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ABSTRACT

Described is the application of error-free learning to the education of severely retarded and multiply handicapped children (infancy through middle school years). It is explained that two projects at the University of Kentucky (Programmed Environments and Telecommunications for the Severely Handicapped) focus on a programed environment in which the children's interactions with automated learning devices and with adults are arranged to increase the probability of correct responses. Data in the form of graphs and tables are presented for selected children's performance on programs to establish stimulus control, build a simple response repertoire, select reinforcers, and improve basic reading and math skills. In each example, problems in the development of errorless programs and resulting modifications are noted. (CL)

AMERICAN ASSOCIATION FOR THE EDUCATION
OF THE SEVERELY/PROFOUNDLY HANDICAPPED

Developing Curricula for Errorless Learning:

A Search for Order in an Unorderly World

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of Research and Demonstration Centers
for Severely Handicapped Children and Youth

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DEVELOPING CURRICULA FOR ERRORLESS LEARNING: A SEARCH FOR ORDER IN AN UNORDERLY WORLD

Introduction

Jerome Bruner's statement, roughly paraphrased, that you can teach anything to anybody if you go about the task properly (1960, p. 33), generated considerable professional debate at the time, and raised as well a number of questions related to curriculum design. The basic question, "can you really," naturally led to another, "if you can, should you." No definitive answer has been offered for either question, and in all honesty, the issue is about to pass into history, if it has not done so already. A new consideration, "how much can persons with severe developmental retardation learn, when environments and instruction are properly engineered?", may revive interest in Bruner's assumption. The question was raised when the right to education for severely retarded persons was established by litigation in Pennsylvania. The need for an answer has become apparent as national attention has centered on the severely handicapped in the wake of a score of lawsuits and subsequent enabling legislation.

To some, the right to education is generally understood to mean access to public education dollars and instruction in local communities. To others it means access to, or a place in, public school classes. These views reflect a social philosophy that institutions are no place for children and an assumption that severely retarded children do have potential to learn. It is one thing to hold a positive view of human potential, and quite another to document that one's position is well-founded. This is particularly true with respect to the educability of those persons assumed to be severely retarded.

Tawney (1972a, 1974) noted that the short history of research on the efficacy of special education offered little evidence to inspire confidence that traditional special education practices might provide a basis for curriculum programming which would document the learning potential of the severely retarded. He also noted that the field of special education was ill prepared to meet the demand for education with effective program models, teachers or curricula. In contrast, he noted that studies in the experimental analysis of behavior consistently demonstrated positive results when well-defined strategies were programmed, and when environmental conditions were arranged to increase the probability of success. The work of Allyon and Azrin (1968), Ferster and DeMeyer (1961), Lindsley (1964), Screven, Straka and LaFond (1971), and Ulrich, Louisell and Wolfe (1971) suggested that programming a learning environment might enable those with assumed developmental retardation to demonstrate their learning performance. Similarly, many studies (Bijou, Birnbrauer, Kidder and Tague, 1967; Bijou, 1968; Sidman and Stoddard, 1966; Sidman and Stoddard, 1967; Tawney, 1972b; Terrace, 1967) which showed that human and infrahuman subjects demonstrated acquisition of complex or fine discriminations when antecedent stimuli were carefully sequenced led the senior author to consider that, the concept of errorless learning might be applied to the development of curricula for the "severely retarded." A project, Programmed Environments for the Developmentally Retarded, was initiated in 1972 with support from the Division of Research, Bureau of Education for the Handicapped, to develop a programmed preschool environment and an errorless learning curriculum.

This paper describes the methodology used to develop instructional programs; presents examples of programs which are in various stages of development; and describes how child-performance errors are used to revise programs so that, when completed, a majority of the children for whom they were designed will progress through them in a relatively error-free manner. The paper illustrates the application of the errorless learning to the education of children assumed to be severely retarded and to the process of curriculum development.

The Environment

First, what do we mean when we say we have developed a programmed environment? In our case, the physical environment looks very much like a regular preschool. The project is located on the campus of the University of Kentucky, in a building that formerly housed a church. Although the preschool area was renovated specifically for the project, certain environmental constraints, e.g. location of bathrooms, dictate that it be considered a desirable though not ideal setting.

One instructional area is comprised of a large room which has individual tutorial rooms located around the periphery. Another includes a large play area, separated from a smaller instructional area by a folding door. A second small instructional area is adjacent to the first, and separated by a teacher's lounge. Another room, the learning booth, is located across the hall from the other classroom areas. Approximately 10' x 18', this room contains the interfaces for the automated equipment. Presently, these include a Human Test Console (BRS/LVE model HTC603) and a nine-panel interface similar to the one described by Sidman and Stoddard (1966). An interact computer, integrated with a solid-state logic system, is located in a room adjacent to the learning booth. Presently, a learning carrel which contains three active learning stations is located in one of the small instructional areas. Thus, with the exception of the presence of the automated devices, the physical environment appears much like a traditional preschool or day care center.

The term programmed environment, then, refers more specifically to the interactions between the child and his environment. In our case, children interact with two classes of environmental stimuli, automated learning devices and adults. Interactions with both are programmed from the same model, an errorless learning strategy. In theory, every child-environment interaction during the school day is programmed. In practice, many are not. When curriculum development is complete, we expect every activity during the child's school day to be programmed so precisely that he rarely encounters failure.

Errorless Learning Strategy

The term errorless learning has three referents for our project. First, it is a statement of philosophy and, as such, reflects an assumption that the learning potential of children assumed to be severely retarded will best be demonstrated when the environment is arranged to increase the probability of success (correct responses). There is another underlying assumption of course; that children called severely retarded can learn, and can demonstrate their "knowledge" by responding correctly and consistently to sequences of instructional tasks. Second, errorless learning is a strategy or technology for developing curriculum. We assume that it is possible to assess children's behaviors precisely, and to determine the starting point for an instructional task. Then, by careful arrangement of stimulus materials, demonstration, precise sequencing of tasks, and immediate reinforcement or correction of emitted responses, we assume we can develop teaching programs which will take the learner through increasingly more complex tasks with a minimum of errors. Finally, the errorless learning concept is applied to our program validation model. As a funded project, we have a committment to validate our curricula, and prepare them for commercial publication. Our strategy is to develop a teaching program, present it to a child and revise it until he meets criterion, usually expressed as 80% correct, or n correct responses in a set of $n + 1$ trials on each step or stage of the program, e.g. 5 correct responses in a set of 6 trials. When one child meets criterion, the program is used with other children on the project, and revised until they meet criterion. Then the program is ready for validation off the project. Some programs are ready for off-site validation and when that phase is implemented, the same process (teach-revise-repeat to criterion) will be used. The performance data presented in this paper clearly show that our children do not learn without error. The failures are ours, however, and represent a combination of program and teacher error. We expect to reduce those errors and to show that the term errorless learning also represents a realistic goal for the development of curricula, as demonstrated by the learning performance of children.

Scope of the Project

Through the Programmed Environments project and a recently funded project, Telecommunications for the Severely Handicapped, the errorless learning strategy is applied to a wide range of activities. The scope of the curriculum begins with the building or shaping of response repertoires, and ends with materials for pre-academic and academic behaviors which include reading and math.

Our materials are designed for children whose ages range from infancy through the middle school years. At the present time, one group of children in our preschool includes those termed "trainable" and includes a high percent of Down's children. The second group more nearly represents those whom others call severely retarded and multiply handicapped. Each group serves as a test population for a specific project activity. Data from both groups are presented in this paper.

When considered together, the children represent a range of functional level on critical behavioral attributes. All are ambulatory. Vocal behavior ranges from no intelligible speech to a fairly well established repertoire of words and phrases. Some children are completely toilet trained, others have no consistent bowel or bladder control. When left to their own devices in play areas, some interact with toys "appropriately," others wander aimlessly about. Self destructive behaviors are emitted by only one or two children, are usually episodic and are quickly extinguished. Some children have highly developed self-help skills, others are learning to drink from a glass or eat with a utensil without spilling food. Some stereotyped or superstitious behaviors can be observed; generally they are not emitted at a rate or intensity sufficient to interfere with instruction.

Our first activities centered on the development of a prototype for a model preschool environment. As noted earlier, four automated learning stations are active, and three additional stations will be activated shortly. Our programming efforts have been directed toward establishing behaviors in highly controlled environments (the learning booth), then transferring them to less controlled (classroom) environments and into the home, through a parent training program. Under the auspices of the telecommunications project we are developing automated learning devices to be placed in home settings geographically dispersed across Kentucky, and controlled by an Interact Computer, via a telephone linkage. When these activities are completed, we will have developed errorless learning curricula appropriate for infant learning through academic behaviors, which can be presented to a child in any environment, e.g., home, school, workshop. Concurrently, we will have developed teaching programs for adult-child interactions. Together, these will provide instruction in the areas of language, concept learning, motor behavior, self-help and socialization skills.

The Errorless Learning Methodology

This portion of the paper describes the methodology used to develop errorless learning programs for children with assumed severe developmental retardation and attendant multiple handicaps. The working plan is to present child performance data on specific programs, and use children's deviations from 100% correct responding to illustrate how their errors tell us to modify programs. The basic format for adult-controlled programs closely follows one which Tawney and Hipsher (1970) developed for Systematic Language Instruction (SLI), a curriculum for young trainable retarded children. Programs contain an objective, rationale, list of prerequisite behaviors, and materials needed to perform the task. If the child fails the pretest, he proceeds through increasingly more complex stages in the program until he meets criterion for the final stage and posttests out of the program. Generally, the first stage of the program contains only the positive stimulus, and a teacher demonstration is programmed so that _if_ the child _does_ respond and imitates the teacher's response, he will respond correctly.

The format for apparatus controlled programs differs slightly from the SLI program format. A program objective is specified, children are adapted into the learning booth, and their responses are recorded under specified conditions. Attainment of criterion performance under one condition leads to the presentation of another.

Children are required to complete a set of learning trials to a specified criterion in order to advance to the next more complex step in a program. A learning trial contains three components.

a) S^D (task request)

b) R (response)

c) S^{+-} (subsequent stimulus event, S^+ is a reinforcing event, S^- is an interruption or correction of an incorrect response)

Each child response is recorded, and notes are written after an adult-child teaching interaction. This information, combined with the child's error rate, forms the basis for program revision.

Three assumptions can be inferred from an analysis of the components of a learning trial. That is, if a child is to respond correctly (a) he must be under stimulus control, (b) he must have a response in his repertoire which is sufficiently precise to enable the "instructor" to discriminate correct from incorrect responses, and (c) he has demonstrated preference for reinforcers which will maintain responding over long periods of time, on a sufficiently lean schedule to demonstrate that success or failure is a function of teacher or program error. It is necessary to establish that children attend to instructional stimuli, that they do have a sufficient response repertoire, and that they will work consistently during the course of an instructional session. Therefore, curriculum development activities include programs to document that the assumptions have been met.

The following programs present data on machine and adult-controlled teaching programs. They include descriptions of programs to establish stimulus control, simple response repertoire building and reinforcer selection, as well as rudimentary programs in math and reading behavior. The data presented here was generated in the learning booth, from individual sessions in the classroom, and from home instruction sessions. In each instance, attention is drawn to the analysis of children's errors as the basis for our curriculum revision efforts. In simplest form -- here are some of our programs, this is how children responded to early versions, this is what we learned from that experience, and this is where we have gone from that point. While we tell that story, we also intend to emphasize the generally high correct response rates of our children, as documentation that children with assumed developmental retardation do learn when conditions are arranged to increase the probability of correct responses.

Programming Controlled Antecedent and Consequent Stimulus Events

Reinforcer evaluation. There are numerous ways to determine a child's hierarchy of reinforcer preferences. If a child is verbal, and has a large experiential repertoire, one can simply ask him to state his preference. The reinforcer preference program described here employs a systematic evaluation of reinforcer preference, conducted under highly controlled conditions with children who cannot state preferences, and who initially appear to be nonreinforceable. The procedure was based on the assumption that preferred reinforcers will generate a higher response, when a variety of reinforcers are made available to a child, one at a time.

To determine reinforcer preference, the child was placed in the learning booth for daily ten minute sessions. A reinforcer was dispensed by an adult or with an M&M dispenser, contingent upon a press of a universal lever.

Data for Mark B. are shown in Figure 1. Mark is 6½ years old.

Insert Figure 1 about here

He and his twin brother have been in the project for two years. He is assumed to be severely retarded, is ambulatory, is not toilet trained, feeds himself with a spoon, and drinks from a cup with assistance. He emits some babbling sounds and engages in isolate play when left alone. He has little attending behaviors, and grabs or throws materials in instructional sessions. He was described by staff as "nonreinforceable" during adult-child interactions when he entered the project.

At the beginning of the program, Mark's interactions with the apparatus were limited to one or two responses, usually emitted at the beginning of each session. He occupied the remainder of the session by crawling around the room or kneeling at the door and rocking. Many reinforcers were used in sessions 1-24, but none succeeded in increasing the response rate.

Beginning with session 25, the procedure was changed. Subsequent to each response, a box which contained a variety of reinforcers was presented to him. Gradually, Mark's response rate increased. On session 31, the single reinforcer availablity procedure was reinstated. M&M's were used as reinforcers as these stimuli were most preferred during sessions 27-30. By session 38, this reinforcement was maintaining a stable rate of performance on an FR10 schedule.

Mark's data show an interesting phenomenon. After severel sessions of M&M reinforcement on an FR10 schedule, cereal (shown to be ineffective in sessions 15-24) was reinstated as a reinforcer. After a brief decrement in performance, his rate increased to the level established with the M&M's and on one occasion exceeded it considerably.

This example is illustrative of one child's performance on a reinforcer evaluation program. Although the procedure was cumbersome with respect to the total number of sessions required to identify the first reinforcer, it provided a starting point for a child assumed to show no preference for food reinforcers. The shift to a selection procedure appeared, in this instance, to be more effective than presentation of a single potential reinforcer.

Schedule Shifts

The first requirement of a successful automated program is the establishment of continuous child-apparatus interaction. Tawney (1972a) suggested a method for generating this type of behavior by starting children on a CRF, then shifting to FR with leaner ratios, then VI schedules to insure a durable and stable rate of responding. The program described below was an attempt to establish the first part of the sequence outlined above, FR schedule control.

This program was carried out in the learning booth, a 10' x 18' room which contained a human test console (BRS/LVE model HTC603). For this program the interface was filled with blank (white) panels, except for one panel which held a universal lever, and one panel which contained 3 stimulus lamps.

Data for one child, Jenny, are shown in Figure 2. Jenny is 11 years old and a triplet. She has been in the project for 2 years. She is presumed to be severely retarded and cerebral palsied with slight paralysis of the left side of her body. She is ambulatory and partially toilet trained. Her verbal behavior is limited to "MM" and "Ah" sounds. When left alone, she engages in isolate play behaviors. When she first received individual instruction, Jenny was likely to throw the materials, clear the table with a sweep of her arm or try repeatedly to get out of her chair and leave the situation.

Jenny had received training on increasing FR schedules in earlier sessions (not shown here). Schedules were incremented by one unit, from CRF to FR25, over 25 sessions. Daily records showed that she responded reliably, but not differentially across schedule changes. To determine if she was discriminating schedule shifts, a series of abrupt schedule shifts was programmed. The sequence of schedule shifts is noted in Figure 2. Shifts were made only after performance had stabilized on the schedule in effect. Stabilization was defined as less than 20% variability across three consecutive sessions.

Insert Figure 2 about here

The data show that a different rate of responding was associated with each reinforcement schedule. Specifically, there was an inverse relationship between rate of reinforcement and rate of responding. This would suggest that Jenny was under schedule control, and that her behavior was controlled by the rate at which reinforcements were delivered.

Data from a number of children indicated that the stable response rates typical of VI schedule of reinforcement were more difficult to generate than had been expected. These data suggest that the establishment of schedule control is dependent on careful attention to schedule changes.

Repertoire Building Programs

Children must respond to document that they have or have not learned a specific instructional task. In the case of children with limited vocal behavior, it is necessary to build or shape a variety of motor responses to substitute for vocal responses, until such time as an intelligible vocal repertoire is developed. The most basic level of repertoire building requires shaping random arm and hand movements into systematic attempts to hit, slap, push, or pull a simple lever, button, or press panel. At a more refined level, a child may be required to use a pointing response to identify a specific object in a stimulus array, or to complete an action at a teacher's request. Thus, the ability to "touch," "give me," "show me the ___," or "put the ___ in the ___," requires a limited repertoire of motor responses, which must be developed as a prerequisite to participation in instructional activities. The format for the programs described in this session was based on the "touch," "touch another" lesson plans included as prerequisite skills in the Systematic Language Instruction (SLI) program (Tawney and Hipsher, 1970). Although those programs were developed for "young, preschool age trainable retarded children," they proved to be too complex for children with more severe handicapping conditions. Those program revisions led to the development of the following more highly structured programs.

The touch series. The Touch I, Touch II and Touch Another programs described are the first revisions of the SLI programs, and are referred to as Stage I programs, the descriptor for programs in the earliest stage of development. Programs at this level are developed on a single child, and are usually characterized at the outset by a high error rate, which declines with subsequent program revisions. When a child meets a specified criterion (usually 80% correct), the revised program is begun with another child as a Stage II program.

Brad's data illustrate problems characteristic in the Stage I process. Brad is a 10½ year old male who has been in the project 1½ years. His medical diagnosis is severe mental retardation with accompanying handicaps of visual impairment, mild microcephaly and excessive drooling. His verbal behavior consists of two spontaneous intelligible vocalizations, "NAH," and "DA." When he is not performing a task or interacting with another child or adult he engages in self-stimulatory behavior (fingers in mouth, face-slapping and rocking). He responds to task requests and will perform a task when presented with verbal praise and juice or water. When this program was begun, Brad's behavior in instructional sessions consisted of rocking, rolling his eyes and hitting his chin with his fists.

Insert Figure 3 about here

Brad's performance on the Touch 1 (Stage 1) program is shown in Figure 3. There are seven steps in this program, as shown on the abscissa of the graph. Each step is presumably more complex than the last, and a child must meet criterion on one step before progressing to the next. Again, criterion for each step is usually defined as n correct responses in a set of n + 1 trials. The original criterion on this program was 9 correct responses in a set of 10 trials (the set of trials referred to in Figure 3 as response blocks, and shown on the ordinate). If Brad met criterion on the first presentation of each step in the program, his graph would contain 7 response blocks, and would be represented by a set of linear data points. That is, his criterion performance would increment him one step vertically, and one step horizontally. However, if a child never met criterion, and a program was continued indefinitely, his performance would be represented by a continuous horizontal line, parallel to the ordinate, and extending into infinity. He would increment only on the ordinate, and additional instruction would be represented by additional response blocks. Figure 4 shows two theoretical graphs of responses on a 6 step program. The broken line shows that criterion was met at each step, while the unbroken line indicates failure through a series of response blocks.

Insert Figure 4 about here

Inspection of Figure 3 shows that Brad's performance represents neither of the theoretical limits.

The terminal behavior for this program required Brad to touch 1 object when only 1 object was placed in front of him. Four different objects were used, and were presented in varying order. A prompt (physical assistance in completing the motor response) was introduced in Step 1, and gradually faded out after Step 4. Brad completed the first 4 steps on Day 1 without error. Instruction was begun at Step 4 on Day 2, and Brad repeated Step 4 without error, but failed to meet criterion without the prompt. He was returned to Step 1, taken through each step, and met criterion on Step 5 during Day 3, after 127 learning trials, and 121 correct responses.

During the first 13 response blocks, Brad was presented with the same stimulus (a block) on each trial. After he had met criterion, he was returned to Step 4, and went through a series of trials with the 3 other stimulus objects, with no additional errors.

Brad was reinforced on CRF through response block 19. Then, two additional Steps (6 and 7) were added to the program to shift the schedule of reinforcement in an attempt to solve a problem related to differences in pre-posttest and instructional procedures. That is, typically no reinforcement is given in pre-posttest trials, but is given on every instructional trial. The difference between these two procedures is assumed to cause errors in children with fragile repertoires who are being reinforced on rich, e.g., CRF, schedules. Thus, for Brad, Steps 6 and 7 represent shifts from CRF to FR2 and then FR4.

Brad completed the program in 217 trials with 95% correct responses. Three program modifications were made before the program was implemented in Stage I validation; one fading step was deleted, the criterion was reduced from 9/10 to 5/6 correct responses, and the schedule of reinforcement was changed.

Brad's performance on the Touch II program is shown in Figure 5. The terminal behavior for this program requires that a child touch each of four blocks, presented one at a time, in each of four different positions in front of him. Ths program differs from Touch I in that the stimulus object in Touch I is placed in one location (center), and in Touch II it is presented front, back, left, and right of center. As shown, Brad progressed through this position and object alternation program with a high percent of correct responses.

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Insert Figure 5 about here

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Reinforcement was administered on CRF, until response block 15. The remaining steps represent schedule shifts to FR2 with all four objects then FR5. When this program was revised for Stage II validation, the criterion was changed from 9/10 to 5/6, the schedule changes were deleted, and the procedure was changed so that a child went through all position alternations with one object, before the next object was introduced. It was noted that Brad would have completed the program in approximately 55 trials, if the criterion had been changed early in the program and if the schedule changes had been deleted. This information was gained from an analysis of daily records, which showed that errors never occurred before the 6th trial.

The next program in the series, Touch Another, requires the child to touch first one then another object when two or more stimuli are presented simultaneously. Another is defined as any object except the one just touched. The program contains 7 steps (see Figure 6). Two stimuli are presented in Steps 1-3, although the teacher initially covers one stimulus with her hand in order to decrease the probability of an incorrect response, then slowly removes her hand so that a two-choice discrimination is required in Step 3. In Step 4, no assistance is provided. At response block 41, criterion was changed from 9/10 to 5/6 because of repeated failure. BJ then passed Step 4 with the 5/6 criterion at the 41st response block. Two additional blocks were introduced in Step 5. In Steps 6 and 7 the 4 stimuli were presented with two schedule changes, FR2 and FR5. Obviously, Brad was unable to complete the task when he was required to make the two choice discrimination without assistance. During Response blocks 11-14, he was reinforced whether he touched the correct block first, or touched the incorrect stimulus, then touched the correct stimulus. Again, daily records showed that he would have progressed to Step 5 during the second day of the program if the criterion had been 5/6 rather than 9/10. Consequently, for each program in the Touch Series, the criterion was changed, and strategies were introduced to reduce the differences between pre-posttests and instruction.

Insert Figure 6 about here

Programming efforts with Brad have been used to illustrate problems in Stage I of program development. Stage II data on the Touch Series is represented by the performance of Mike (Figure 7), a 6½ year old, enrolled in the project for 2 years. He has been medically diagnosed as severely retarded, has some discriminable speech sounds and words, some self dressing and eating skills, is partially toilet trained, sits on a chair throughout an individual program (approximately 12 minutes), feeds himself with a spoon, approaches adults for physical contact, and sometimes responds to task requests presented by adults. When Mike first received instruction in individual sessions, he was likely to grab or throw materials, cry, get out of his chair and run around the room, and avoid eye contact with adults. Prior to entering the Stage II Touch programs, Mike received 456 trials of a rudimentary program. However, when more than one object was placed in front of him, he grabbed and threw objects and responded inconsistently.

Mike went through the Touch I and II series without error. In the Touch Another Program, he met criterion on Steps 1 and 3 (two stimuli present) in 5 response blocks during Session 1.

When 3 stimuli were presented at Step 4, Mike responded below criterion and his teacher dropped back one step. This strategy was not successful so an alternate strategy was introduced which allowed Mike to self-correct his error. After response blocks 13, 14 and 15, using this strategy, he met criterion, then went through the final step of the program without error. Having met criterion on these prerequisite skills, he went on to the object discrimination program, described in a following section.

The "give me" program. While the touch response enables a child to identify a specific object in a stimulus array, the "pick up" and "give me" responses enable a child to hand a specified object to the person requesting it, a common response in the environment of a young child. The data on the "pick up" program were obtained from the interaction of Jenny, with family members in a home instruction program. This program was initiated after Jenny, who has previously been described, had gone through an intensive response shaping process which required increasingly finger responses to a universal lever, palm press, push button and press panel.

