RAPID DEVELOPMENT OF MULTIPLE-SCHEDULE PERFORMANCES WITH RETARDED CHILDREN[1,2]

SIDNEY W. BIJOU and ROBERT ORLANDO

UNIVERSITY OF WASHINGTON

Problems encountered in the process of modifying simple operant behavior of a retarded *S* from what is observed at the beginning of a study to that required by a multiple schedule have two major implications. One bears on an experimental analysis of individual differences; the other, on the development of techniques for the efficient establishment of complex-schedule performances.

When a child enters an experimental situation, receives instructions, and sets about to perform the task, the behavior displayed is, of course, a function of the current situation and interactions with similar situations in the *S*'s history. The influences of such antecedents may be conceptualized as effects of independent variables (e.g., kinds of reinforcers received, typical schedules, and frequency of punishment contingencies), and of differences in behavioral processes (e.g., rate of change in operant conditioning) (Skinner, 1953). Such effects may be quantified by psychometric devices such as inventories of traits and abilities, or by experimental procedures. The latter, which involve observation of the successive changes in behavior required to perform an experimental task to criterion, may be approached in two ways. One consists of presenting the task and recording time (and "errors"). This procedure is often abortive. If the task is complex, even slightly so, learning may take an unreasonable length of time, or may not be achieved at all. The other approach involves presenting *S* with a series of graded tasks and reinforcing responses that approximate more and more the final performance required. The procedure is designed so that the *S* sets the pace; that is, each response class is strengthened to criterion before the next task is introduced.

This alternative has several advantages. Most important, it yields not only measures in terms of time, but also an account of the strengthening and weakening operations necessary to arrive at final performance. Experimental studies of retarded children in which the second procedure is being used are currently in progress.

Studying initial behavior is especially pertinent from a technique point of view, particularly for investigations on human *S*s using individual base lines. At the current stage of our knowledge of operant procedures with humans, many *E*s spend considerable time and effort exploring ways of establishing a schedule or multiple schedules. The objective of this paper is to describe and illustrate a method that has proven satisfactory for the rapid establishment of multiple-schedule performance in a single-response, free-operant, experimental situation with retarded subjects. A multiple schedule has been described as one ". . . in which reinforcement is programmed by two or more schedules alternating, usually at random. Each schedule is accompanied by a different stimulus, which is present as long as the schedule is in force." (Ferster & Skinner, 1957, p. 7). The multiple schedules discussed here have *two* components (one always involving extinction), with the accompanying discriminative stimuli presented in *regular* alternation.

[1]This investigation was supported by a research grant (M-2232) from the National Institute of Mental Health, Public Health Service.

[2]The authors are grateful to Russell M. Tyler and David A. Marshall, Research Assistants, for their fine work in conducting many of the individual sessions.

Initial attempts in this laboratory to establish discriminated-operant base lines in children (Bijou, in press) started with principles outlined for infrahuman *Ss* (Keller & Schoenfeld, 1950) and "hand-shaping" techniques popular as classroom demonstrations and developed most fully in animal training (Breland & Breland, 1951). Satisfactory two-component base-line performances were obtained, but only after an investment of seven or more weekly sessions. The technique reported here is the result of subsequent studies in which progressively refined procedures were explored on retarded children. Data to be presented are illustrations of the technique.

The steps in training to a multiple schedule are described in detail, not because they are expected to be followed as given, but because this is a convenient way of giving an account of the technique. Investigators probably will find it necessary to modify the steps in accordance with the nature of their subjects, the type of multiple schedules desired, and variations in the experimental situation.

THE LABORATORY SITUATION

The experimental setting is a well-illuminated room, 10 by 8 feet, with a standard table and two chairs. A wooden box approximately 12 by 12 by 16 inches is on the table. A wooden chute with tray attached for presenting reinforcers is at the left of the box. The upper end of the chute extends through an opening in the wall separating the experimental and control rooms. On the front panel of the box are a red jewel light in the upper left-hand side, a blue jewel light in the upper right-hand side, and a sturdy metal lever (a handle grip for the squeezer of an O'Cedar sponge mop) protruding from a rectangular opening in the center. Pressing the lever down is always accompanied by a relay click and occasionally by a reinforcer dispensed by a Gerbrands Universal Feeder in the control room. Reinforcers are: M & M's, Hersheyettes, candy corn, Payroll mint coins, and Sixlets. These candies were selected because they are readily consumed, easily dispensed, and are not sticky (Bijou & Sturges, 1959).

