHAINING

     Mean Rank    Cases

        6.43          7  - Ranks (RESP5 LT RESP2)
       12.08         12  + Ranks (RESP5 GT RESP2)
                      1    Ties  (RESP5 EQ RESP2)
                     --
                     20    Total

        Z =    -2.0121           2-Tailed P =  .0442
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RESP2      RESPONSES - BACKWARD CHAINING
with RESP6      RESPONSES - WHOLE TASK TRAINING

     Mean Rank    Cases

       11.63         15  - Ranks (RESP6 LT RESP2)
        7.10          5  + Ranks (RESP6 GT RESP2)
                      0    Ties  (RESP6 EQ RESP2)
                     --
                     20    Total

        Z =    -2.5946           2-Tailed P =  .0095
```

Appendix Z (cont'd)

Experiment 6

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RESP3      RESPONSES - RANDOM CHAINING
with RESP4      RESPONSES - RANDOM-2 CHAINING

 Mean Rank    Cases

    9.73        11  - Ranks (RESP4 LT RESP3)
   10.38         8  + Ranks (RESP4 GT RESP3)
                 1    Ties  (RESP4 EQ RESP3)
                --
                20    Total

  Z =     -.4829              2-Tailed P =  .6292
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RESP3      RESPONSES - RANDOM CHAINING
with RESP5      RESPONSES - RANDOM-3 CHAINING

 Mean Rank    Cases

    8.40        10  - Ranks (RESP5 LT RESP3)
   12.60        10  + Ranks (RESP5 GT RESP3)
                 0    Ties  (RESP5 EQ RESP3)
                --
                20    Total

  Z =     -.7840              2-Tailed P =  .4330
```

Experiment 6

```
        Wilcoxon Matched-Pairs Signed-Ranks Test

     RESP3      RESPONSES - RANDOM CHAINING
with RESP6      RESPONSES - WHOLE TASK TRAINING

     Mean Rank    Cases

        11.06       17  - Ranks (RESP6 LT RESP3)
         7.33        3  + Ranks (RESP6 GT RESP3)
                     0    Ties  (RESP6 EQ RESP3)
                    --
                    20    Total

        Z =    -3.0986             2-Tailed P =  .0019
```

```
        Wilcoxon Matched-Pairs Signed-Ranks Test

     RESP4      RESPONSES - RANDOM-2 CHAINING
with RESP5      RESPONSES - RANDOM-3 CHAINING

     Mean Rank    Cases

         9.39        9  - Ranks (RESP5 LT RESP4)
        11.41       11  + Ranks (RESP5 GT RESP4)
                     0    Ties  (RESP5 EQ RESP4)
                    --
                    20    Total

        Z =     -.7653             2-Tailed P =  .4441
```

EXPERIMENT 6

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RESP4      RESPONSES - RANDOM-2 CHAINING
with RESP6      RESPONSES - WHOLE TASK TRAINING

     Mean Rank     Cases

        11.38        16   - Ranks  (RESP6 LT RESP4)
         7.00         4   + Ranks  (RESP6 GT RESP4)
                      0     Ties   (RESP6 EQ RESP4)
                     --
                     20     Total

        Z =     -2.8746               2-Tailed P =   .0040
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     RESP5      RESPONSES - RANDOM-3 CHAINING
with RESP6      RESPONSES - WHOLE TASK TRAINING

     Mean Rank     Cases

        11.88        16   - Ranks  (RESP6 LT RESP5)
         5.00         4   + Ranks  (RESP6 GT RESP5)
                      0     Ties   (RESP6 EQ RESP5)
                     --
                     20     Total

        Z =     -3.1733               2-Tailed P =   .0015
```

APPENDIX Z (cont'd)

EXPERIMENT 6

Friedman Two-Way Anova

Mean Rank	Variable	
2.60	TIME1	TIME - FORWARD CHAINING
2.95	TIME2	TIME - BACKWARD CHAINING
4.05	TIME3	TIME - RANDOM CHAINING
4.35	TIME4	TIME - RANDOM-2 CHAINING
5.35	TIME5	TIME - RANDOM-3 CHAINING
1.70	TIME6	TIME - WHOLE TASK TRAINING

Cases	Chi-Square	D.F.	Significance
20	50.2857	5	.0000

Wilcoxon Matched-Pairs Signed-Ranks Test

TIME1 TIME - FORWARD CHAINING
with TIME2 TIME - BACKWARD CHAINING

Mean Rank	Cases	
9.86	7	- Ranks (TIME2 LT TIME1)
10.85	13	+ Ranks (TIME2 GT TIME1)
	0	Ties (TIME2 EQ TIME1)
	20	Total

Z = -1.3440 2-Tailed P = .1790

APPENDIX Z (cont'd)

EXPERIMENT 6