The terminal behavior of this program requires that the child pick up and hand a ball or block to the teacher, upon request. This program consists of a set of 11 steps, which are considered sub-programs, each presumably more complex than the previous step. To meet criterion on the first step, the child is requested to give an object to the teacher, after it has been placed in the child's hand. The task is changed so that the object is placed on a table, later a different object is used, and then two objects are placed on the table simultaneously and one is masked to prevent the child from touching it. The mask (the teacher's hand) is gradually removed, more stimuli are added to the array, and the task is arranged as described for the terminal behavior. Jenny's performance is shown in Figure 8.

Insert Figure 8 about here

These response shaping programs illustrate the number of steps programmed to enable children to respond without a high percent of errors on increasingly more complex tasks. Object and position alternation trials are built into each program to avoid establishment of inappropriate error patterns. When children have a small repertoire of these motor responses, they have the prerequisites to engage in language, math and concept learning programs, such as those described in the next section.

Complex Concept Development Programs

Visitors to our project hear many "Touch ___," "Touch another ___," "Put the ___ in the ___," "Give me ___" commands. Those who focus on the first part of the task request are likely to conclude that an inordinate amount of time is spent shaping motor responses. Those who attend to the last half of the request and to the stimulus array are more likely to attend to the concepts which are being taught. The programs in this section show problems related to sequencing of complex instructional tasks, including object discrimination (identification or concept learning), reading and math behaviors.

Object discrimination. Earlier sections of this paper have described strategies to establish behaviors which are considered important as prerequisites to "academic" instruction. Similarly, the development of a repertoire of known objects and actions is considered prerequisite to the development of language.

The basic format for programs to teach objects, or labeling, or concepts, is taken from the object discrimination lesson plan of the SLI curriculum. That format, as described earlier, enables a child to utilize a motor response if he has no intelligible vocal behaviors. Materials are presented in stimulus arrays in such a fashion that only "instances" of a concept, or S^d's are presented initially, to insure that if a child responds, he must respond correctly. Gradually "not instances" or S^Δ's are faded into the stimulus array so that a correct response represents discrimination among objects or events. Generally, a variety of stimuli are present when a child is posttested, and are arranged to preclude responding to irrelevant cues such as color, size, position, novelty, etc. Just as the SLI "Touch" program was expanded for use with children with more limited functional levels, the object discrimination program was modified for lower functioning children.

The first revised program was presented to Mike, described earlier, whose performance is shown in Figures 9 and 10. He responded correctly (touched), was placed directly in the stimulus array in Step 3, and error occurred. Varying placement of S^Δ's did not result in criterion performance, nor did other similar procedures. However, when S^Δ was placed at the edge of the table and faded into the stimulus array, in very small steps, Mike met criterion, responding correctly to 77% of the 151 trials. His performance on revised programs is shown in Figure 10 on a program to teach cup and bowl, both functional objects in the environment. Performance was below criterion on Steps 4 and 5 (cup) and Step 2 (bowl). This was corrected by repeating the demonstration-task request sequence. Teacher error occurred when Step 7 of the bowl lesson was skipped. Again, criterion performance was established when the teacher repeated the sequence.

Insert Figures 9 and 10 about here

Mike was pretested on the Touch I, II, Touch Another and Object Discrimination concepts after the summer recess, to determine the extent to which initial learning was retained. He failed the pretest on Touch I, II and then Touch Another (as shown on Figure 11), went through Touch I and II programs meeting criteria on each step. He met criterion on Touch Another with few trials (58) and responded without error on 86% of the trials. He passed the pretest on object discrimination block but failed the cup pretest.

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Insert Figure 11 about here

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The S^{Δ}'s in the program were unfamiliar objects. After Mike met criterion on block and cup, both objects were included in the same stimulus array to determine if he could discriminate block from cup. "Touch cup," or "Touch block" tasks were alternated, and he responded at chance. Analysis of his response patterns, led to the inference that there were multiple reasons for failure. Analysis of the stimulus array revealed that, due to program error, a numerosity cue was present. The possibility was raised that Mike was not attending to the teacher's verbal statement, but to other cues. A modification of program design changed the numbers of items used in a program, to resolve the first problem. The latter was changed by masking stimulus materials, to insure that children attended to task requests.

Reading programs. Reading and math are generally considered to be highly developed forms of language behavior, thought to be beyond the capability of children with assumed severe developmental retardation. As views change with respect to the development of human potential, instruction in these "academic" areas is seen as valid and functional. However, because of the complexity of the task, it seems that Bruner's (1960) assumption that anyone can be taught a form of any concept effectively will be most sorely tested in these areas.

The scope of development for an errorless learning reading program begins with the prerequisite behaviors which have been described here and is to end presumably with a "reading" repertoire sufficient to enable a child to enter existing reading programs. Several different activities are currently in progress to design stimuli and apparatus for reading programs. Table 1 shows a tentative set of behaviors which may be considered a preliminary list of prerequisite skills and reading performances derived from a task analysis of reading behavior.

- -

Insert Table 1 about here

- -

As one component of an automated reading program, children are taught to interact with simple manipulanda to develop prerequisite behaviors. Preliminary match to sample activities are designed to be presented on a 9 panel matrix, similar to one described by Sidman and Cressen, 1973, and on a 6 panel (1 sample, 5 match) interface described by Bijou (1968). A match to sample interface will be designed to approximate the size and shape of a pre-primer, for automated reading comprehension activities. Concurrently, reading programs have been developed for adult-child instruction, and some rudimentary attempts to teach reading have been attempted. Data are presented which were obtained in an adult-child program to teach components of reading behavior to Lafaithia, a Down's child who attended the program for two years. She is toilet trained, feeds herself, emits a number of phrases, of which some are functional and others are not. She interacts appropriately in group and individual instruction, seeks adult interactions but rarely interacts with other children.

The components of this reading program are shown in Table 2.

Insert Table 2 about here

This version of the program contained six sections, 31 steps and three major activities: visual and auditory discrimination, and a match to sample task. In the first section of the program, 1A (Figure 12), Lafaithia was simply requested to touch a card, S^d, representing the word chair. The card was then positioned at random on one of eight squares on the periphery of the nine panel matrix until criterion was met. Then, each cell was filled with blank white cards in Steps 2-8. After each panel was filled (1 word-7 blank cards), a card with a word on it replaced one blank card (S^Δ), so that after 7 more steps, Lafaithia was required to discriminate the word chair from 7 other words in the stimulus array. Criterion was 6 consecutive correct responses on each of the 15 steps in this section of the program. An additional 15 steps, section 1B (Figure 13) were presented with an auditory cue. Sections II A and B represent the same procedure, but with another S^d, the word cup,

Insert Figure 12 about here

Lafaithia made few errors, until 2 S^Δ's were presented in section IA of the program, Figure 12, when an indiscriminate response pattern became evident. She met criterion for Step 9 in the first session, after a time out procedure (loss of teacher's eye contact) was introduced subsequent to an incorrect responses. She progressed through the remainder of the program without error (Figure 12), and performed similarly on section IB, auditory discrimination (Figure 13). She met criterion at each step on each program with word 2 (Figures 14 & 15) but when both words were presented (Section III, steps 16-22), multiple errors occurred (Figure 15). The program was modified to present each S^d for a block of trials rather than alternating S^d's in a random sequence. Alternating blocks of trials initially consisted of 15 presentations of each word, but were gradually reduced in steps of 15, 10, 5 and 1 (Steps 16A, B, C, and D) until random alternation (Step 16E) was reintroduced and criterion was met. Lafaithia then quickly met criterion on Steps 17-22 as S^Δ's (7 other words) were added to the periphery.

- -

Insert Figures 13, 14, and 15 about here

- -

Figure 16 represents performance on a match to sample task. The picture corresponding to $word_1$, chair, was placed in the center of the matrix. The word chair was then placed at random on one of the eight panels on the periphery. The picture than became an S^d for touching the word chair (Step 23). After the criterion of six correct touching responses in a row was met, trials for Steps 24 through 30 were begun. After each set of trials, another word was added to the array so that, when she reached criterion, Lafaithia was selecting the word which matched the picture from a stimulus array of 8 words. She completed the program with 96% correct responses for $word_1$ and 90% for $word_2$ (Figure 17).

- -

Insert Figures 16 and 17 about here

- -

One series of steps, introduction of blank cards, was deleted before she entered section 4. This shortened the program considerably. The program shortened even more when the teacher decided to skip the last 4 steps of Section V for $word_2$, and terminated Section V of the program after $word_2$ was presented with only three other words. This decision was made because Lafaithia was responding at a rapid rate with few errors. However, this decision did not take the task requirements of the next program step into account. Subsequently (Figure 18), the consequences of this decision became evident.

- -

Insert Figure 18 about here

- -

When the picture of cup and chair were alternately placed in the center panel of the matrix, Lafaithia was required to touch the word cup or chair, with 1 to 8 words presented in the outer panels of the matrix. The procedure for fading S^d's to random alternations (previously described Step 16A, B, C and D) was employed. Although Lafaithia initially progressed through Step 31A, she began to engage in a variety of off task behaviors and failed to respond correctly when the teacher probed performance on Step 31D. A two second delay between presentation of the sample and the matching stimuli was introduced, with little success. The original order for presentation, Step 31B, was reinstated but failed to improve performance, so three alternate strategies were employed:

1. She was required to touch the sample (picture) before selecting a word.

2. An auditory cue was given when the sample was presented, e.g. "Cup" or "Chair" when presenting the picture cup or chair.

3. No primary reinforcement was given for a self-corrected incorrect response.

The terminal behavior was not reached in this program, despite the strategies used to regain stimulus control, and attempts to utilize more powerful reinforcers. Lafaithia left this program for a public school placement and further program revision ended.

In summary, the data presented give examples of:

1. Loss of stimulus control due to allowing repeated error to occur.

2. Loss of stimulus control due to programming error, e.g. skipping steps.

3. How precise programming can overcome error, e.g. fading in of random alternation.

4. Necessity for systematically planning reinforcer change so as not to satiate S.

It is also evident that the program was based on too many erroneous assumptions. Lafaithia was assumed to be able to discriminate among picture stimuli, to identify object-picture coorespondences, and to discriminate among selected word stimuli. None of the assumptions may have been valid and, again, more precise programming sequences are being developed (Table 2) to insure that all the assumptions can be tested.

<u>Math programming</u>. Math concept learning is considered a complex form of language learning. As such, the development of a language repertoire is considered prerequisite to the learning of number concepts.

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Insert Table 3 about here

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A preliminary set of math tasks is listed in Table 3, along with the behaviors required to teach the tasks. The data shown in the following examples were obtained in adult-child interactions with children whose functional level is more representative of children often found in public school "TMR" classes. Each child, as noted, had a history of 1-2 years in the project and had a highly developed language repertoire, though not necessarily an extensive repertoire of useful vocal behavior.

Based on this information, a first sequence of math programs for number concepts 1 to 5 was written. However, as often happens, too many assumptions were made about children's competence; and it was necessary to revise the program to include strategies to establish stimulus control. Kathy's performance illustrates the response patterns which led to the downward revision of the program (Figure 19).

Insert Figure 19 about here

Kathy is six years old, presumed to be severely retarded and has been in the program sporadically for a year and a half. She spontaneously uses a few words, is toilet trained, feeds herself and follows simple tasks request. Kathy responds fairly well in an individual instructional setting but does not interact well in group situations. When she is unable to meet demands in instructional settings, she cries and screams. In fact, when she first entered the program, crying and screaming constituted most of her behavioral repertoire.

The objective for the first program required that Kathy match two colored one inch cubes to two black one inch squares on 3" x 5" white cards in response to the task request "Kathy, put two on two." On the pretest, four correct number cards (the concept being taught) and 12 incorrect number cards (3 each of non-concept numbers) were present in the stimulus array.

During the first session, Kathy failed the pretest and stage 1, where she was required to respond to the task request by placing the cubes one at a time on two one inch blank squares on each of four 3" x 5" number cards. Her performance was marked by non-attending, block stacking, shuffling of the cards used in the program and superstitious behavior such as hand clapping.

A fading strategy was employed, starting with only one correct stimulus card present, and fading in other cards one at a time. After a set of response blocks (50 trials) Kathy met criterion on step one, and on step two, which faded four additional number cards with 1, 3, 4 or 5 one inch squares on them into the stimulus array.

A probe procedure was then introduced to determine if Kathy met the terminal criterion. This procedure required Kathy to perform as requested on the pretest. The stimulus array was rearranged a total of four times, with four task requests given for each arrangement. Kathy failed to meet criterion, and step three was taught. Again, she was required to place the cubes, one at a time, on each of four cards containing two black one inch squares when given the task request by the teacher. The position of the stimulus materials (C number cards) was different from that of step two. All eight cards were presented at the same time, fading the non-concept (1, 3, 4, and 5) cards into the row of number two cards. Kathy failed to meet criterion. The non-concept cards were then faded into the stimulus array, then introduced, one at a time, in random positions until eight cards were present.

Kathy met criterion on two of three position changes in step three but only after a lengthy set of fading procedures was introduced. As shown in Figure 18, she required 100 trials in six sessions to partially complete step three. Had she met criterion on steps one and two and the portion she completed on step three, Kathy would have had to respond to only 28 task requests.

Her performance led to the assumption that a stimulus control program was prerequisite to instruction. Following this assumption a program was developed to establish stimulus control so that 1-1 correspondence activities might be facilitated. As a basis for further number concepts, stimulus control was begun with the concept one, since materials for concepts two through five initially involve the same type stimuli, black one-inch squares. The task request was "S, put one on one."

The first stimulus control program was presented to Joe, a six year old Down's syndrome youngster who had been in the project two years. He is toilet trained, feeds himself and is able to dress himself. He interacts well with other children, initiates imaginative play situations such as "house," and appropriately makes requests of adults. In an individual teaching session, however, he usually completes only a few task requests, then stops responding.

The stimulus control program required Joe to place 1" cubes on each of four cards containing a black triangle, with no other stimuli present. The size of the rectangle was initially 3" x 5" and was faded to a one inch square in 10 steps with 40 trials required to meet criterion. Joe went through 6 steps of the program without error in the first session (Figure 20), but made an error in the first set of trials during the second session when he placed the cube outside the rectangle, and failed to meet criterion. He completed the program without further error. However, the stimulus control program was considered too lengthy and was revised by introducing probes and by changing the criterion for a correct response.

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Insert Figure 20 about here

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This revised program was presented to Polly, a five year old Down's syndrome child who has been in the project a year and a half, attending half days for two days out of the week. She answers questions with one word responses, uses complex sentences when initiating verbal behavior during play with other children and imitating adult behavior, feeds herself, but is not yet fully toilet trained and does not completely dress herself. She follows simple commands, seeks out adults in situations and prefers to play by herself rather than with other youngsters. When confronted with instructional demands, she often times out the teacher, begins sucking her thumb, and/or repeats statements such as "No, I don't want to ___."

In this version of the program, where size is faded from 3" x 5" rectangle to 1" squares, a probe is defined as presentation of a stimulus card, planned for use in a later step of the program. If, for example, Polly passed Step 1 (3" x 5" black rectangle on each of 4 stimulus cards with 4 trials to meet criterion) she received probe A (presentation of Step 6, a 2" x 3¼" black rectangle on each of four stimulus cards with 4 trials to meet criterion). If she passed, she was presented with the next probe, B (presentation of Step 11, a 1-1/3" x 2" black rectangle on each of four stimulus cards with four trials to meet criterion). Figure 21 shows that Polly met criterion on the stimulus control program in 20 trials, without error, passing from probe to probe.

- -

Insert Figure 21 about here

- -

The final set of program revisions for stimulus control is shown in Table 4. The materials were expanded to provide a more gradual fading of size where error was more apt to occur, the criterion was changed to permit placement of the cube within a parameter around the form, and probe stages were introduced which reduced the number of trials to complete the programs.

- -

Insert Table 4 about here

- -

Mary Beth's performance on the revised math program is shown in Figure 22. Mary Beth is 4 years old, Down's syndrome, and has been in the project for 1½ years. She spontaneously uses words, some phrases, feeds herself, is toilet trained, and follows a 3 sequence command. She attends to task requests in an individual session but when given materials and a task request will often "hide" the materials. Mary Beth was not in the stimulus control program.

- -

Insert Figure 22 about here

- -

Although she passed the first step of the program, error occurred when four non-concept cards were introduced in Step 2 (previously described), an indication that she was not under stimulus control. A time-out procedure was used when she engaged in inappropriate behaviors like hiding cubes, playing with them, etc. This reduced the number of trials per session and therefore increased the number of sessions. After a revised series of correction procedures was introduced she met criterion at Step 2. The correction procedure initially involved a repetition of a demonstration but when error still occurred, the number of trials necessary to complete a step was increased as well as the criterion. Mary Beth then passed through the remainder of the program without further errors.

An additional stimulus change was made in the next program (Figure 23), by introducing a variety of objects and removing the one inch cubes.

- -

Insert Figure 23 about here

- -

Mary Beth progressed without error through a set of steps which required her to place the small object, such as a chip, on a card with the same stimuli used in program IA. A probe (the posttest for the program) was presented, and error occurred. However, since failure to pass a probe does not require repetition of a step, or a return to a lower step, Mary Beth was presented with Step 7, which required that she place the counting objects on the correct number cards with 12 cards present in the stimulus array instead of the 16 present in the posttest. Plateaus on Step 7 and the posttest appeared when inappropriate behavior was consequated with time out.

Mary Beth progressed rapidly on the next program (IC) which required her to place different counting objects within a black outline of a one inch square.

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Insert Table 5 about here

- -

Table 5 represents the revised sequence of programs that proved effective. At this time, data has been collected on programs I through VB.

The revised set of programs was presented to Tina, who recently entered the program. She is five, has a repertoire of garbled speech sounds, rarely interacts with teachers, hits other children and frequently takes toys away from them. She follows compound verbal commands and functions successfully on gross and fine motor tasks.

Insert Figure 24 about here

Tina completed the stimulus control program with few errors, she progressed rapidly through program IA (Figure 24), which required that she place a one inch cube on each of four concept cards, present with 12 additional non-concept cards in the array. She went through the remainder of the programs in that series (IB-E) without error, completing tasks which required her to place a different object on concept cards and systematically changed the color and shape of the outline on the cards. When her performance was contrasted with that of children on early stages of the program, it was concluded that programming position changes and fading other stimuli into the array were significant factors in improved instruction.

Tine progressed to the yes-no confirmative component of the program which required her to respond "yes" or "no" when the teacher pointed to a group of objects on the table and asked "Is this one?". During Steps 1 and 2 (Figure 25) where only 1 object at a time was presented as the stimulus and the correct response was "yes," Tina met criterion. At Step 3, the task changed, and she was required to respond "no" for the first time when the teacher pointed to the appropriate set of objects, a non-concept grouping.

Insert Figure 25 about here

She failed to meet criterion and additional teacher demonstrations of correct responding were programmed. When that strategy did not produce the desired response, the objects in groups were removed, and replaced with the materials used in previous programs. Then, the number of "yes" cards in the array was increased to insure responding to the correspondence between the spoken number and the number present on the card rather than to numerosity. If the task request was "Is this four?", the child was required to respond to 4 concept cards (one) and 4 non-concept cards with other groupings (two, three, four or five).

Error still occurred, and further program modifications were instituted. The number of cards in the stimulus array was reduced to four for the first two steps and incremented one at a time till eight cards were present (Step 6). Increments then occurred to 12, to 15 and finally to 16 cards presented on the posttest. As an additional strategy, Tina was asked to count the number of squares after she had made a correct "yes" response.

Fewer errors occurred at Step 4, and Tina met criterion on Step 5 in one set of trials. Due to teacher error, Step 5 was repeated in the next teaching session (response block 15). In Step 6, the number of non-concept cards was increased so that 8 cards were presented for the first time.

Up to this point, criterion was 100% correct responding. In Step 6, criterion changed to 7 correct responses in a set of 8 trials, and incorrect verbal responses were counted as correct, if self corrected within 2 seconds. Three repetitions of this stage were required before the criterion was met. A probe, the posttest, was introduced and failed.

In Step 7, a number concept not previously presented in the program was introduced, to determine if generalization of the "no" response would occur at this time. Cards were held one at a time in front of the child and the teacher asked "Is this one?". The task request was presented for twelve cards (four each of the different number concepts including the concept one). Criterion at this point allowed for one error in twelve responses.

On Step 8, another number concept was introduced, but the number of cards presented remained the same. Three cards of each of four concepts were shown one at a time to Tina and a "yes" or "no" response was given. If the correct response was "yes," Tina was given the added task request "Count."

Tina then passed the posttest, responding correctly 15 out of 16 times, with 16 cards presented. Since Tina went through the program in 210 trials, the program was reduced in length and alternate strategies employed in stage one were built into the next version of the program. Additional teacher demonstrations and verbal prompts were added into the earlier steps of the program, facilitating generalization of the "no" response in the later steps of the program. A second task request "S, count" was consistently used after a "yes" response and a fading in of "no" or non-concepts followed.

The revised program was presented to Corey, a six year old Down's syndrome child who has been in the project for a year and a half. He speaks spontaneously and in phrases, but speaks very softly and often cannot be understood. Corey is toilet trained, feeds himself, follows multiple commands, sorts by two attributes and traces his name as well as numbers. He initiates activities and engages in play with his peers. Corey does not initiate verbal interaction with adults unless making a request for a toy, food, or some preferred activity, but he is outgoing with his peers, expressing his feeling about situations and giving task requests to others.

Insert Figure 26 about here

Corey completed the first 2 steps (Figure 26) in the "yes-no" confirmative program in 1 session, without error. In Step 3, when a "no" response is required, a verbal prompt was sufficient to correct his incorrect responses. He passed Step 4 with no error when six cards were presented, skipped Step 5 and passed Step 6, in which 8 cards are presented without error. To this point, a "no" response involved only the number concept four.

Corey passed the probe (posttest) in which 16 cards representing number concepts one to five were presented when given the task request "Is this one?". Corey was able to generalize the "no" concept to numbers 2, 3, and 5 without having been "taught" to respond to these specific configurations.

The data presented in this section illustrates a number of problems occurring in the development of an "errorless" math sequence. First, the children disproved the hypothesis that their prior experience was sufficient to establish stimulus control on the math program. When error occurred, the programs were expanded by adding additional steps to fade in extraneous stimuli in a more gradual process. In some instances, these changes reinstated correct responding, but at the expense of time and a large number of trials. To partial out numerousity cues, an exceedingly large number of cards were added to the stimulus array. Program modifications are in progress to resolve these problems, concurrent with the testing of rote and rationale counting activities. As each graph shows, program modifications generally reestablish criterion performance, but often at the cost of efficiency. Resolution of this problem is necessary before the final curriculum is effective and efficient.

Summary

The establishment of educational opportunities for children with severe and multiple developmental problems is not likely to be an easy task, but one which can be simplified by providing data to document that such children do have potential to learn. This paper has described one method for obtaining such data. A concept, errorless learning, has been identified as a potentially useful framework for programming environments and events (curricula). As an alternative to traditional special education practices, procedures and instrumentation from the operant laboratory have been utilized to begin the development of curricula for children presently called "severely retarded." Through the process of task analysis, and careful arrangement of events (stimuli), preliminary attempts are underway to develop curricula for infants and young children in language, concept development, motor development, self-help and socialization skills. A programmed preschool environment has been designed and implemented, and activities are underway to develop home-placed apparatus; eventually to begin instruction within a few day of birth, and continuing into the middle school years.

Data have been presented on samples of curricular activities from different components of a tentative curricula. In each example, the problems involved in the development of errorless programs have been described. Program modifications, based on children's correct or incorrect patterns of errors, have been discussed. Since it seems important that the behavior taught (or not taught, as the case may be) be specified clearly, tasks and the stimulus conditions under which they are presented have been listed in detail. Similarly, because there is often confusion about what is meant by "severely retarded," each program description has included a set of behavioral attributes of the child whose performance has been described. We would recommend this procedure to others who work with children such as these, but feel particularly obliged to do so since we work with children at different functional levels.

