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REPEATED ACQUISITION IN THE ANALYSIS OF RULE-GOVERNED BEHAVIOR

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Five children, ranging in age from 3½ years to 5½ years, were taught various four-response chains using conditioned reinforcement. Experiment 1 investigated the effects of presenting "instruction" stimuli—a sequence of lights over the correct response buttons—to assess their role in facilitating the acquisition of a chain of responses. Without the "instruction" stimuli, children made many errors before responses were brought under the control of the programmed contingencies. When confronted with the same contingencies later in the day, these subjects made fewer errors. In contrast, in the presence of the "instruction" stimuli, subjects made virtually no errors. However, when the "instruction" stimuli were discontinued in the subsequent session, all 5 subjects made errors. In Experiment 2, the subjects were taught to verbalize the contingencies during the phase without the "instruction" stimuli. This resulted in errorless performance during the subsequent exposure to the same procedure, but errors nevertheless occurred again during reexposure to the procedure with the "instruction" stimuli discontinued.

Key words: rule-governed behavior, self-instruction, repeated acquisition, children

That people talk to themselves and, as a consequence, alter their nonverbal behavior has previously been noted by several writers (Bem, 1967; Birch, 1966; Bornstein & Quevillon, 1976; Catania, Matthews, & Shimoff, 1982; Harzem, Lowe, & Bagshaw, 1978; Salzinger, 1978). The development of such complex behavior, however, has not received much attention in the experimental analysis of behavior (see Luria, 1961). Although many researchers have suggested a need for experimentally studying the acquisition of self-instruction and the way it relates to the programmed contingencies (Catania et al., 1982; Lowe, Beasty, & Bentall, 1983; Poppen, 1982), most studies have used adult subjects, already equipped with extensive repertoires of formulating rules and reacting to them.

Self-instruction appears to be a particular case of what Skinner (1969) has referred to as "rule-governed behavior" (p. 146 ff.). People learn to be affected by a description of a contingency somewhat as they would be affected by the contingency itself. Skinner has referred to such a description as a "rule," or more technically, as a "contingency-specifying discriminative stimulus" (p. 149). Adults teach a child to react to such rules, and to describe contingencies for the benefit of others. In self-instruction, the person describes contingencies and then reacts to the description as if it were given by someone else. In comparing rule-governed behavior and contingency-shaped behavior, Skinner (1974) identifies three features of rules that make rule-governed behavior an especially valuable human accomplishment:

> Rules can usually be learned more quickly than the behavior shaped by the contingencies they describe. . . . Rules make it easier to profit from similarities between

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> contingencies. . . . Rules are particularly valuable when contingencies are complex or unclear or for any other reason not very effective. (p. 125)

Hence, self-instruction, too, may act as an effective discriminative stimulus for further behavior and, more important, may evoke appropriate behavior more rapidly than do the contingencies it describes.

Because in self-instruction additional behavior is brought under the control of stimuli that are not yet adequate in evoking the appropriate behavior, it would be desirable to find a situation where novel units of behavior are emitted frequently so that their acquisition can be studied. The repeated-acquisition procedure described by Boren and Devine (1968) provides the needed arrangement. In that study, subjects learned a new multiresponse chain each session. The chains were similar enough so that eventually "the pattern of learning and the number of errors reached a steady state from session to session" (p. 652). This steady state of learning then served as a baseline for evaluating the effects of manipulating some independent variable.

One of Boren and Devine's (1968) experiments was particularly relevant to the topic of instruction, and thus served as a starting point for the present research. With monkeys as subjects, they studied the effects of what they called an "instruction" stimulus (a light over the correct lever) on the error rate during learning of four-response chains. Boren and Devine considered the procedure "analogous to instructing a human subject, step by step, exactly what to do" (p. 657). The monkeys, however, did not profit from the "instruction."

It is reasonable to suppose that adult human subjects would be affected by such instruction. That is, they would probably: (1) engage in verbal behavior descriptive of the experimental contingencies; (2) react to this description as a discriminative stimulus for subsequent nonverbal behavior; and thus (3) forego a long process of direct contingency shaping. On the other hand, nonverbal humans should not do much better than monkeys, given the specific experimental arrangement used by Boren and Devine. It may be asked, for example, whether preschool children, with only rudimentary verbal repertoires, would, in such situations, respond in ways similar to monkeys or to human adults—or whether they would show some intermediate performance. Specifically, could they describe the experimental contingencies and then react to that description? Experiment 1 was an attempt to answer these questions.

