The Repeated Acquisition Procedure as a Means of Analyzing Instructional Stimulus Control and Rule-Directed Behavior

Danforth

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THE REPEATED ACQUISITION PROCEDURE AS A MEANS OF ANALYZING INSTRUCTIONAL STIMULUS CONTROL AND RULE-DIRECTED BEHAVIOR

Jeffrey S. Danforth, M.A.
Western Michigan University, 1983

Pre-school children were taught to emit four-response chains using the repeated acquisition design. Experiment 1 examined the effect of instructional stimuli. Many errors were made in Control Learning, followed by few errors in Control Relearning. Instructional cues resulted in few errors in the morning learning session, but many relearning errors were made. Experiment 2A determined if two-trial cuing with instructional stimuli would improve relearning performance. The result was fewer relearning errors, but the criterion required more learning trials. In Experiment 2B a rule was taught relevant to two-trial cuing. In Experiment 3 a child was told that the morning and afternoon chains were identical. These rules had an inconsistent effect. In Experiment 4 the criterion to end the session was doubled. This decreased errors in Control Relearning, but not Instructional Relearning. The results show a failure to transfer stimulus control from instructional stimuli to the response sequence.
ACKNOWLEDGEMENTS

To Julie Danforth and Jack Michael.

Jeffrey S. Danforth
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CHAPTER I

INTRODUCTION

The repeated acquisition design can be used to study the effects of numerous variables on the acquisition of chains of behavior. This single subject design emanated from the learning set studies done by Harlow (1949). Repeated acquisition was first described by Boren (1963), and the procedure for this research was similar to Boren's initial study of learned chains, which worked as follows: Each subject (three rhesus monkeys) was reinforced for lever pressing in an experimental chamber. The chamber had twelve levers in four groups of three mounted on the wall in a single line. During each session a subject's task was to learn a new four-response chain which included one correct lever press in each group of three. As the sessions progressed a stable pattern of learning resulted, and the number of errors in acquisition reached a steady state from session to session (Boren & Devine, 1968).

In this experiment poker chips were laid out on a board in four groups of three. The correct response consisted of sequentially turning over one specific chip in each component of the chain. A "Control" sequence is one in which reinforcement is contingent upon the completion of the chain, with a general discriminative stimulus paired with the link of the chain that the subject should be attending to. Letter "E" in Figure 1 shows the general $S^D$ bar. In this example the subject would have already turned over the correct chip...
FIGURE 1

Stimulus Array
in each of the first three links, and would be working on the fourth and final component. The correct chip is always one of the three under this bar. Learning sessions were run in the morning and relearning sessions, requiring the same correct responses, were run in the afternoon. Afternoon Control Relearning sessions were identical to the morning Control Learning sessions.

In many repeated acquisition studies the focus of research included the effect of a specific discriminative stimulus on learning a response chain (Boren & Devine; Hursh, 1977; Moershchbaecher, Boren, & Schrat, 1978; Thompson, 1975). An "Instructional" sequence is one in which a specific discriminative stimulus is paired with the correct response in each component link. Letter "F" in Figure 1 represents a red chip. In morning Instructional Learning this chip was used for a specific $S^D$ and was placed above the correct chip in each component of the four-link response chain. Afternoon Instructional Relearning sessions actually had no specific instructional $S^D$'s, but instead used the general $S^D$ bar like the control sessions.

In the present study Experiment 1 examined the effect of an instructional stimulus. During the control feature of this experiment the general $S^D$ bar was always paired with the link the child was working on. When the child turned over the correct chip the bar was moved to a position directly above the next link. Children learned a new chain each morning and performed the same response chain that afternoon. During the morning Control Learning subjects tend to make a high number of errors, followed by very few errors in the Control Relearning sessions with the same response sequence that afternoon.
Each day the correct responses in the chain were changed and control session days alternated with instructional days. In the morning on instructional days the children interacted with a new chain with the aid of specific discriminative stimuli for each correct response, followed by a session that afternoon where the subject performed the same response chain without the aid of specific discriminative stimuli.