Control and recording equipment similar to devices used with infrahuman *S*s (Ferster & Skinner, 1957; Skinner, 1957; Verhave, 1959) are located in the adjoining room. They consist of timers, tape-programmers, and relay circuits for scheduling stimulus events and reinforcements. Impulse counters and a Gerbrands cumulative recorder are used to record responses on the lever. The cumulative recorder also indicates reinforcements and the type and duration of discriminative stimuli. "Blips" on the cumulative curve indicate reinforcements, while the event-pen base line under each curve records which of the two discriminative stimuli is present.

SUBJECTS

The 46 subjects are residents at the Rainier School, Buckley, Washington. The 25 girls and 21 boys ranged in age from 9 to 21 with a median of 16 years, and in IQ from 23 to 64 with a median of 42. Length of residence was from 1 to 14 years with a median of 6 years. Their clinical diagnoses spread over most categories. Since all were ambulatory, they came on request to the reception room of the laboratory from their residence halls, classrooms, or work assignments.

INSTRUCTIONS

Instructions are treated as drive operations, considered to be verbal and nonverbal procedures which may affect *S*s' rates and patterns of responding. The instructions described here, deliberately simple and brief, were designed to get lever-pressing behavior emitted at a moderate rate. Uncomplicated instructions such as these may be applied without modification to a wide range of *S*s (e.g., those with physical immaturities, sensory defects, and emotional disturbances, as well as normal children), and are less likely to contain discriminative and conditioned stimuli which may successfully compete with shaping the experimental operant (Azrin & Lindsley, 1956; Bijou & Sturges, 1959).

1. Instructions to a new *S* begin when *E* enters the reception room and says, "Hello, now it's your turn to get some of these." (He shows a handful of reinforcers.) "Come with me." (The *E* ushers *S* into the experimental room, closes the door, and points to the chair in front of the response box.) "Sit here."

2A. If *S* pulls his chair up to the table and works the lever up and down five times, a piece of candy comes down the chute. If *S* notices the candy and continues to respond, no instructions on performing the experimental task are given. Then *E* says, "I'll be back when it is time for you to go," and leaves the room. He goes into the control room, where he observes *S* through a one-way screen and monitors the controls for the next 60 seconds in accordance with the next step in the procedure.

2B. If *S* sits in the chair and waits for instructions, *E* says, as he places his *own* hand on the lever, "Now watch me; I'll show you how to get candy." (Then *E* responds at the rate of approximately two per second for five responses.) "Look. Here is some candy. It is yours. You may eat it if you wish. Now you do it. Go ahead and get some candy." If *S* responds as instructed (a reinforcement is delivered after 5 responses), *E* says, "I'll be back when the time is up for you to go," and leaves the room. As in 2A, *E* enters the control room and observes *S*'s behavior for the next 60 seconds. If *S* stops responding during the 60-second period, *E* returns and repeats the instructions beginning with, "Now watch me." If *S* repeatedly presses the lever in response to this repetition, but again stops during the 60-second period following instructions, *E* returns and terminates the session. (If *S* is needed for the study, he is brought back on another day and given training to abolish this discriminative behavior.)

2C. Some *S*s do not respond to the lever after the first set of instructions. Under these circumstances, *E* repeats the instructions beginning with "Now watch me." If *S* does not work the lever after repetition, *E* repeats the instruction a third time. This time, however, he takes *S*'s hand and puts him through the motions of responding and handling the reinforcers. If *S* does not work the lever with this assistance, the session is terminated. (He is eliminated if a substitute *S* is available. If not, he is brought back another day, and an attempt is made to shape his behavior toward the lever response in gradual stages.)

3. When it is time to end the session, *E* returns and says, "That's all for today. Go and sit in the waiting room." (If necessary, *E* gives *S* a waxed-paper sack for his candy.)

4. On subsequent sessions, *E* goes to the reception room and tells *S* it is his turn to go to the experimental room. After *S* is seated, *E* says, "Go ahead and get some candy. I'll be back when it is time for you to go." At the end of the session, *E*

terminates in the standard manner: "That's all for today. You may go and sit in the waiting room."