METHOD

Subjects

Five children—2 females and 3 males ranging in age from 3 years, 4 months to 5 years, 6 months—served as subjects. They were selected from the population at the Child Development Center, a preschool in Kalamazoo, Michigan. The physical and academic development of all subjects was normal. The study was approved by the Human Subjects Review Committee at Western Michigan University.

Apparatus

An intelligence panel that was constructed from plywood measured 45.7 cm vertically and 61 cm horizontally. Mounted in a line across the panel were 12 push-buttons and 12 lights. They were arranged in four groups of three lights and three push-buttons, with a light 5.1 cm above each button. A speaker, for delivering tones, and a buzzer were mounted behind the panel, and a point counter was mounted at the top center of the panel. Responses on all buttons, correct and incorrect, were recorded separately on a 15-pen event recorder. Electromechanical equipment located in an adjacent room was used to control the experiment.

The study was conducted in a large conference room with a partition separating the experimental area from the rest of the room. Each child sat directly in front of the intelligence panel during each session.

Preliminary Training

To assess whether experimenter instructions would substantially alter the number of errors during acquisition, 2 subjects (S3 and S5) underwent a shaping procedure while the other

3 (S1, S2, and S4) were given instructions by the experimenter. For the uninstructed subjects, preliminary training resembled the procedure outlined by Boren and Devine: (1) Points were produced by presses on any of the 12 push-buttons. (2) Next, any response on Buttons 10, 11, or 12 (the last group of three buttons), when the three pilot lights above these buttons were lit, resulted in a tone and a one-point increment on the counter. Other responses had no such consequence. (3) Point delivery was contingent upon a chained sequence of two responses: When the lights were lit over Buttons 7, 8, and 9, a response on any one of these extinguished those lights, produced a 2-s tone, and lit the next set of three lights over Buttons 10, 11, and 12. A response on any one of these buttons extinguished these lights and produced both a 2-s tone and a one-point increment on the counter. The chain was then extended to include all four groups of push-buttons. Incorrect responses activated a 2-s buzzer and led to a 2-s timeout (TO) during which time all pilot lights were turned off. Any responses during this period reset the timer. After a timeout, the lights above the group of buttons where the error had occurred were again lit. (4) Only responses on a particular button with each of the four groups were reinforced; incorrect responses again initiated the correction procedure.

Prior to Step 4, the criterion for moving through the phases of preliminary training was met when a subject was able to perform the specified task 10 consecutive times without error. For each step, this criterion was met by both subjects within one session. Step 4 was maintained for three sessions, each of which was terminated when the subject emitted the four-response sequence correctly five times in succession. This criterion remained in effect for the entire study for all subjects in the experiment.

Step 5 involved changing the sequence of correct buttons each session. For example, the first day of Step 5 entailed the following sequence: 2, 1, 3, 1 (the second button in the first group, the first button in the second group, the third button in the third group, and the first button in the last group). The next day the sequence 1, 3, 1, 2 was in effect. Thus, the subjects were required in each session to learn the new four-button sequence making up the reinforced chain. The correct button sequence in one session was not repeated in the following session. Within any one programmed sequence, no simple ordering of the location of correct buttons (i.e., left, middle, right) was permitted. Step 5 ran for four consecutive sessions.

The only verbal instructions given these 2 subjects occurred on the first day of preliminary training. They were an explanation of points on the counter and the way they could be exchanged for a small toy that the children would choose at the beginning of each session. Thus, each subject, prior to sitting at the experimental table, chose a small toy from the "reinforcement box." The toy was then set along side the experimental table so that the subject could view it during the session.