In previous studies the specific \( S^D \) improved performance (as shown by a lower error rate) during the morning instructional phase, but resulted in a poor demonstration of acquisition in the later relearning sessions using the same response sequence (Hursh, 1977; Ozuzu, 1982; Peterson, 1980; Thompson, 1970). It appears that the subjects are controlled by the \( S^D \) that is paired with the correct response without coming under control of the response sequence itself. Stimulus control was not transferred from the instructional stimulus to the correct response sequence. In addition to serving as baseline for the following studies, the question to be answered in Experiment 1 was whether the children would learn to accurately emit the response chain in the afternoon as a result of morning learning trials with this stimulus control procedure, or whether the children would simply pick up the chip paired with the \( S^D \) without coming under control of the response sequence that morning.

Experiment 2 was an attempt to decrease the high number of afternoon instructional errors to the moderate level usually seen in the afternoon Control Relearning, while at the same time teaching a response sequence in just a few trials as might be permitted with
instructional stimuli in the morning. Ozuzu learned that gradually fading the $s^D$ during the instructional phase led to "no consistent improvement" in the error rate of that afternoon's session. The experimental question in study 2A was: would "two-trial cuing" during the morning Instructional Learning phase improve the maintenance of the response chain in later control conditions? "Two-trial cuing" consisted of two morning Instructional Learning trials with a specific instructional $s^D$ for each component of the chain. Then the cues were replaced by the general $s^D$ bar until criterion was reached and the response chain was being emitted correctly.

Numerous recent articles have studied the apparent human/infrahuman differences in the operant laboratory, and many researchers have suggested that verbal behavior controlling nonverbal behavior plays a major role in this dichotomy. Lowe, Beasty, & Bentall (1983) working with FI schedules conclude that their research with children, "suggests that verbal behavior can, and does, serve a discriminative function that alters the effects of other variables" (p. 162). Catania, Matthews, & Shimoff (1982) go one step further. In a study with college students they conclude that shaped verbal behavior, "controls nonverbal behavior more reliably" (p. 246) than does instructed verbal behavior. Experiment 2B attempted to determine whether specific vocal directions relevant to the two-trial cuing during the morning instructional phase would facilitate learning the response chains. Specifically, the children were told that the correct responses would remain as such after the specific instructional stimuli were replaced by the general $s^D$ bar.
Peterson's results showed that adults benefitted from instructional stimuli whereas children did not. She speculated that adults had abstracted rules, based on their history, with respect to the paired sequences of chains. In Experiment 3 the question is: if we tell children that the morning and afternoon sequences are identical will they benefit from the instructional stimuli, as the adults did in Peterson's study, by making fewer afternoon relearning errors?

In many previous studies (Boren & Devine; Peterson) a fixed number of trials, regardless of error performance, served as the criterion to end each session. In keeping with this study's goal to teach response sequences in as few learning trials as possible, five consecutive correctly emitted response chains served as the criterion which ended each session. Yet results from two subjects often showed more errors in afternoon Control Relearning sessions than in the initial morning learning sessions using the same correct response sequences. These results were inconsistent with data from any previously mentioned study. Since the criterion of five consecutive errorless trials was arbitrary, the experimental question in study 4 was simply to determine if raising the criterion to ten consecutive errorless trials would result in improved relearning performance.
CHAPTER II

METHOD

Subjects

Seven children, four males and three females, served as subjects. They were chosen from students at the Child Development Center, a preschool in Kalamazoo, Michigan. Six of the children were age four and one was age five. All subjects showed normal academic, social, and physical development. The study was approved by the director of the Child Development Center and the Western Michigan University Human Subjects Review Board.

Apparatus

A white piece of foam board measuring 81 cm by 12 cm was used for the stimulus array. Twelve self-adhesive blue labels, 1.2 cm in diameter, were used as position markers on the board. They were placed the length of the board in four sets of three (Fig. 1). 3.7 cm separated markers within each set, and 8.7 cm separated one set from another. Twelve blue Hoyle plastic poker chips, measuring 3.8 cm in diameter, were dispersed on the array according to the position markers. Chips designated as "correct" in each set of three had a 1.5 cm self-adhesive star on the underside. A bright red chip, identical in size to the poker chips, was used for the specific discriminative stimulus. A piece of wood measuring 13.5 cm by 1.8 cm
was used for the discriminative stimulus bar. Three bright red chips, separated the same distance as a set of chips on the stimulus board, were affixed to the top of this bar. A black piece of foam board measuring 82 cm by 8 cm was used as the time out screen.

A Sport Craft lap counter implanted in a piece of styrofoam was placed at the experimenter's foot and was used to count errors. A Park Sherman desk top calendar with numbers on the front served as a point counter. The numbers were sequentially changed by pressing a small bar on top of the calendar. Another piece of foam board measuring 21 cm by 8 cm was used for the training board. On this board three position markers were dispersed along the same dimensions as a set of markers on the stimulus board.