PROCEDURE

The procedure has four phases: (1) rate evaluation and strengthening, (2) pause building, (3) rate-recovery evaluation, and (4) final multiple-schedule training. To simplify the description of the procedure, the *blue* light will be referred to as the discriminative stimulus for pause building and nonreinforcement, and the *red* light as the discriminative stimulus for reinforcement.

Rate Evaluation and Strengthening

The purpose of evaluating *S*'s initial rate of responding is to arrive at a workable rate for training *S* to increase, for longer and longer periods, the intervals between responses in the presence of the blue light. If training on low rates of responding is undertaken when the initial rate is low or is weakened by the schedule in force, extinction may develop. Hence, this stage includes operations designed to strengthen rate when required. On the other hand, if pause training is attempted when the initial rate is very high, pausing may require an excessive amount of time to develop and stabilize. The second function of the evaluation procedure, therefore, is to detect high rates as early as possible to avoid dispensing any more reinforcers than necessary.

The *S* begins (with the red light on) on a schedule in which he is reinforced every 15 seconds (FI 15 seconds). This continues for 1 minute. If *S* makes at least 20 responses and receives at least one reinforcement during this minute, the red light goes off, the blue comes on, and the next stage of training (pause building) begins. If *S* makes fewer than 20 responses but shows an acceleration in rate during the latter part of the period, the red light remains on and the schedule remains in force for an additional minute. If 40 responses or more are made in the 2 minutes, the red light goes off, the blue comes on, and pause training begins.

If *S* gives fewer than 20 responses in the first minute and does not show acceleration in rate, or does not make 40 responses in 2 minutes, the red light stays on but the schedule is changed from FI 15 seconds to an "increasing ratio." In this schedule, the ratio is gradually increased from 1:1 to 1:5 by successively requiring more responses between reinforcements. The schedule used here reinforces response numbers 1, 2, 4, 6, 9, 12, 16, 20, 25, and 30. If the rate has increased by the end of this increasing-ratio regime, *S* is again given the FI 15-second schedule and re-evaluated, i.e., observed to determine whether he will make 20 responses in 1 minute or 40 in 2. If he does not perform at the rate-level required, the session is terminated. Like those terminated in the other stages, *S* is eliminated or requested to return for further training depending on the needs of the study.

Pause Building

The purpose of pause training is to strengthen response "withholding" for increasing periods while the blue light is present, and, at the same time, maintain prompt responding with the onset of the red light. To do this, pausing is differentially reinforced in gradually more demanding stages.

The procedure is:

1. After *S* has demonstrated a rate of responding at or above the minimum required, the red light goes off and the blue light comes on.

2. When *S* pauses for a predetermined number of seconds (IRT x seconds), the blue light goes off and the red comes on. The time unit (x) selected depends, in part, upon *S*'s performance during the rate-evaluation phase.

3. The first response (with red on) is reinforced, and the red light is replaced by the blue. The blue remains on until *S again* pauses for x seconds.

4. This sequence is repeated until *S* pauses for x seconds, y times.

5. The length of the pause is then increased by an amount z, and the conditions alternated as previously described until *S* pauses $x + z$ seconds for y' times.

6. The procedure in Step 5 is repeated with a further extension of time, and the whole process is continued until the duration of pausing with blue light on meets specifications.

The following is an example of pause building with three repetitions at 5, 10, 15, and 30 seconds of pause ($x = 5$, $x + z = 10$, $x + 2z = 15$, etc.).

1. When rate evaluation is completed, the red light is replaced by the blue.

2. The *first* time *S* gives an inter-response time of 5 seconds, the blue light goes off and the red comes on. The first response is reinforced and the red light is replaced by the blue.

3. Immediately after the *second* 5-second inter-response time, the red light replaces the blue. The first response is reinforced and the blue replaces the red light.

4. Immediately after the *third* 5-second inter-response time, the red light replaces the blue. The first response is reinforced and the blue light replaces the red.

5. When *S* delays responding for 10 seconds, the blue light goes off, the red comes on, and the first response is reinforced.

6. The procedure in Step 5 is repeated twice more, and then a 15-second pause is required.

7. After three successful 15-second pauses on blue, a delay of 30 seconds is required.

8. After three successive 30-second pauses on blue (and reinforcements on red), the next stage of training begins. This involves lengthening the time on the red light or on both the red and blue lights, and changing from a continuous to an intermittent schedule.