There are undoubtedly numerous lessons to be learned from analysis of child performance as presented here. However, in the context of what we were required to do when our programs did not produce the desired result, there are some specific modifications in our behavior that should be summarized. First, make fewer assumptions about behaviors, or their absence, until they have been tested. Anticipate certain typical response patterns, e.g., position responding, and structure programs to reduce the probability that they will occur. Arrange stimulus materials with reference to how they will be sequenced in the terminal stages of the task. Where necessary, be prepared to shape a response repertoire carefully and systematically, to insure that children have sufficient opportunity to demonstrate that they have learned what they have been taught.

A persistent problem, which we have yet to resolve, is the programming of reinforcing events so that children will respond consistently to a variety of instructional settings during the course of a typical school day. Similarly we are currently determining the strategies for structuring adult-machine-child interactions so that children who intially learn with massive physical prompts from adults can become independent learners who self-initiate interactions with automated equipment. A final problem relates to sequencing of curricula, and environment and programming activities, to insure that when children do interact with "teaching machines," the curricula presented on them will be sufficiently precise to allow others to learn with a minimum of errors. When this point is reached, perhaps we will have some tentative answers to properly address the questions raised by Bruner's assumption.

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Reinforcer Evaluation

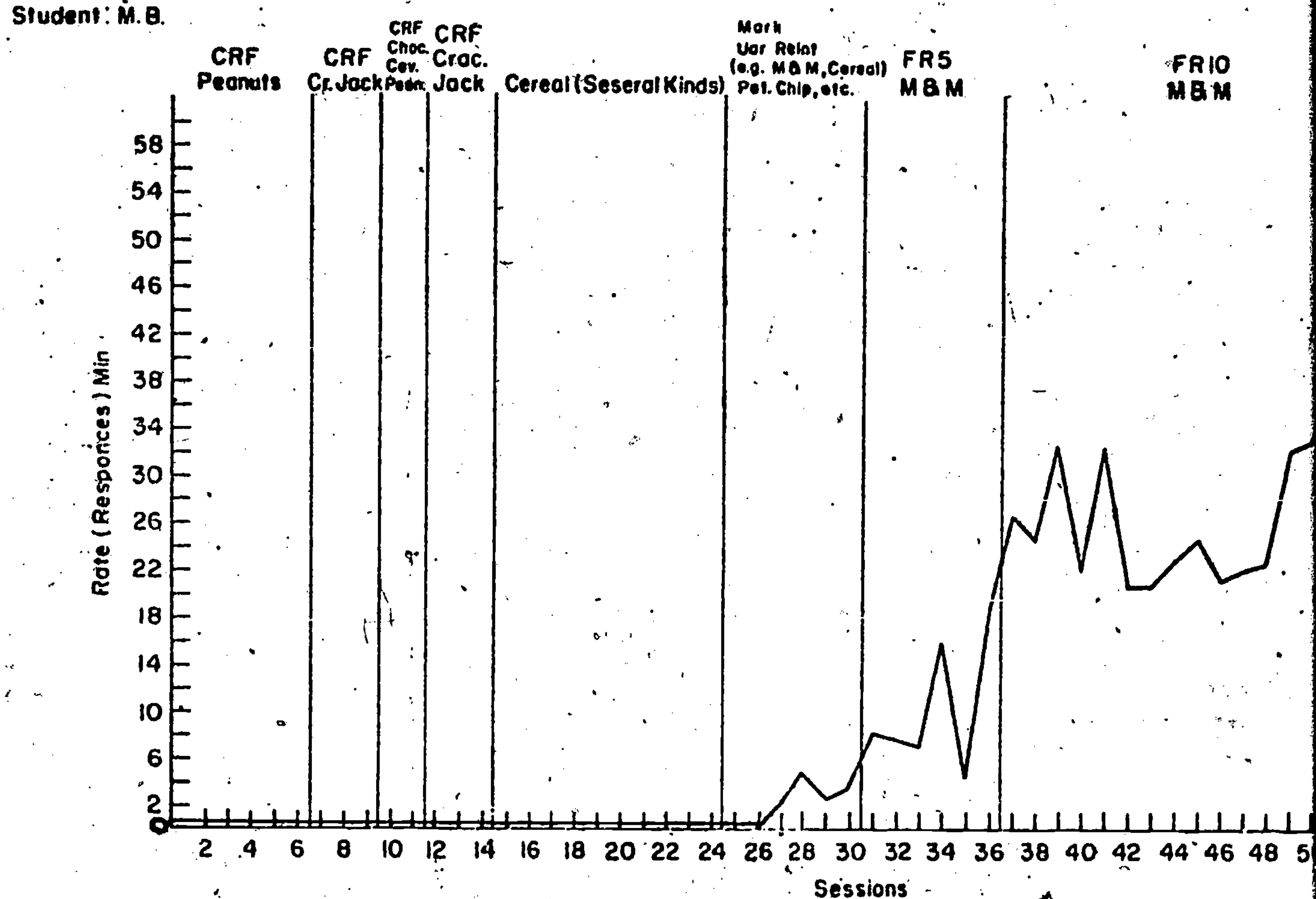


FIGURE 1

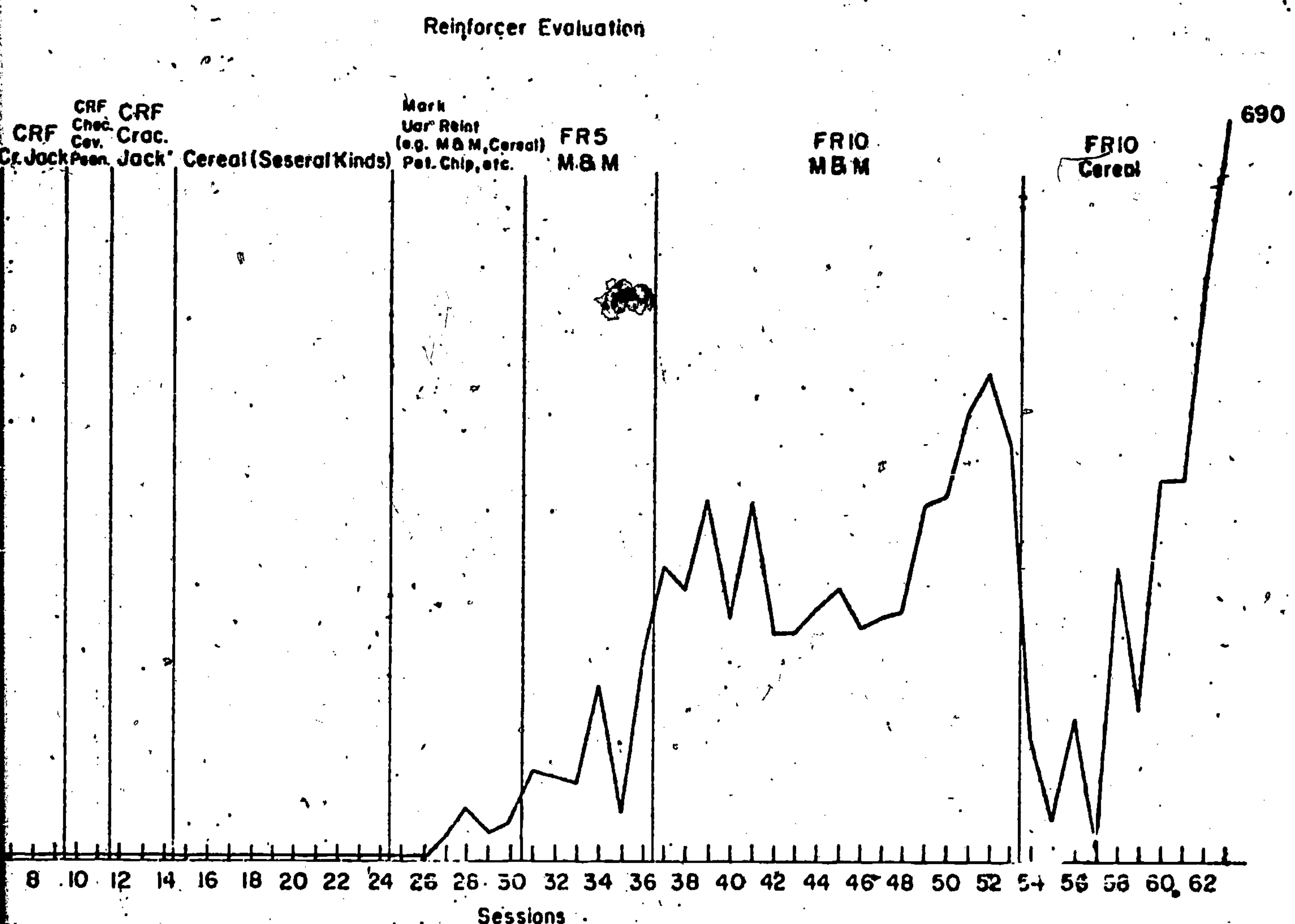

Reinforcer Evaluation
CRF
Cr. Jack
CRF
Choc.
Cov.
Pean.
CRF
Crac.
Jack
Cereal (Seseral Kinds)
Mark
Var Reinf
(e.g. M & M, Cereal)
Pot. Chip, etc.
FR5
M & M
FR10
M & M
FR10
Cereal
690
8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60 62
Sessions

FIGURE 1

30A

Student: J.R.

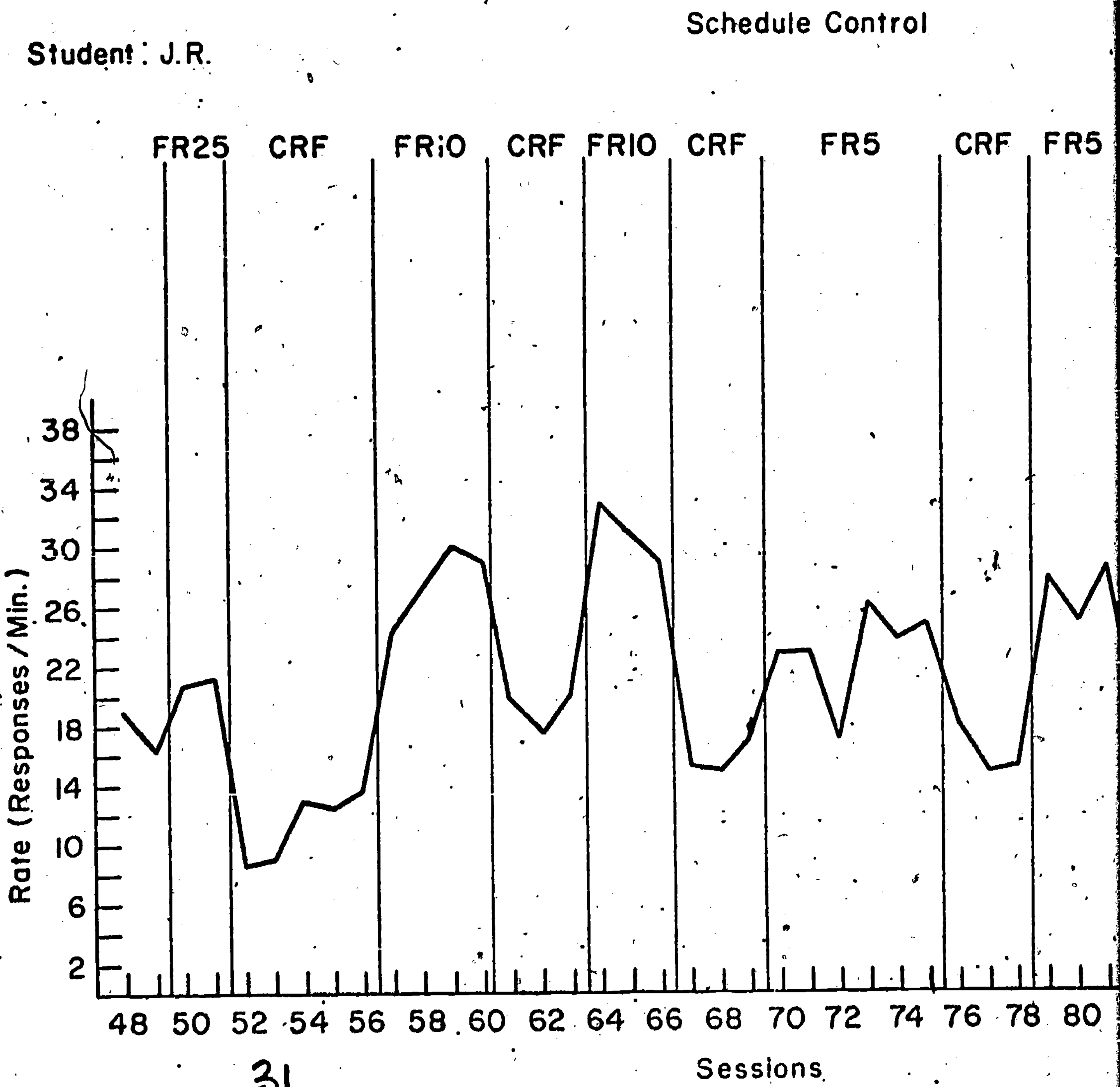
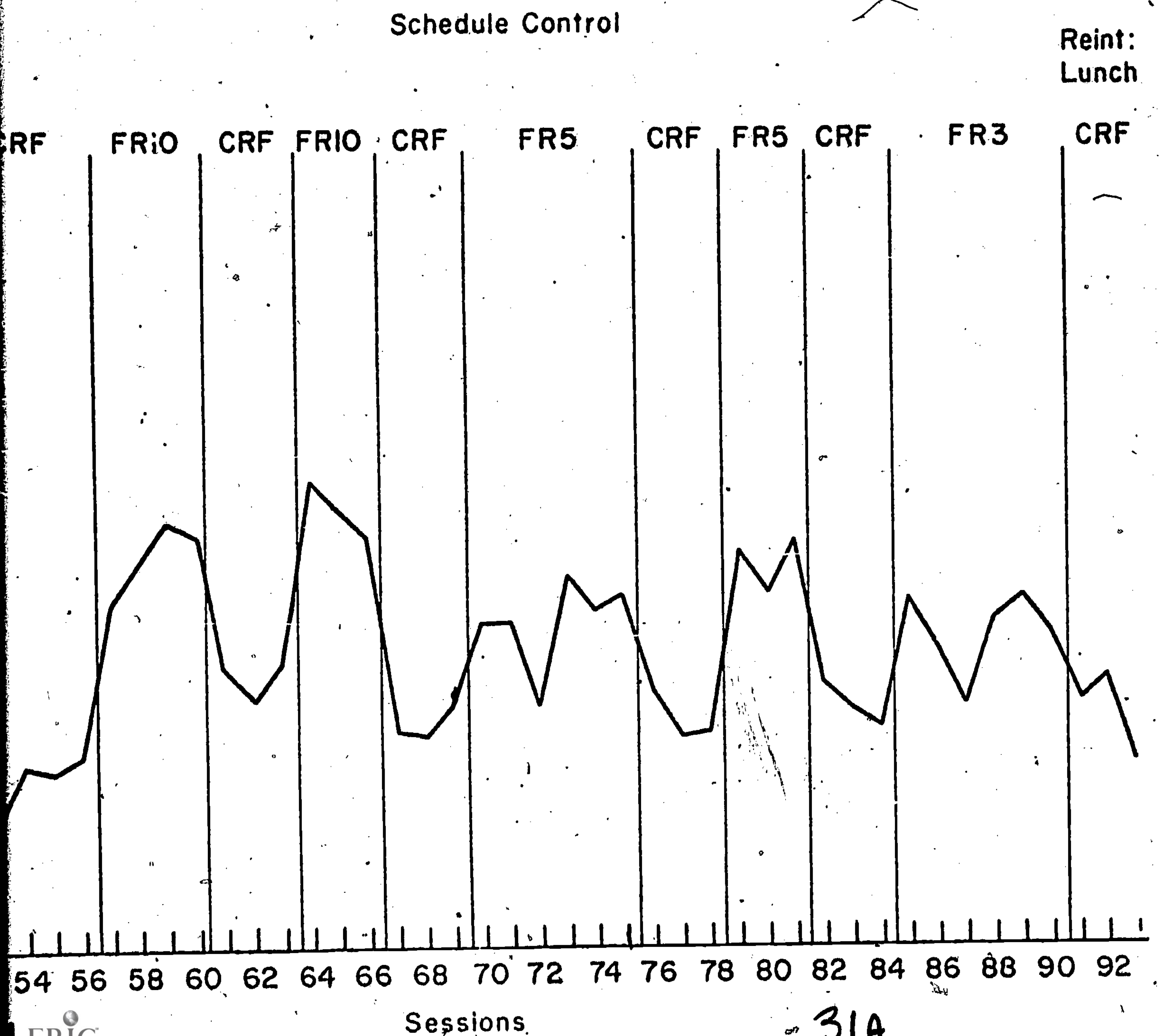


FIGURE 2



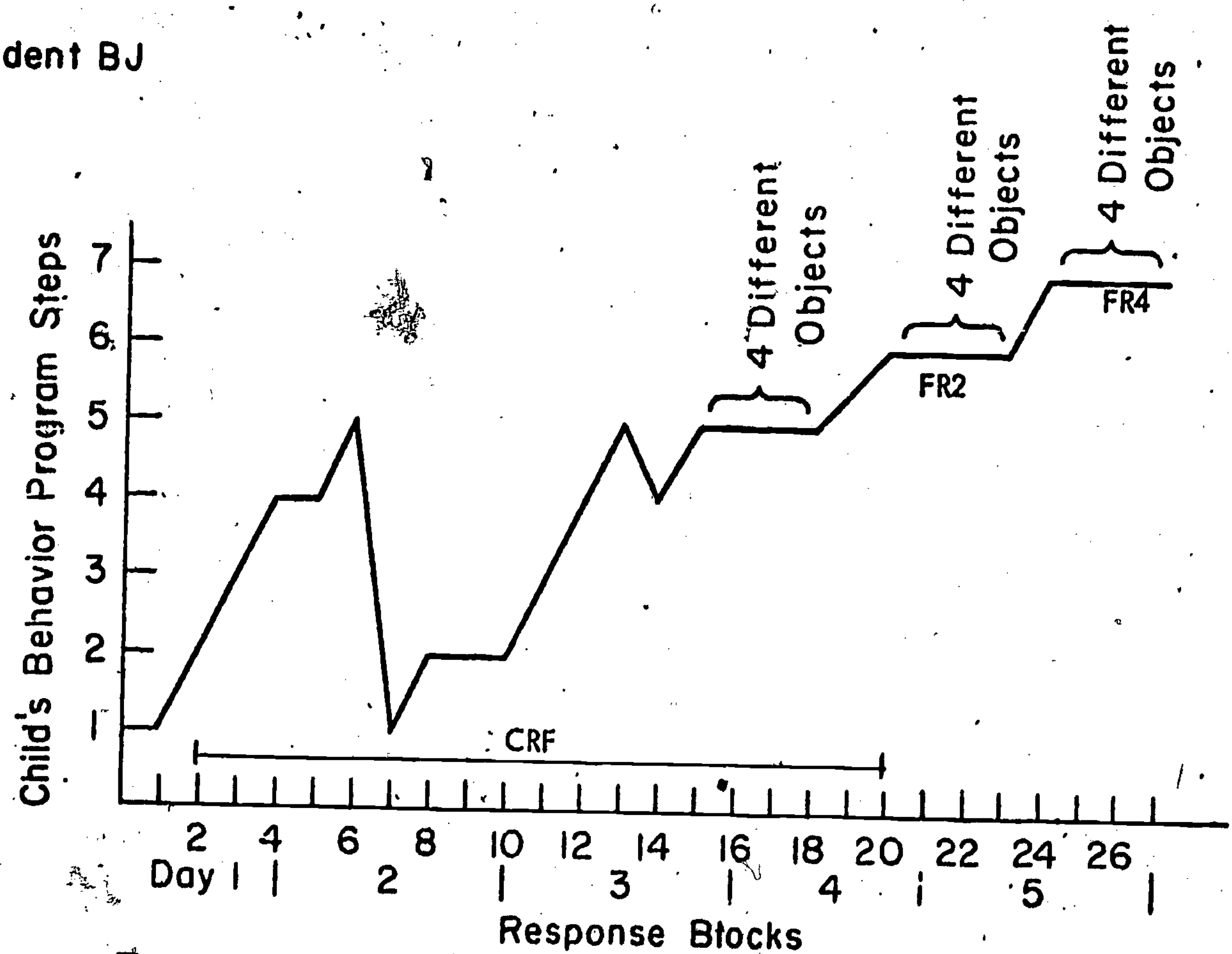
Schedule Control
Reint: Lunch
CRF
FR10
CRF
FR10
CRF
FR5
CRF
FR5
CRF
FR3
CRF
54 56 58 60 62 64 66 68 70 72 74 76 78 80 82 84 86 88 90 92
Sessions

31A

FIGURE 2

Touch I
Stage I

Student BJ

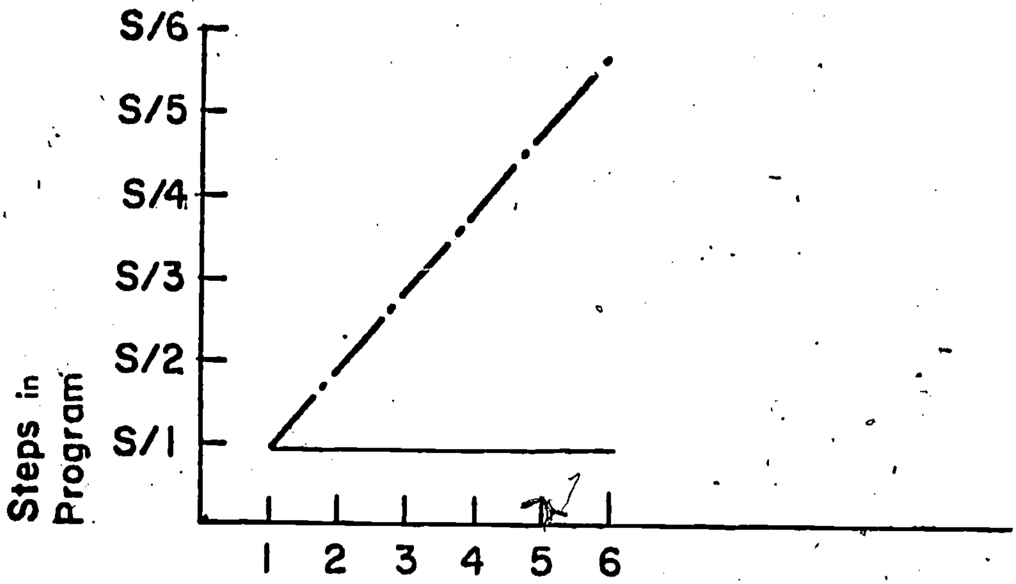


Total Sessions 5 Trials 217 % Correct 95%

10/8/73 - 10/12/73

FIGURE 3

Hypothetical Slopes for Criterion and Below Criterion Performance

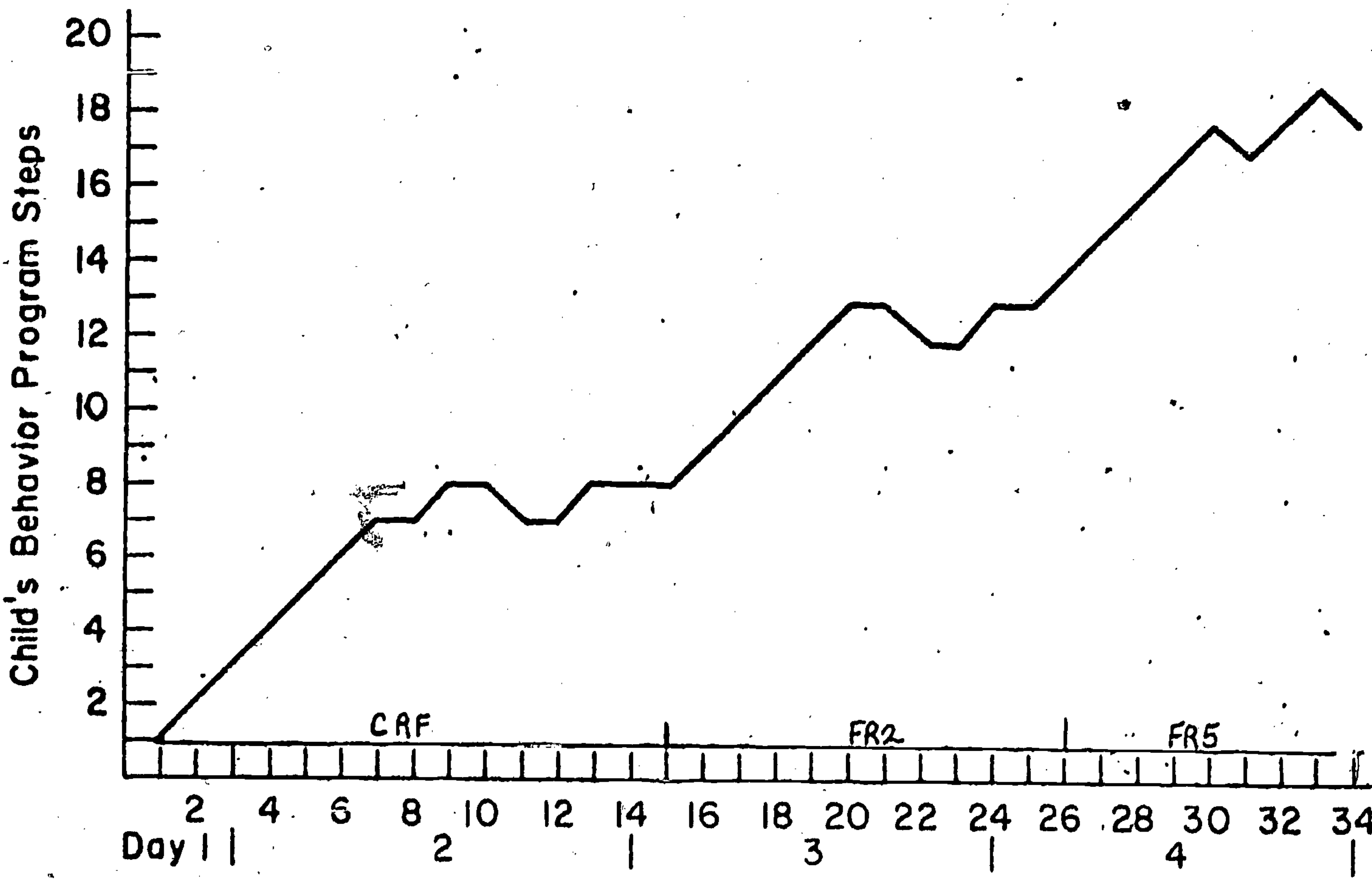


Response Blocks (n responses required to progress from one step to another within a program)