Procedure

Preliminary Training

While the sessions were in progress each subject sat directly opposite the experimenter at a small half-moon shaped table. Two Western Michigan University undergraduate students assisted as part of a course requirement. For each subject two 5-20 minute sessions were run on weekdays, one in the morning and another approximately 4 1/2 hours later after lunch.

Each subject, prior to being seated at the experimental table, was asked to, "Choose the prize you would like to have" from a reward box. Small toys and bits of food served as reinforcers. The child was then instructed to place the reward on the experimental table in front of the point counter where they could see it during the session.
The following was read to each subject before the start of the first session:

The work you do here will earn points on this counter, (E. pointed to the counter and demonstrated how it worked). At the end of each session you will receive the prize you chose at the beginning of the session for the points you earn on the counter. The way to earn points on the counter is to turn certain chips (E. pointed to the chips) over one at a time and put them back on the blue dot.

Except where noted, no further verbal instructions were ever provided by the experimenter. If the subject did not respond or asked what to do the experimenter said, "It is up to you to figure out what to do." If a child spoke during a session the experimenter never responded.

Step 1. Subjects were given one point for picking up any of the chips and turning it over on the position dot. The criterion for passing this step was three consecutive correct responses.

Step 2. The $S^D$ bar was placed over a set of chips to which the subject was to respond. A correct response was turning over any of the three chips under the $S^D$ bar. A point was earned for each correct response. The $S^D$ bar was randomly moved over a different component after each response. Picking up any chip other than those under the $S^D$ bar resulted in a two-second time out during which the black foam board was placed over the entire array. Fifteen consecutive correct responses served as the criterion for passing this step. The first two steps took one session.

Step 3. Reinforcement was contingent on a chain of correct responses. When the $S^D$ bar was over chips 7, 8, 9 picking up any one of these chips resulted in the $S^D$ bar being moved over chips 10, 11, 12. Turning over any one of these chips was then reinforced with a
point on the counter. After this response chain was emitted five times consecutively without error the sequence was altered to begin at chip cluster 4, 5, 6. The chain was gradually extended to include all four groups of chips. An error consisted of picking up any chip other than one under the $S^D$ bar, and this resulted in a two-second time out. The incorrectly chosen chip was maneuvered back to its original position while the time out screen covered the board. After time out the subject attended again to the set of three chips that s/he erred on. The two-second time out followed errors throughout this entire study. This step took one session.

Step 4. Only responses on one pre-determined specified chip from each component of the four links resulted in the $S^D$ bar being moved over the next cluster. All other responses ended in a two-second time out. The correct chip was identified with a star pasted on the under side. Step four was maintained for three sessions. Each session ended when the subject emitted the four response sequence five trials in succession without error. This criterion was in effect for the remainder of the entire study.

As a result of the preliminary training the subjects were able to learn a new four component response chain each morning. The first correct chip was always in the first group of three on the subject's left. The second correct chip was always in the next group of three from the left, and so on. After the child emitted the behavioral chain five consecutive times without error the session ended and the child received the prize s/he chose before the session started.
Experiment 1-Baseline

All subjects were involved in Experiment 1. It was derived from Boren and Devine's (1968), Peterson's (1980), and Ozuzu's (1982) studies which examined, in part, the effect instructional stimuli had on the acquisition of response chains. The purpose was to develop a steady state of learning against which the effects of independent variables could be assessed. The experiment had four segments which ran as follows: Control Learning (CL) - morning session, Control Relearning (CR) - afternoon session; and two sessions the next research day, Instructional Learning (IL) - morning session, and Instructional Relearning (IR) - afternoon session (Peterson, 1980). The segments followed the same order for all reported experiments.

Each morning session began with a novel correct response sequence. Each afternoon session had the same correct response sequence as that morning's session. For example the first day consisted of the following sequence: 2, 3, 2, 1. The next day's sequence was 3, 1, 3, 2. Care was taken to ensure that the correct chips one day were not repeated the following day. Also, simple ordering was avoided. For example sequences like 1, 2, 1, 2 were not used.