In contrast, the remaining 3 subjects were instructed without a shaping procedure. The following instructions were read to Subjects 1, 2, and 4 individually on their first training session:

> See this? (Experimenter points to panel.) There are twelve lights across the board and there are twelve buttons directly under these lights. Directly ahead of you is a counter which will show the number of points you have earned. By pressing certain buttons you will earn points on this counter. These points can be turned in at the end of the session for the small toy you have chosen from the "reinforcement box." Sometimes you will hear a nice sound for pressing a button, but other times you will hear a loud buzzer telling you that you have pushed the wrong button (Experimenter pushes button which activates the tone and one that activates the buzzer). You must figure out which buttons will lead to a point on the counter. Now I am going to leave you here while you work with the buttons. After you have earned five points, I will turn off the lights on the board and come and get you. While the lights are on, you should remain in your seat. You may push

Table 1
Procedure of Experiment 1

Phase		
1. Control Learning (C/L)	–	
Morning Session	3 Lights	New Sequence
2. Control Relearning (C/R)	–	
Afternoon Session	3 Lights	Same Sequence as C/L
3. Instruction Learning (I/L)	–	
Morning Session	1 Light	New Sequence
4. Instruction Relearning (I/R)	–	
Afternoon Session	3 Lights	Same Sequence as I/L

only one button at a time. Do not begin pushing buttons until the panel lights come on.

After each subject was exposed to four sessions (each consisting of a new response sequence), he/she was informed that the session would end from that point on after he/she had completed five trials successfully without any errors. In no other way were the instructed subjects treated differently than the shaped subjects. The conditions for all remaining sessions were the same for both groups of subjects.

EXPERIMENT 1

Procedure

The procedure for Experiment 1 was virtually identical to that reported by Boren and Devine (1968). Two paired sessions—one in the morning (Learning Phase) and one in the afternoon of the same day (Relearning Phase)—were allotted for the acquisition of a four-response chain. The first day involved the Control Learning (C/L) phase and the Control Relearning (C/R) phase. The next day involved the Instruction Learning (I/L) phase and the Instruction Relearning (I/R) phase. These phases were repeated in the same order throughout the entire study. The number of four-session blocks run varied across subjects.

At the start of the first session, the C/L phase, the first three pilot lights were lit above the first group of three buttons. A correct response led to a 2-s tone, extinguished the lights in the first group, lit the lights in the next bank of three, and so on until the chain was completed. Errors initiated the correction procedure. Each C/L session initiated a new sequence of correct responses and was terminated upon completion of five consecutive trials without error. The afternoon session of each C/R phase consisted of the same sequence used in the morning; the overall procedures for C/L and C/R were identical.

Performance of the subjects during the control phases was contrasted with performance during the instruction phases. The I/L phase, conducted in the morning of the next day, consisted of a new sequence of correct responses that included the use of "instructional" stimuli. During this phase, a single pilot light (an "instruction" stimulus) was turned on over the correct button in the first bank. When the child pressed the correct button, this light went off and the next light, located directly above the correct button in the second bank, was lit, and so on until the entire response sequence had been emitted and a point was earned. For each subject this procedure continued throughout the session until he/she had earned as many points as during the preceding C/L session (e.g., if a subject required 15 trials during C/L to meet criterion, this subject was then required to go through 15 trials during I/L.)

The final phase of the procedure, I/R, conducted in the afternoon, consisted of the same programmed sequence from the I/L session, but without the benefit of "instructional" stimuli. That is, all three lights again were turned on over successive groups of three buttons as the subjects moved through the chain. In this way it was possible to evaluate the degree to which "instructional" stimuli used during the morning session facilitated "uninstructed" performance in the afternoon session.

Table 2
Mean Error Rates and Standard Deviations for All Sessions in Each Phase of Experiment 1

Subject	*C/L*	*SD*	*C/R*	*SD*	*I/L*	*SD*	*I/R*	*SD*
1	25.7	15.6	11.8	5.9	0.3	0.5	11.7	11.8
2	5.8	2.6	2.0	2.7	0.0	0.0	3.5	1.3
3	27.4	26.2	15.0	24.5	0.4	0.9	17.0	20.0
4	13.9	8.4	5.8	5.0	0.1	0.3	4.4	1.1
5	11.9	16.3	5.2	4.7	0.3	0.5	11.0	12.3

Thus, two paired sessions, the learning and relearning phases, were allotted for the acquisition of each new response sequence. Only one session per block of four, however, was "instructed"—the I/L session.

Twice during Experiment 1, at points immediately following C/L and I/L sessions, each subject was asked separately to tell the experimenter what had just been done to earn points on the counter (see Table 1).