FIGURE 4

Student BJ

Touch II
Stage I



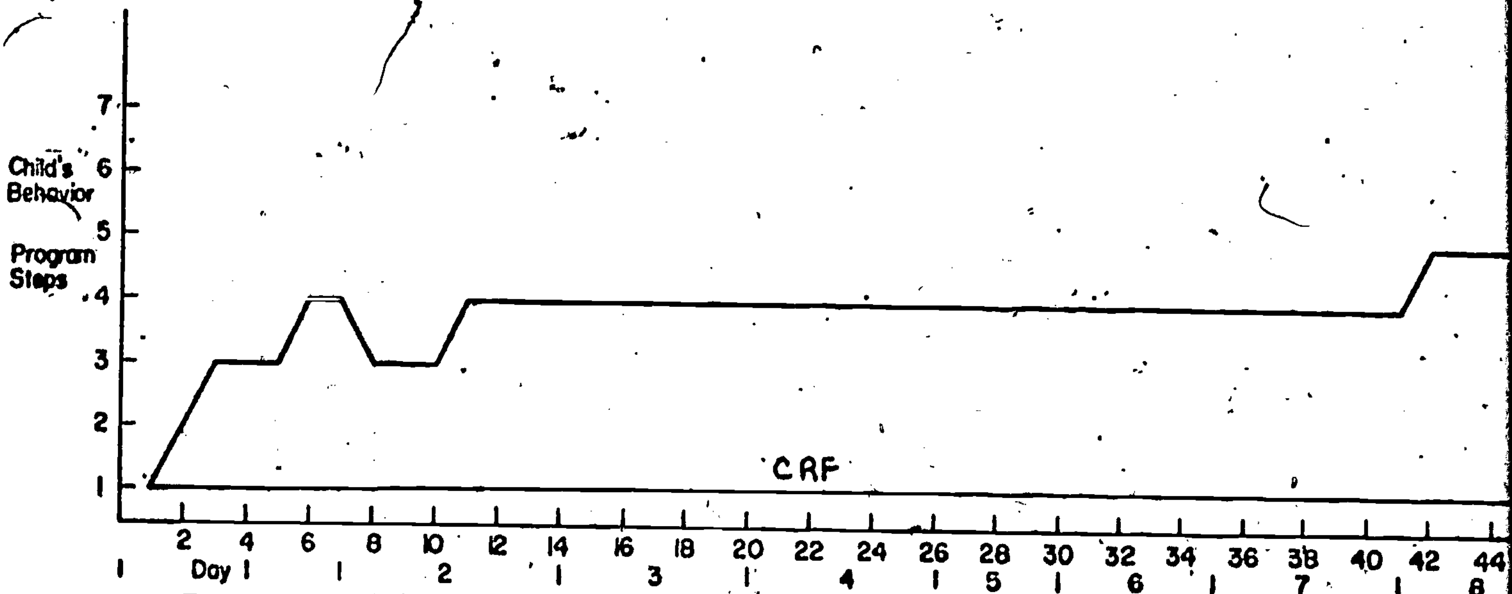
Response Blocks

4 Sessions 417 Responses 95% Correct

10/12/73 - 10/24/73

FIGURE 5

Student B.J.   Touch Another   Stage I

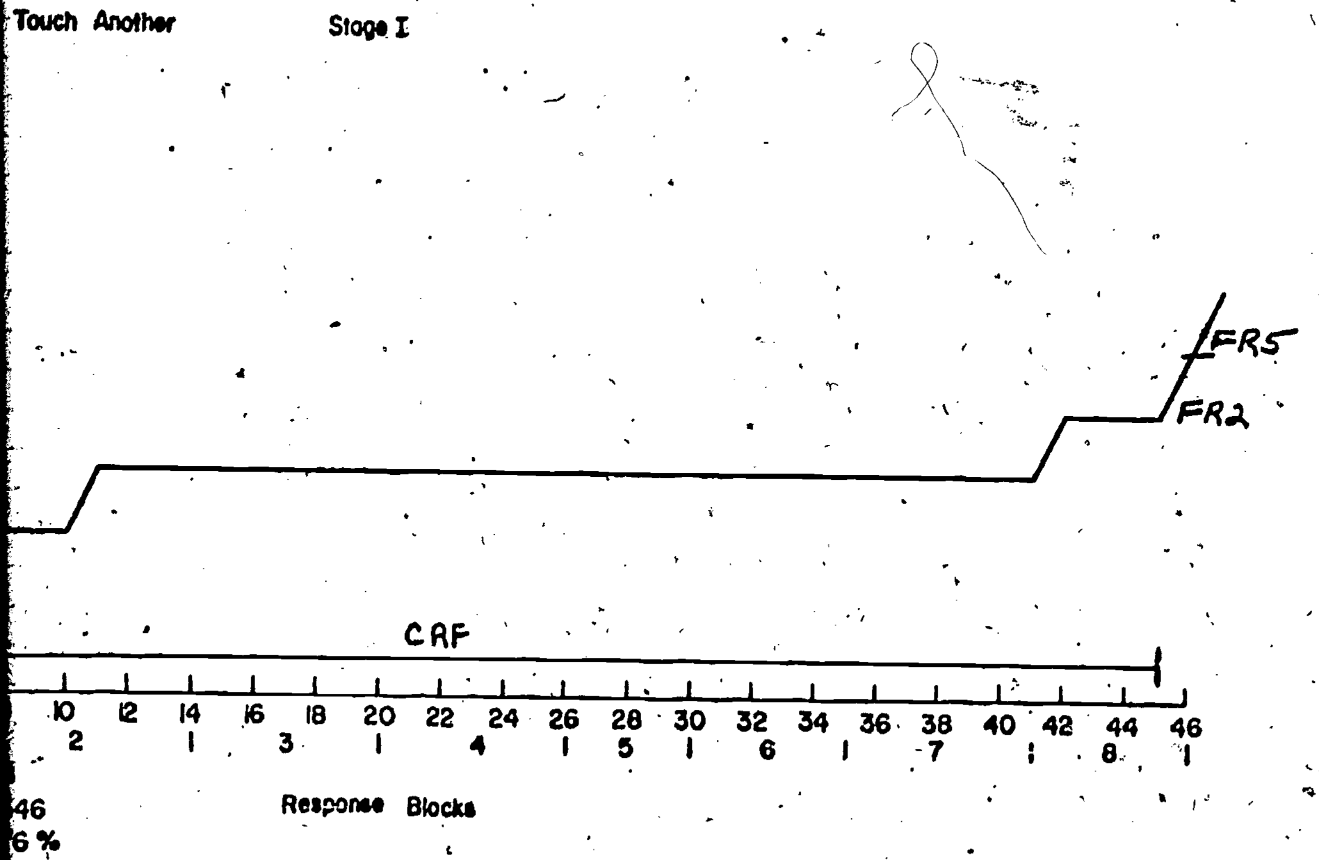


Response Blocks

Total Sessions 8
Trials 546
Correct 76 %

10/24-11/7/73

FIGURE 6



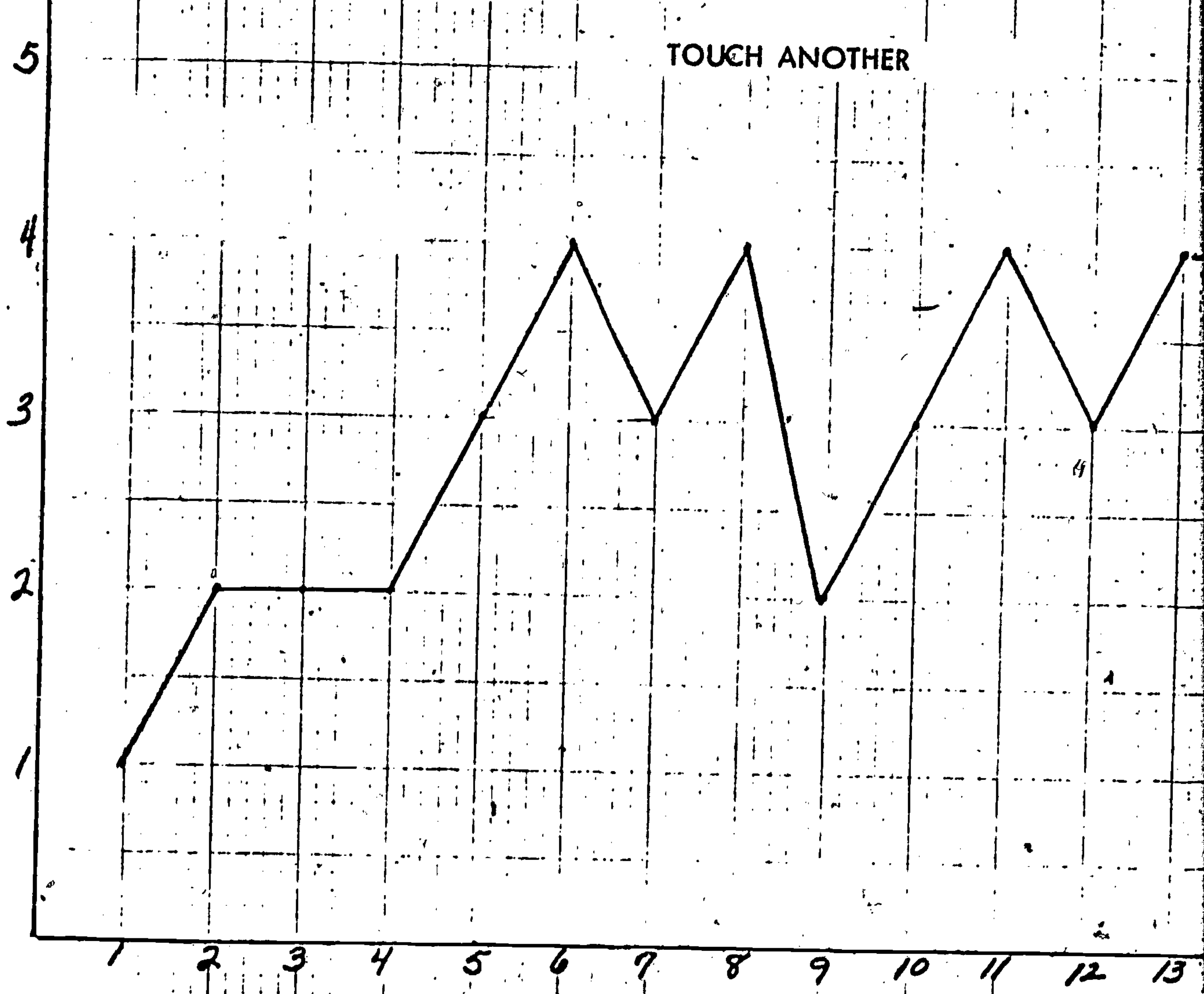
Touch Another
Stage I
FR5
FR2
CRF
10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46
2 1 3 1 4 1 5 1 6 1 7 1 8 1
46
6 %
Response Blocks

FIGURE 6

STUDENT: MB

FIGURE 7

TOUCH ANOTHER



4 SESSIONS

126 TRIALS

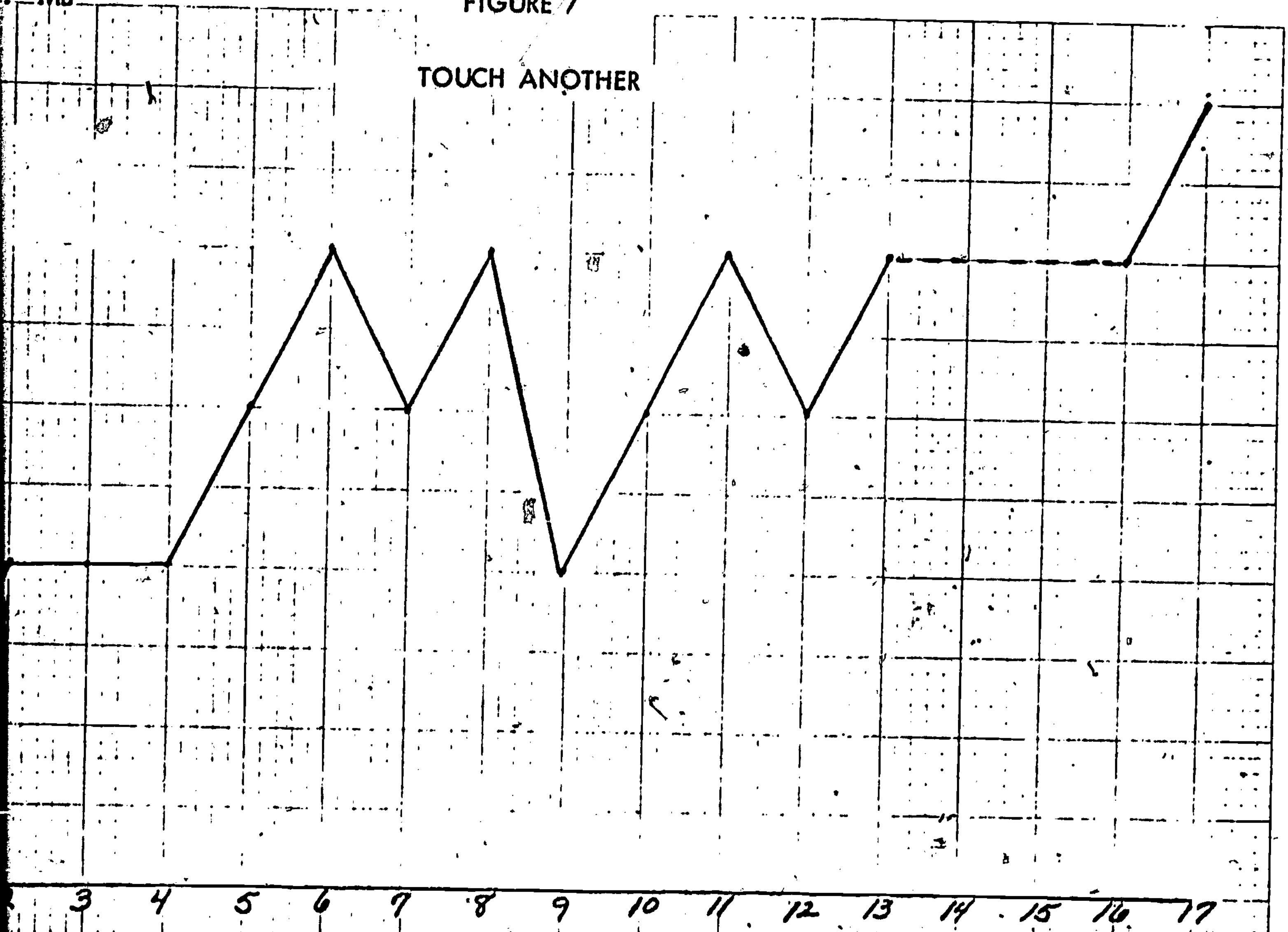
81%

10/24 - 11/7/73

MB

FIGURE 7

TOUCH ANOTHER

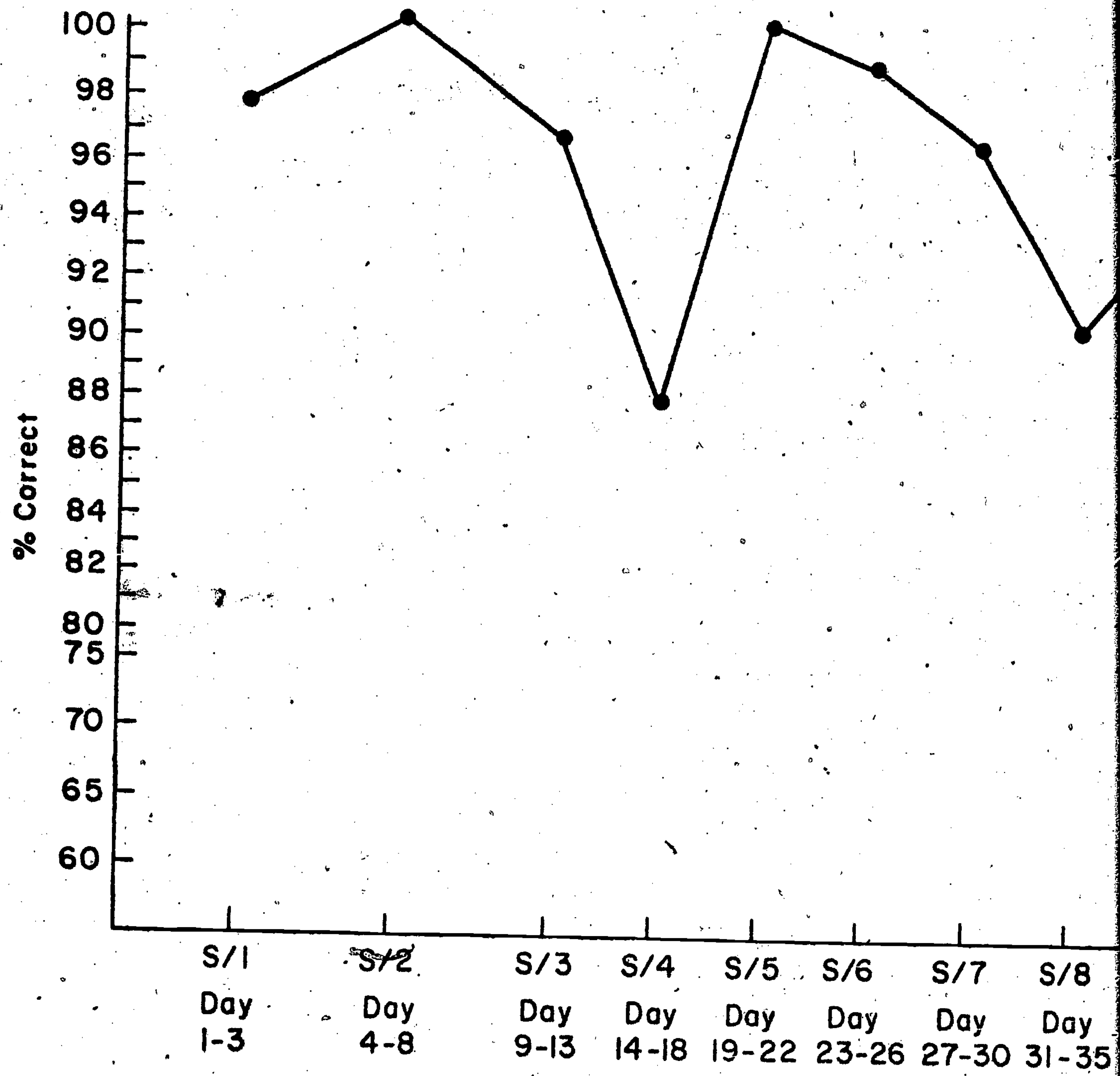


4 SESSIONS 126 TRIALS 81% CORRECT

10/24 - 11/7/73

Students: J.R.

