

Psychiatry

THE DEVELOPMENT OF PERFORMANCES IN AUTISTIC CHILDREN IN AN AUTOMATICALLY CONTROLLED ENVIRONMENT

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THIS experiment reports data from a technique for producing behavior in autistic children¹ under an automatically controlled environment. The experiment is an explicit attempt to develop techniques for enlarging the very narrow range of performances generally present in these children's repertoires. Performances were developed and maintained in order to determine some facts about these children's existing repertoires, and to discover what potentiality exists for extending them. We created each child's repertoire by arranging specific consequences to his performance (reinforcement) which increased the subsequent frequency of those performances. Early in the experiment, the reinforcements which were delivered were food, candy, and trinkets*; later, coins were delivered which could be cashed in for various other rewarding consequences.

The experiment involved pressing a key. This simple arbitrary act was chosen because: (1) The response took little time or effort to execute, and it left the child in a position to respond again. The frequency with which the child pressed the key could therefore vary over a wide range, from a few responses per hour to several thousand. Such a dependent variable is potentially sensitive to many independent variables, and gives a continuous measurement of their effects. (2) A performance such as pressing a key actuates an electrical contact and hence can be objectively and automatically recorded. It also permits the automatic programming of the entire experiment, so that all of the experimental procedures can be arranged precisely and without error. Extended training and long-term exposure to the conditions of the experiment which would be impossible manually become possible because the experiment is carried out by automatic devices. Over 50,000 coins were delivered and 400,000 responses recorded for Subject 1 alone. (3) The frequency of key pressing is intuitively analogous to the major problem in the measurement of human behavior: measuring the child's

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*Assortments of trinkets were purchased from the Penny King Co., 2538 Mission St., Pittsburgh, Pa., and Plastic Processes, Inc., 83 House Ave., Freeport, N. Y.

disposition to behave; the probability of his acting. A simple recording of whether the child acted or not gives little information about his general tendency to behave. A single occurrence of an act may be caused by a strong or a weak repertoire. The child's disposition to act can vary from low to quite high, and the level of motivation is best determined by examining the frequency of key pressing; the child's disposition to engage in the experimental behavior is recorded as the frequency of occurrence of the key press. (4) The use of an arbitrary response, such as pressing a key, has been used extensively in animal experiments dealing with general problems in maintaining behavior of the organisms. Many of the processes discovered have proved to be phylogenetically general among a wide range of mammals, including man; and this information may be used to determine when we have established normal control over the child's behavior. Recording of the behavior as the effect of the animal's performance on an electrical switch makes possible the comparisons of the performance of a wide range of species.

These tendencies have already been used successfully in the study of the behavior of normal children.^{2,3} One of the problems in developing experimental techniques for creating new behaviors in these children and maintaining old ones is the development or discovery of reinforcers which are powerful enough to sustain large amounts of behavior. The problem of a reinforcer is especially acute with the autistic child because of his general deficit in positively maintained behavior. The frequency with which the child presses the key, particularly when it is reinforced only intermittently, provides a technique whereby new and more effective reinforcers can be discovered. By observing which experimental procedures increase and decrease the frequency with which the child presses the key, an experimental environment can be constructed which becomes increasingly effective in supporting strong behavior in the child. A major accomplishment of the research reported here is the development of procedures which can strongly maintain the behavior of a child under conditions where the form of the behavior occurs explicitly as a result of the experimental procedures.

A durable reinforcer is especially necessary for the development of complex behavior. While the child is being exposed to the development of new complex performances, nonreinforcement of inappropriate responses is inevitable. This nonreinforcement weakens the performance; and if the new behavior is to be developed, the child must continue to emit the performance first. After the child's performance can be sustained in the experimental environment, it should become possible to investigate many aspects of the autistic repertoire which have heretofore been inaccessible. The child's auditory and visual repertoires could be studied if various stimuli were presented to him while at the same time reinforcement was differentially given or withheld, depending upon which stimulus was present. The ability of the child to come under the control of the relevant stimuli would be shown by the differential performance in the presence of the various stimuli.

Complex forms of behavior could be developed after the child has begun performing by successively approximating more complex activities. Reinforcements can be shifted in the direction of the complex form of activity required.

Once the child's performance conforms to the new condition of reinforcement, the contingency is again subtly shifted. Ultimately, studies of even such complex forms of behavior as speech may be carried out by reinforcing vocal sounds in the child's repertoire and gradually approximating more and more complex forms.

Subject 1.—The first subject is male, and was 8 years old and in good physical condition at the start of the experiment. Speech occurred at the later part of his first year, and proceeded to sentences of two or three words. Motor development and coordination were good. According to parental reports, the child's illness began when he was 18 months old. The father was under strong financial pressure, holding a job while maintaining a farm, and at the same time experiencing considerable ill health. The parents spent evenings "barking" at each other. During the period of development of the boy's illness, the mother was subject to severe depressions, usually stemming from arguments with her husband and sometimes lasting for several days. During these depressions, she was almost completely inactive, paying nearly no attention to the subject beyond minimal care. The subject began taking off clothing unpredictably, tearing down curtains, upsetting furniture, pounding his head against the wall, and wandering 2 or 3 miles from home. The father's ways of dealing with the boy's disturbances ranged variously from severe punishment to isolation; he built a fenced-in cage to control the subject's increasingly destructive behavior. Speech began to diminish at this time, and the child has been practically mute since the age of 4, when the parents sought medical care. At 7 years, the child was admitted to the LaRue D. Carter Memorial Hospital. During his stay there he remained nonverbal, except for rare occasions when he spoke one or two words. He characteristically tore his clothing and broke toys and articles belonging to other children. Severe tantrums that had no relationship to current events occurred frequently. He spent long periods of time simply standing idly, lying on the floor, or shuffling through the ward. His most frequent activities consisted of agilely climbing on objects and playing with water and clay. He also spent large amounts of time smearing and mouthing clay or candy. His performance during his stay at the hospital had changed little before the experiment described here.

Subject 2.—The second subject is a female who was 9½ years old at the start of the experiment. The girl developed normally until she was about 3, when she began to lose speech, play destructively with toys, smear feces, and lose bladder and bowel control. She became phobic in regard to animals. Some speech remained, however. From the age of 19 months to 3 years, an adolescent high school girl was the subject's constant companion. The adolescent handled the subject completely permissively and with much "babying." The mother was passive and allowed the adolescent to take over all of her functions. The subject's behavioral difficulties began when the adolescent girl left and the mother became pregnant with a second child.

Neither subject showed any evidence of brain damage in standard neurological and EEG examinations at the time of admission or subsequently.

Control Subjects.—Control subjects were inpatients in the Children's Service who did not appear to have any intellectual deficits and were essentially normal except in respect to the general level of social control. The control subjects were approximately the same ages as Subjects 1 and 2.

First Exposure to the Experiment.—When Subject 1 was first exposed to the experiment, only the single-column vendor was present (Fig. 1). During the first session, an attendant who knew the subject led him to the experimental room and gave him candy. During the second session, the subject found candy that had been previously placed in the trough of the vending machine. During the third session, the candy was delivered remotely by the solenoids on the vending machine; and during the fourth session, the key was installed, with every press of the key operating the vending machine. Several sessions later, the subject entered the room alone.

With Subject 2 the eight-column vendor, the pigeon, phonograph, and pin-ball machine were present. The subject was brought to the room by an attendant whom she knew, and all of the devices were demonstrated. The session was

completed with the attendant in the room. Starting with the second session, the subject was placed in the room alone, the door locked, and the normal procedure carried out.

Except at the beginning of the experiment, Subject 1's experimental duration was 60 minutes or 80 reinforcements, whichever occurred first. The duration was increased to 90 minutes on the seventieth session. Subject 2's experimental duration was 90 minutes throughout.

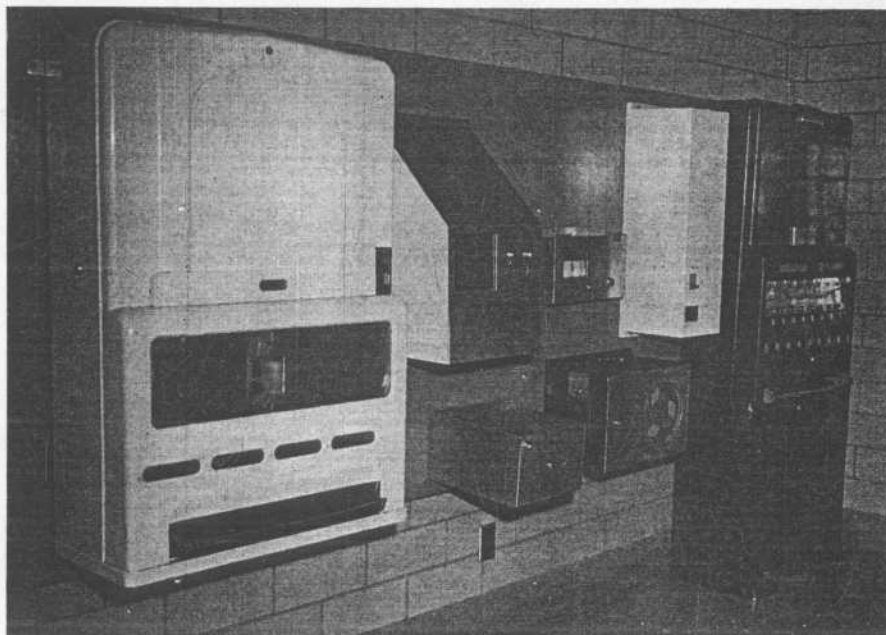


Fig. 1.—Photograph of the experimental room. The eight-column vendor is at the extreme right, the single-column vendor on the left. The other devices on the wall, from left to lower right, are phonograph and color wheel. Above the color wheel is the coin dispenser with the coin key and the coin trough. The other two devices were installed subsequently to the experiment reported here. The pigeon is not shown.