The first Control Learning (CL) session began with the $S^D$ bar over the first component of the chain, chips 1, 2, 3. If the subject chose the correct chip the $S^D$ bar was moved over the next set of three, and so on until the entire chain was completed. A point on the counter was given for completed chains. Errors were followed by a two-second time out. The Control Learning (CL) session, as well as every other session, was terminated after five consecutive
errorless trials, with the subjects receiving their reinforcer.

The afternoon Control Relearning (CR) phase was identical to the morning session and consisted of the same correct response chain. The performance of each subject during the Control Learning and Control Relearning (CL and CR) phases was compared to their performance during the Instructional Learning and Instructional Relearning (IL and IR) phases. The dependent variable was number of errors prior to reaching criterion.

Control days always alternated with instructional days. The third segment, Instructional Learning (IL), used a new sequence and instructional stimuli. During this phase a bright red chip served as a specific instructional stimulus and the $S^D$ bar was absent. The red chip was placed upon the ridge behind the correct chip in the first component (Fig. 1). If the child responded correctly to the chip below this specific $S^D$ then the red chip was moved to a position directly over the correct chip in the next set of three, and so on, just like the $S^D$ bar is moved after correct responses. Errors continued to be followed by time out and the sessions continued until five error-free trials were emitted.

That afternoon the Instructional Relearning (IR) paradigm was followed and the correct response was identical to that of the IL (Instructional Learning) phase. Specific instructional stimuli were not used. Instead, the $S^D$ bar was placed over groups of three chips just like the CL and CR (Control Learning and Control Relearning) phases. Experiment 1 was run until a steady state of error rates appeared to emerge in all phases.
Experiment 2A-Two-Trial Cuing

The purpose of Experiment 2A was to (1) determine conditions that improved the maintenance of response sequences learned with instructional aid, and (2) to attempt to take advantage of the quick accurate performance that is possible with the aid of instructional cues in the morning IL (Instructional Learning) trial. Subjects 1 and 2 participated in Experiment 2A.

The procedure was identical to Experiment 1 except for one modification in the IL phase. During this phase the instructional stimulus chip was removed after two consecutive trials without an error. When the specific instructional stimulus was removed the $S^D$ bar was placed over each group of chips that was being attended to, just as in the CL, CR, and IR phases. IL was then continued until a total of five consecutive errorless sequences had been emitted, two with the specific instructional stimulus and three with the $S^D$ bar. If the subject made an error after the instructional stimulus was removed time out began, and the specific instructional stimulus above the correct chip in each component was returned until two more consecutive trials were emitted error free. Experiment 2A was continued until a steady rate of errors was being emitted in each of the four phases.

Experiment 2B-Cuing with Instruction

The purpose of Experiment 2B was to examine the effect that verbalizing the contingencies relevant to two-trial cuing would have
on the subjects' behavior. Subjects 1-5 were involved in Experiment 2B. Subjects 1 and 2 had already been in Experiment 2A.

Prior to each IL phase every subject was orally read the following rule:

(Part 1) "The chip that's right (i.e. correct) is under the bright one

(Part 2) And when the bright one goes away
the right one stays the same."

The experimenter repeated the instructions as was necessary until the child could echo the rule in its entirety.

Following this, a probe was used to determine, by way of demonstration, that each subject understood the rule. In this manner the experimenter was certain that the rule had the same meaning for all subjects, and their behavior with respect to that verbal stimulus was identical. During the probe a small training board was placed over the regular stimulus board. Three chips were on the training board with a bright red chip acting as an instructional stimulus for one of the chips. It was determined a priori which chip would be designated correct. The subject was asked to repeat part one of the rule. If they did so correctly they were told to, "Choose the right chip."

After they chose the correct chip, the red chip was replaced by the $S^D$ bar and the subject was asked to vocalize part two of the rule. If done correctly they were once again told to, "Choose the right chip." Correct responses were reinforced by vocal praise from the experimenter and failure resulted in a two-second time out. In the first IL session of Experiment 2B this procedure continued until the subject demonstrated understanding of the rule by choosing the
correct chip eight times in succession, alternating when the instructional stimulus was present and after it was replaced by the $s^D$ bar. The chip that had a star on the underside changed after every pair of correct responses. For each of the following IL phases the subject was required to choose the correct chip twice. After training criteria was reached the IL phase continued as in Experiment 2A. This was the only difference between Experiments 2A and 2B.