"Give Me" Home Program

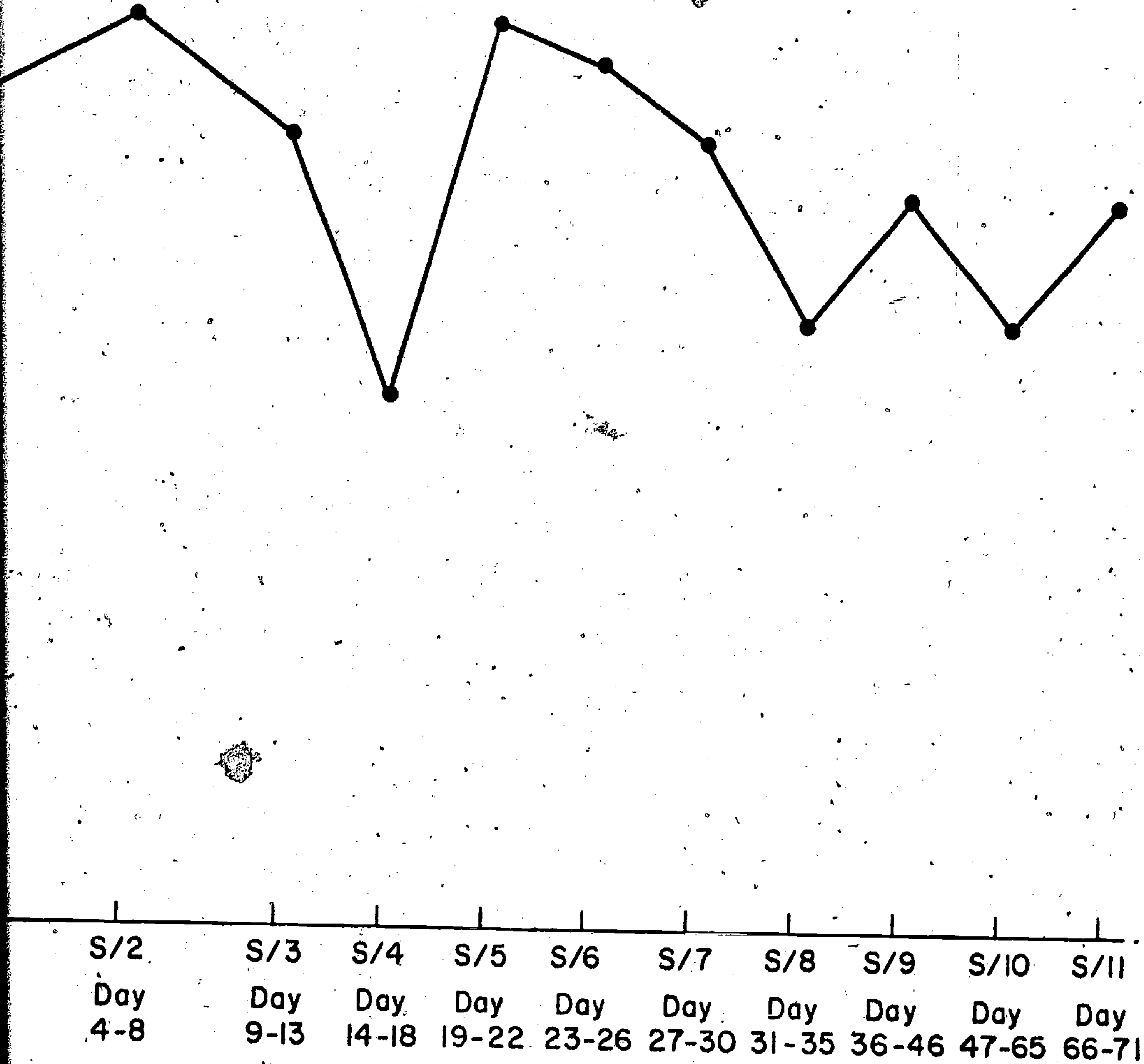


37

Sessions 68 Trials 2722 % Correct

FIGURE 8

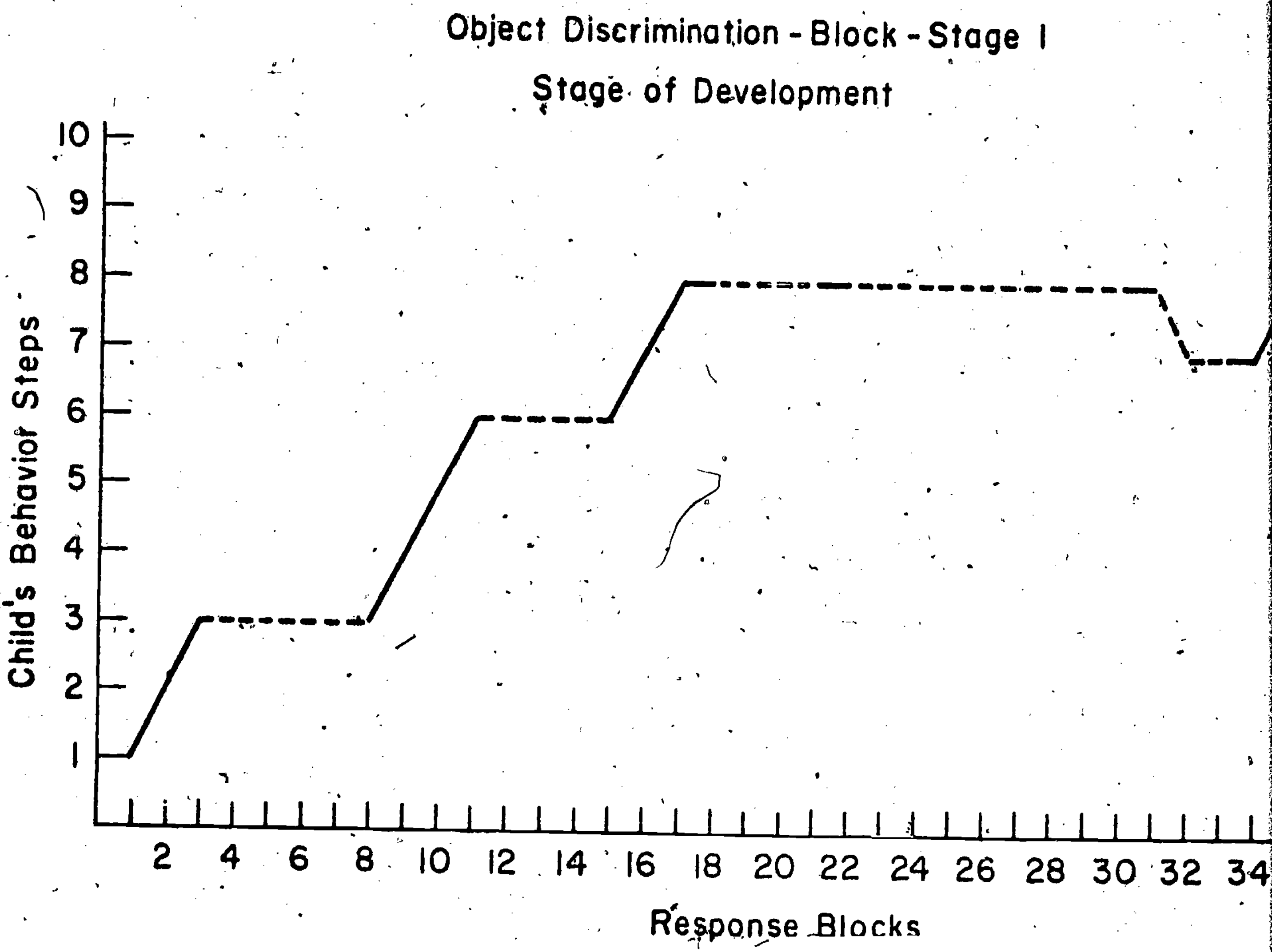
"Give Me" Home Program



essions 68 Trials 2722 % Correct 97

FIGURE 8

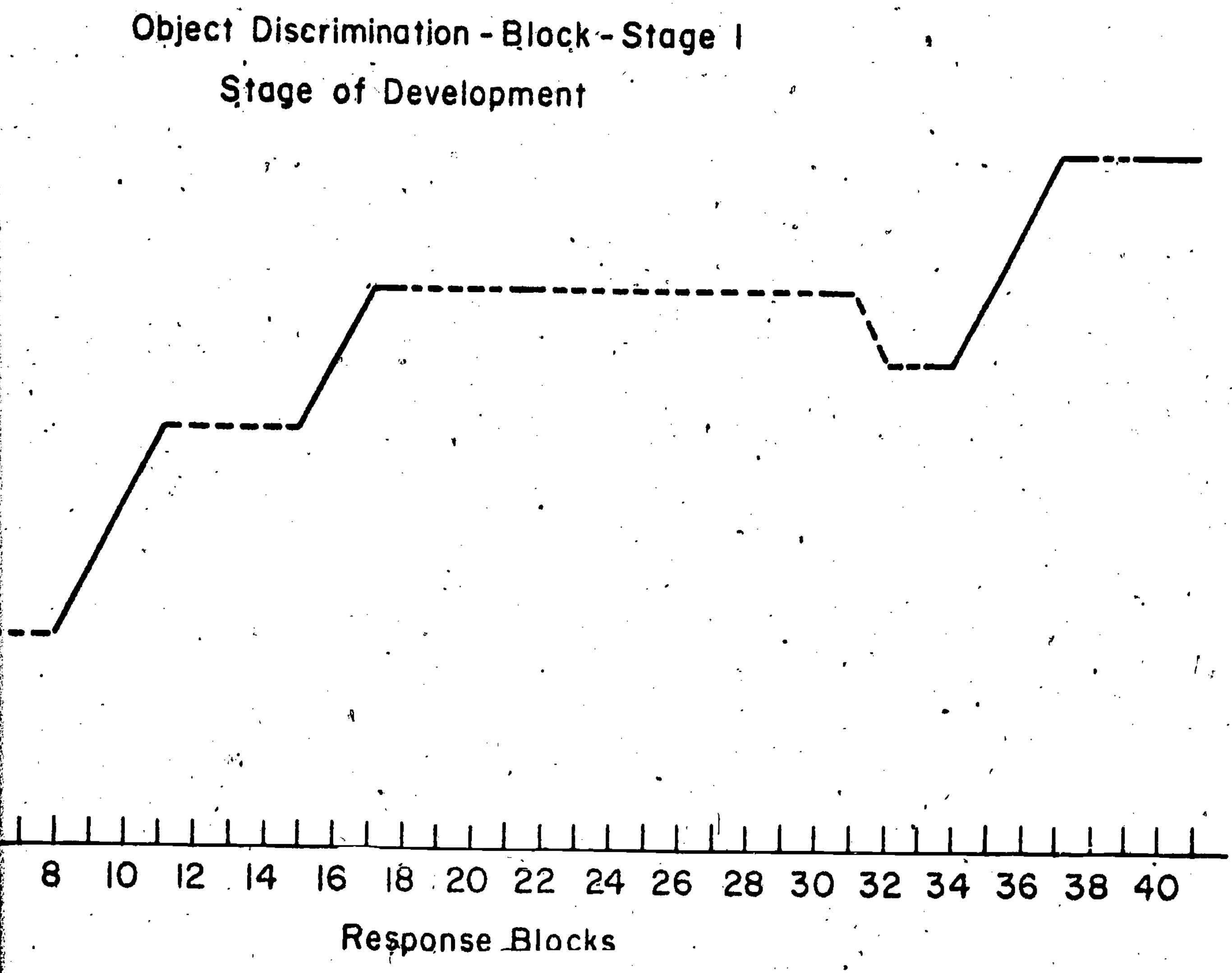
Student M.B.



Sessions 6 Trials 151 % Correct 77%

3/6/74 – 3/15/74

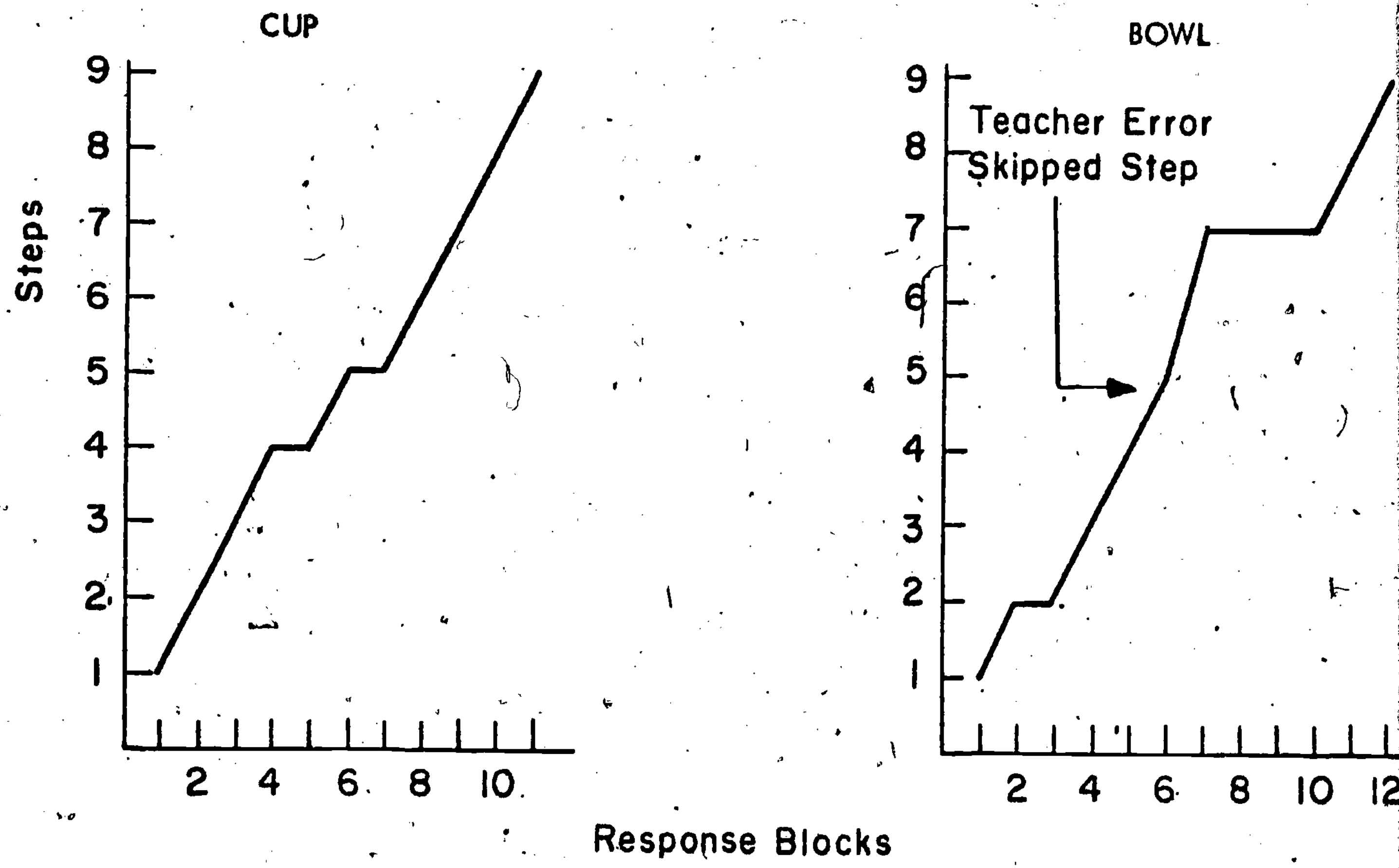
FIGURE 9



Sessions 6 Trials 151 % Correct 77%
3/6/74 – 3/15/74
FIGURE 9

Student MB

Object Discrimination - Stage II



2 Sessions
50 Trials
88% Correct

2 Sessions
57 Trials
79% Correct

1st Training Session 3/18 - 3/20/74

FIGURE 10

	ABILITY	PROGRAM	TERM
LEARNING BOOTH	1. INTERACT WITH APPARATUS	1A. FR SCHEDULE (ONE MANIPULANDA) B. SITTING IN CHAIR	1A. SITS MIN B. REA RES
	2. DISCRIMINATE LIGHT ON-LIGHT OFF	2. MULT CRF-EXT (ONE MANIPULANDA)	2. RESPO DOES OFF.
	3. DIFFERENTIAL RESPONDING WITH TWO STIMULI	3. MULT CRF-CRF (2MANIPULANDA)	3. RESPO WHEN RIGHT
SIDMAN PANEL	4. DISCRIMINATE WRITTEN WORDS	4. MATCH TO SAMPLE: WRITTEN WORDS TO WRITTEN WORDS	4. CHOO 8 WO
	5. AUDITORY COMPREHENSION I	5. MATCH TO SAMPLE: DICTATED WORD TO PICTURE	5. CHOO AMON
	6. AUDITORY COMPREHENSION II	6. MATCH TO SAMPLE: DICTATED WORD TO WRITTEN WORD	6. CHOO AMON
	7. READING COMPREHENSION I	7. MATCH TO SAMPLE: PICTURE TO WRITTEN WORD (AND REVERSE)	7. CHOO AMON REVERS
BIJOU PANEL	8. READING COMPREHENSION II	8. MATCH TO SAMPLE: WORD COMBINATION	8. CHOOS COMBI AMON

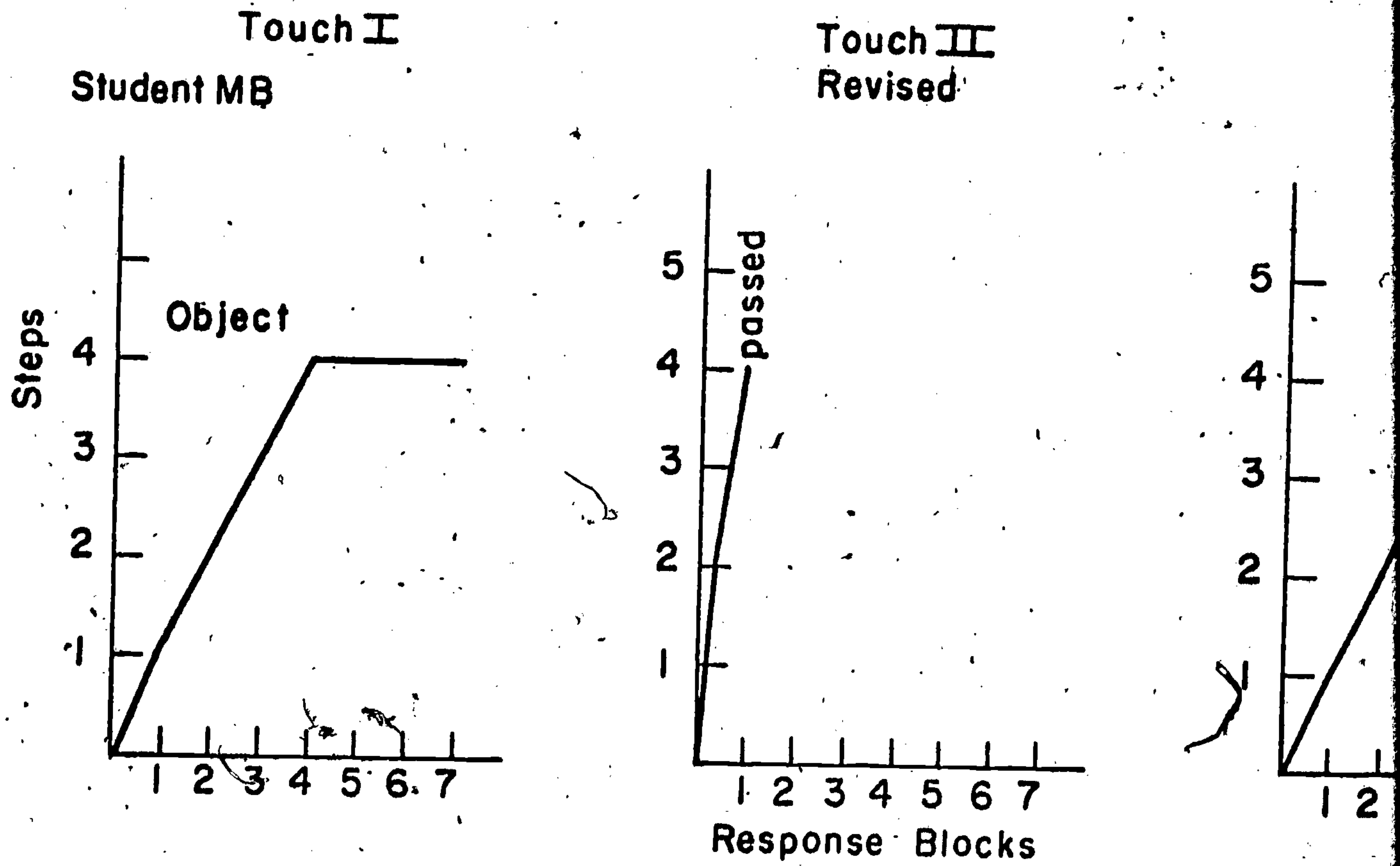
Hypothesized Behaviors leading to reading comprehension

TABLE 1

	PROGRAM	TERMINAL BEHAVIOR
ARATUS	1A. FR SCHEDULE (ONE MANIPULANDA) B. SITTING IN CHAIR	1A. SITS IN CHAIR FOR 5 CONSECUTIVE MINUTES B. REACHES CRITERION RATE OF RESPONDING
T ON-	2. MULT CRF-EXT (ONE MANIPULANDA)	2. RESPONDS WHEN LIGHT IS ON. DOESN'T RESPOND WHEN LIGHT IS OFF.
NDING	3. MULT CRF-CRF (2MANIPULANDA)	3. RESPONDS ON LEFT MANIPULANDA WHEN S1 ON. RESPONDS ON RIGHT MANIPULANDA WHEN S2 ON.
EN WORDS	4. MATCH TO SAMPLE: WRITTEN WORDS TO WRITTEN WORDS	4. CHOOSE SAMPLE WORD FROM AMONG 8 WORDS
ENSION I	5. MATCH TO SAMPLE: DICTATED WORD TO PICTURE	5. CHOOSE PICTURE DICTATED FROM AMONG 8 PICTURES
ENSION II	6. MATCH TO SAMPLE: DICTATED WORD TO WRITTEN WORD	6. CHOOSE WORD DICTATED FROM AMONG 8 WRITTEN WORDS
NSION I	7. MATCH TO SAMPLE: PICTURE TO WRITTEN WORD (AND REVERSE)	7. CHOOSE WORD PICTURED FROM AMONG 8 WRITTEN WORDS (AND REVERSE)
NSION II	8. MATCH TO SAMPLE: WORD COMBINATION	8. CHOOSE PICTURE DESCRIBED BY A COMBINATION OF WORDS FROM AMONG 5 PICTURES

Hypothesized Behaviors leading to reading comprehension

TABLE 1



1 Session
28 Trials
89% Correct

1 Session
5 Trials
100% Correct

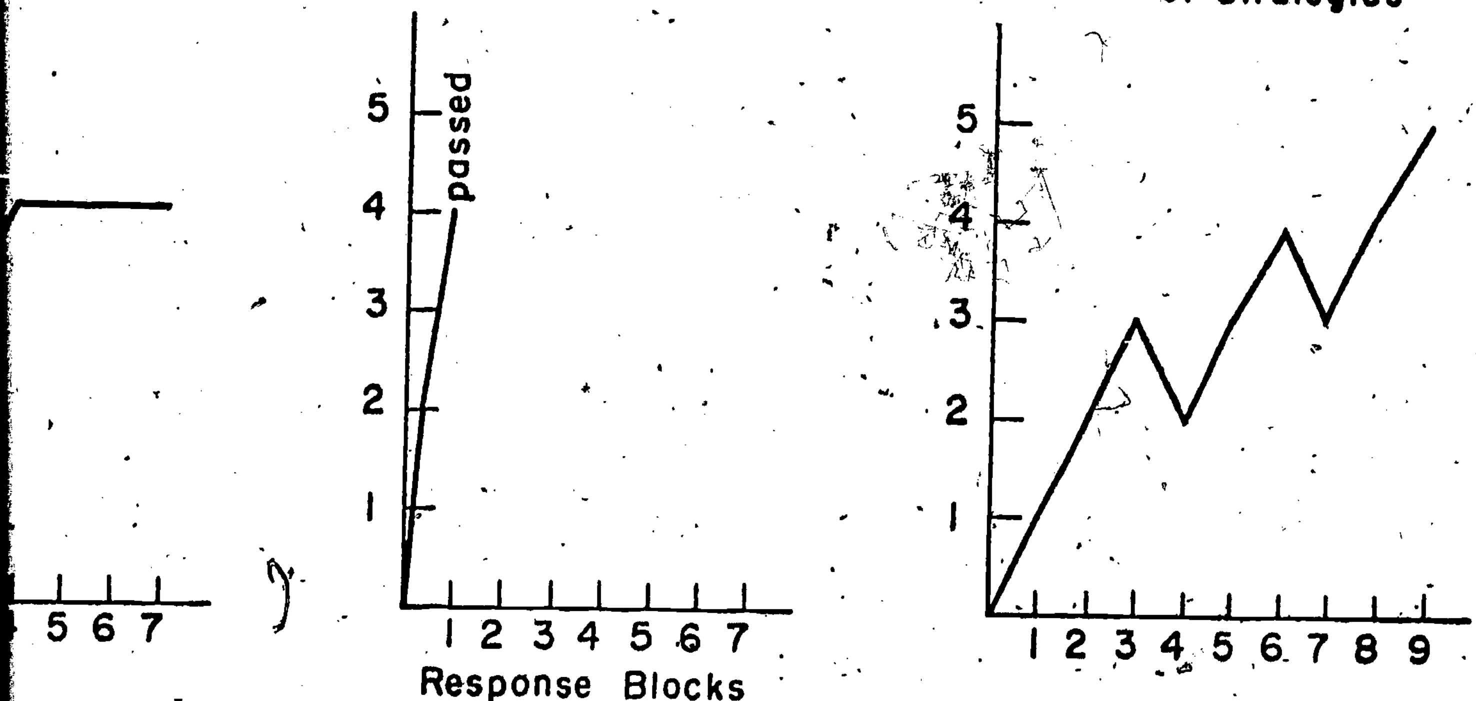
2nd Training Session 9/20/74

FIGURE 11

ch I

Touch II
Revised

Touch Another
Revised Clarification
of Strategies



sion
rials
orrect

1 Session
5 Trials
100% Correct

2 Sessions
58 Trials
86% Correct

2nd Training Session 9/20/74

FIGURE 11

TABLE 2

READING PROGRAM

Section	Steps	Activity	Stimulus-Location on Matri
IA	S/1-S/15	Visual Discrimination	Word 1 on periphery
IB	S/1-S/15	Auditory Discrimination	Word 1 on periphery
IIA	S/1-S/15	Visual Discrimination	Word 2 on periphery
IIB	S/1-S/15	Auditory Discrimination	Word 2 on periphery
III	S/16-S/22	Auditory Discrimination	W_1 and W_2 - on periphery
IV	S/23-S/30		Picture 1 in center-Word 1 on periphe
V	S/23-S/30		Picture 2 in center-Word 2 on periphe
VI	S/31	Match to Sample	Picture 1 and Picture 2 - alternate in center
			Word_1 and Word_2 on periphe