Reinforcing Devices.—Food appeared to be the most effective reinforcer available. Nevertheless, an attempt was made to establish a more durable reinforcer by delivering a coin that in turn could be used in a wide variety of reinforcing devices. The experimental use of the coin parallels its use in the normal social environment.⁴ It is an occasion which makes possible other behavior producing a variety of reinforcers. Such a conditioned, generalized reinforcer has the advantage that it derives its reinforcing effect from other reinforcers which are effective under various kinds of deprivation. Should the level of deprivation in respect to several of the specific reinforcements used in the experiments be low, the generalized reinforcer would continue to maintain behavior through the remaining devices which might be relevant to current deprivations. If the

number of reinforcing devices were large enough so that at least some of these would be reinforcing for each subject, the same experimental room could be used for a number of subjects. There is also the possibility that the generalized reinforcer may have its effect by the sum of the specific reinforcers.

The children operated the reinforcing devices in the room either by pressing a key or depositing a coin. The key was a telephone-type lever switch, mounted in a translucent plastic panel which could be lighted from behind. A solenoid gave an audible click whenever the switch was sufficiently depressed. When the key was inoperative (before and after the experimental sessions and during time out) the clicker and light were disconnected. The coin slots resembled those ordinarily found on vending machines, except that small pilot lights next to them indicated when the slots were operative. Coins deposited when the coin light was off were recorded but did not operate the device. The coins were stainless-steel discs the size of a 1-cent piece. Reinforcing devices were added gradually during the early stages of the experiment. Tables I and II give the exact points of introduction of the reinforcing devices.

Coin Dispenser: The coin dispenser and key were mounted together in a wall unit. The coins were delivered to a tray just below the response key.

Single-Column Vendor: The single-column vendor, a modified pastry-vending machine, was operated by solenoids which emptied the compartments of the columns of the machine in sequence. When the vendor's 80 compartments were emptied, the light next to the coin slot went out.

Pigeon: A transparent plastic wall unit, 12 by 12 by 14 inches, contained a hungry pigeon and associated devices so that the bird pecked at the disc only when the light was on. A coin deposited in the coin slot turned on the lights in the apparatus so that the child could observe the bird's performance for 30 seconds.

Phonograph: An aluminum box, approximately 12 by 12 by 8 inches, contained a speaker, a coin slot with an associated light, and a light that came on whenever the phonograph was operating. When a coin was deposited in the slot, the phonograph, which was located in the adjoining room, played through the speaker for 30 seconds. A coin deposited in the coin slot while the phonograph was on reinstated the full 30-second period. The records were generally lively marches or children's records. The material was varied from day to day, and was a rough attempt at presenting records of interest to the child.

Pinball Machine: The pinball machine simulated a baseball game with many moving parts, bells, flashing lights, etc. Depositing a coin in the coin slot of the pinball machine released two balls for play.

Eight-Column Vendor: The eight-column vendor was adapted from a cigarette machine by installing solenoids, and an independent coin switch and coin light on each column. Part of the face of the machine was made of Plexiglas so that the subjects could inspect the kind of candy in each column. When a column became empty, its coin light went out. When the whole vending machine was inoperative, all of the coin lights were extinguished. The eight-column vendor was operated with coins only.

Color Wheel: The color wheel consisted of three discs, each red, blue, and yellow, rotating on a common shaft and in respect to each other, and driven by a variable-speed motor. The result was a kaleidoscopic color change. The subject would vary the speed of the motor by turning a knob on the face of the panel, thus changing the kaleidoscopic color effects. A coin in the slot whenever the light was on provided operation of the color wheel for 30 seconds.

Organ: A portable electric organ was modified by installing a rod which locked the keys until the solenoid was released. A coin in the coin slot freed the keys for 30 seconds.

Food, Candy, Toys, and Trinkets Delivered in the Vending Machines.—In general, the kinds of candy, crackers, and foods delivered were varied during different phases of the experiment, and between subjects, depending upon their preferences. Candy and food delivered included candy corn, M & M's, peppermints, chocolate mints, Tootsie-Rolls, raisins, dried apricots, burnt-sugar-coated peanuts, marshmallows, various kinds of crackers and cookies, plain chocolate, and chocolate-covered raisins. The single-column vendor was used to deliver small trinkets, 1-ounce portions variously of fruit juice, water, and milk in covered plastic containers, candy, crackers, and some larger toys, such as Tinker toys, miniature cars and harmonicas, and blocks. The trinkets were selected from a large assortment and were changed daily.

Schedules of Reinforcement.—The schedule of reinforcement describes the program by which the experimentally recorded performance operates the reinforcing devices.⁵

Fixed-Ratio Schedule (FR).—Every n th response activates the reinforcer. This schedule normally produces a high, sustained rate of responding. When the number of responses required for reinforcement is increased, responding stops after reinforcement, followed by an abrupt shift to the high rate.

Variable-Interval Schedule (VI).—Passage of time determines when a response activates the reinforcer. The average interval between reinforcements is specified, but the actual intervals vary from reinforcement to reinforcement. This schedule normally produces a moderate, roughly constant rate of responding.

Multiple Fixed-Ratio, Variable-Interval Schedule.—The color behind the key changes between red and green after each reinforcement. When the color is red, the coin is delivered by the n th (e.g., fifteenth) response. When the color is green, the first response after a variable period of time produces a coin. The performance that normally emerges from each color is appropriate to the schedule of reinforcement in its presence.

PLAN OF THE EXPERIMENT

Tables I and II contain a detailed summary of the experimental procedures for Subject 1 and Subject 2, respectively. These specific procedures were in effect for the session numbers indicated in the first column. The second column refers to the schedule by which pressing of the key produced coins. The third column indicates the session at which the various reinforcing devices were introduced,

SESSIONS	SCHEDULE OF REINFORCEMENT (COINS)	REINFORCING DEVICES							STIMULUS CONTROL	ILLUSTRATIONS	GENERAL FACTORS	
		SINGLE-COLOR-UMN VENDOR	8-COLUMN VENDOR	PIGEON	PHONOGRAPH	PINBALL	COLOR WHEEL	ORGAN				
1-21	VI† 7-30 (candy and coins)	Coins									Sparine 50 mg. t.i.d.	
22-30	Multiple VI FR											
31	FR† 9											
32-37	VI 30											
38-39												
40-44												
45	FR 15											Coins
46-49												Coins
50-56	Key Disconnected											Coins
57-70	FR 13											Coins
71-78	Mult VI 60"											
79-81	FR 13											
82-85	FR—Mult—FR etc.	Coins	Coins									
86-94	FR 15											

95-104									Coin slot operative every 2nd-3rd coin for 20 sec.	Fig. 13	Tantrums and frequent atavisms
105-128		Crf		Crf§	Crf				Coin slots operative continuously except when a column is emptied		Pinworm infection. Tantrums and frequent atavisms
129-137	FR 2-5										Experimental room remodeled. Pacatal 50 mg. t.i.d. Tantrums and frequent atavism
138-146	FR 15										Electrical shock discovered and removed. Thorazine 25 mg. t.i.d. Session 171. Pacatal 50 mg. h.s. Compazine 10 mg. t.i.d. Session 179
147-187	FR 4-5		FR 2	FR 2	FR 2	FR 2			Coin slots operative every 2nd or 3rd coin for 30 sec.	Fig. 15	
187-198									Coin slots alternately operative and inoperative every 30-40 sec.		
199-204									As above coin in inoperative slot extends inoperative period		
205-215									As above—coin in empty column makes entire vendor inoperative		
229-235	FR 8-15										
236-239	FR 5										
240-244	FR 15	Coins	Coins	Coins	Coins	Coins	Coins				
245-251	FR 1-2 New Key										
252-256	FR 15-25										
257-	FR 2 New Key										

*Schedule of reinforcement by a key mounted directly on the device.
†Variable interval.

‡Fixed ratio.
§Continuous reinforcement.

TABLE II. SUMMARY OF EXPERIMENTAL PROCEDURES FOR SUBJECT 2																			
SESSIONS	SCHEDULE OF REINFORCEMENT (COINS)	REINFORCING DEVICES*						STIMULUS CONTROL	ILLUSTRATIONS	GENERAL FACTORS									
		SINGLE-COLUMN VENDOR	8-COLUMN VENDOR	PIGEON	PHONOGRAPH	PINBALL	COLOR WHEEL				ORGAN								
1-5	FR 15		Coins	Coins	Coins	Coins	Coins	Coins	Coins	10 sec. time out after reinforcement	Fig. 7	Compazine 10 mg. b.i.d. Pinworm infection discovered and treated. Piperazine for 2 weeks Compazine discontinued. Thorazine† Pharyngitis. Electric shock discovered and removed. Thorazine †, §							
6-17																			
18-37																			
38-45	FR 2-5																		
46-53	FR 2-15																		
54-56																			
57-91	FR 1-5																		
92-100																			
101-103																			
104-136	FR 8—FR 15																		
137-143	FR 5																		
144-149	FR 15																		
150-155	FR 2—Paper-drive																		
156-162	FR 15-30																		

*Schedule of reinforcement via a key mounted on the device.

†Thorazine 25 mg. t.i.d. and h.s.; 3 days later, 40 mg. t.i.d. and 60 mg. h.s.; 3 days later, 50 mg. t.i.d. and 100 mg. h.s.

‡25 mg. t.i.d. and 50 mg. h.s.

§Session 77, 25 mg. t.i.d. and 50 mg. h.s.

¶Rectal temperature.

and whether they were operated by a coin or by a lever mounted directly on the device. The fourth column, "Stimulus Control," indicates the presence or absence of stimuli correlated with conditions of reinforcement, e.g., the lamp which is on when the coin slot can be operated by a coin. Abbreviated procedures are explained in more detail in the footnotes following the tables.

The experimental procedures are grouped into the following phases.

Subject 1.—

Phase 1, Sessions 1 to 30: During this period, the general technique was developed, reinforcers discovered, and the experimental procedures integrated with the ward routine. A stable key-pressing performance was developed on a variable-interval schedule of reinforcement.

Phase 2, Sessions 31 to 70: The schedule of reinforcement with coins was changed from variable interval to fixed ratio. Both subjects performed appropriately to the control normally produced by the fixed-ratio schedule.