As is apparent, the objective of pause training is not only to increase the delays between responses in the presence of the blue light, but also to maintain prompt responding with the onset of the red light. There are two clear-cut indications if this stage is proceeding too rapidly: long periods of failure to pause, and/or increased latency to the red light. In both instances, completion of a sequence will be delayed and additional training may be required before pauses can be longer. The following procedure has been shown to be serviceable. When a given y series has not been completed in 5 minutes, the entire series is repeated before training on a longer pause is begun. For example, if *S* required more than 5 minutes to make three successive 5-second pauses, training is given in making three more 5-second pauses (total of 6) prior to training on 10-second pausing. Similarly, if more than 5 minutes is required to complete three 10-second pauses, three more 10-second pauses are programmed before 15-second pauses are begun.

Rate-recovery Evaluation

The objective in this phase is to assess the *S*'s reaction to lengthening the duration of the red light and to change from a continuous to an intermittent schedule. After the last pause in the final series under blue light, the red light comes on and *S* is given 1 minute on a 15-second, fixed-interval schedule. If he makes more than 20 responses, he is moved to the next (multiple-schedule) phase. If he makes fewer than 20 responses, the schedule is changed to increasing ratio (the one used for strengthening rate in phase one). This training continues until the rate reaches 20 responses for a 60-second period.

Final Phase: Multiple-schedule Training

The *S*s who meet the criterion of rate in the previous stage are moved to the final multiple-schedule stage, provided the times of the discriminative stimuli are not over approximately 3 minutes each and the intermittency of reinforcement is not greater than a ratio of 50 or any interval of 1 minute. If discriminative-stimuli duration or schedules are greater than these values, it is suggested that changes take place in graduated steps.

DATA AND DISCUSSION

The performances of eight *S*s in two experimental sessions each are presented as representative illustrations of the data. These *S*s show a variety of behavioral effects and demonstrate a range of schedules and procedures. The clinical diagnosis is included in the brief descriptions of each *S* for whatever value it might have. However, because this study was not concerned with the relationship between diagnoses and operant behavior, implications of such relationships from these data are not intended. To facilitate identification of the figures, each record is identified by *S* (e.g., EMN), session number (e.g., S-1, S-2), and the schedule during the final phase (e.g., mult VR 25 ext).

The first four *S*s shown in Fig. 1 illustrate the procedure, with particular emphasis on variations in development rather than in the final schedule. The last four *S*s, presented in Fig. 2, show some of the range of final schedules established with the procedure.

The top two records in Fig. 1 show the first and second sessions of EMN, a 16-year-old girl with an MA of 5 years 3 months and an IQ of 42. She has been living at the institution for 4 years and is diagnosed as undifferentiated. In these records, as well as in the others, the horizontal line under the cumulative-response curve indicates the discriminative stimulus in force. When the line is elevated, the blue light was on; and when depressed, the red light was on. The colored light serving as S^D can be inferred from the reinforcement marks in the cumulative curve.

Since EMN's initial rate was high, rate strengthening was omitted. Pause building proceeded slowly and steadily. When shifted to mult VR 25 ext with fixed 1-minute alternation of lights, she performed at a steady rate under VR 25 and showed some anticipatory responses during S^Δ. The Session 2 (S-2) performance on mult VR 25 ext with 2-minute alternation is orderly, with some tendency to respond during S^Δ.

The second *S* (FJL) is a 14-year-old mongoloid girl with an MA of 3 years 1 month and an IQ of 32. She has lived in the institution for 4 years. The initial reaction to pause building in Session 1 consisted of a rate increase. After pause building, a rate-recovery interval showed that rate strengthening was not necessary, and she was shifted immediately to mult VR 25 ext with fixed 2-minute alternation of S^D and S^Δ. Evidence of a discrimination is shown during the middle part of the session. Performance is good, but rate drops toward the end. This extinction trend was continued during the second session, S-2 (not shown), in which only 2 responses were made. In the third session (S-3), the increasing-ratio schedule recovered the rate, and discriminative performance on mult VR 25 ext with variable 2-minute alternation followed.