In summary, before each IL phase the subject was asked to verbalize the rule and demonstrate his/her understanding of the rule by emitting the behavior specified by the rule on the training board. Prior to the first IL phase they were required to choose the correct chip eight consecutive times without error, four times with, and the corresponding four times without the instructional stimulus. Before each subsequent IL phase the subject was required to respond correctly two times. No points were allotted when the training board was used, verbal praise followed all correct responses. After training, Experiment 2B proceeded exactly like Experiment 2A.

**Experiment 3-Sequence Similarity Rule**

Peterson (1980) reported that, "adults clearly benefitted from the IL instruction stimulus but four of the five children did not." In speculating as to the cause of this discrepancy she noted that,

The critical difference may have been the tendency of the adults to consider the IR response sequence to be the same as the preceding IL sequence, on the basis of this relation having prevailed in the CL-CR sequence the day before. This abstraction, based on similar sequential relations, for the adults, overshadowed any tendency to react to the IL and IR tasks as different because of the obvious stimulus differences.
(one light or chip vs. three). The children on the other hand were more strongly affected by these stimulus differences. It is reasonable to suppose that adults often have an extensive history regarding the importance of sequence as a discriminative stimulus, but the preschool children are just beginning to make contact with this type of abstract relation. It is quite possible that had the children been told of the similarity between the morning and afternoon sessions, their performance (on the IR phase) would have improved greatly (p. 35).

The purpose of Experiment 3 was to examine the effect of informing children about the similarity between each day's paired sessions. Subject 6 was used for this experiment. If Peterson's speculation was accurate it would be illustrated by the child making less errors in the afternoon CR and IR sessions.

Subject 6 was informed vocally that the correct response sequences were the same for paired CL/CR phases and the paired IL/IR phases. Prior to each CL and IL session the experimenter said, "The chips that are the right ones to pick up this morning will also be the right ones for this afternoon. That means the chips with stars under them this morning will be the same chips that have stars under them this afternoon." Prior to each CR and IR session the subject was told, "The chips that are the right ones to choose this afternoon are the same chips that were right this morning. That means that the same chips that had stars under them this morning have stars under them now."

Experiment 4-Criterion Increase

The data began to reveal that Subjects 6 and 7 were not performing in Experiment 1 as did subjects in previous research. As
expected they were making a steady moderate rate of errors in IR, but they were also making a similar rate of errors in CR. They often made more errors in CR than CL. In the afternoon sessions the subjects were behaving as if they were learning the response chain for the first time. The criterion of five consecutive error-less trials before each session's termination was an arbitrary choice. Thus for Subjects 6 and 7 the criterion for all sessions was raised to ten consecutive trials without error. This was the only distinction between Experiments 1 and 4.
CHAPTER III

RESULTS

Experiment 1 - Baseline

The purpose of Experiment 1 was to examine the effect instructional stimuli had on the acquisition of a four-line response chain. In addition, the results from Experiment 1 served as steady state data against which the effect of interventions could be compared.

All subjects learned the response chain in CL, with the number of errors to criterion varying across subjects. Figures 2 and 3 show data from Subjects 1 and 3. This data is representative of Subjects 1 through 5. These graphs show the number of errors each child made prior to meeting the session criterion. Control days are on the top and instructional days are on the bottom. These children consistently showed a high rate of error in the morning CL, with fewer errors in the afternoon CR session. This is similar to Boren and Devine's (1968) results with monkeys, and Peterson's (1980) and Ozuzu's (1982) findings with humans.

Unexpectedly, Subjects 6 and 7 often made more errors in the afternoon CR than in that morning's CL. The top half of Figures 4 and 5 show this data. These children often behaved as if they had not benefitted from the morning CL experience. In 10 of the first 18 control days Subject 6 (Fig. 4) made more errors in the afternoon relearning session, even though each afternoon's correct response sequence was the same as that morning's.
Figure 2, Subject 1. Control days are on the top and instructional days are on the bottom. Total number of errors per session are located on the ordinate. Session days are on the abscissa. Circles represent morning learning sessions, and squares represent afternoon relearning sessions.
Figure 3, Subject 3. Control days are on the top and instructional
days are on the bottom. Total number of errors per session are
located on the ordinate. Session days are on the abscissa. Circles
represent morning learning sessions, and squares represent afternoon
relearning sessions.
Figure 4, Subject 6. Control days are on the top and instructional days are on the bottom. Total number of errors per session are located on the ordinate. Session days are on the abscissa. Circles represent morning learning sessions, and squares represent afternoon relearning sessions.
Figure 5, Subject 7. Control days are on the top and instructional days are on the bottom. Total number of errors per session are located on the ordinate. Session days are on the abscissa. Circles represent morning learning sessions, and squares represent afternoon relearning sessions.
Figure 6. Shows a trials to criterion comparison between morning CL and IL sessions. Control and instructional days alternated. The criterion was five consecutive errorless chains after which the session ended. The total number of trials needed to reach criterion is located on the ordinate. An IL session and the CL session from the preceding day are represented along each unit on the abscissa.
Subject 7 (Fig. 5) made more CR errors in 5 of the first 11 control days.