Key pressing was brought under the control of the lights behind the key by periodically turning off the lights and discontinuing reinforcement. Both children stopped pressing the key when the light was off. Control by the coin lights was developed similarly. The coin light was only periodically lighted, and coins deposited when it was off were wasted. In another procedure, designed to make the subjects accumulate coins before using them, the coin light came on for a brief period with every n th coin delivered (e.g., 3). Coins deposited as soon as they were received (except for the n th coin) were wasted. During this period, the children's performances were weaker than those previously recorded. However, this was at least in part because both children had a pinworm infection and had received accidental electric shocks delivered by the experimental devices.

Phase 3, Sessions 71 to 104: Here, intermittent reinforcement of the behavior was emphasized, in order to determine the degree to which large amounts of behavior could be sustained with minimal reinforcement. The stimulus control by the coin light which had developed previously with the one-column vendor was lost when the eight-column vendor was introduced. There were many tantrums during this period, and the recorded performance became considerably weaker.

Phase 4, Sessions 105 to 165: Because of this weakened performance, the schedules of reinforcement were made optimal by delivering coins on small fixed-ratios and operating all of the reinforcing devices except the eight-column vendor directly by one or two presses of the key mounted directly upon the device. At Session 138, all of the reinforcing devices except the electric organ, had been installed.

Phase 5, Sessions 166 to 186: During this period, the pinworm infection was cured and the electric shock was eliminated, the schedules of reinforcement remained optimal, and strong performances were recovered.

Phase 6, Sessions 187 to 235: The control by the coin lights was re-established by additional coin-saving procedures.

Phase 7, Sessions 236 to 239: The reinforcing devices were operated only by coins, with the direct levers removed. The size of the fixed-ratio was reduced to facilitate the transition.

Phase 8, Sessions 240 to 261: During this period, the number of wasted coins approached zero, and a performance was maintained with the use of the coin as a generalized reinforcer at larger fixed ratios.

Subject 2.—Experimentation on Subject 2 began some months after that on Subject 1, so that nearly all of the reinforcing devices had been already installed at her first experimental session. Fewer procedural apparatus changes were required for Subject 2 because of her generally more advanced behavioral repertoire, and because some of the experimental problems had been solved with the first subject.

Phase 1, Sessions 1 to 37: The first development of a performance occurred in these sessions. Stimulus control was developed by the lights associated with the coin switches and keys.

This subject came under the control of these contingencies very rapidly; and, in general, the procedures developed with the first subject were sufficient to generate the required performance during the early sessions.

Phase 2, Sessions 38 to 104: A severe pinworm infection was discovered and treated at the start of this period, and at Session 53, a high-voltage shock between the floor and the reinforcing devices was discovered. By Session 91, the effects of the shock disappeared. During this phase, all of the reinforcing devices were operated by direct levers except for the eight-column vendor, which still was operated by means of coins.

Phase 3, Sessions 105 to 162: All of the reinforcing devices were operated through coins produced by pressing the key, and the schedule of reinforcement by coins was increased first to 15, then to 25. Stimulus-control procedures remained in force during part of this period.

RESULTS

First Development of a Performance.—

Subject 1: Fig. 2 shows the continuous development from a weak performance at the start of the experiment to a well-sustained performance by the twelfth session. Only the single-column vendor with the key mounted on it was present. Compartments of the vending machine were loaded with either candy, food, or a coin. When a coin was delivered, it could be deposited in the coin slot, thereby operating the next compartment.

The child's responses are graphed against time, and the marks oblique to the record indicate the occurrence of a reinforcement. The scale of the record is given by the grid at the right of the figure. Coins are delivered on a variable-interval schedule whose mean interval of reinforcement was increased progressively during the first session. Each segment is a record of the entire daily session. The amount of responding increased progressively over the sessions, reaching an over-all rate of approximately 15 responses per minute.

Fig. 3, Records A through E, continues the next sessions on VI 30, and shows a fall in the over-all level of responses until the performance reaches a low, constant rate just sufficient to produce reinforcements roughly on schedule. Part of

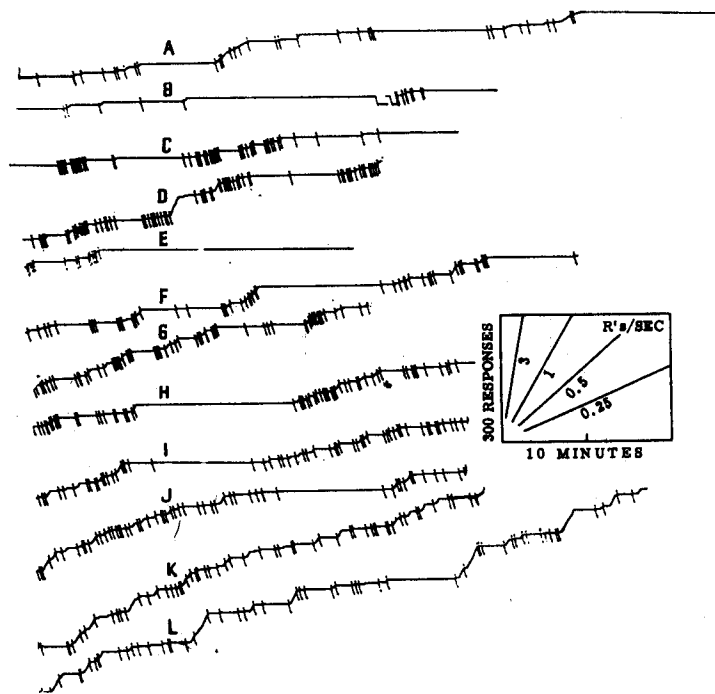


Fig. 2.—Cumulative records of the first 12 sessions of the experiment under variable-interval reinforcement. Records A-E, VI (variable interval) 7 (seconds); Records F-H, VI 10; Records I-K, VI 25; Records K-L, VI 30.

the fall in the over-all rate of responding was produced by "ritualistic" climbing over the top of the machines which occurred between presses of the lever.

Beginning with the fourth session (Record D), a coin dispenser was installed inside the vending machine and the lever delivered only coins. These coins in turn operated the vending machine through its coin slot. Records F through L continue the twenty-second to the twenty-eighth session of the experiment when the schedule of reinforcement had been changed to multiple FR 5 blue, VI 30 red. There was no evidence that any differential performance emerged during the red and blue colors corresponding to the different schedules of reinforcement. However, the performance was sustained over the 60-minute experimental session with a steady emission of behavior, and no pauses longer than a minute or two occurred. Much of the pausing involved time spent eating the candy. Approximately 200 to 400 responses were emitted per session. Key presses were frequently followed by the ritualistic climbing behavior, as in the early parts of the record. By the end of this period, this subject ate the candy as he received it, without the previous smearing, licking, and other kinds of handling.

Transition to Fixed Ratio and Development of Stimulus Control by Time Out After Reinforcement.—

Subject 1: Fig. 4 describes the development of the fixed-ratio performance

on the thirty-eighth session after the previous reinforcement on this variable-interval schedule. The fixed-ratio reinforcement soon altered the performance, producing its characteristic pattern of responding: sustained responding at small fixed ratios; pausing, when it occurs, after reinforcement; and an abrupt shift from pausing to the high fixed-ratio rate. The ritualistic climbing which occurred on the variable-interval schedule disappeared almost immediately on the fixed-ratio schedule. This sudden loss of the climbing occurs because it no longer accidentally reinforces as in the variable-interval schedule, where the probability of reinforcement increases after time spent climbing. The order of the records in the figure is inverted for more compact presentation. The fixed-ratio schedule of reinforcement was in force beginning with the fifth reinforcement of Record A. Records A and B, the first two sessions under FR 9, showed a very rapid development of the fixed-ratio pattern. By Record B, most of the responding occurred in sustained bursts; and in frequent instances, responding began immediately after the delivery of a coin. Any pauses tended to occur just after reinforcement. Beginning with Record C, a 10-second time out (lights out, keys inoperative) occurred after each coin delivery. Any response occurring during the time out extended the time out its full duration to facilitate the development of the discrimination. The frequency of pressing the key when the light was out first increased as the new fixed-ratio program increased the over-all responding and then gradually declined (Fig. 5) as the light behind the key came to control the child's performance. The graphic recorder did not run during the time out, so that the nonreinforced responding is evident in the vertical segments of the records. The amount of nonreinforced responding reached a peak of approximately 1,800 responses. Five sessions later (Record F), no responses occurred during the 10-second time out following each reinforcement. In addition to the nearly perfect control by the stimulus behind the key, the child performed almost continuously during the 60-minute experimental session.

During the one hundred nineteenth session, an extinction curve after reinforcement on FR 15 was recorded, where the coin dispenser jammed so that no further coins were delivered but the solenoid continued to operate normally. This extinction curve, shown in Fig. 6, indicates another aspect of normal control by the fixed-ratio schedule of reinforcement. The pauses after reinforcement disappeared, representing the time that would ordinarily be spent in using the coins; and a high rate of responding was sustained for over 600 responses, followed by no further responding for the remaining 40 minutes of the experimental sessions.

Subject 2: This subject began using all of the devices in the room almost immediately, and quickly performed appropriately to the fixed-ratio schedule of reinforcement. Fig. 7 shows records of the first four sessions after continuous reinforcement. The over-all level of responding is high and sustained in the first session, but falls progressively thereafter. The pigeon could be operated directly by a key mounted on the pigeon box. The subject operated the pigeon apparatus once in Record B and 26 times in the session represented in Record D. The lower rate of responding is partly attributable to interference from activity around the trained pigeon. Only the eight-column vender was present at this time, and it

was almost immediately controlled by the coin lights associated with the eight coin slots. A 10-second time out occurred after each coin delivery. (The recorder did not run during the time out.) This subject showed no tendency to press the key during the 10-second time out after reinforcement.