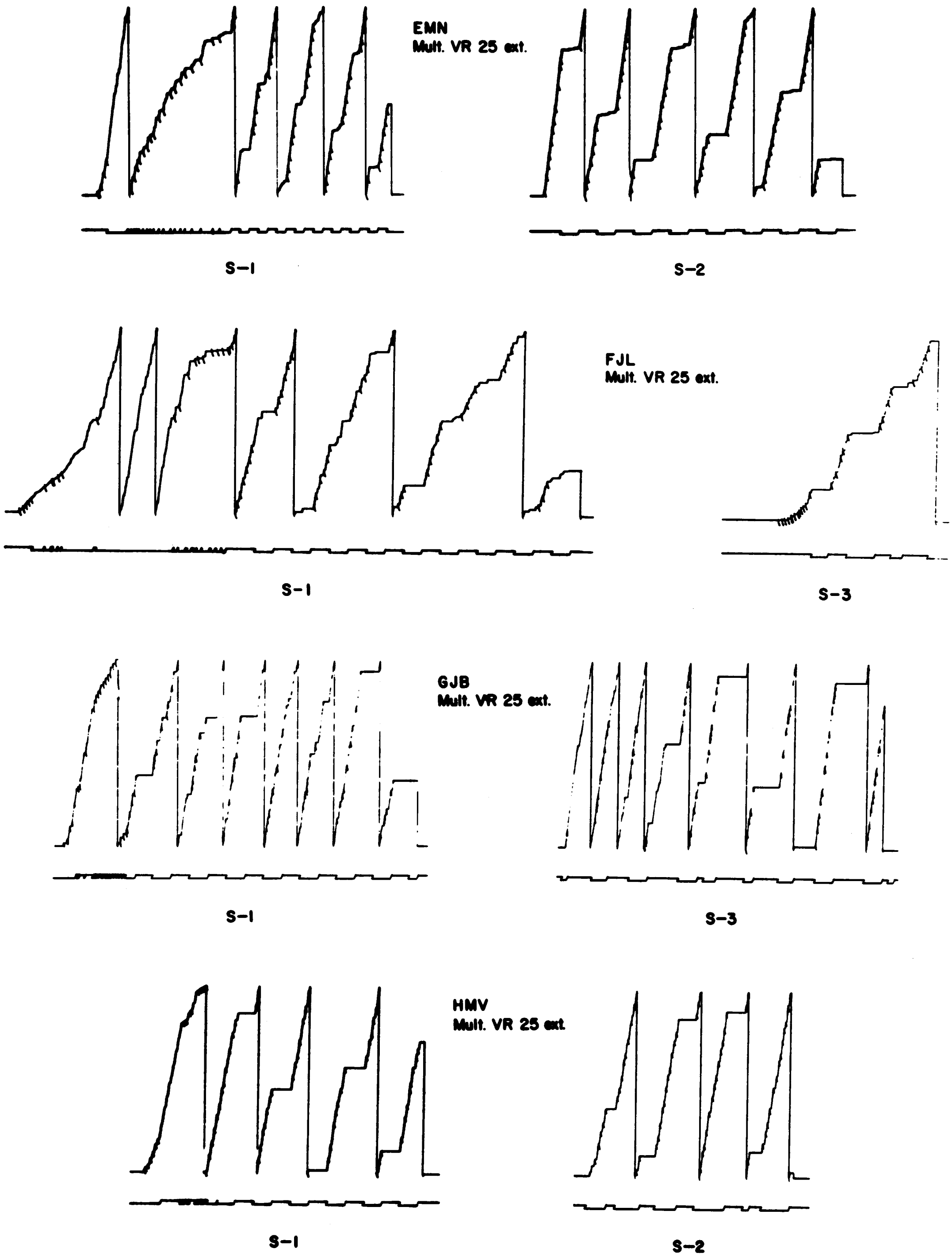

Figure 1. Records of two sessions each for *S*s EMN, FJL, GJB, and HMV showing the development of mult VR 25 ext.

The third *S* in Fig. 1 (GJB) is a 21-year-old mongoloid girl with an MA of 3 years 5 months and an IQ of 30. She has lived at the institution for 11 years. She began Session 1 with a high rate; and although pause building progressed well, she responded to the onset of S^D with "runs" of responses. Rate recovery was good; and when shifted to mult VR 25 ext with fixed 2-minute alternation, discrimination was only fair because of the large numbers of responses during S^Δ shown in the middle of the session.

Session 2 for GJB is not shown. The performance was almost continuous responding, very much as in the initial part of Session 3. In Session 3 the schedule was mult VR 25 ext, with variable 2-minute alternation of the stimulus condition.