```
         Wilcoxon Matched-Pairs Signed-Ranks Test

     TIME1       TIME - FORWARD CHAINING
with TIME3       TIME - RANDOM CHAINING

     Mean Rank    Cases

        5.75          4   - Ranks (TIME3 LT TIME1)
       11.69         16   + Ranks (TIME3 GT TIME1)
                      0     Ties  (TIME3 EQ TIME1)
                     --
                     20     Total

       Z =    -3.0613                2-Tailed P =  .0022


         Wilcoxon Matched-Pairs Signed-Ranks Test

     TIME1       TIME - FORWARD CHAINING
with TIME4       TIME - RANDOM-2 CHAINING

     Mean Rank    Cases

        3.50          4   - Ranks (TIME4 LT TIME1)
       12.25         16   + Ranks (TIME4 GT TIME1)
                      0     Ties  (TIME4 EQ TIME1)
                     --
                     20     Total

       Z =    -3.3973                2-Tailed P =  .0007
```

Appendix Z (cont'd)

Experiment 6

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TIME1     TIME - FORWARD CHAINING
with TIME5     TIME - RANDOM-3 CHAINING

     Mean Rank    Cases

        3.00         1  - Ranks (TIME5 LT TIME1)
       10.89        19  + Ranks (TIME5 GT TIME1)
                     0    Ties  (TIME5 EQ TIME1)
                    --
                    20    Total

       Z =   -3.8079           2-Tailed P =   .0001
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TIME1     TIME - FORWARD CHAINING
with TIME6     TIME - WHOLE TASK TRAINING

     Mean Rank    Cases

       10.56        16  - Ranks (TIME6 LT TIME1)
       10.25         4  + Ranks (TIME6 GT TIME1)
                     0    Ties  (TIME6 EQ TIME1)
                    --
                    20    Total

       Z =   -2.3893           2-Tailed P =   .0169
```

Appendix Z (cont'd)

Experiment 6

```
          Wilcoxon Matched-Pairs Signed-Ranks Test

     TIME2      TIME - BACKWARD CHAINING
with TIME3      TIME - RANDOM CHAINING

     Mean Rank    Cases

         10.60        5  - Ranks (TIME3 LT TIME2)
         10.47       15  + Ranks (TIME3 GT TIME2)
                      0    Ties  (TIME3 EQ TIME2)
                     --
                     20    Total

         Z =    -1.9413             2-Tailed P =  .0522


          Wilcoxon Matched-Pairs Signed-Ranks Test

     TIME2      TIME - BACKWARD CHAINING
with TIME4      TIME - RANDOM-2 CHAINING

     Mean Rank    Cases

          8.13        4  - Ranks (TIME4 LT TIME2)
         11.09       16  + Ranks (TIME4 GT TIME2)
                      0    Ties  (TIME4 EQ TIME2)
                     --
                     20    Total

         Z =    -2.7066             2-Tailed P =  .0068
```

Experiment 6

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TIME2      TIME - BACKWARD CHAINING
with TIME5      TIME - RANDOM-3 CHAINING

     Mean Rank    Cases

         4.00        1  - Ranks (TIME5 LT TIME2)
        10.84       19  + Ranks (TIME5 GT TIME2)
                     0    Ties  (TIME5 EQ TIME2)
                    --
                    20    Total

        Z =    -3.7706              2-Tailed P =   .0002
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TIME2      TIME - BACKWARD CHAINING
with TIME6      TIME - WHOLE TASK TRAINING

     Mean Rank    Cases

        11.22       16  - Ranks (TIME6 LT TIME2)
         7.63        4  + Ranks (TIME6 GT TIME2)
                     0    Ties  (TIME6 EQ TIME2)
                    --
                    20    Total

        Z =    -2.7813              2-Tailed P =   .0054
```

ExperimenT 6

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TIME3      TIME - RANDOM CHAINING
with TIME4      TIME - RANDOM-2 CHAINING

     Mean Rank    Cases

       10.56          8   - Ranks (TIME4 LT TIME3)
       10.46         12   + Ranks (TIME4 GT TIME3)
                      0     Ties  (TIME4 EQ TIME3)
                     --
                     20     Total

       Z =     -.7653              2-Tailed P =  .4441
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TIME3      TIME - RANDOM CHAINING
with TIME5      TIME - RANDOM-3 CHAINING

     Mean Rank    Cases

        4.50          4   - Ranks (TIME5 LT TIME3)
       12.00         16   + Ranks (TIME5 GT TIME3)
                      0     Ties  (TIME5 EQ TIME3)
                     --
                     20     Total

       Z =    -3.2479              2-Tailed P =  .0012
```

Appendix Z (cont'd)