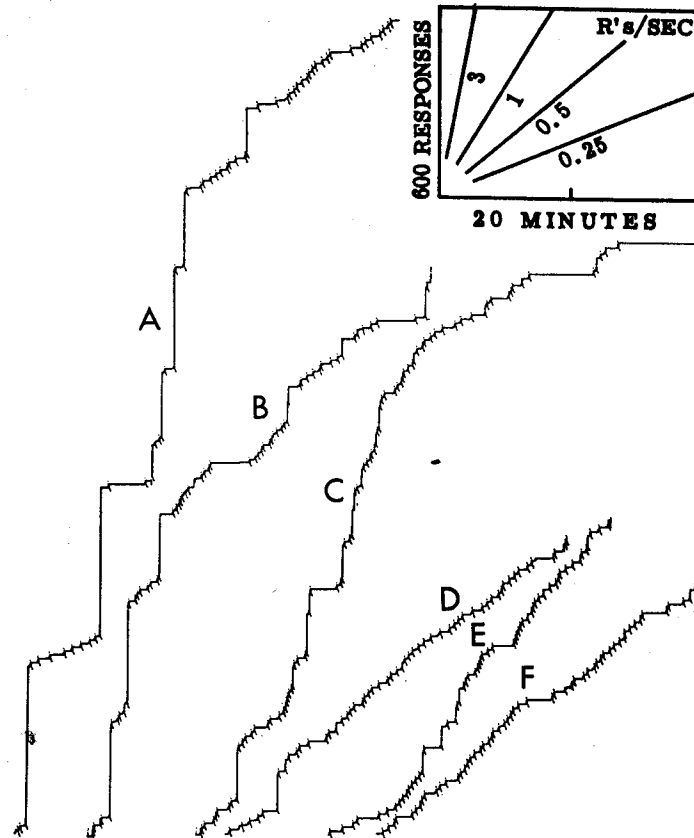


Fig. 5.—Subject 1. Decline in response during the time out after reinforcement.

Beginning with the sixth session, the coin-saving procedure was put into effect. Every second coin delivered lighted the coin-slot lights for 30 seconds. Coins deposited when the lights were out were wasted. The procedure is the same as the one used previously by Kelleher⁶ in the study of conditioned reinforcement in chimpanzees. Subject 2 soon stopped placing coins in the inoperative coin slots when the coin lights were off. During the eighth to the twelfth sessions, the numbers of coins deposited in inoperative coin slots of the vending machines were 2, 4, 2, 14, and 4, respectively.

Development of Stimulus Control by the Coin Light.—

Subject 1: In an attempt to bring the behavior of depositing coins in the coin slot under the control of the coin light, Subject 1 was given, variously, 200 to 250

free coins at the end of the regular experimental session beginning with Record D of Fig. 5, and for four sessions thereafter. In the presence of the coin light, appearing every 15 seconds (later 30, and then 60 seconds), a coin deposited in the slot produced candy. Coins deposited in the vending machine when the coin light was out postponed the inoperative interval, and did not produce candy. The subject continued to place coins in the inoperative slot, and there was no evidence of any control of behavior by the light. For the next eight sessions, the regular experimental procedure was discontinued. After seven sessions, a small degree of control by the coin light began to emerge. Of the 110 coins deposited in the various devices, 56 produced reinforcement, 54 were deposited while the light was out, 6 were used in the pigeon device, 15 were used in the phonograph, and the remainder went in the single-column candy-vending machine.

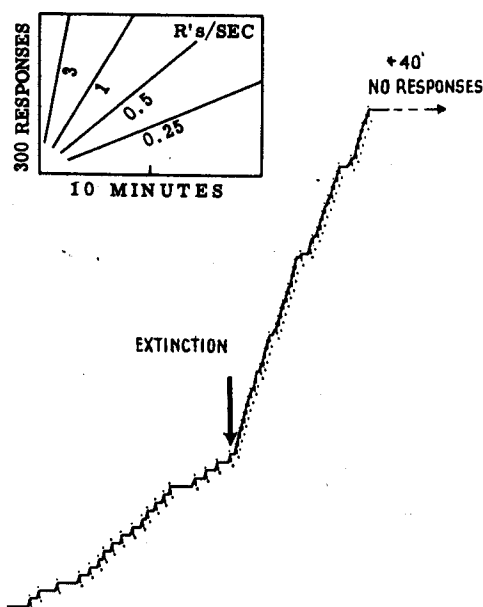


Fig. 6.—Subject 1. Extinction after reinforcement on FR 15. At the arrow, coins are no longer being delivered, although the coin dispenser makes its characteristic sounds.

The development of the control by the coin light was continued by reconnecting the key and arranging the coin-saving procedure described above for Subject 1. The coin-slot lights were made to appear for 15 seconds after every second coin that was delivered. The coin-saving procedure was continued for 14 sessions, during which the coin-slot lights were made to come on after 3, 4, and 5 coins, progressively. The successful development of this technique makes it possible to record the key pressing uncontaminated by the intervening behavior with the reinforcement (e.g., eating). Pauses are difficult to interpret because they may be caused by either a disinclination to respond or time spent consuming the reinforcement.

During the first eight sessions of the coin-saving procedure, the subject inserted coins in the coin slots as soon as they were received, whether or not the coin light was on. Thereafter, the coin-light control began to emerge in the 6 sessions represented in Fig. 8. The performance is sustained throughout the session and the child is performing continuously; either pressing the key and receiving coins, or using coins in the various devices. In Record A, the coin light appears after every second coin; 39 of the 77 coins received during the session

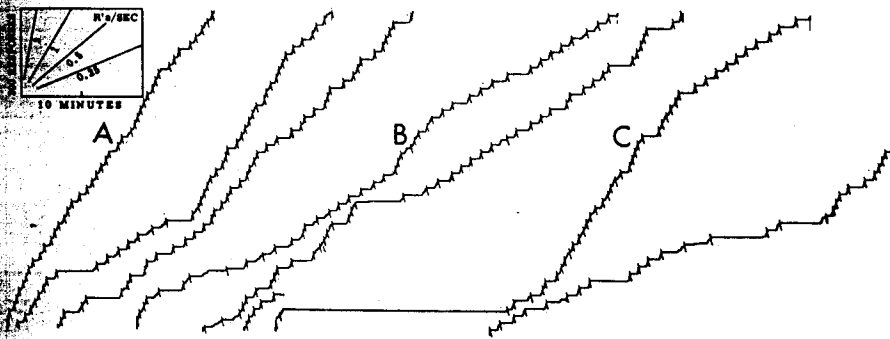


Fig. 7.—Subject 2. The first four sessions of the experiment. The schedule of reinforcement is FR 15.

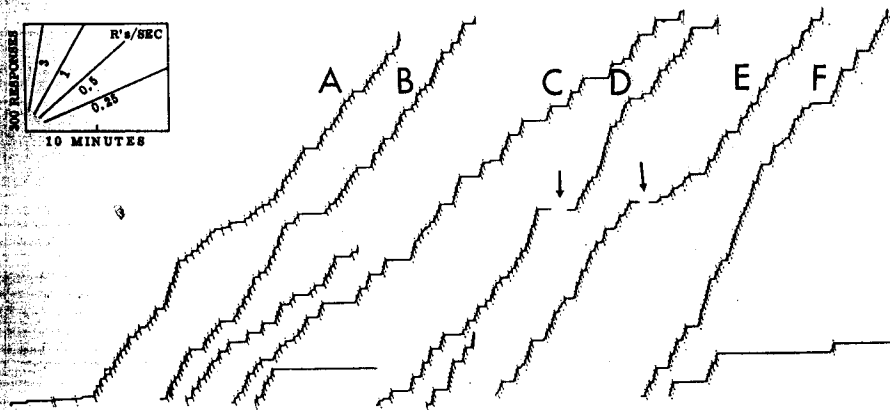


Fig. 8.—Subject 1. Performances recorded under FR 15 when the light above the coin slot began to control the subject's performances.

were deposited while the coin light was on and 38 when it was off. This performance is typical of the previous sessions on the same procedure. Beginning with Record B, however, the subject saved coins delivered when the coin light was off, and deposited them later when it came on again. Of the 113 coins received during this session, 34 were deposited with the coin light off. In Record C, every third coin produced the lighted coin slot for 45 seconds, and only 9 of 89 coins received were deposited when the coin slot was inoperative. In the following

session, in Record D, only 7 coins were wasted. A 23-minute pause occurred at the arrow. In Record E, all 84 coins received were deposited while the coin slot was operative. A 14-minute pause occurred at the arrow. In Record F, every fourth coin produced the coin light correlated with the operative coin slot, and eight coins were deposited in the inoperative coin slots.

The pinball machine was present for the first time and demonstrated to the subject in Record F, but it was not used. On the following session, however, with the pinball machine continuously operative, he played without interruption for 52 minutes.

In the following session, when the pinball machine could be operated only by a coin in the coin slot, 52 coins, of a total of 90, were deposited in the pinball machine. Much smiling and vocalizing of the form "Da-da-da," "Ba-ba-ba" occurred. The movement of the balls produced considerable excitement, and the subject frequently sat on the machine, following its action and the course of the balls. The detailed attention to the operation of the pinball machine disappeared progressively during the ensuing months.

Subject 2: The second subject's performance on the coin-saving procedure showed almost perfect control by the coin lights of the vending machine from the very start of the procedure.

Performance Under Multiple VI 60 Second FR 13 (Subject 1).—In his first exposure to the multiple schedule, the subject responded appropriately to the fixed ratio in the variable-interval color, and hence emitted many more responses for reinforcement than usual. The normal control by this schedule—fixed ratio performance in the one color and a variable-interval performance in the second color—never developed. Probably as a result of the decrease in the frequency of reinforcement, the over-all rate of responding fell, reaching the values seen in Fig. 9, containing the sixth to the ninth sessions on the multiple schedules. By the eighth and ninth sessions, Records E and F, the over-all performance levels were among the lowest recorded in the experiment. The fall in the level of responding was also caused by the introduction of the eight-column vendor. When the subject emptied a column of the vendor, he continued to deposit coins in the same column even though the coin light went out when the last compartment of the column was emptied. The previously developed control by the coin lights did not transfer to the eight lights and coin slots of the eight-column vendor.