The final *S* in Fig. 1 (HMV) is a 21-year-old mongoloid boy with an MA of 4 years 9 months and an IQ of 32. He has been institutionalized for only 3 years. His initial high rate and virtually continuous responding during pause building quite suddenly gave way to rapid learning to pause. The pause series was terminated at the end of five 10-second pauses, and rate recovery showed no necessity for strengthening. Performance on mult VR 25 ext with fixed 2-minute alternation was nearly perfect, and this high level of discrimination was continued in Session 2 on mult VR 25 ext with variable 2-minute alternation.

The first *S* in Fig. 2 is ADP, an 11-year-old boy with an MA of 3 years 2 months and an IQ of 46. He has been at the institution for 5 years and is classified as cerebral birth trauma. Subject ADP maintained a high steady rate for more than 2000 responses during pause building, then suddenly learned the discrimination. All of the series of 20-second pauses were nearly perfect. Performance on mult FR 25 ext with fixed 2-minute alternation shows good stimulus control, and regular postreinforcement pauses appear in Session 2.

Subject BRB is an 18-year-old boy with an MA of 6 years 6 months and an IQ of 43. He is diagnosed as familial, and has been in the institution for 12 years. Pause control was quickly established; and although no rate recovery was given, an adequate rate was immediately obtained and performance on mult FI 1 ext with fixed 2-minute alternation was at a high level. This performance continued in Session 2, with some suggestions of FI scallops.

Subject CMW is a 17-year-old boy with an MA of 3 years 7 months and an IQ of 43. He has been institutionalized for 11 years and is diagnosed as cranial anomaly. His initial high rate in Session 1 was rapidly replaced by pause control. After pause building, both lights were turned off, and a buzzer was introduced as the cue in a mult CRF VI 0.5 schedule. Generalization is shown by continued low rate and few responses in the absence of the buzzer. Close-to-perfect performance is shown in Session 2, where he responded immediately to cue onset and refrained from responding in the absence of the cue.

Subject DJS is a 19-year-old girl with an MA of 4 years 8 months and an IQ of 36. She has been in the institution for 8 years and is classified as undifferentiated. Very rapid learning to pause followed a period of steady responding. She was shifted in gradual stages to a final schedule of mult VR 100 ext with fixed 3-minute alternation of lights. Successively, the stages were 4 minutes on mult VR 25 ext (fixed 0.5 alternation), 10 minutes on mult VR 25 ext (fixed 1-minute alternation), and 8 minutes on mult VR 50 ext (fixed 2-minute alternation). This progression is shown by changes in segment lengths in the event line. Stimulus control is evident, but a strong tendency to make responses in the presence of the S^Δ persisted. During Session 2, discrimination increased gradually but did not reach a high level.