Reinforcemnt - food

Original Criterion - 6 correct responses in a row

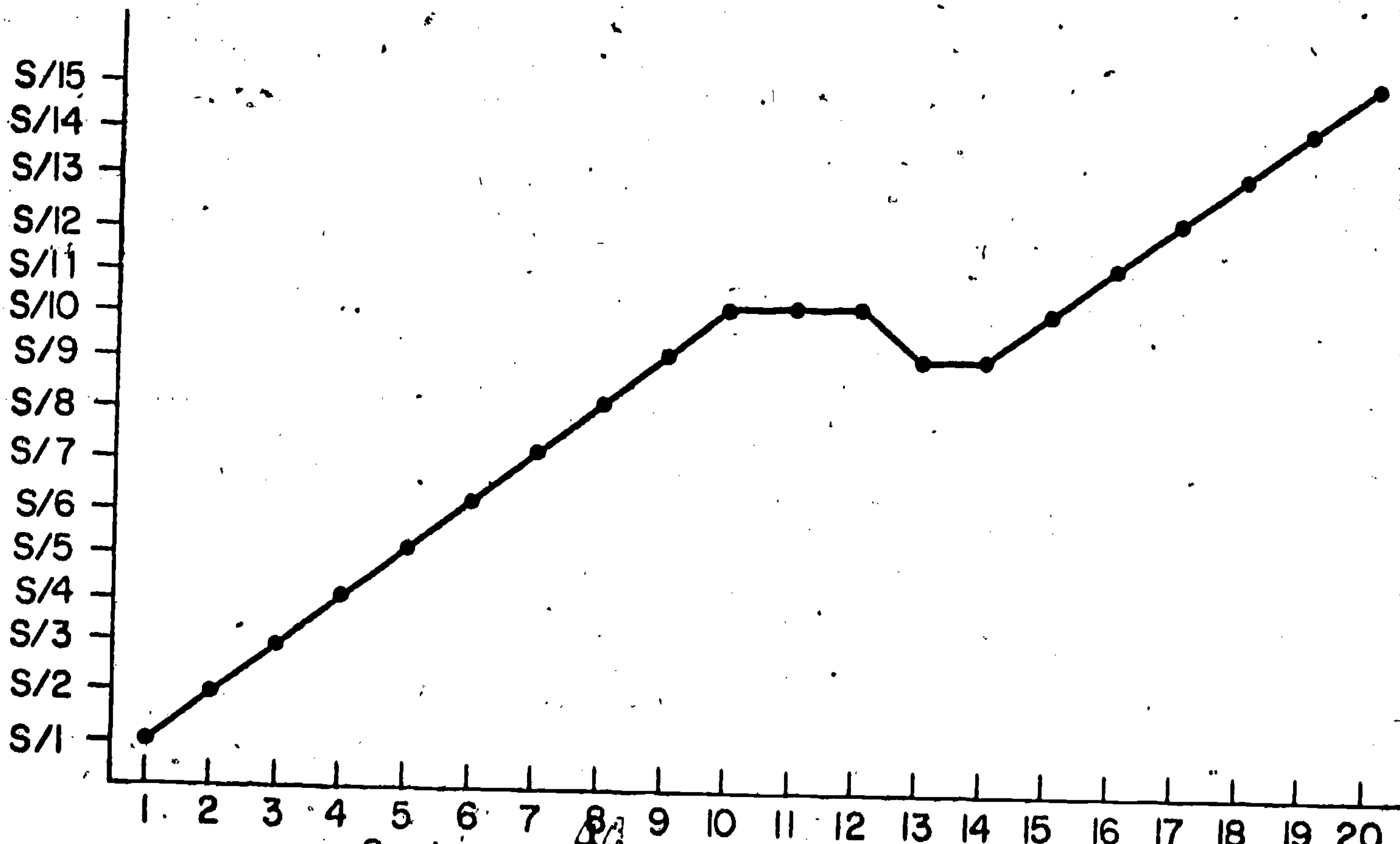
Alternate Strategy Criterion for fading to random alternation -

6 correct responses in a row
5 correct responses in a row
80% correct responses in 30 trials

Student: L.T.

FIGURE 12

IA Visual Discrimination
Word I



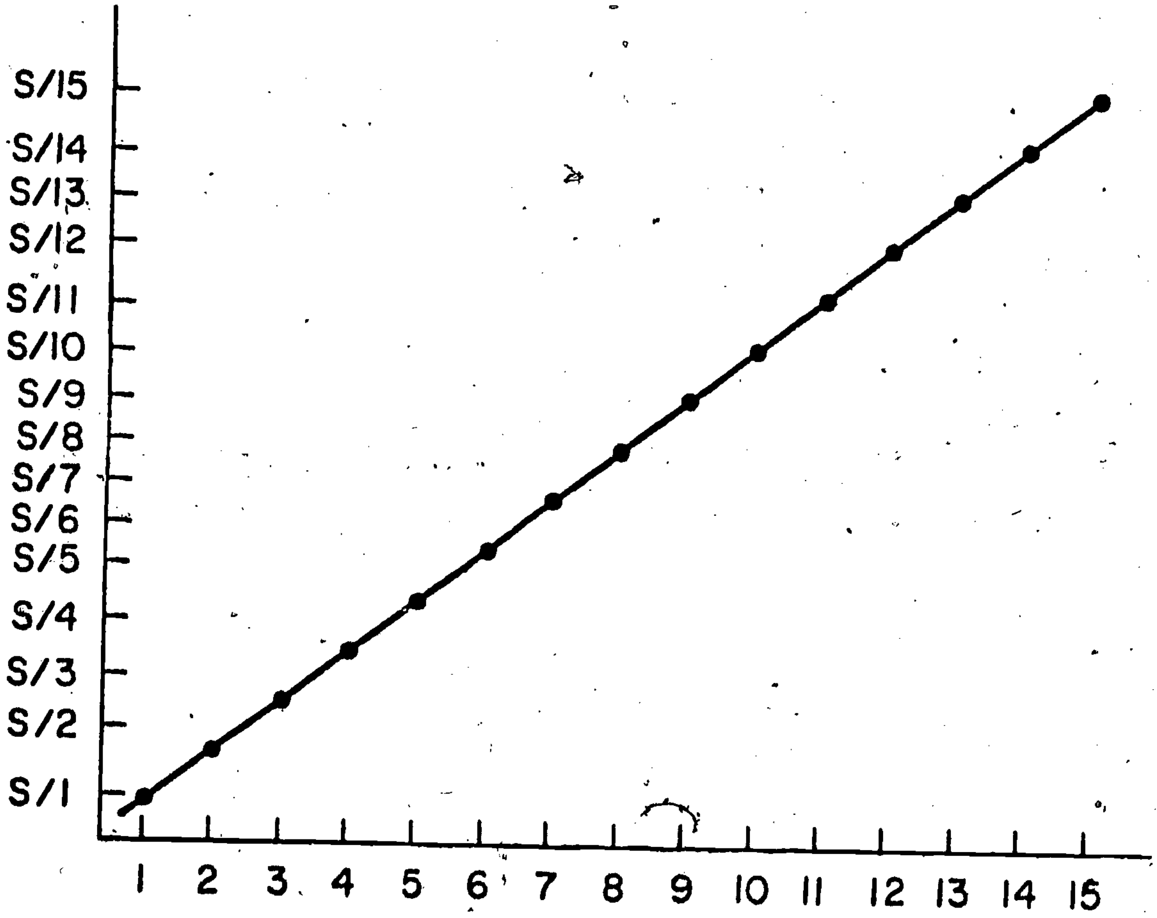
Sessions
2

Trials
160

% Correct
75%

Student: L.T.

IB Auditory Discrimination
Word I

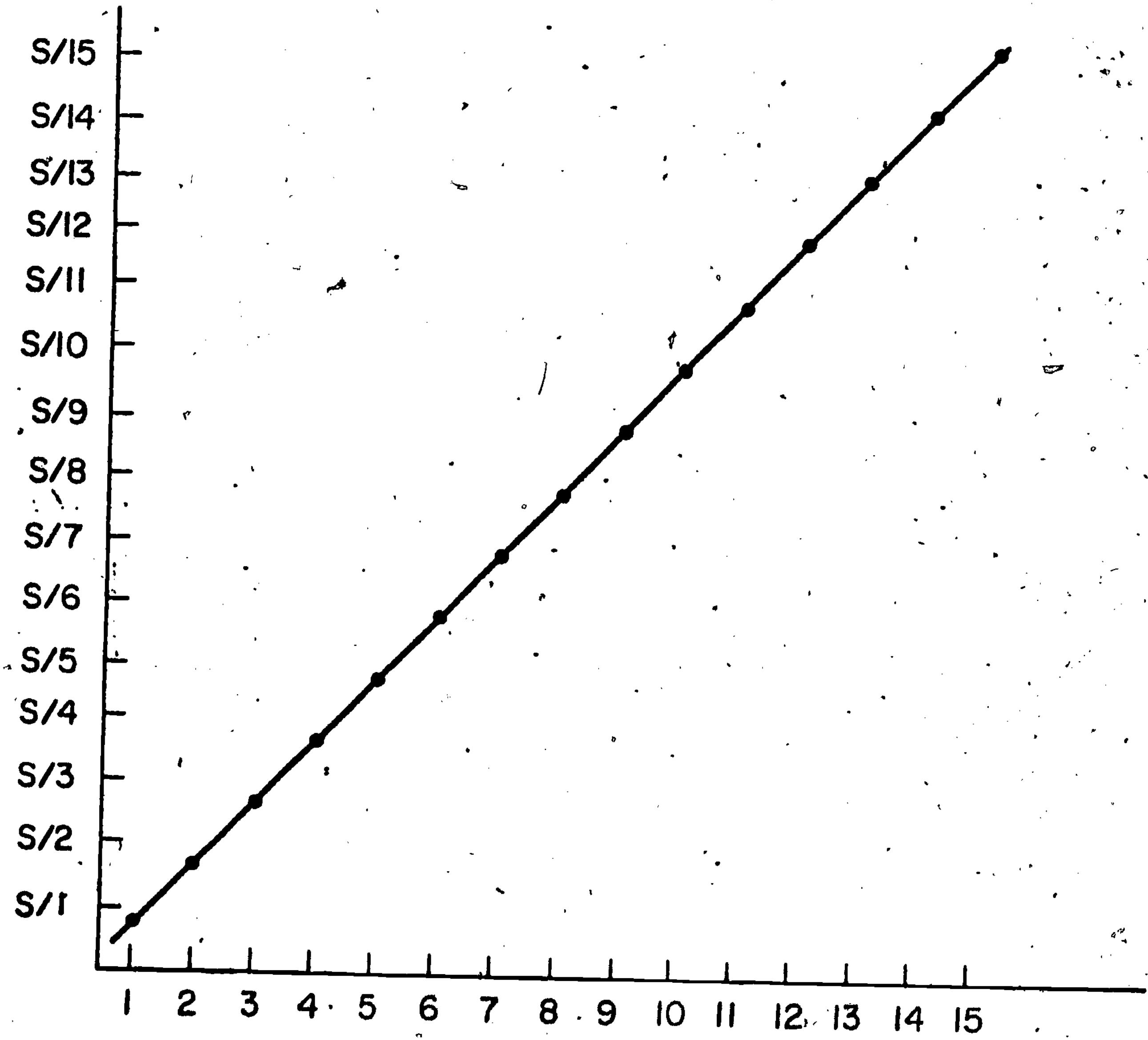


Sessions	Trials	% Correct
1	90	100 %

FIGURE 13

Student: L.T.

IIA Visual Discrimination
Word 2

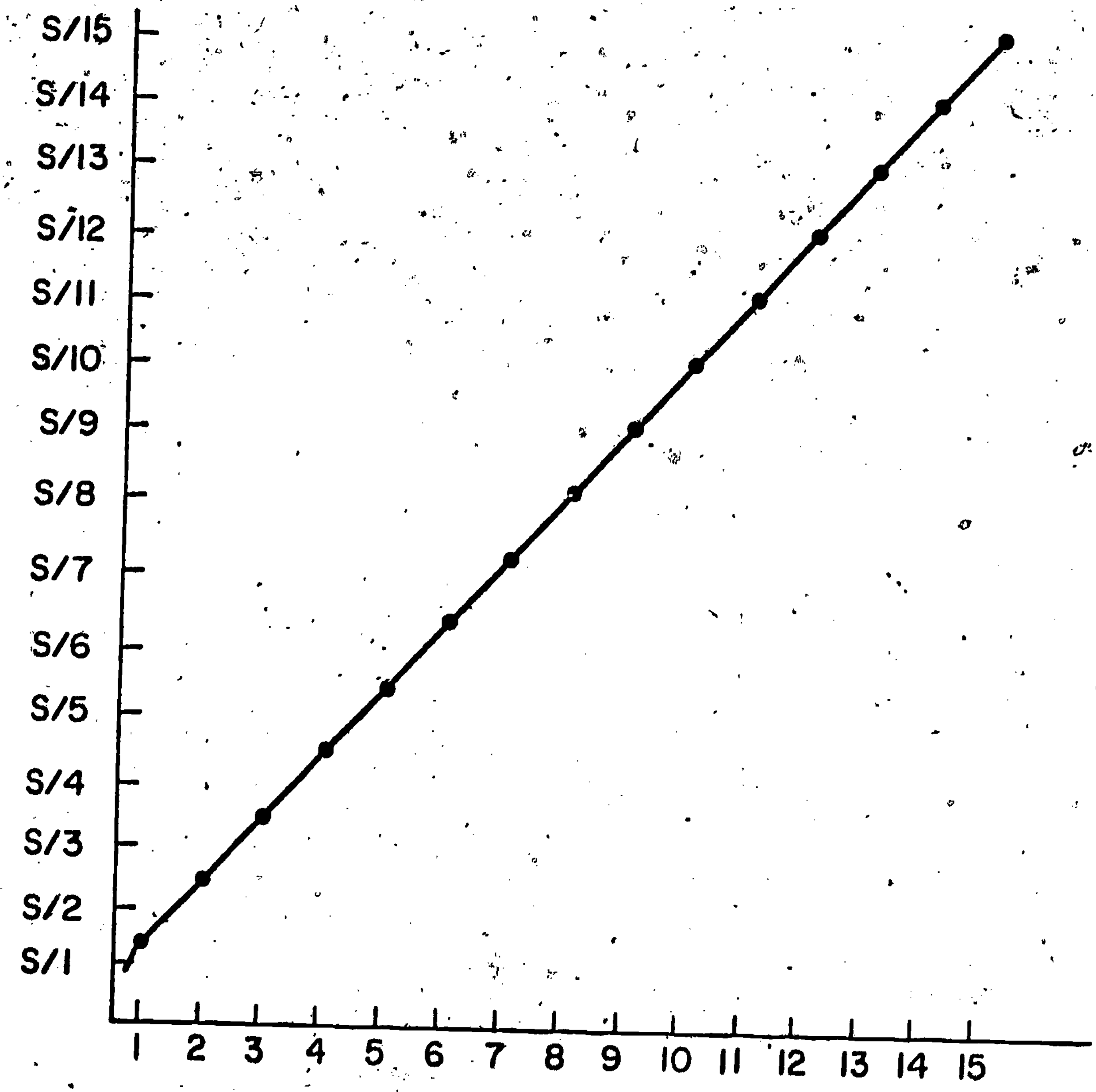


Sessions	Trials	% Correct
2	145	86 %

FIGURE 14

Student: L.T.

IIB Auditory Discrimination
Word 2



Sessions
1

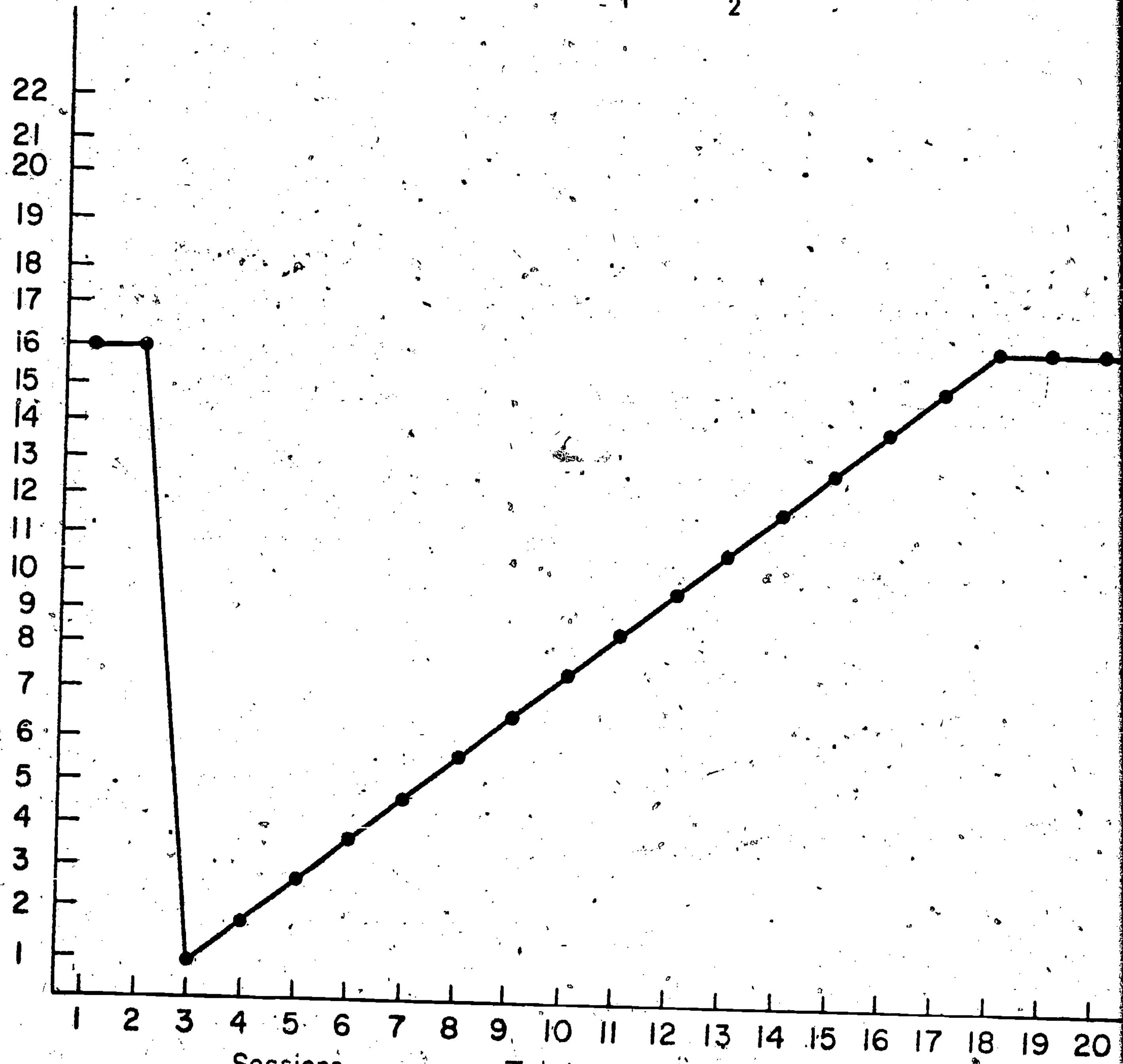
47 Trials
135

% Correct
87%

FIGURE 15

Student: L.I.

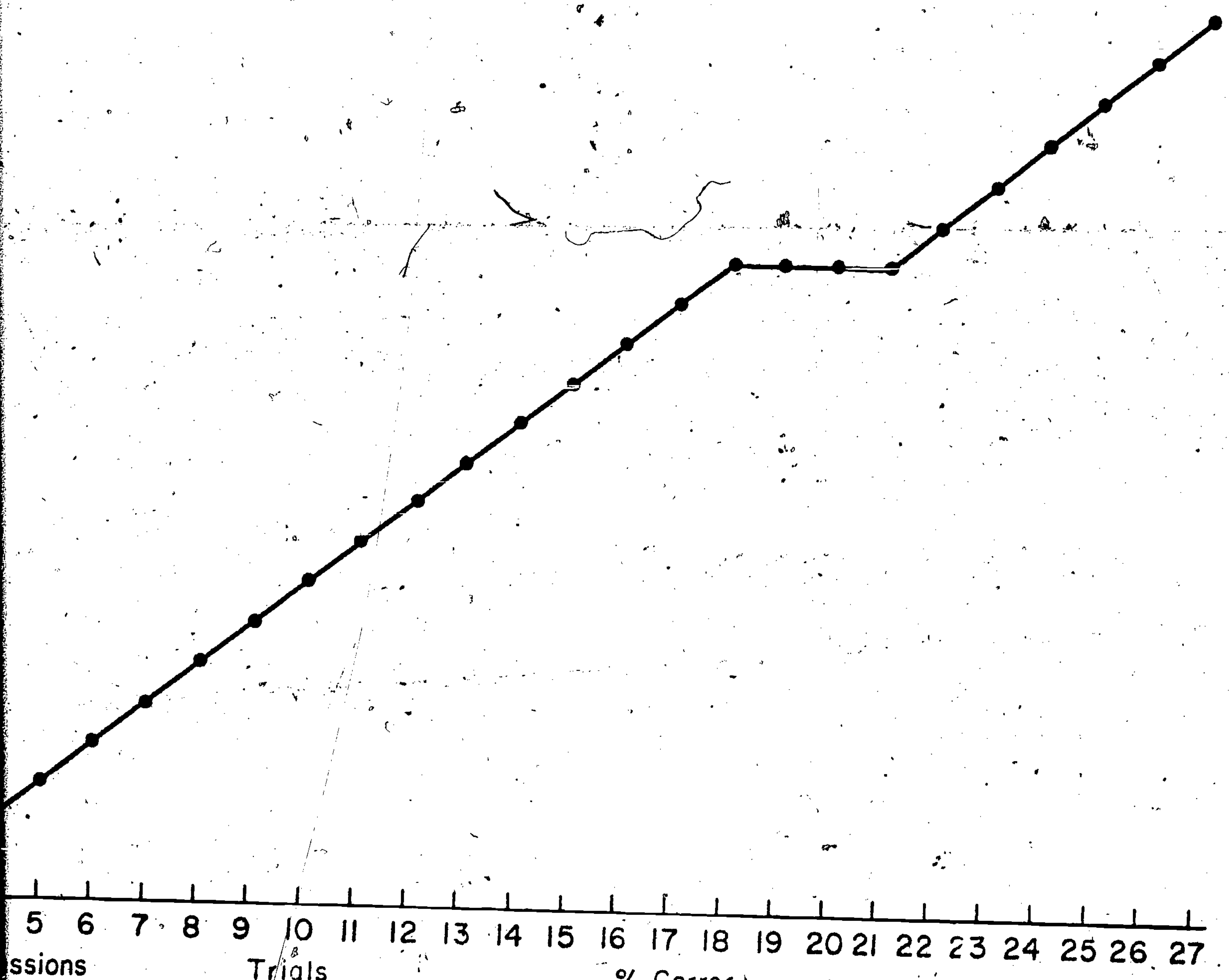
III Auditory Discrimination
Alternate W_1 and W_2