Results and Discussion

This experiment investigated the effects of an "instruction" stimulus on learning and relearning a specific four-response chain. Of particular interest was whether the subjects could verbalize the contingencies and benefit from them in the relearning sessions. Individual data for all 5 subjects are presented in Figure 1.

Although the subjects differed with respect to the number of errors to acquisition during the C/L phase, each subject showed a decreased number of errors during the C/R phase. This can be seen by comparing the first data point for each subject in the C/L quadrant with the first data point in the C/R quadrant, the second data point in the C/L quadrant with the second data point in the C/R quadrant, and so on.

Providing an "instruction" stimulus during the I/L phase resulted in virtually errorless performance by all subjects during this phase. In contrast, when the "instruction" stimulus was no longer presented, the I/R phase, subjects again made errors. The "instructional" stimuli did not substitute for contingency shaping.

The mean error rates and standard deviations for each phase are provided in Table 2 for all subjects. In general, the error rates for all subjects in the C/R phase were close to half the corresponding error rates in the C/L phase and thus showed some savings across the control phases. For Subjects 1 and 4 the error rates in the I/R phase were a bit lower than the error rates in the C/R phase. For Subjects 2 and 3, however, the error rates were higher in the I/R phase, but still lower than in the C/L phase. Thus, performances of these 4 subjects showed slight benefit from the "instructional" stimuli.

Only Subject 5 appears not to have benefited from the "instructional" stimuli in that this subject's error rates in the I/R phase were almost identical to those in the C/L phase. However, this subject eventually stopped making errors in the C/R and I/R sessions near the end of Experiment 1. On the 11th day of the C/R session, Subject 5 produced an errorless performance. At the end of the session he was asked by the experimenter what he had to do to get points on the counter. He was able to report the correct sequence, and added that it was the same in the morning. He again made no errors the next day on the I/L and I/R phases. When asked by the experimenter at the end of the I/R session what he had to do to get points on the counter, he again reported the correct sequence and observed that the morning and afternoon sessions were alike. It was clear that he had developed verbal behavior related to the programmed contingencies and performed accordingly. He was not, however, always able to verbalize the experimental contingencies. When asked at earlier points in the experiment, immediately following a C/L and I/L session, he literally said nothing.

When the other subjects were asked during the middle of the experiment and again at the end what they had to do to earn points on the counter, they did not verbalize any contin-