Experiment 6

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TIME3      TIME - RANDOM CHAINING
with TIME6      TIME - WHOLE TASK TRAINING

     Mean Rank    Cases

        10.58        18  - Ranks (TIME6 LT TIME3)
         9.75         2  + Ranks (TIME6 GT TIME3)
                      0    Ties  (TIME6 EQ TIME3)
                     --
                     20    Total

        Z =    -3.1919             2-Tailed P =   .0014
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TIME4      TIME - RANDOM-2 CHAINING
with TIME5      TIME - RANDOM-3 CHAINING

     Mean Rank    Cases

         7.58         6  - Ranks (TIME5 LT TIME4)
        11.75        14  + Ranks (TIME5 GT TIME4)
                      0    Ties  (TIME5 EQ TIME4)
                     --
                     20    Total

        Z =    -2.2213             2-Tailed P =   .0263
```

Experiment 6

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TIME4      TIME - RANDOM-2 CHAINING
with TIME6      TIME - WHOLE TASK TRAINING

     Mean Rank     Cases

       11.24         17    - Ranks  (TIME6 LT TIME4)
        6.33          3    + Ranks  (TIME6 GT TIME4)
                      0      Ties   (TIME6 EQ TIME4)
                     --
                     20      Total

       Z =    -3.2106               2-Tailed P =   .0013
```

Wilcoxon Matched-Pairs Signed-Ranks Test

```
     TIME5      TIME - RANDOM-3 CHAINING
with TIME6      TIME - WHOLE TASK TRAINING

     Mean Rank     Cases

       10.63         19    - Ranks  (TIME6 LT TIME5)
        8.00          1    + Ranks  (TIME6 GT TIME5)
                      0      Ties   (TIME6 EQ TIME5)
                     --
                     20      Total

       Z =    -3.6213               2-Tailed P =   .0003
```

Appendix AA

Experiment 6

Post Experiment Questionnaire Data

The following section summarizes the results to the questions that each subject was asked after performing the four sequences.

Question 1: Subjects were requested to draw the symbols and numbers in the order that the buttons were pushed. Results were as follows:

Ten subjects drew the order of key presses correctly, three drew six of the eight correctly, one drew four of the eight correctly, three drew two, one drew one and two drew none. Subjects were divided into groups according to the method by which the last sequence was taught. There were no significant differences in the accuracy of order recall among the three groups ($F(5) = 4.0914$, $p = .0169$).

Fifteen subjects drew the symbols in the correct keys, three drew six, one drew two and one drew none. Subjects were divided into groups according to the method by which the last sequence was taught. There were no significant differences in symbol recall among the three groups ($F(5) = 1.2163$, $p = .3520$).

Question 2: Subjects were asked to identify any differences between the six training methods. Fourteen subjects stated there was a random order but could not articulate what made it random (subjects could not differentiate between types of random order). Six stated there was a whole task type of method. Statistics were not conducted on this test because there were so many methods used that subjects had difficulty recalling differences.

Question 3: Subjects were asked whether they had used the percent score listed on the screen. Seventeen subjects indicated thay had used percent scores, one could not figure the scores out so did not use them, one did sometimes and one did not.

Question 4: Subjects were asked whether they found the task boring or reasonably interesting. Eighteen found it interesting, one found it boring and one found it interesting only in the beginning and then found it boring.

Question 5: In reference to what strategy subjects used to learn the task, seven used symbol and key,five used a combination of key, symbol and finger position, two used finger and key, four changed strategies from a combination to keys in the simpler techniques (forward and backward chaining), one used symbol and finger position, and one used keys.

Question 6: No other strategies were used.

Question 7: Subjects were asked to state the method they found the most comfortable and easy. Subjects were not asked to rank order methods because too many methods were used for accurate recall. Seventeen subjects indicated a logical gradual method such as forward chaining or backward chaining was easiest. One said random, one said whole task and one said random and whole task, Seventeen subjects did best on the training method they found the most easiest and most comfortable.

Question 8: Subjects were asked to state the training method they did best on. Sixteen said a logical gradual method such as forward chaining or backward chaining, one said random one said whole task training, one said random or whole task and one did not know. Fourteen subjects predicted the method they performed best on.

Question 9 and 10: Some subjects found random-2 chaining difficult whereas others found it challenging.

Question 11: Only seven subjects knew the definitions of forward and backward chaining and whole task training and thirteen did not know them.

Question 12: Subjects were asked what the criterion to teach a new subsequence was: two said five, one said four or five, two said four, three said three or four, four said three,two said depends and six did not know.

Question 13: Six liked the gradual logical methods best (forward and backward chaining), five liked the random chaining, and nine liked whole task training. Only six performed best on the training methods they liked best.