Data from the bottom half of Figures 2, 3, 4, and 5 is representative of all subjects. These graphs show that after the first session, errors in IL were very rare; the children could emit the four response chain five successive times without error (a total of twenty correct responses). Consistent with previous studies already cited, all subjects in Experiment 1 made numerous errors in the afternoon IR. They behaved as if interacting with the sequence for the first time. The children made an approximately equal number of errors here as they did in the morning CL session.

Experiment 2A - Two-Trial Cuing

As data from Experiment 1 illustrates, during the CL the speed of acquiring the response chain was slow (more errors, more trials) while the number of errors in CR was usually lower. Conversely, during IL the subjects emitted the correct response chains quickly with the aid of cues, but made many errors in that afternoon's IR. In Experiment 2A the researcher attempted to design conditions which decreased the number of IR errors, while not requiring a large number of learning trials like morning CL. Subjects 1 and 2 participated in 2A.

The procedure for CL and CR remained unchanged in Experiment 2A, and the top half of Figure 2 shows that the rate of control errors also remained relatively unchanged. The data on the bottom half show that during IL with two-trial cuing the error rate
increased compared to baseline. After the child emitted the correct response sequence two times with the aid of the specific instructional stimulus he began to make errors when just the $S^D$ bar was placed over the appropriate group of three chips. The errors were made in spite of the subjects twice emitting the correct response sequence only seconds earlier.

The number of afternoon errors in IR decreased compared to Experiment 1, but the top half of Figure 6 shows that the number of morning trials to criterion in IL two-trial cuing increased. Figure 6 shows the number of morning learning errors made before a subject emitted five consecutive chains without error. The top of Figure 6 shows data from the same days as Figure 2, Subject 1. The bottom shows data from the same days as Figure 3, Subject 3. In Experiment 1 the criterion required Subject 1 to perform the response chain only five times in each of the last seven IL sessions. In Experiment 2A, two-trial cuing, this boy needed an average of fifteen trials to reach criterion in IL. Thus the decreased number of afternoon errors in 2A, IR (bottom of Fig. 2) was due to the increased number of trials made necessary when the subjects began to err in the morning IL. In 2A, IL, Subject 1 actually required more trials to criterion than on comparable CL days (Fig. 6), and this was incompatible with the experimenter's goal of decreased errors in the afternoon sessions with a minimum number of trials required in the morning learning sessions.
Experiment 2B - Cuing with Instruction

Subjects 1 through 5 participated in Experiment 2B. The procedure was the same as Experiment 2A except the subjects also learned a rule relevant to the two-trial cuing in IL.

Subjects 1 and 2 both participated in 2B after 2A, and the bottom half of Figure 2 shows characteristic data for Subject 1. The boy made slightly fewer errors in 2B, IR compared to Experiment 2A, IR. This is significant because the top of Figure 6 also shows that in the morning learning trials using cuing with instruction he began to reach criterion in fewer trials than 2A. Thus the verbal rule pertaining to two-trial cuing allowed Subject 1 to learn the response chain quicker in the morning (Fig. 6) without affecting his relearning performance adversely (Fig. 2). Compared to his results from 2A, Subject 2 did not benefit from learning the rule. It took just as many trials, and just as many errors, to reach criterion in 2B as in 2A. IR performance also did not improve for Subject 2 in cuing with instruction.

Subjects 3, 4, and 5 skipped 2A and began with 2B following baseline. Figure 3 shows representative data from Subject 3. The number of errors in the control sessions remained steady for all three subjects while the errors in IR decreased. The bottom half of Figure 6 accounts for this by showing the increased number of morning learning trials required in 2B cuing with instruction. These data show that for Subject 3, trials to criterion in IL, 2B often reached the lowest point possible (5); but just as many IL sessions required more trials to criterion than CL. Sometimes cuing with
instruction helped minimize the number of trials required to meet IL
criterion, but just as often this boy had sessions where the verbal
rule appeared not to influence his behavior.