Transition Between Fixed Ratio and Multiple Fixed Interval, Fixed Ratio.—The effect of the multiple schedule of reinforcement in weakening the subject's performance was explored briefly by alternating between blocks of the simple fixed-ratio schedule and the multiple schedule. In general, the subject's performance was well-sustained under the fixed-ratio schedule and weak under the multiple schedule. Record A of Fig. 10 begins with only the fixed-ratio schedule; at the arrow, the schedule was changed to the multiple schedule. A high rate of responding occurs under the fixed-ratio schedule, and carries over in the multiple schedule for approximately the next 10 minutes, after which it falls sharply to nearly zero by the middle of the session. In the next session, shown in Record B, responding is sustained, as typical with the start of a session; but when the schedule is switched to fixed ratio, the severe decline in rate that usually occurs toward

inoperative coin slots. The remaining sessions represent an attempt to strengthen the performances in the experimental room by providing optimal conditions of reinforcement.

The procedures used between Sessions 86 and 104 reflect the large number of coins wasted in inoperative (unlighted) coin slots. From the ninety-fourth through ninety-ninth sessions, 35 to 175 coins are wasted per session. The performance becomes weak between the ninety-ninth and one hundred fourth sessions, when the largest number of coins delivered was 30 (Session 101); and no coins were delivered during two sessions. Most of the coins in the non-food devices were used in the pinball machine. The non-food devices were, in general, not used.

The period of the experiment represented in Fig. 15 was characterized by atavistic behavior, tantrums, and frequent disruption of the performances normally generated by these experimental procedures. During Sessions 99 to 103, the subject used the sharp edge of the coin to scrape slivers from the Plexiglas surface of the pinball machine and spent whole sessions marring the surface of these two devices. The child stopped scraping the Plexiglas only when the edges of the coins were smoothed.

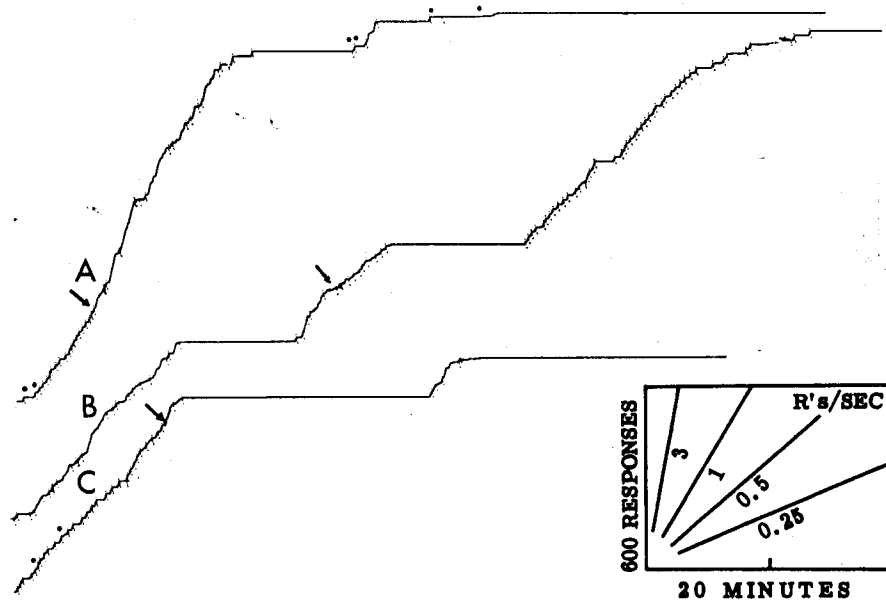


Fig. 10.—Subject 1. Transitions between the fixed-ratio and multiple schedules. The dots above the curves indicate when coins were used in the pinball machine.

When the performance deteriorated at about Session 100, keys were mounted on the face of each non-food device. A single press of the key operated the device. The single-column vendor (also operated by a key) was reintroduced, delivering trinkets, fruit juice, crackers, and toys. Under these more favorable reinforcement schedules, the number of coins increased to values comparable with those in the

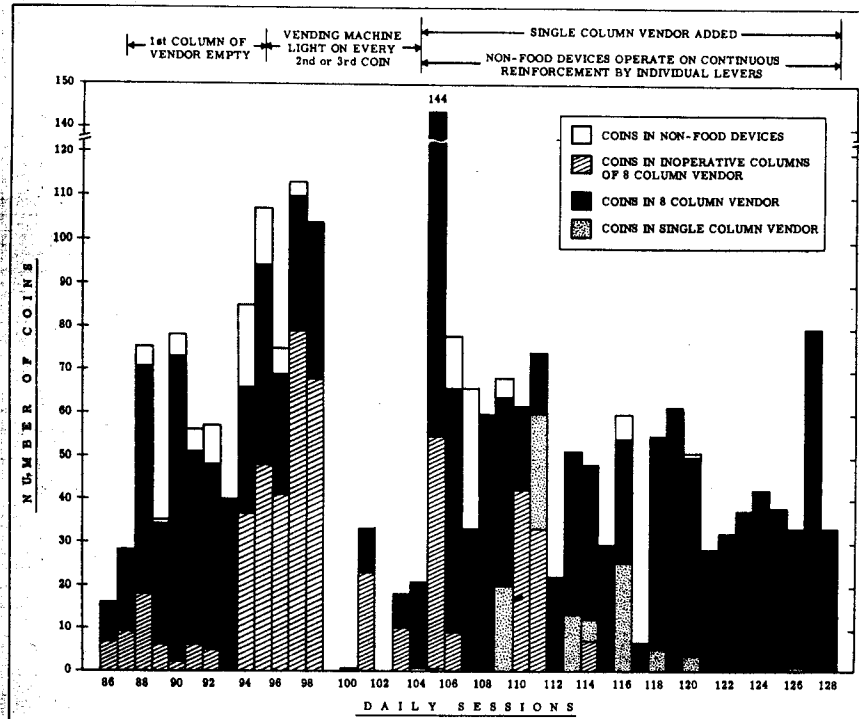


Fig. 11.—Subject 1. Summary of the performance during the period when it is weakened by large numbers of coins wasted in an inoperative coin slot.

eighty-sixth to ninety-ninth sessions; but large numbers of coins were still wasted when a column of the eight-column vendor became empty. Toward the end of the period shown in the figure, the subject began to vary the column in which he deposited coins. No columns were emptied; hence, very few coins were wasted. During this period, the non-food devices, including the single-column vendor, were hardly used, even though the subject had to press a key only once to operate any of them. After periodic previous demonstrations, the phonograph was demonstrated again during the one hundred twenty-sixth session, and the subject began pressing the key mounted on the phonograph device. At Session 129, the severe pinworm infection was discovered and treatment was begun. It is not known for how long the infection had been present, but the period is presumed to have been at least 2 to 3 weeks.

Fig. 12 gives details of the performances represented in Fig. 11, ranging from the well-sustained performance in the one hundred fifth session, where the subject is continuously performing during the entire session, to the one hundred seventeenth session, when only 7 coins were received. Toward the end of the one hundred fifth session, a column failed to deliver candy because of an equipment failure even though the coin light was on. After wasting many coins in the inoperative but lighted coin slot, the subject finally ceased responding and returned

to scratching the Plexiglas on the pinball machine. A severe tantrum occurred during the last part of the session (*a* to *b* on the record), even though the vending machine was operating at this time. The subject went through the normal performance in the midst of shouting, screaming, and head banging. The subject was in the midst of a severe tantrum when he was taken from the ward to the experimental room at the start of Session 117. During a pause in the tantrum, the subject noticed the experimenter and went along quietly to the experimental room. He spent most of the session lying on the floor and on top of the pinball machine. Except for the few coins received, there was little activity of any kind except a brief period, of about 15 minutes, of looking at the pigeon, smiling and saying "A-a-a-a" in drawn-out syllables.

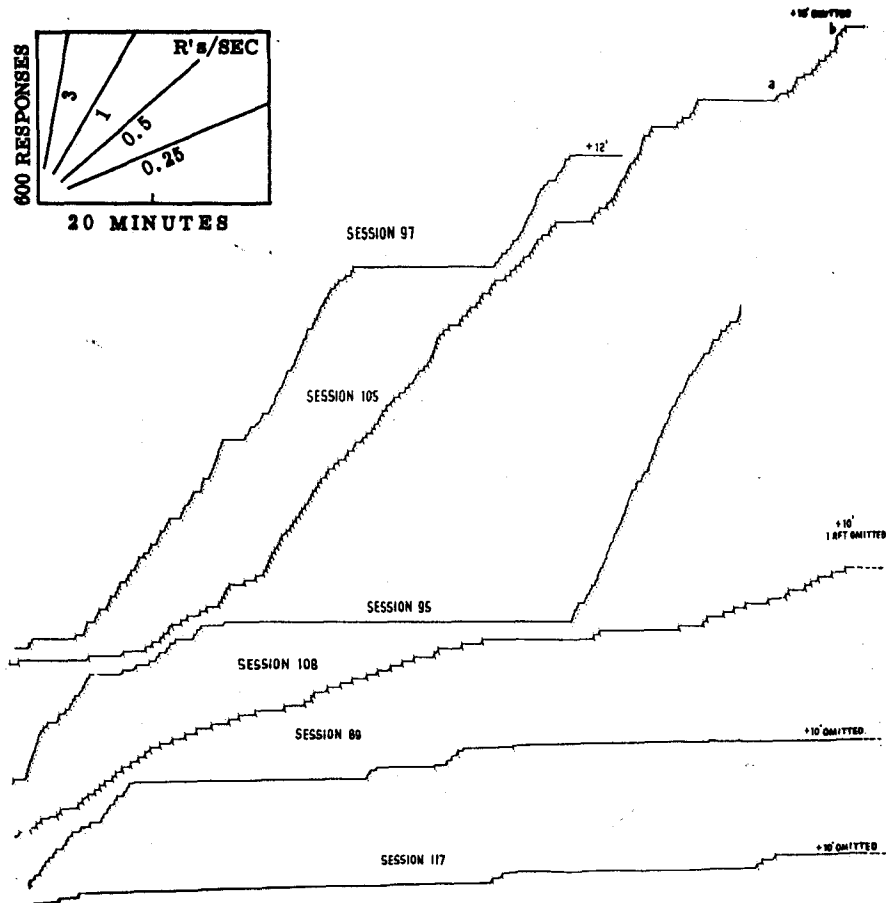


Fig. 12.—Subject 1. Cumulative curves of representative daily experimental sessions taken from the period of the experiment shown in Fig. 11

During the third session, the subject began putting coins in a slit in one wall of the experimental room during a tantrum that increased in intensity with each of the 10 or 12 coins that were deposited. He then hammered on the door with increasing intensity during the 20-minute pause in the middle of the session. After a short period of quietly sitting on the floor by the door, he resumed the sustained activity recorded at the end of the session.