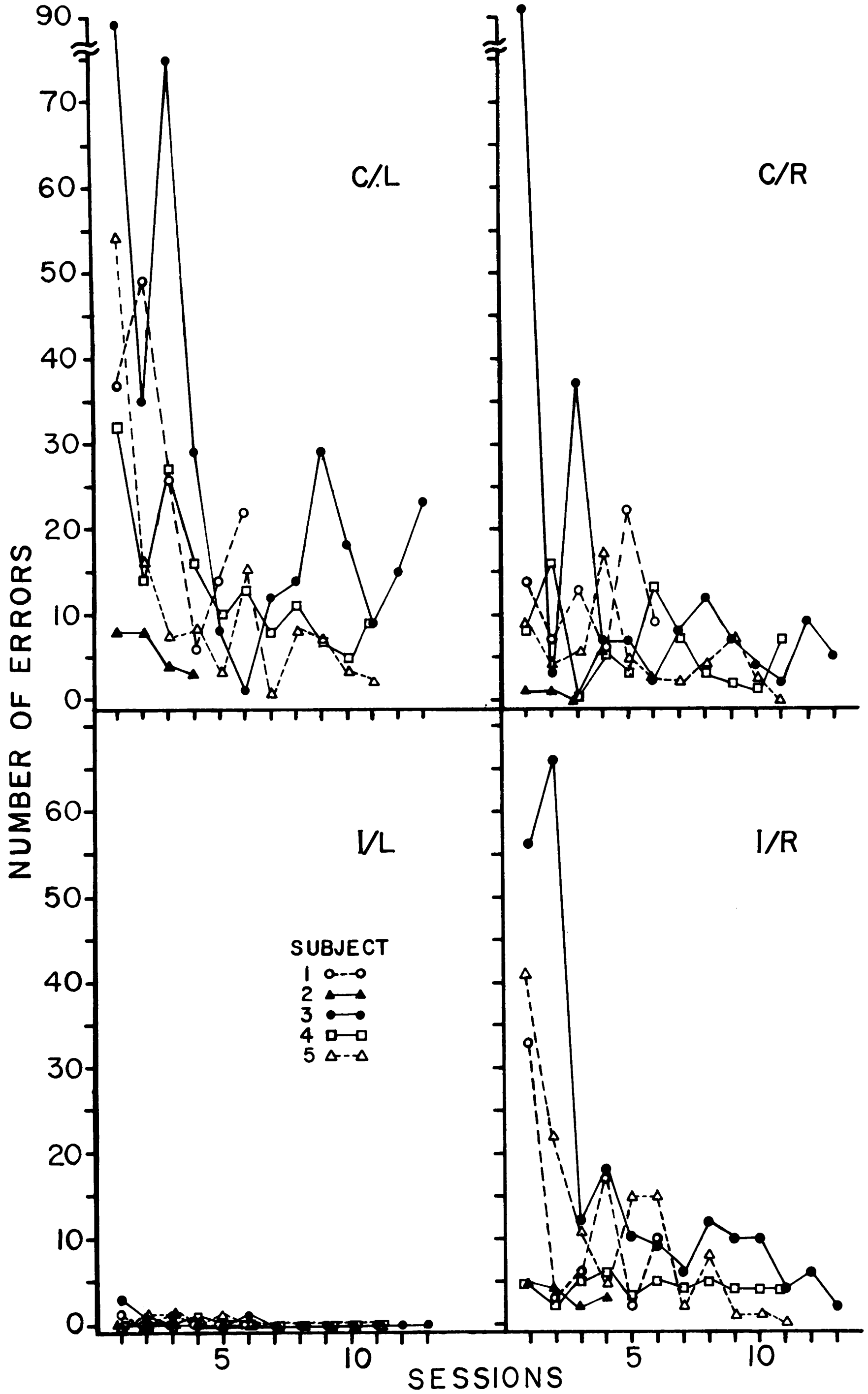

Fig. 1. Total numbers of errors made by each subject in successive sessions of Experiment 1. Data for the Control Learning phase (C/L) are located in the upper left quadrant; data for the Control Relearning phase (C/R) are located in the upper right quadrant; data for the Instruction Learning phase (I/L) are located in the lower left quadrant; data for the Instruction Relearning phase (I/R) are located in the lower right quadrant. The first session in C/L and in C/R involved the same four-response sequence; the second session in C/L and in C/R involved the same four-response sequence; and so on. Similarly, the first session in I/L and in I/R involved the same four-response sequence; the second session in I/L and I/R involved the same four-response sequence, and so on.

gency. They were able to correctly point to the buttons they had pressed but did not emit any verbal behavior with respect to them.

Little information can be drawn from these data that bears on the issue of shaping versus instructing behavior. Subject 3, who went through the shaping procedure, did show a higher number of errors in the initial phases of the experiment than did the other subjects. But these results may point merely to individual differences.

Errors within sessions for each of the individual subjects showed two main features. First, subjects usually mastered the last component of the chain before mastering the earlier components. Second, early in the experiment the errors made during I/R sometimes consisted of responses that were correct for the preceding control phase. However, as the experiment progressed, these types of errors became no more likely than any other error.

These results were similar to those reported by Boren and Devine (1968). Four of the 5 children made approximately half as many errors in the C/R sessions as they did in the C/L sessions. This transfer of learning to the relearning phase had also been found in the experiment with monkeys. However, during the I/L phase, one monkey's behavior was not controlled by the "instruction" stimulus at all, and the other had approximately the same number of errors in the I/R and C/L phases. Two monkeys showed some transfer of learning when the stimulus conditions were similar, but this advantage was lost when the stimulus conditions were altered. The children, on the other hand, did show some transfer of learning in the I/R phase; however, the "instructional" stimuli did not strongly affect subsequent uninstructed performance, which was only slightly better in the I/R sessions than in the C/R sessions.