An example of rules directing behavior was illustrated in 2B,
IL when Subject 3 correctly repeated the response sequence three
more times after the specific instructional stimuli were removed.
During sessions where the rule did not help direct behavior the
specific instructional stimuli were removed and the boy began to
make errors. The data for Subject 5 are very similar to that of
Subject 3. The IL/IR performance of Subject 4 worsened as sessions
in 2B progressed; her number of trials and errors both increased.
The verbal rule seemed to have limited control over her behavior.

When the data from the instructional phase of 2B are compared
to the control days they alternated with, it should be noted that
IL in 2B was no better than CL in teaching Subject 3 a response chain.
The combined effects of two-trial cuing with instruction resulted
in IL sessions lasting the same number of trials as CL sessions
(Fig. 6); with the error rate in the afternoon relearning sessions
also being equivalent (Fig. 3). This suggests that even though the
rule sometimes helped direct behavior, the final results were also
influenced by the environmental contingency. This also points out
the failure of this experiment to discover a method that quickly
teaches a response chain in a manner that results in a good relearn-
ing performance. The cuing and the rule were no more effective than
pure contingency shaping.
Experiment 3 - Sequence Similarity Rule

Figure 4 shows the data for Subject 6 who was carefully told that the morning and afternoon sequence requirements were the same. During Experiment 3, when this information was given, the rate of afternoon CR and IR errors remained steady. This subject was absent eight days and when he returned he was put back on baseline. About two weeks since last hearing the rule about sequence similarity he began making fewer errors in afternoon CR. For two days a similar decrease in afternoon errors occurred in IR.

It is obvious that the rule about sequence similarity did not benefit this boy on the days he heard it. It is also doubtful that the rule was responsible for the improved afternoon performance nearly two weeks later, but this cannot be ruled out entirely as the influence of verbal stimuli cannot be turned off like a key light in an operant chamber. Verbal stimuli may have sequence effects that are very difficult (if not impossible) to control for.

Experiment 4 - Criterion Increase

Subjects 6 and 7 were used in Experiment 4 where the criterion for completing a session was raised from five to ten consecutive correct response chains. The data for the first baseline of Subject 6 (Fig. 4) and for the entire baseline of Subject 7 (Fig. 5) are comparable. Their high rate of errors in the afternoon CR shows that often times neither benefitted from the morning CL experience. Subject six's data (Fig. 4) reveal a slight error decrease in
Experiment 4, CR, with a similar error decrease in IR. But this boy's data show a decreasing trend in afternoon errors prior to this intervention. Thus it is doubtful the rule about sequence similarity had a significant effect.

Data from the top half of Figure 5 show that in Experiment 4 increasing the session criterion for Subject 7 resulted in fewer errors in the afternoon CR. This intervention had little effect on improving her IR performance (Fig. 5, bottom half). When a specific instructional stimulus was used in the morning, the afternoon error rate was similar whether the subject went through the morning chain five or ten times.
Experiment I illustrated the instructional stimulus design of Boren and Devine (1968). The results indicate that for all seven subjects the use of specific instructional stimuli overshadowed any stimulus control generated by the correct response sequence. This is shown in the data when the subjects made almost no errors in IL, followed by numerous errors in IR after the specific instructional stimulus was removed. During IL the children turned over chips under the specific $S^D$ without any control by the correct sequence. It is likely that compared to the control situation, stimulus change decrement influenced the results in the instructional paradigm. In the control setting the stimulus features were identical morning and afternoon. In the instructional setting a single red chip served as the morning $S^D$ and that afternoon three red chips affixed to a wooden bar served as the $S^D$. There might be a decrement in the effect of the conditioning that took place in IL due to the stimulus change that occurred in the relearning condition.

It is interesting to note that neither of these explanations for a higher error rate in the afternoon have any validity with respect to Subjects 6 and 7 in the Control Relearning paradigm of Experiment I (Figs. 4 and 5). It is not clear why these two children performed in the afternoon as if they had never interacted with the morning sequence. It is as if they were not "changed organisms" as the
result of prior operant conditioning.