Sessions	Trials	% Correct
8	713	[illegible]0 %

FIGURE 16

III Auditory Discrimination
Alternate W_1 and W_2

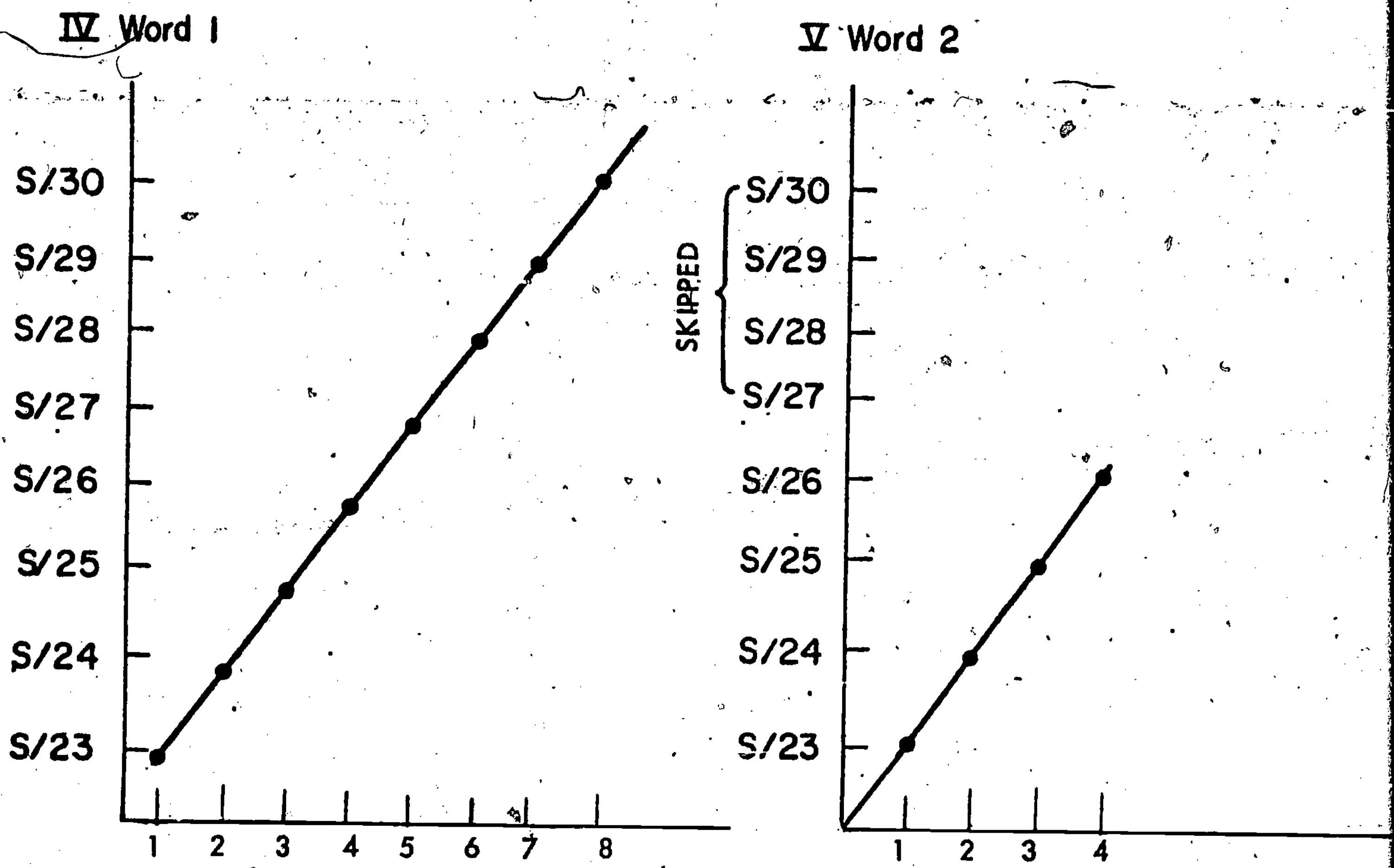


ssions	Trials	% Correc
	713	?0 %

FIGURE 16

48A

Student: L.T. Picture - Word Association



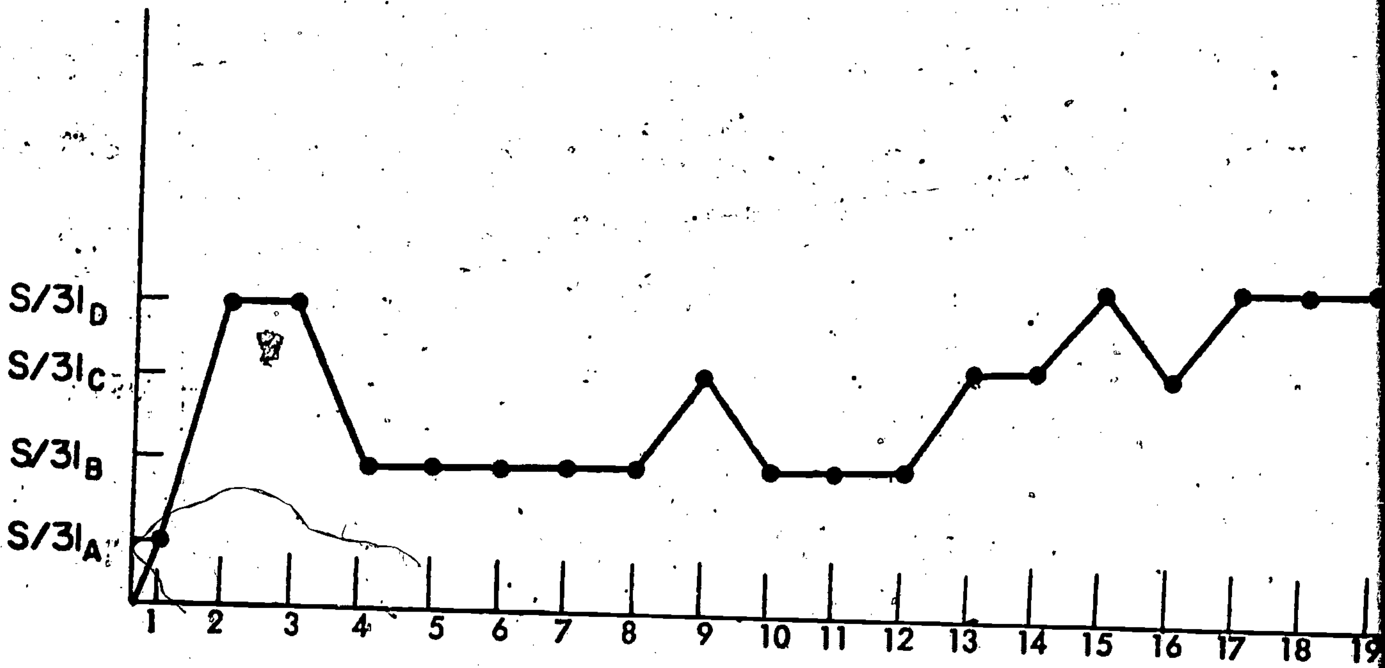
Sessions	Trials	% Correct
1	54	94%

Sessions	Trials	% Corre
1	29	90%

FIGURE 17

Student: L.T.

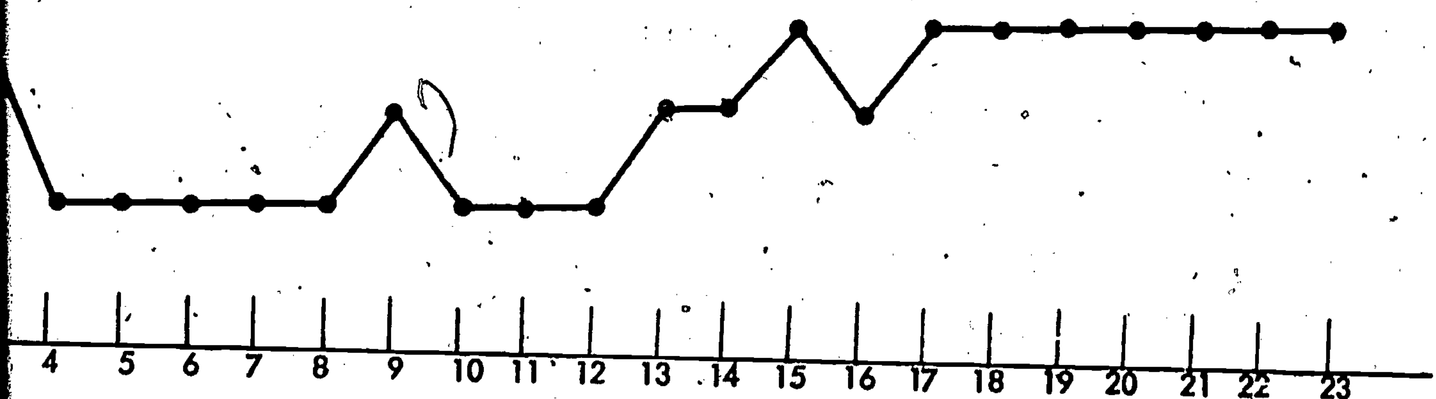
V Picture - Word Association
Alternate $Picture_1$ - $Picture_2$



Sessions	Trials	% Correct
15	912	68 %

FIGURE 18

V Picture - Word Association
Alternate Picture$_1$ - Picture$_2$



ssions	Trials	% Correct
15	912	68 %

FIGURE 18

TABLE 3

Behavioral Analysis	Pr
By visual observation alone, S can state the number of objects in an (a) defined (objects within boundaries) (b) undefined set (objects only in close proximity)	Fade manipulatio touching and cou counting stimuli and finally silent
S can count out a stated number of objects from a larger set	Presented with or on request the co then objects and than is needed
S can count a group of objects in an (a) defined, (b) undefined set	Chain rote counti stimulus cards fad set with boundari in a group withou
S can recite number names from 1 to 10	Establish a vocal of number names
S demonstrates discrimination of sets of forms and objects from other sets by matching and 1-1 correspondence	Match counting ob visual dimension at of stimulus on card,
S attends to a specific visual stimulus	Using variation of a present S with a sti materials on that sti

TABLE 3

S can state the number (objects within boundaries) ly in close proximity)

mber of objects from

cts in an (a) defined,

om 1 to 10

of sets of forms
-matching and 1-1

stimulus

Program Analysis

Fade manipulation of materials while counting to touching and counting, counting without touching, counting stimuli that "disappear" (e.g. hand claps), and finally silently counting both types of stimuli

↑

Presented with original stimulus cards S will give on request the card with a stated number of forms, then objects and then objects in a larger quantity than is needed

↑

Chain rote counting with touching the forms on stimulus cards fading tomanipulation of objects in a set with boundaries and finally manipulation of objec in a group without boundaries

↑

Establish a vocal imitation and sequence recitation of number names

↑

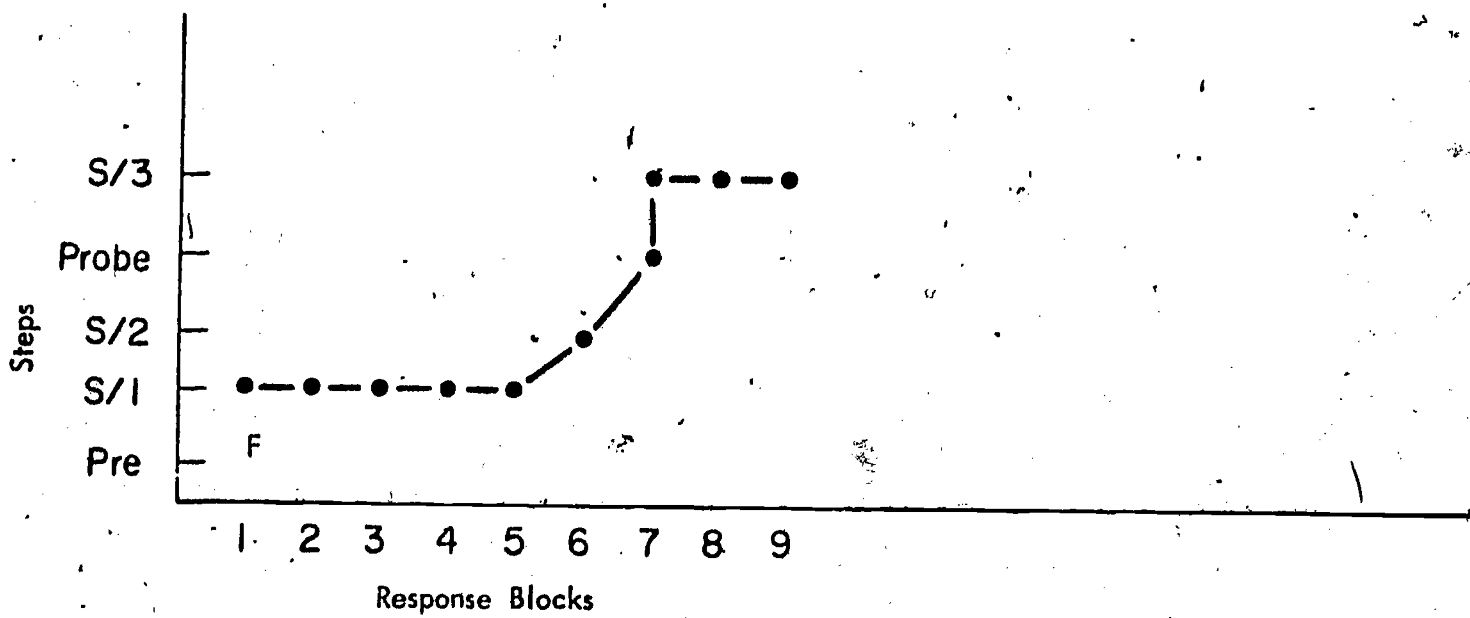
Match counting objects to stimuli, vary only one visual dimension at a time - form of stimulus, position of stimulus on card, position of card on table

↑

Using variation of only one visual dimension, size, present S with a stimulus which requires manipulation of materials on that stimulus

Student: K.D.

Math Program
Number Concepts One to Five
Matching Object to Form
Stage I

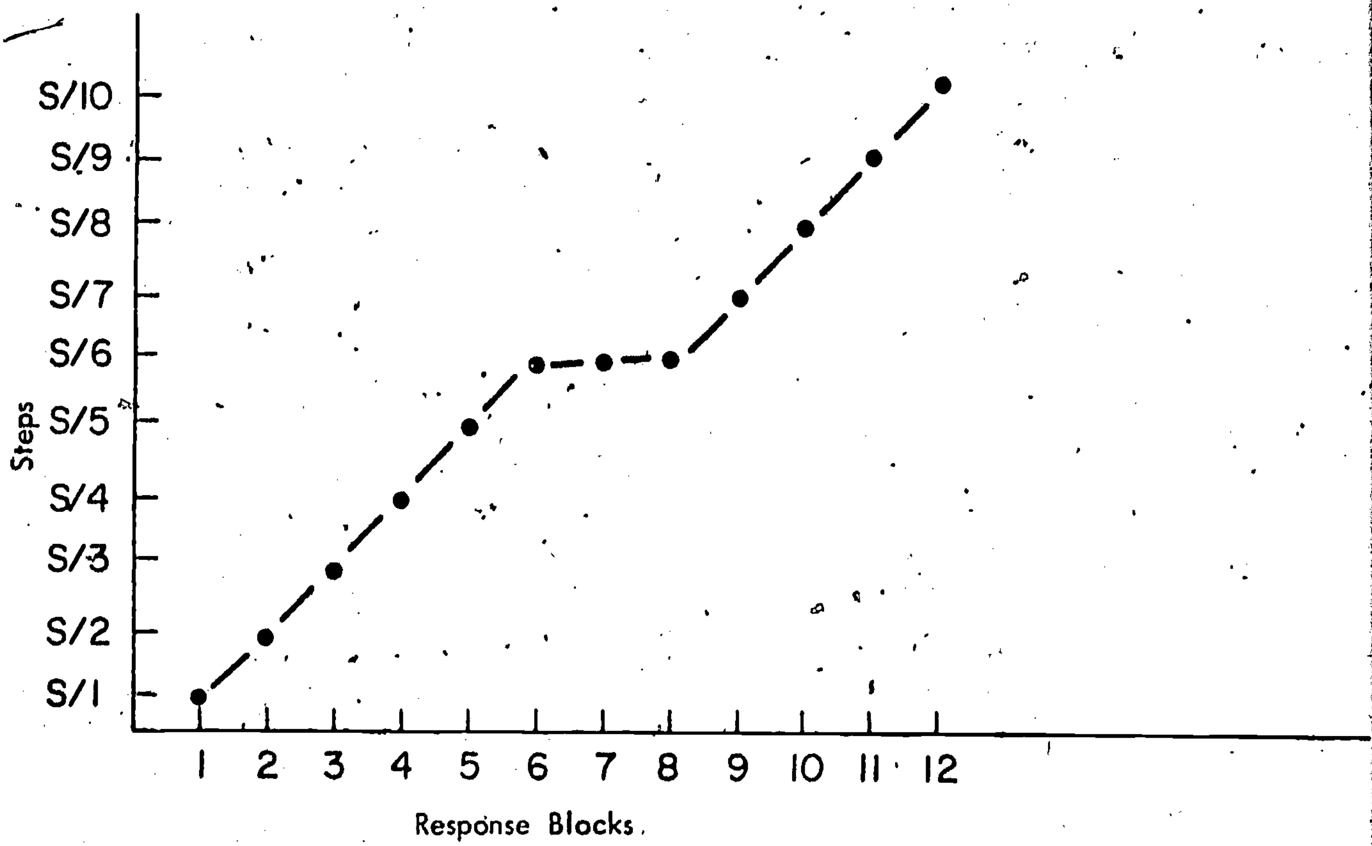


Sessions	Trials	% Correct
6	100	80 %

FIGURE 19

Student: J.J.

Math Program
Establishing Stimulus Control
Stage I

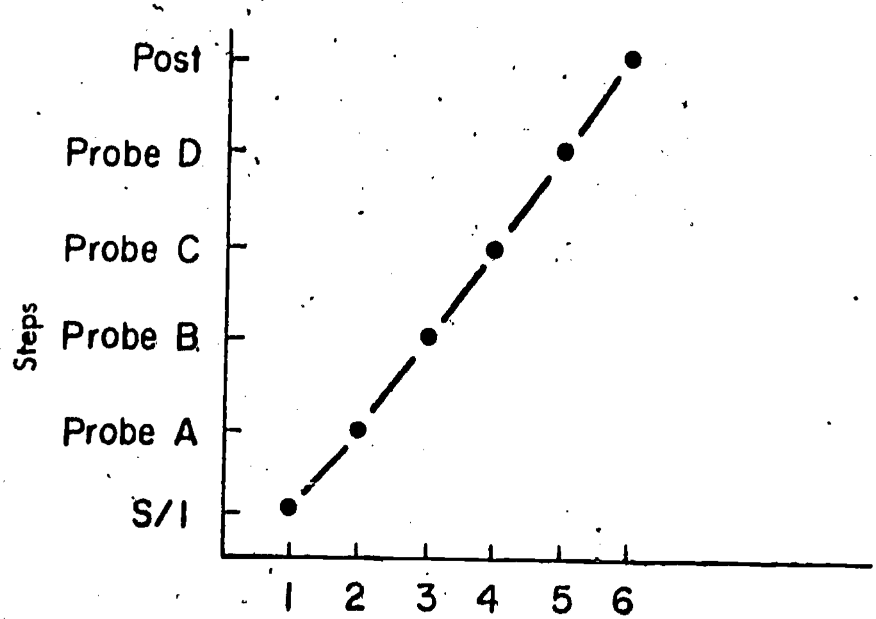


Sessions	Trails	% Correct
2	46	98%

FIGURE 20

Student: P.S.

Math Program
Establishing Stimulus Control
Stage II



Response Blocks Sessions	Trials	% Correct
[redacted]	20	100 %

FIGURE 21

TABLE 4
STIMULUS CONTROL PROGRAM

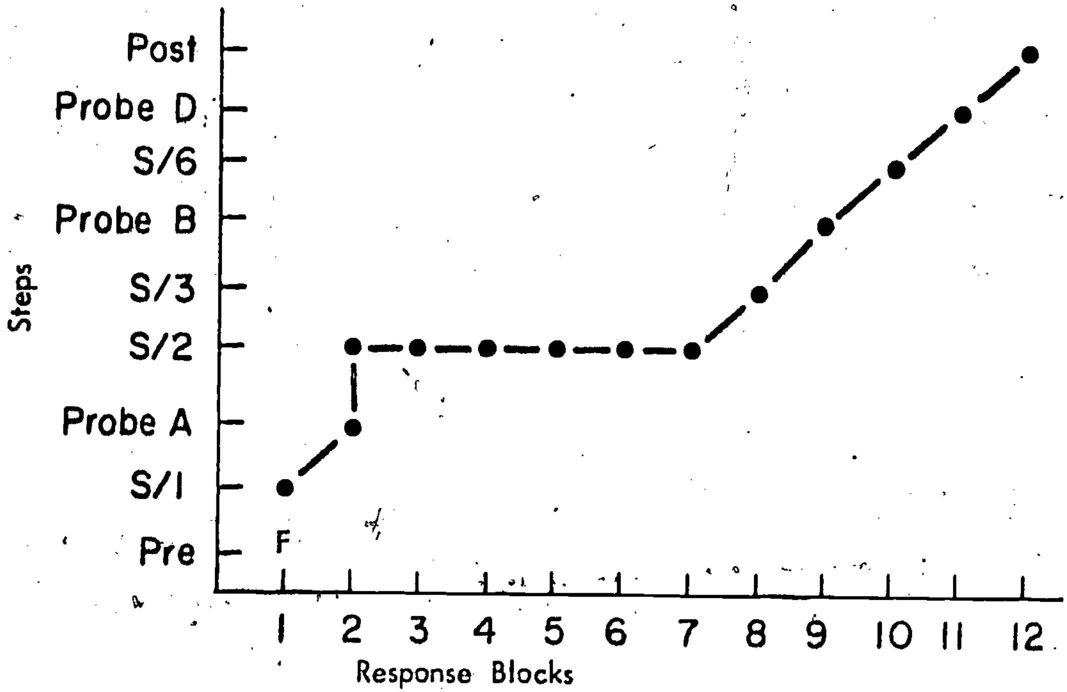
STAGE II

MATERIALS	STEP	PROBES	CRITERION
3" x 5"	S/1	← PROBE A (S/6)	S TO PLACE 1" CUBE BLOC[K] COMPLETELY [O]N BLACK FORM
2 3/4" x 4 3/4"	S/2		
2 1/2" x 4 1/4"	S/3		
2 1/4" x 3 3/4"	S/4		
2 1/8" x 3 1/2" •	S/5		
2" x 3 1/4"	S/6	← PROBE B (S/11)	
1 7/8" x 3" •	S/7		
1 3/4" x 2 3/4"	S/8		
1 5/8" x 2 1/2" •	S/9		
1 1/2" x 2 1/4"	S/10		↓
1 3/8" x 2" •	S/11	← PROBE C (S/16)	S TO PLACE 1" CUBE BLOCK A[T] LEAST 3/4 ON BLACK FORM
1 1/4" x 1 3/4"	S/12		
1 1/8" x 1 1/2" •	S/13		
1" x 1 1/4"	S/14		
1" x 1 1/8" •	S/15		
1" x 1"	S/16	← POST	↓

Student: M.B.D.

Math Program
Number Concepts One to F
Matching Object to Form
Stage II
(Not Preceded by Stimulus

IA



Sessions	Trials	% Correct
6	118	85%

FI URE 22

. D.