Table 3
Procedure for Experiment 2

Phase	
1. Control Learning (C/L)	Same as Experiment 1 but subjects required also to verbalize contingencies
2. Control Relearning (C/R)	Same as Experiment 1
3. Instruction Learning (I/L)	Same as Experiment 1 but Subject 3 was required also to verbalize contingencies starting on the fifth I/L session; Subject 4 on the first
4. Instruction Relearning (I/R)	Same as Experiment 1

EXPERIMENT 2

Although all the children in Experiment 1 ultimately learned chains of responses with few errors, their behavior appeared not to be under the control of any self-generated verbal stimuli (except for Subject 5 late in Experiment 1); rather, they appeared to have "learned how to learn" through direct contingency shaping. Experiment 2 was designed to explicitly introduce rule-extracting/rule-stating (self-instruction) and to examine its role in this type of learning. If each subject were taught to verbalize the experimental contingencies in effect during the C/L phase, would he/she then benefit from this immediately (during the C/L phase) and/or at some later time (during the C/R and I/R phases)? If so, the long shaping process observed in Experiment 1 should be by-passed, with one effect being a decrease in error rates.

Procedure

The procedure of Experiment 1 was used with one slight modification. During all C/L sessions each child was asked to (1) specify the button (1, 2, or 3) he/she was going to press; (2) specify whether it was the correct button; and (3) at the end of the session, tell the experimenter which buttons were the correct ones for reinforcement (see Table 3).

In addition, Subject 4 was given the same instructions during the first and all subsequent I/R sessions; Subject 3 was given the same instructions during the fifth and all subsequent I/R sessions. The experimenter sat beside each child during all sessions in Experiment 2.

To ensure verbalizing by number (1, 2, or 3) on the part of the subjects, rather than by some other method (e.g., left, middle, or

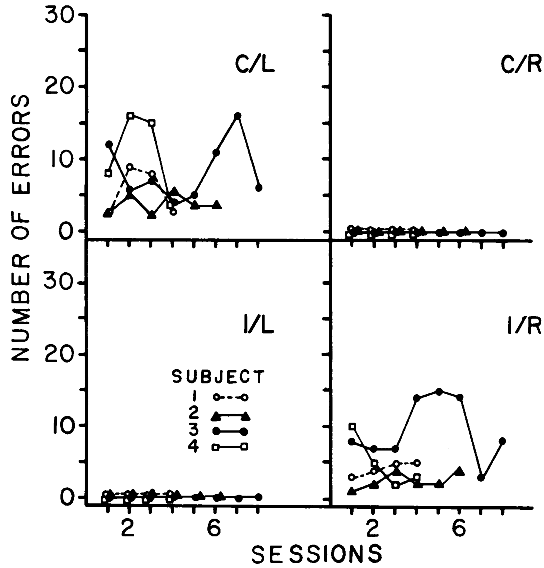

Fig. 2. Total numbers of errors made by each subject in successive sessions of Experiment 2. Data for the Control Learning phase (C/L) are located in the upper left quadrant; data for the Control Relearning phase (C/R) are located in the upper right quadrant; data for the Instruction Learning phase (I/L) are located in the lower left quadrant; data for the Instruction Relearning phase (I/R) are located in the lower right quadrant. The first session in C/L and in C/R involved the same four-response sequence; the second session in C/L and in C/R involved the same four-response sequence; and so on. Similarly, corresponding sessions in I/L and I/R involved identical four-response sequences.

right), a set of three 5.1-cm by 5.1-cm cards was placed under each of the four groups of buttons with the numbers 1, 2, or 3 on them. To rule out any possible effect the cards might have on facilitating self-instruction, they were placed on the intelligence panel at mid-point in Experiment 1.

Twice during Experiment 2 each subject was asked, immediately following a C/L session, to describe what had to be done to earn points on the counter. Likewise, twice they were asked at about mid-day, a few hours after the C/L session and a few hours prior to the C/R session, if they remembered what they had to do in the morning to earn points on the counter.

Results and Discussion

Verbalizing during the C/L phase had no appreciable effect on error rate for this phase. There was, however, an immediate cessation of errors during the C/R phase for all subjects (Figure 2 and Table 4). It appears that the verbal behavior taught in the C/L session supported subsequent performance of the particular sequence. That is, subjects' performances in the C/R phase were strongly affected by their having verbalized the experimental contingencies in the C/L phase. Once the verbal training began in the C/L phase, all 4 subjects also started to verbalize in the C/R phase. When seated at the intelligence panel, the subjects would immediately start talking about which button they were going to press. They would first give a number and then follow the announcement with the appropriate button press. Although the experimenter did not react to this verbal behavior, the behavior persisted.