Fig. 13 summarizes the main facts of the experiment from Sessions 129 to 166. These performances show the effects of the electric shock, the recovery from the pinworm infection, and the continued lack of development of the stimulus control by the coin-slot lights. The over-all performance varies markedly from day to day, but is, in general, sustained. Responding occurs about equally among the eight-column vendor, the non-food devices, and the single-column vendor.

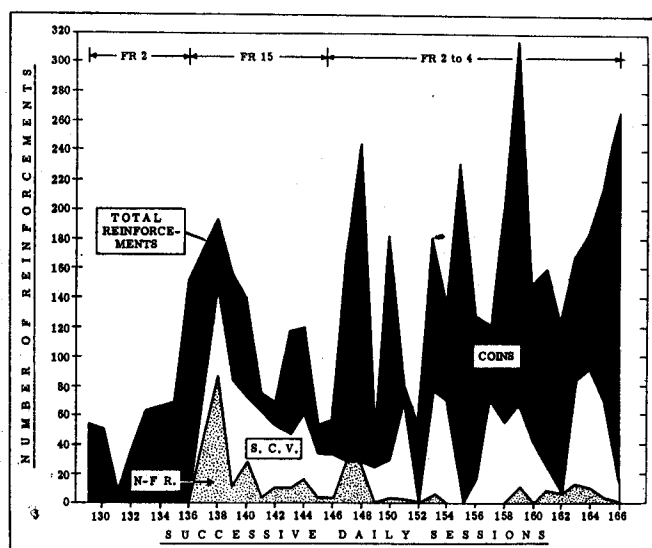


Fig. 13.—Subject 1. Summary of performances from the period when they are being affected by electric shock, pinworm infection, and continued lack of development of control by the coin-slot lights. S. C. V., Single-column vendor; N-F R., Non-food reinforcements.

The pinworm infection discovered on the one hundred twenty-eighth session was treated, and was probably gone by the one hundred thirty-eighth session. The exposed voltages were discovered on the one hundred forty-fifth session and were removed, and the effects of the shock were probably gone by the one hundred sixtieth session. Except for the one hundred thirty-eighth to one hundred forty-sixth sessions, the schedule of coin reinforcement was kept very optimal in order to sustain the subject's performance. All of the non-food reinforcing devices, as well as the single-column vendor, continued to be operated by keys mounted directly on them. Fig. 17 records the total number of reinforcements received other than responses or coins. In general, the non-food reinforcing devices are scarcely used; and most of the activity produces candy from the eight-column vendor by coins, or trinkets and candy from the single-column vendor through

the key mounted on the face of the unit. On the one hundred forty-fourth session, the subject withdrew his hand from the trough of the coin dispenser as if he were getting a shock, and then began using his shirt tail to take the coins from the trough. He also began to deposit coins in the green vendor by holding them in his shirt tail to insulate himself from the eight-column vending machine. During this period, this child responded in bursts, so that coins accumulated in the coin trough, occasionally falling to the floor. Many of the coins delivered during this period were not used. Even though the electric shock had been eliminated by the one hundred forty-sixth session, the subject continued to accumulate coins rapidly until the one hundred sixtieth session, taking only those falling on the floor and using his shirt tail to deposit them in the eight-column vendor. The apparatus was probably delivering shocks between the one hundred thirty-fifth and one hundred forty-sixth sessions.

Frequent tantrums and generally large amounts of atavistic performances occurred: for example, urinating over the various devices; head banging; screaming; smearing candy into the various orifices of the room; and reversion to the older pattern of eating candy by rolling it into a ball and licking it from the hands, floor, etc., rather than placing discrete pieces in the mouth and chewing them. Most of the non-food reinforcements occurred about equally among the pigeon, color wheel, pinball machine, and phonograph. The subject used a variety of compartments from the eight-column vendor; but during those sessions when the larger number of coins was deposited, he wasted many coins in empty columns. Numbers of coins wasted in various sessions occurred as follows: Session 159, 45 coins; Session 161, 24; Session 162, 36; Session 163, 16; Session 164, 23; Session 165, 55; and Session 166, 144.

Subject 2: Fig. 14 contains an over-all summary of Subject 2's performance from the sixty-fourth to ninety-eighth sessions. The graph gives the number of reinforcements occurring among the various devices. These performances occurred when all of the reinforcing devices were present and were operated via direct keys, and after the pinworm infection and the effects of the electric shock had been eliminated.

Subject 2's behavior, controlled more by the non-food devices than that of Subject 1, was distributed about equally among the phonograph, color wheel, and pigeon. The pinball machine was not used. Consistent with the higher level of the non-food devices, this subject used the single-column vendor (delivering trinkets) more than the first subject. The large number of reinforcements in Sessions 96 to 98 occurred largely on direct keys on the color wheel and phonograph.

Final Development of a Performance.—

Subject 1: Fig. 15 summarizes redevelopment of control by the lights above the coin switches and the final development of a performance for the remaining 85 sessions of the experiment. The curve at the top of the black area gives the number of coins wasted in empty columns (C. E. C.) or when the vendor is off (V. O.). The curve over the stippled area gives the number of coins wasted when the whole vending machine is off. The number of coins deposited in inoperative slots falls slowly, reaching near zero around the two hundred fiftieth session. Control by the coin lights when the whole vendor is off develops before the

stimulus control by a single empty column. Before the end of the period, all of the devices operate by coins rather than by direct keys (Session 236); and the performance in the experimental room continues to be maintained under the conditions of a generalized reinforcer, although the over-all level of activity is lower. The procedures by which Subject 1 learned to deposit coins only when the lights were on were as follows:

1. Sessions 188 to 197: The coin light came on for 30 seconds at every second, then at every third coin that was delivered. Coins deposited when the lights were off were wasted. The subject continued to deposit coins when all of the vending lights were on. The coin lights flashed on and off at 1 cycle per second.

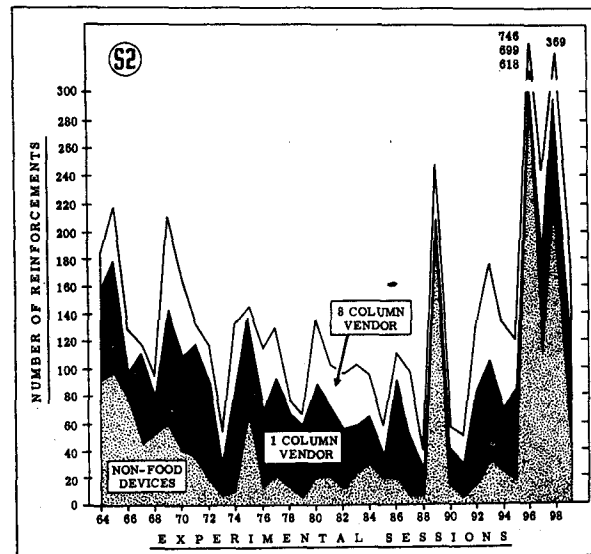


Fig. 14.—Subject 2. Summary of performances during a period when all of the reinforcing devices were operated by direct keys.

2. Session 198: The coin lights were lighted on a time basis rather than after a fixed number of coins as before. Coins deposited when the coin light was out delayed their coming on again. This procedure immediately reduced the number of coins deposited when the whole vendor was off, but did not change the number of coins deposited in empty columns.

3. Session 214: Coins deposited in empty columns shut off the whole vendor for 40 seconds, a mild punishment. Further coins deposited when the vendor was off extended the inoperative period its full duration as before. The number of coins deposited in the inoperative coin slots then began to fall, reaching zero by the two hundred fifty-fourth session. The number of coins wasted is roughly proportional to the total number of coins being deposited.

The schedule of reinforcement and the manner in which the coins were received varied from time to time during this period of this figure. Until the two hundred twenty-ninth session, all of the reinforcing devices (except the

eight-column vendor) operated by direct keys rather than coins. Beginning with Session 229, all of the keys were made inoperative and the reinforcing devices operated only by depositing coins. The schedule of reinforcement was reduced to FR 5 at the same time, in order to ease the transition to the generalized reinforcer; but it was increased to 15 with Session 240, when it was apparent that the performance could be sustained with the generalized (conditioned) reinforcer. From the two hundred forty-fifth to the two hundred fifty-first sessions, coins were delivered by new keys designed to explore the child's perceptual repertoire. These data are presented here only in respect to the continued development of the stimulus control on the vending machine. From the two hundred fifty-second to two hundred fifty-sixth sessions, the schedule of reinforcement was increased progressively to 15, the original key was restored, and the performance was examined under the slightly larger ratios.