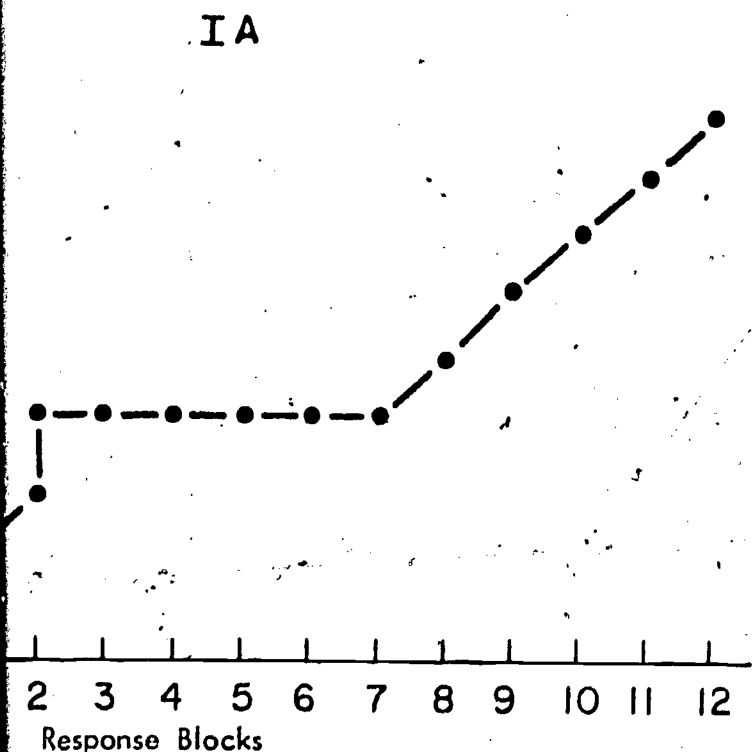
Math Program

Number Concepts One to Five

Matching Object to Form

Stage II

(Not Preceded by Stimulus Control Program)



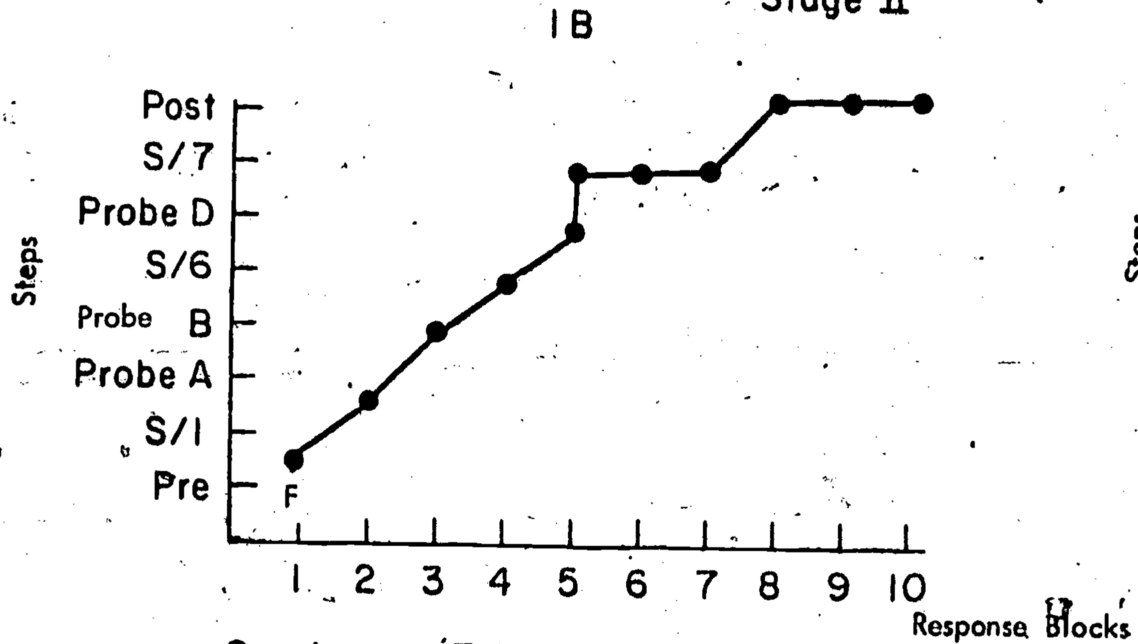
Sessions	Trials	% Correct
	118	85%

FI URE 22

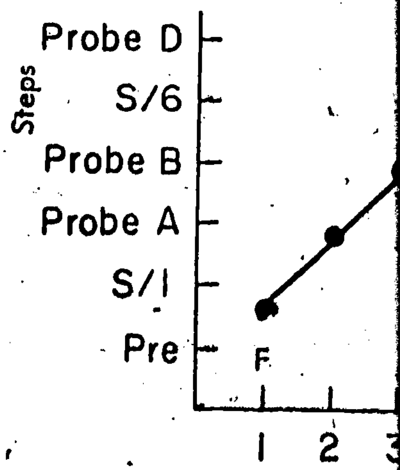
56A

Student: M.B.D.

Math Program
Number Concepts One to Five
Matching Object to Form
Stage II



Sessions	Trials	% Correct
5	77	86 %

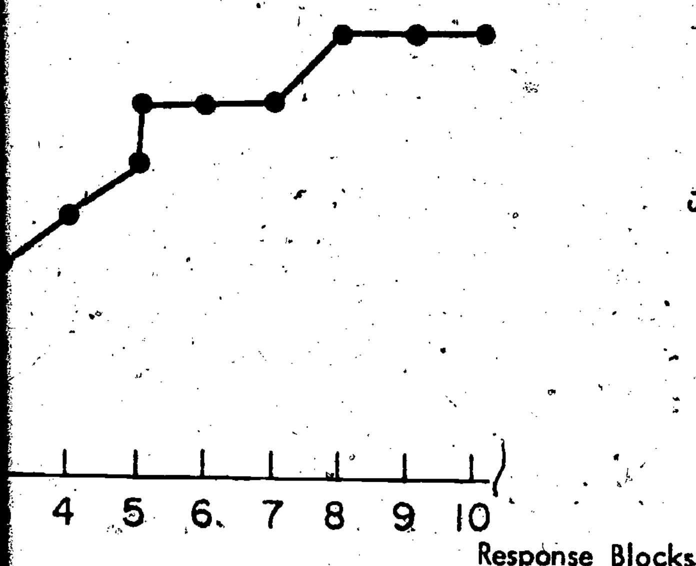


Sessions	Tr
1	3

FIGURE 23

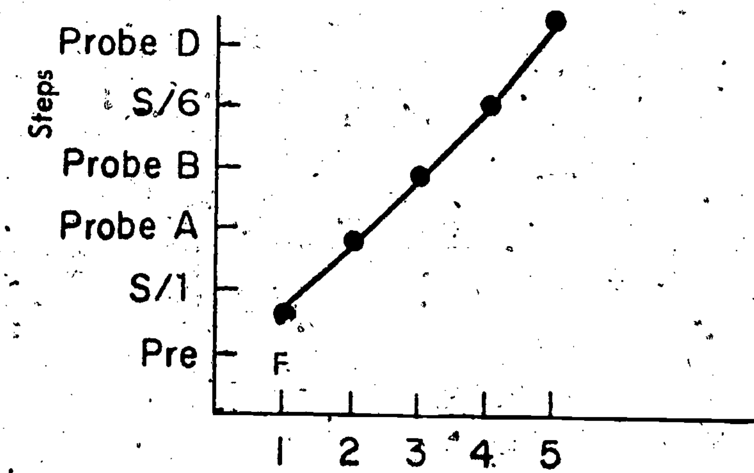
Math Program
Number Concepts One to Five
Matching Object to Form
Stage II

I B



Trials	% Correct
77	86 %

I C



Sessions	Trials	% Correct
1	39	92 %

FIGURE 23

TABLE 5

Math Program
Number Concepts One to Five

Program	Critical Beha
Establishing Stimulus Control	Motor response-pl Attend to form as Eliminate inapprop
I ABCDE I ABCD Matching Object to Form I ABCD	Scan stimulus arra Match objects to Discriminate a set sets when the fo stimulus configur of card in array three
Imitative Counting Program	Elicit verbal imita Chain vocal respon
V Counting Using Number Cards, Defined and Undefined Sets	
A	Manipulate objects Stop number recita
B	Yes-No confirmativ within boundaries '(close proximity (an
C	How Many? - atta number cards, then objects in close pr

TABLE 5

Math Program
Number Concepts One to Five

	Critical Behaviors
	Motor response-place object on stimulus form Attend to form as size of stimulus decreases Eliminate inappropriate interaction with materials
bject to Form	Scan stimulus array Match objects to appropriate stimulus card Discriminate a set of stimuli from all other sets when the following dimensions are changed; stimulus configuration, position in card, position of card in array and finally a combination of all three
	Elicit verbal imitative response Chain vocal responses
Cards, Defined and Undefined Sets	
	Manipulate objects while sequencing number names Stop number recitation when all objects are counted
	Yes-No confirmative with original stimuli, then objec within boundaries (a defined set) and finally objects i close proximity (an undefined set)
	How Many? - attach verbal label to stimulus sets on number cards, then objects within boundaries and fina objects in close proximity

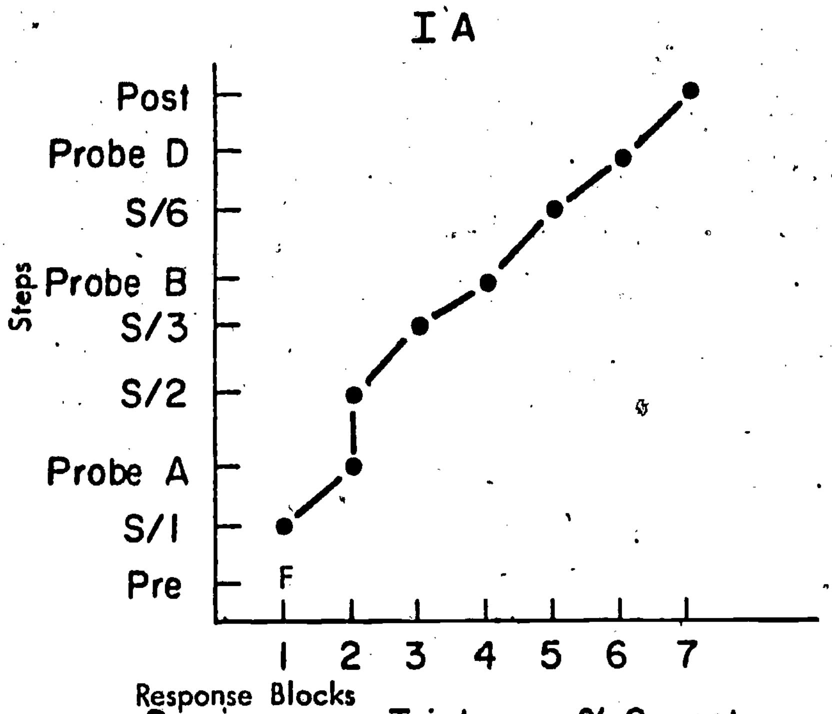
VI Counting a set of objects out of a larger group	Attach verbal cue of original stimul systematic presen then a group larg
VII Stating the Number of Objects in a Set	Fade manipulation counting silently touching forms Present stimuli whi and fade to soun

TABLE 5 (continued)

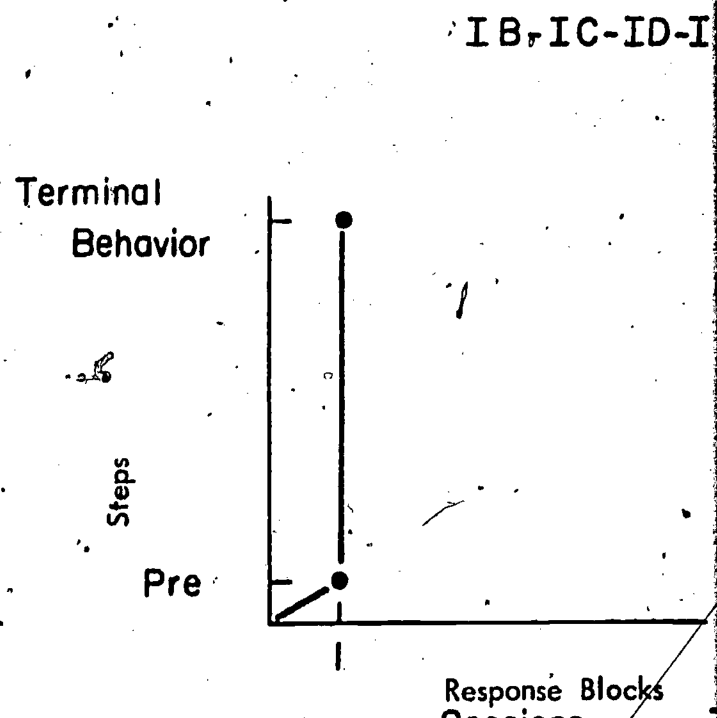
out of a larger group	Attach verbal cue (a stated number) to manipulation of original stimulus cards, then objects in a defined systematic presentation of extraneous stimuli, and then a group larger than the stated number
jects in a Set	Fade manipulation of materials while counting to counting silently without manipulating objects or touching forms Present stimuli which "disappear"–cover real objects and fade to sound stimuli

Student: T.Y.

Math Program
Number Concepts One to Five
Matching Object to Form
Stage II
(Preceded by Stimulus Control Program)



Sessions	Trials	% Correct
1	65	92%



	Sessions
I B	1
I C	1
I D	1
I E	1

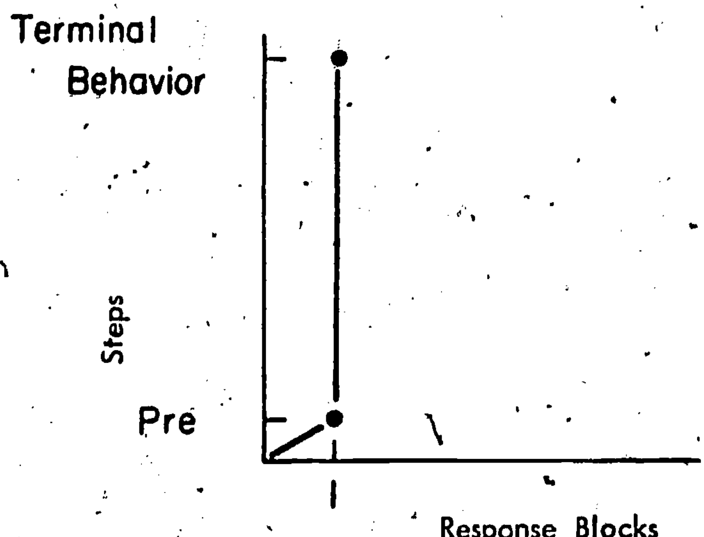
FIGURE

62

Math Program
Number Concepts One to Five
Matching Object to Form
Stage II
(Preceded by Stimulus Control Program)

% Correct
92%

IB-IC-ID-IE

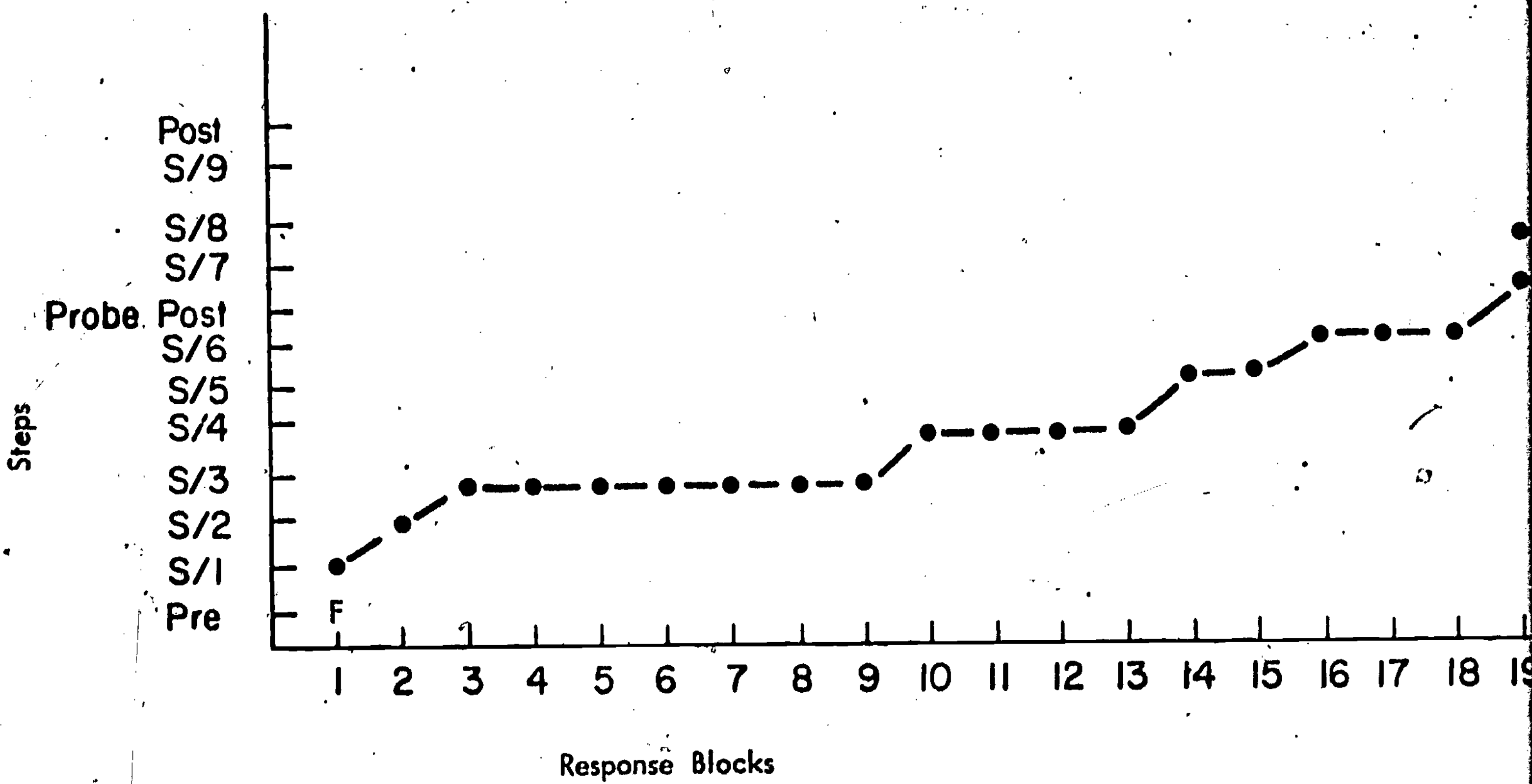


	Sessions	Trials	% Correct
I B	1	8	100%
I C	1	8	100%
I D	1	8	100%
I E	1	8	100%

FIGURE 62A

Student: T.Y.

Math Program
Number Concepts One to Five
Yes-No Confirmative
Stage I

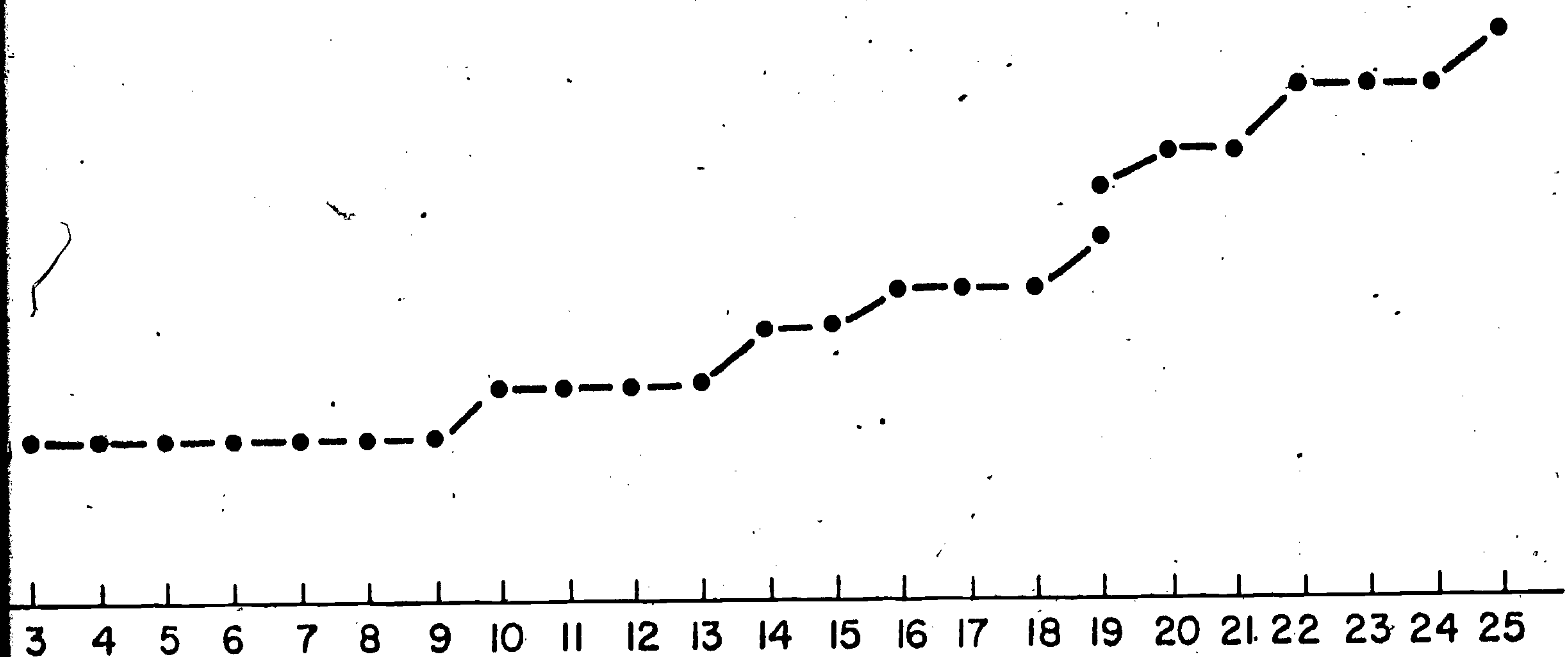


Sessions	Trials	% Correct
6	210	80%

FIG[illegible]E 25

63

Math Program
Number Concepts One to Five
Yes - No Confirmative
Stage I



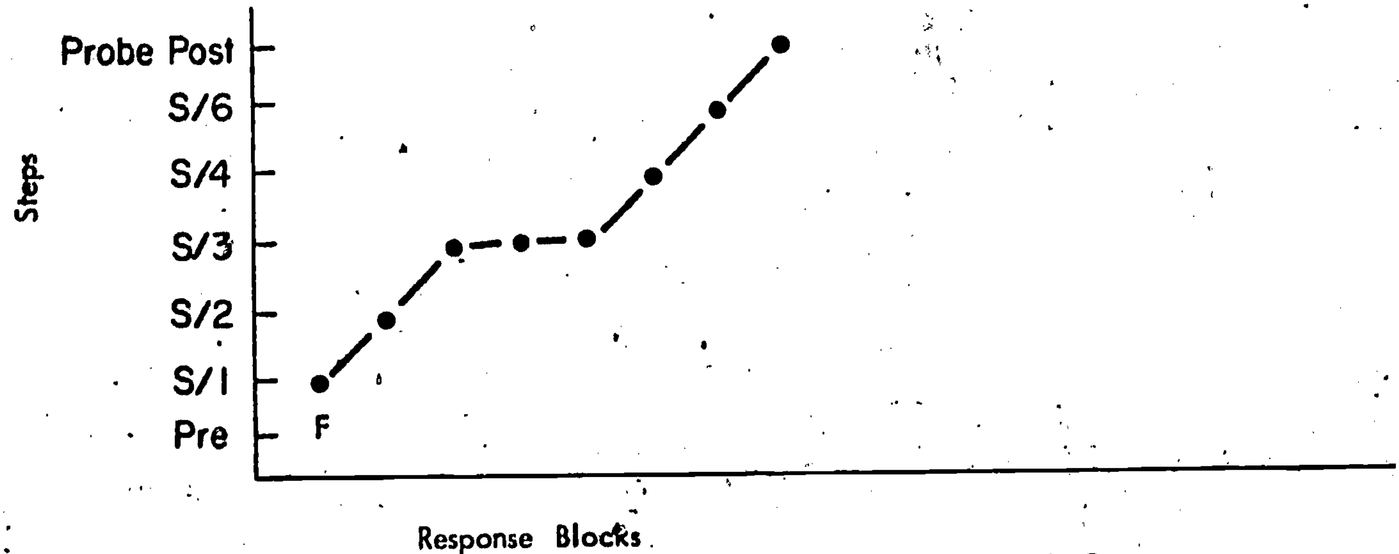
Response Blocks

Sessions	Trials	% Correct
6	210	80 %

FIGURE 25

Student: C.B.

Math Program
Number Concepts One to Five
Yes-No Confirmative
Stage II



Sessions	Trials	% Correct
2	57	93%

FIGURE 26