When asked, following the C/L session, what the sequence was for earning points, each subject was able to correctly tell the experimenter. Moreover, when each subject was asked mid-day what the sequence had been for the morning session, all answered correctly.

The performances of all 4 subjects during the I/R phase of Experiment 2 were quite similar to their performances during this phase of Experiment 1. Subjects failed to generalize effectively from the C/L phase to the I/L phase. Even Subjects 3 and 4, who underwent the verbal training during the I/L phase, showed no tendency to engage in verbal behavior during I/R.

To examine more closely what might be working against rule-stating and/or rule-following during I/R, the experimenter, prior to beginning the last I/R session, asked all 4 subjects what they thought the sequence would be for that afternoon. When there were no stimulus lights on, none of the subjects could give the correct sequence, although each subject did provide a guess that was incorrect. When all three lights were turned on above the first bank of three buttons, and the subjects were again asked what they thought the correct sequence might be, each subject made an attempt but none gave the correct sequence. Finally, when the "instruction" stimulus was turned on over the correct button in the first

Table 4
Mean Error Rates and Standard Deviations for All Sessions in Each Phase of Experiment 2

Subject	*C/L*	*S/D*	*C/R*	*S/D*	*I/L*	*S/D*	*I/R*	*S/D*
1	5.8	3.2	0.0	0.0	0.0	0.0	4.3	1.0
2	3.7	1.4	0.0	0.0	0.0	0.0	2.0	1.1
3	8.4	4.2	0.0	0.0	0.0	0.0	9.5	4.3
4	10.8	5.7	0.0	0.0	0.0	0.0	5.0	3.6

bank, subjects were again asked the same question. Under these conditions, 3 of the subjects (Subjects 2, 3, and 4) verbalized the last three buttons in the sequence correctly.

GENERAL DISCUSSION

The results reported here suggest that self-generated instructions can be taught and can be effective discriminative stimuli for subsequent nonverbal behavior. In addition, they support the notion that rules can be learned more quickly than the contingencies they describe and can have the effect of evoking appropriate behavior more rapidly than the acting contingencies from which the rules were derived. However, in the present situation this appears to have been true only when the stimulus conditions were identical. The children did not seem to profit from the rules when the stimulus conditions were slightly altered (the I/L-I/R comparison).

The fact that the children engaged in self-instructive verbal behavior during the C/R phase but not during the I/R phase of Experiment 2 suggests that explicit training was necessary to vocalize the contingencies. Some previous reports support this finding. For example, White (1965) has noted:

> A fairly basic and important change in the character of learning appears to take place after age 5. Before this age, the pattern of findings obtained with children resembles those obtained when animals are used in like procedures. After this age, the pattern of findings approximates that found for human adults. The transition is from animal-like to human-like learning. This transition is associated with an increased apparent influence of language upon learning. (pp. 195-196)

This transition change has often been couched in terms of mediated responses and the first signs of higher mental processes. For example, White stated: "The focal idea is that at the transition the child begins to be guided by a mediating response which he makes to a presenting stimulus as well as by the stimulus itself" (p. 212). Given the present research, however, it appears that the transition can be taught. Moreover, similar stimulus conditions seem to evoke the newly learned strategy.

Why the children did not engage in self-instructive verbal behavior during the I/R phase is less clear. The abstraction, based upon the relation between the C/L and C/R sequences, did not overshadow the tendency to react to the I/L and I/R sequence as different, presumably because of the salient stimulus differences (one light vs. three).

Another issue relevant to this research is the distinction that Skinner (1974) has made between directions and instructions.

> Directions do not impart knowledge or convey information: they describe behavior to be executed and state or imply consequences. Instructions are designed to make further directions unnecessary. A person learning to drive a car responds to the verbal behavior of the person sitting beside him; he starts, stops, shifts, signals, and so on when told to do so. These verbal stimuli may at first be directions, but they become instructions if verbal help is given only as needed. (p. 120)

The "instructional" stimuli in Experiment 1 perhaps can best be described as directions, in that children did not show lasting effects as a function of contact with them.

In addition to investigating the various parameters of the present experiments, it would be useful to collect data from subjects encompassing a wider range of ages. And perhaps more important, it would be especially fruitful to study the possible dependency of one set of self-instructions on other, more abstract self-generated instructions such as rules about rules.

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