Experiment 2A, two-trial cuing, exemplified the strong stimulus control maintained by the specific instructional stimulus chip. Subjects would emit the correct response sequence two times in a row with aid from the instructional stimulus, and just seconds later they often turned over the wrong chips on the same response sequence when the SD bar replaced the instructional stimulus. Once again the presence of the instructional stimulus overshadowed the stimulus control maintained by the location of the correct chip. This suggests that educators be wary of students who correctly emit complex response patterns in the presence of instructional prompts.

The criterion increase in Experiment 4 served primarily as an internal design question, but it also illustrated the strength of instructional stimuli. Even though Subject 7 (Fig. 5) began running through the morning response chains ten times with the aid of instructional stimuli, twice as long as the previous criterion, her Instructional Relearning error rate showed no consistent improvement. Thus if the location of the correct chip does not have stimulus control, it may be irrelevant how many times a child interacts with that response sequence.

Experiments 2B, cuing with instruction, and 3, the sequence similarity rule, both examined rule-directed behavior. Subject 1 (Fig. 2) ran through nine trials of two-trial cuing, and during 2B, cuing with instruction, his IL/IR error rates both decreased. The top half of Figure 6 shows that his number of trials to IL criterion also decreased. He was learning the sequences quicker in the morning
with fewer errors in the afternoon. This is an example of human behavior being directed by a rule, "Rules make it easier to profit from similarities between the contingencies" (Skinner, 1974, p. 138). At the same time Subject 2 also participated in 2A prior to 2B, and his IL/IR error rates did not improve in cuing with instruction. The IL/IR performance of Subject 4 actually worsened as sessions in 2B progressed; the verbal rule seemed to have no control over her behavior.

Not only did the rule have different effects between subjects, but it also had different effects on within-subject performance. For each child there were IL sessions in 2B, cuing with instruction, where the rules seemed to direct behavior perfectly. The bottom half of Figure 6 shows that on the first day of Subject 3's return to 2B his performance was perfect; he needed the minimum five trials to reach criterion. Just two days later, with another response sequence of equal difficulty, he required 21 trials to reach criterion. Whether or not he was attending to the rule on that first day is unclear, but he certainly was not attending to the rule two days later. At this point he had interacted with the rule for a total of fifteen IL trials. All the subjects were capable of emitting the complex behavior called for, but they did not always do so.

The results in 2B are contrary in some respects to suggestions by Lowe et al. (1983) that verbal behavior will influence nonverbal behavior once the appropriate rules are generated. It should be noted that Lowe et al. did not use verbal behavior as an independent or dependent variable in reaching their conclusion. In the present
study subjects clearly stated the rule relevant to two-trial cuing and they clearly demonstrated understanding on the training board probe; yet the subjects who benefitted from the rule did so inconsistently. This suggests that while exposure to verbal rules can help guide behavior, it will not always do so, and exposure to the actual contingencies is often a necessary proviso.

Another example of the importance of underlying contingencies is the behavior of Subject 6 in the control phase of Experiment 3 (top half of Fig. 4). Here he heard the sequence similarity rule twice each day. This boy did not show improved afternoon relearning as a result of the rule about morning/afternoon sequence similarity, but he did improve two weeks after hearing the rule when he was back in baseline. The point is that behavior directed by rules does not have the same properties as behavior shaped by the contingencies. "A person who is following directions, taking advice, heeding warnings, or obeying rules or laws does not behave precisely as one who had been directly exposed to the contingencies, because a description of the contingencies is never complete or exact (it is usually simplified in order to be easily taught or understood)...

(Skinner, 1974, p. 139).

The verbal behavior in this study appears to influence nonverbal behavior much less than in the results of Catania et al. Catania used college students who had their verbal behavior conditioned to describe the behavior they should emit. This study used four year old children who were instructed to describe part of the contingencies they were performing under. These differences could be responsible,
in part, for the contrasting results.

Rules appear to function as discriminative stimuli (Skinner, 1969) and there are numerous variables that influence whether a person is controlled by verbal rules. Among these, one very important variable is the consequence following the behavior directed by the rule. Also important is the history of the subject with respect to the setting and the person giving the instruction. Whether the subject is capable of emitting the behavior called for is also relevant. If the rule specifies anything less than the appropriate setting, the desired behavior, and the implied consequence there may also be less of an effect. The rule in this study did not name a behavior or imply a consequence. Research on rule-directed behavior should attempt to isolate these and other factors. Creative experiments in this area are likely to emerge as the science of behavior expands in the operant lab.
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