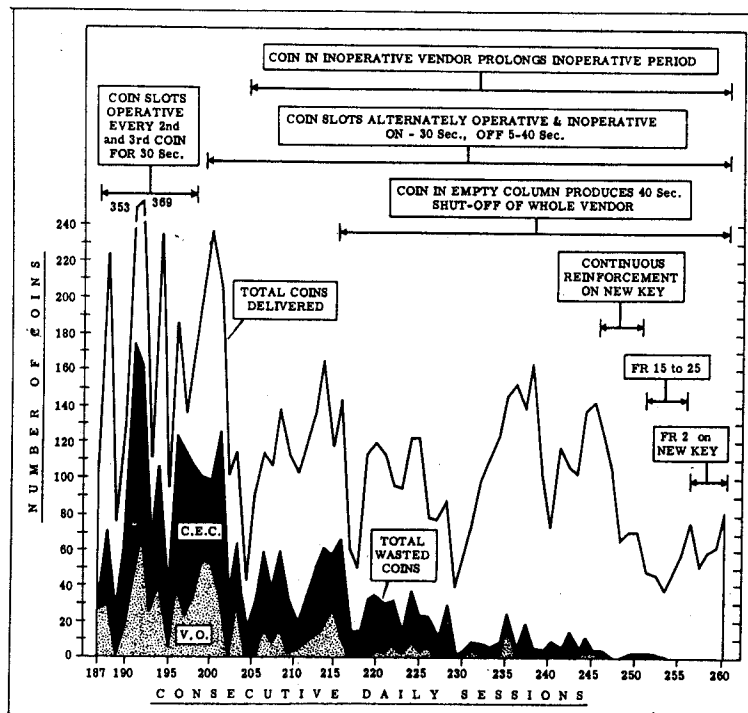


Fig. 15.—Subject 1. An over-all summary of the use of coins showing the development of stimulus control by the coin-slot lights.

The new key and the shift to the coin as a generalized reinforcer have produced a general decline in the total number of coins received. During the last 10 sessions reported in the figure, for example, the over-all level of activity is considerably lower than it was previously, especially when we consider that earlier parts of the graph do not show performances on the devices operated directly through levers.

Subject 2.—Fig. 16 contains the comparable performance for Subject 2 from Sessions 100 to 162. The number of coins received and their distribution in the various reinforcing devices is recorded. All of the devices operated through coins instead of by direct key as with the first subject. For the first part of this period, most of the coins were used in the non-food devices: the pigeon, phonograph, and color wheel. Table III gives the median and interquartile range for these devices. Approximately $\frac{1}{3}$ of the coins were used for candy from the eight-column vendor, and only a small number in the single-column vendor. During the end of the period from the one hundred fifty-sixth to one hundred sixty-second sessions, the performance shifted more heavily in the direction of the single-column vendor, with a corresponding reduction in the number of coins in the eight-column vendor. The break in the curve after Session 143 indicates a period when a new key, not relevant to the material of this report, was used. In general, the performance is sustained at the small as well as at the large fixed ratios, although the rate of responding is slightly lower on the latter ratios. This subject's performance was controlled almost perfectly by the coin lights. Fig. 17 contains four consecutive performances at the end of this period (Sessions 143 through 160), showing in more detail the continuous manner in which the performance is sustained in this subject. The performance is fairly continuous during the 20-minute session, except for occasional long pauses, as, for example, at the end of the second and fourth sessions shown on the figure.

TABLE III. DISTRIBUTION OF PERFORMANCES ON THE NON-FOOD DEVICES DURING SESSIONS 100-162 (SUBJECT 2)

	PHONOGRAPH	PIGEON	COLOR WHEEL
Q_1	36	1	1
<i>Median</i>	51	2	3
Q_3	75	9	12

This subject sustained even the higher fixed ratios in a similar manner. Fig. 18 shows the three consecutive sessions (158 through 160) when the fixed ratio was 25, and the performance remains characteristic of the ratio schedule.

Control Subjects.—Each of three control subjects received a 5-minute explanation of the manner of operation of all of the devices. The door was then closed, and the session continued as with Subjects 1 and 2. All of the devices were operated by coins. Records A and B of Fig. 19 contain performances on FR 30 for two of the subjects, a girl and boy, approximately the same ages as Subjects 1 and 2. The performance conforms to the typical fixed-ratio pattern, with pauses after some reinforcements and an abrupt shift to the prevailing rate. Responding continues throughout the session, and the performance is sustained better than the best record of the experimental subjects. The coins received were used in all of the vending devices. At this time, the devices present were as follows: phonograph, single-column vendor, pigeon, pinball machine, color wheel, electric organ, television set, train, and eight-column vendor.

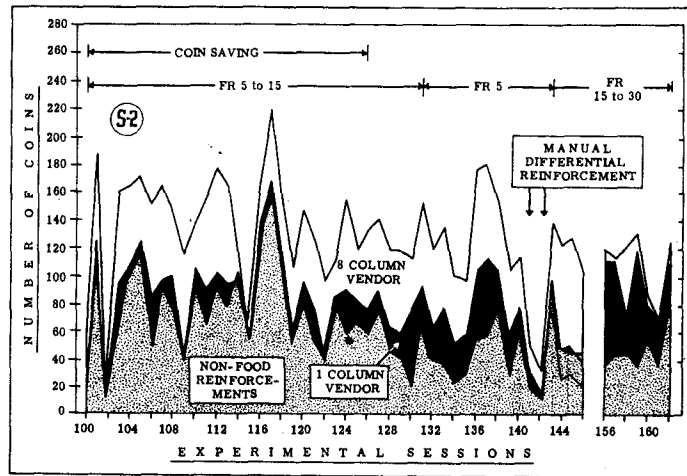


Fig. 16.—Subject 2. Summary of the use of coins and over-all level of performance during the final phase of the experiment.

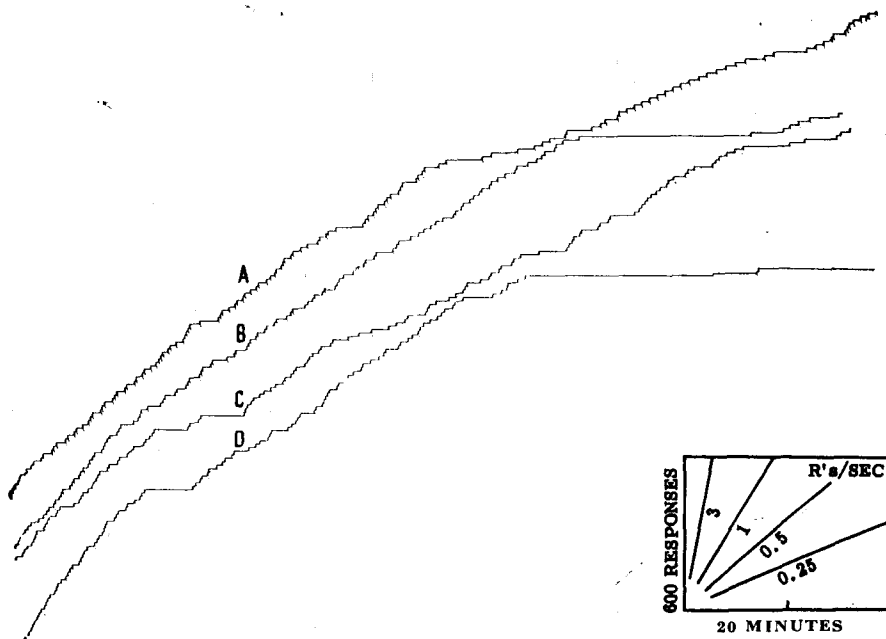


Fig. 17.—Cumulative-response curves showing four consecutive daily sessions on FR 25 toward the end of the period represented in Fig. 16.

Table IV shows the distribution of the total number of coins used by each of the three subjects among the various devices during the entire session. The records in Fig. 19 show only the first 45 minutes of each experimental session. For the remaining 45 minutes, the subjects operated another type of key relevant to an experiment to be reported elsewhere.

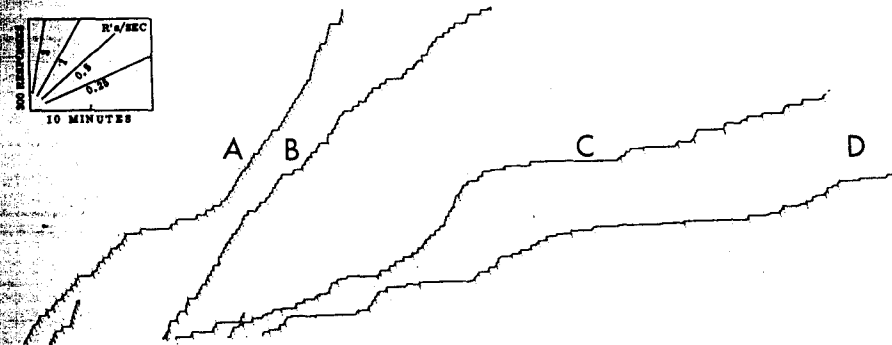


Fig. 18.—Subject 2. Final performance on FR 30.

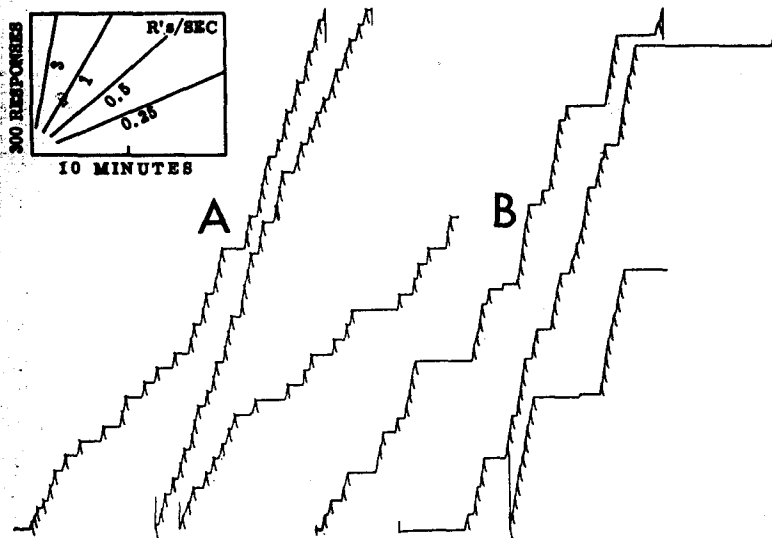


Fig. 19.—Control subjects. Cumulative curves for three subjects showing the first performances in the experimental room with all of the reinforcing devices operated by coins (FR 30)

TABLE IV. NUMBER OF REINFORCEMENTS DELIVERED AND THEIR DISTRIBUTION AMONG THE VARIOUS DEVICES (CONTROL SUBJECTS)

SUBJECT	1	2	3
Single-column vendor	77	42	82
Eight-column vendor	47	28	10
Pigeon	5	11	8
Pinball	18	50	35
Color Wheel	3	3	3
Organ	5	2	2
Television	5	32	5
Train	17	5	13
TOTAL	177	173	158

DISCUSSION

The major result of the experiment is a technique for sustaining and objectively recording performances of autistic children. During many phases of the experiment, performances were sustained continuously up to 90 minutes, with no indication that this was a limit. These performances were under the control of reinforcers and other stimuli programed by the various devices in the experimental room. Altering the reinforcement program produced corresponding changes in the children's performance, similar to the efforts of those procedures in animals and normal subjects.^{2,7}

The results of these experiments confirm the observations that these children have small and narrow behavioral repertoires. The performance in the experimental room developed slowly during the experiment and in contrast to that of control subjects, who responded quickly and appropriately to all the devices in the experimental room.