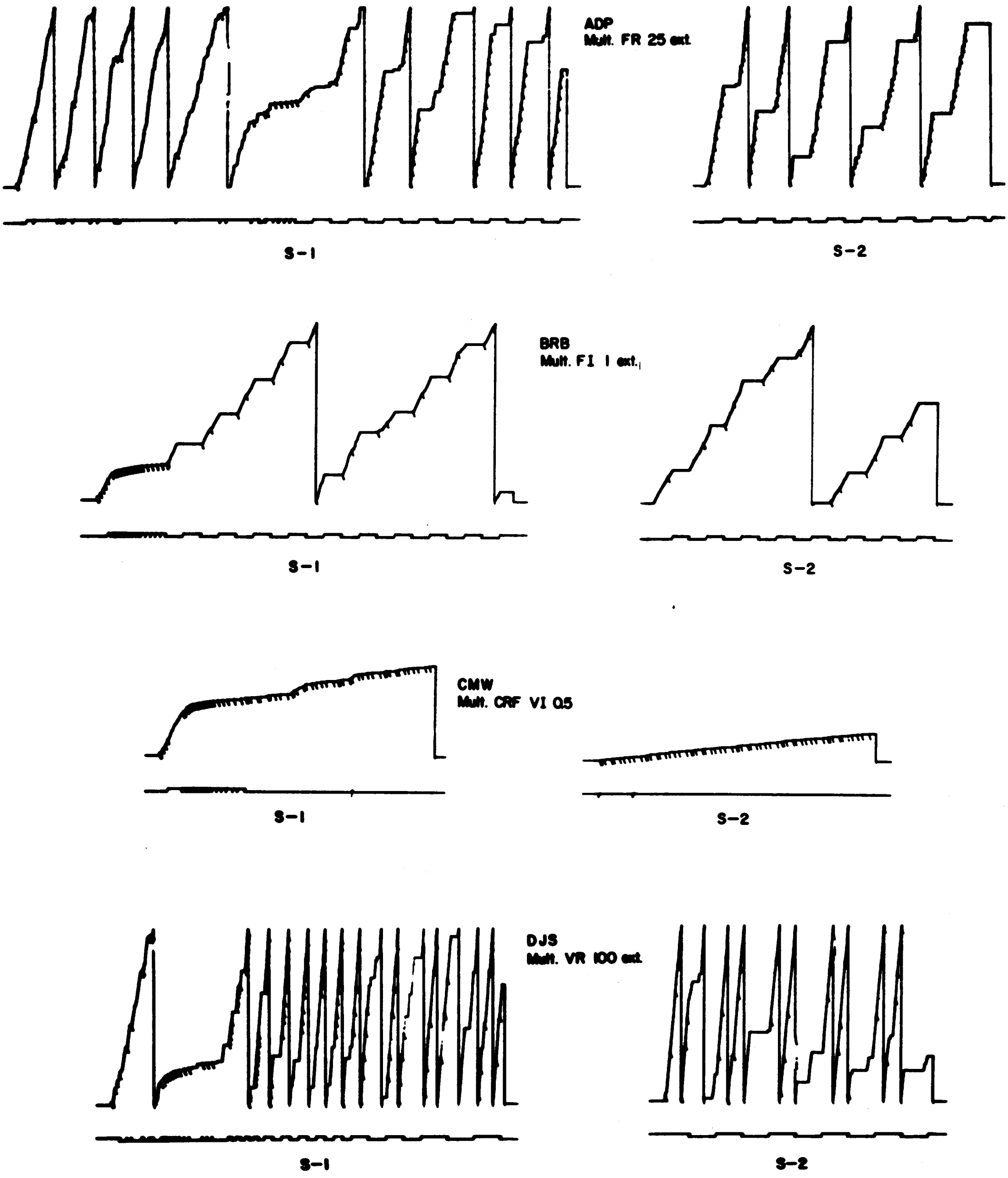

Figure 2. Records of Sessions 1 and 2 of *S*s ADP, BRB, CMW, and DJS showing the development of mult FR 25 ext, mult FI 1 ext, mult CRF VI 0.5, and mult VR 100 ext.

SUMMARY

This paper deals with modifying simple operant behavior of institutionalized retarded children which is observed at the beginning of a study of the behavior required for a multiple schedule. A study of such procedures has promise both for an experimental anal-

ysis of individual differences, and for the development of techniques for the rapid acquisition of discrimination relative to multiple schedules. Concern here is with multiple schedules. The technique, which is designed to allow *S* to set the pace, is outlined in detail. All the multiple schedules described consist of two components which alternate in some fashion. Sample data are presented on eight *S*s illustrating some of the phases and some of the final performances.

REFERENCES

Azrin, N. H., and Lindsley, O. R. The reinforcement of cooperation between children. *J. abnorm. soc. Psychol.*, 1956, **52**, 100–102.

Bijou, S. W., and Sturges, Persis T. Positive reinforcers for experimental studies with children—consumables and manipulatables. *Child Develpm.*, 1959, **30**, 151–170.

Bijou, S. W. Discrimination performance as a baseline for individual analysis of young children. *Child Develpm.* (in press).

Breland, K., and Breland, Marion. A field of applied animal psychology. *Amer. Psychol.*, 1951, **6**, 202–204.

Ferster, C. B., and Skinner, B. F. *Schedules of reinforcement.* New York: Appleton-Century-Crofts, 1957.

Keller, F. S., and Schoenfeld, W. N. *Principles of psychology.* New York: Appleton-Century-Crofts, 1950.

Skinner, B. F. *Science and human behavior.* New York: MacMillan, 1953.

Skinner, B. F. The experimental analysis of behavior. *Amer. Scientist*, 1957, **45**, 343–371.

Verhave, T. Recent developments in the experimental anaysis of behavior. *Proceed. Eleventh Res. Conf., Amer. Meat Inst. Found. of the Univer. of Chicago.*, 1959.

Received June 21, 1960