Both autistic children's performances showed that their behavior could be brought under control of stimuli by the following basic processes:

1. Reinforcement: The frequency with which the subjects responded was increased by using reinforcers such as food, music, candy, etc.

2. Schedule of reinforcement: Both the fixed-ratio and variable-interval schedules of reinforcement produced their normal and characteristic effects on the child's performance. The accidental reinforcement of responses during the periods of interval reinforcement and the loss of this "superstitious behavior" under fixed-ratio reinforcement demonstrated another aspect of normal control.⁸

3. Stimulus control: New stimuli, if present when a response would produce reinforcement and absent when it went unreinforced, came to control whether or not the child performed. Subject 2 came under the control of the relevant stimuli very rapidly. Subject 1 showed a slow development of stimulus control comparable, at least in form, with performances recorded with animals.

4. Conditioned and generalized reinforcer: The delivery of a coin was a conditioned reinforcer in maintaining the performances recorded, and the coin was also used to actuate a wide variety of reinforcers in the manner of a generalized reinforcer.

The control of the subject's performance by the coin-switch light and the light behind the key is of technical importance. For example, the reinforcing value of the coin could be manipulated by turning out the relevant lights, thus restricting the use of various reinforcing devices. Also, the child's performance could be conveniently interrupted by turning off the lights behind the key. When reinforcing devices with limited capacity became empty, the particular device could be discontinued simply by turning off the coin light while letting the rest of the experiment continue. Furthermore, some performances could be punished by the turning out of the key light.

Both subjects emitted more of the experimentally developed behavior with continual exposure to the automatic environment. Conversely, they spent less time in tantrums of inactivity while in the experimental room. The final level of performances on the non-food devices may not have been possible without the gradual accumulation of experience in the experimental room.

The use of the coin as a generalized reinforcer was a second major technique developed here. By the end of the experiment, the experimental performances could be sustained in both subjects by the delivery of coins.

The 2 autistic subjects showed large differences in their experimental performances. Subject 2, who has more speech and a wider behavioral repertoire than Subject 1, quickly came under control of nearly all of the experimental procedures. The fixed-ratio schedule of reinforcement generated the typical fixed-ratio performance rapidly. This subject very quickly came to respond appropriately to the lights which signaled changes in procedure, as, for example, the lights above the coin slots and the lights behind the key. In contrast, Subject 1 came under the control of the coin lights only after one hundred or more experimental sessions. The 2 subjects differed also in the extent to which they used non-food devices in the room. The performance of Subject 1 was largely maintained by the delivery of food and candy, while that of Subject 2 was maintained by the non-food reinforcers, particularly the phonograph. The differences between the 2 children are closely related to the amount of speech present, probably because the verbal repertoire, by itself, represents a large potential of control by the environment.

Subject 1's slow development of stimulus control suggests that his perceptual repertoire is minimal. Both the time out after reinforcement and the coin lights came to control the subject's performance slowly, as compared with a normal subject, or even an animal. Even after the coin lights controlled the subject's behavior during the first part of the experiment, the repertoire was so minimal that similar lights on the eight-column vendor had no effect until after one hundred or more hours of training. The differences between the two machines were sufficient to completely break down stimulus control which had developed with the single-column vendor. The general complexity of the eight-column vendor was probably responsible for the large amount of training required to develop the stimulus control, compared with the relative ease with which the same type of control had developed earlier with the single-column vendor. A more appropriate procedure with such a debilitated subject would have been to introduce gradually small differences in the size, shape, color, and location of the coin light

and coin slot while keeping the general function and pattern constant. Such a procedure would abstract the common features of coin slots and coin lights and make it possible for the child to respond appropriately to similar devices. The failure of the multiple fixed-ratio, variable-interval schedule to develop the normal performances characteristic of these schedules in the two stimuli also illustrates the child's minimal perceptual repertoire. Such failures of stimulus control are sometimes encountered in animals,⁵ and may be corrected by special procedures such as reinforcement on the separate components of the schedule. No such corrective procedure was carried out. Furthermore, we do not know whether it would have been possible to develop the control by such corrective procedures or by trying again later in the experiment, after the subject had acquired other discriminative repertoires.

It cannot be assumed that performances developed in the experimental room will have general effects elsewhere. The performances of these children, as with most organisms, come under the control of the particular situations in which they are reinforced. The performances in the experimental room probably are under very close control of the room itself and are unavailable to the child elsewhere. Even if the behavioral repertoire developed in the experiment had general effects on the child elsewhere, we could not expect the development of normal social behavior unless some kind of social repertoire which could be strengthened were already present. If such social behavior is altogether lacking, there is no chance for any inductive strengthening of it. It still may be possible, however, to develop social behavior outside of the experimental room. Social reinforcers would be used instead of candy, and social responses reinforced instead of key presses. The general plan in developing social behavior would be to manipulate social reinforcers (consequences of the child's performances supplied by other individuals), with the use of the same general principles applied in the artificial environment.

In general, tantrums and atavistic responses appeared less frequently during the latter parts of the experiment, suggesting that these tantrums, at least in part, are socially maintained. Programs of reinforcements were not changed too swiftly because of the possibility of anxiety attacks, temper tantrums, or breakdown of newly formed patterns of behavior following too abrupt procedural changes. The procedure of keeping social influences out of the experimental room may have weakened the tantrums by nonreinforcement. The development of a strong repertoire in the experimental room may have been another possible factor in the reduction in atavistic behavior. The large disposition to operate the devices in the experimental room may have simply displaced the tantrums by prepotency, as with Lindsley's psychotic adults who showed no psychotic performances while under the control of the fixed-ratio schedule of reinforcement.

Much of the schizophrenic's behavior exemplifies very weak performances which appear strong simply because most of the normally maintained behavior is weak. Lindsley⁷ showed that during fixed-ratio reinforcement, the bizarre behavior of chronic schizophrenic adults appeared only during the pauses after reinforcement. Once the patient began responding appropriately to the schedule of reinforcement, the relatively strong behavior maintained by the candy and

igarette reinforcements was prepotent over bizarre performances and other psychosis-like behavior. An example in the present experiment is Subject 1's scraping of the Plexiglas. This possibly occurred after he had deposited most of the coins in inoperative coin slots because his experimental performance became weak after the frequency of reinforcement became very low. If this analysis is correct, then the actual form of the behavior observed in psychotic patients is much less important than the absolute amount of behavior and, particularly, the levels of activity controlled by an effect on a social or socially derived environment. An analogous situation occurs frequently in normal individuals when they are placed in situations in which few of their currently available performances are relevant. Some examples are: experiments on sensory deprivation; waiting for someone to keep an appointment in a relatively isolated place; attending a formal meeting where the speaker's activity is not sufficiently important to the listener, but where at the same time, no behavior other than listening is appropriate. Under these circumstances, many individuals emit performances that are very similar to those of psychotic persons, such as rubbing the table constantly, scratching a particular part of the body, doodling, or some kind of oral activity. All of these activities have the common feature of not being supported by the external environment, particularly the social environment.

This experimental program is not viewed as an attempt at carrying out psychotherapy, but rather as an attempt to demonstrate what kinds of performances could be brought under the control of a specifiable environment with known behavioral processes. To the extent that variables manipulated in the experiment control the child's performances through normal behavioral processes, the child has advanced somewhat toward rehabilitation. Actual rehabilitation, however, would have to be carried out through the manipulation of social contingencies and the development of performances with which the child would interact with other individuals.

The results of these experiments show that the behavioral processes which have been studied are intact in both children, except for the multiple-schedule performance, which did not develop. This low over-all level of the performance, compared with the normal, is reminiscent of some kinds of brain damage which do not affect a performance except in its frequency of occurrence. The behavioral and physiologic histories are confounded in the present experiment, however. The facts are consistent with the hypothesis that these children underwent experiences that produced a very large deficit in behavior. Their repertoires actually may be inadequate because of deficits in performance rather than temporary suppressions by some debilitating mechanism, either physiologic or functional. These children may represent individuals in whom normal performances have never developed because the normal development of their repertoires was temporarily arrested at some time. Such a deficit might occur because the repertoire of the child is weakened through the normal behavioral processes by which behavior can be suppressed or eliminated. All of the basic processes by which new performances are generated, strengthened, maintained, eliminated, punished, suppressed, or controlled by special aspects of the environment are relevant to an analysis of how a particular history could produce a weak,

positively maintained repertoire. Some of these conditions have been tentatively outlined.^{4,9} When conditions exist that severely weaken the existing repertoire of a child for any period of time, the performance becomes progressively more difficult to reinstate. The reason for this is that the environment of the now older child will not support the level of behavior of which he is capable, although this environment would support his level if the child were younger.

SUMMARY

Performances of two autistic children were recorded in an experimental environment consisting of vending machines delivering food and candy, a trained pigeon, a phonograph, a color kaleidoscope, and a pinball machine. These devices were operated either by keys mounted on them or by coins. Coins were delivered on various schedules when the children operated another key. Performances could be sustained on the coin key for 90-minute experimental sessions to demonstrate the normal effect of two schedules of reinforcement, to develop the coin as a generalized reinforcer, and to control the children's performances by the presence or absence of stimuli correlated with reinforcement or nonreinforcement.

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