JOURNAL OF THE EXPERIMENTAL ANALYSIS OF BEHAVIOR 1991, 56, 155-166 NUMBER 1 (JULY)

TRANSIENT EFFECTS OF ACQUISITION HISTORY ON GENERALIZATION IN A MATCHING-TO-SAMPLE TASK

RENEE L. MICHAEL AND DANIEL J. BERNSTEIN

UNIVERSITY OF NEBRASKA-LINCOLN

This study examined the role of learning history on the acquisition of a matching-to-sample task. Twelve preschool children learned four stimulus classes through instructions, shaping, or imitation. After reaching criterion, the subjects were exposed to changed discrimination contingencies to determine how each learning history affected the acquisition of responses appropriate to the new contingencies. All subjects reached criterion on the new relations, although the subjects with a shaping history adapted slightly more quickly than those subjects with a history of instructions or imitation. Given sufficient exposure to changed contingencies, rule-driven insensitivity to contingencies was overcome by experience with consequences. This result may be specific to younger subjects, but it suggests that instructions can be used in education without creating insensitivity to contingencies.

Key words: learning history, rule-governed behavior, shaping, imitation, contingency sensitivity, matching to sample, stimulus classes, children

Differences between rule-governed and contingency-shaped behavior have received much attention from behavior analysts. Interest in the topic can be traced to Skinner's (1969) assertion that rule-governed behavior is not in contact with environmental contingencies and therefore may not be sensitive to changes in those contingencies. Behavior that is shaped makes more contact with environmental contingencies, thereby making it more adaptable to changes. Catania and colleagues reported data on human schedule performance suggesting that behavior acquired through instructions tends to be rigid, whereas behavior acquired through contact with contingencies is more flexible (Matthews, Shimoff, Catania, & Sagvolden, 1977; Shimoff, Catania, & Matthews, 1981). These studies set the pattern for those that followed; all behavior studied has been simple motor responding under schedules of reinforcement. Humans instructed to respond under multiple schedules were less able to detect a reversal of components than subjects whose initial performance was shaped. In these studies, sensitivity was defined as adaptation of responding to an unannounced schedule change.

Lowe (1983) has suggested that when behavior is complex and verbal rules minimized, human and nonhuman behavior is similar. Other investigators have studied the role of instructions in human schedule performance. Baron and Galizio (1983) suggested that performance was not made insensitive by instructions per se but by how much information the instructions provide about consequences. Their work showed that human schedule performance was similar to that of nonhumans if instructions increased the subject's contact with the contingencies.

Recent work has also focused on the differential effects of behavior acquired either through instructions or through shaping. Hayes, Brownstein, Zettle, Rosenfarb, and Korn (1986) varied the correspondence between instructions given to subjects and the degree to which those instructions facilitated contact with the contingencies. Even when instructions were written to maximize information about the consequences, some subjects still did not demonstrate sensitivity when those consequences were changed.

LeFrancois, Chase, and Joyce (1988) were successful in providing an instructional history that produced responding sensitive to changing

This research was supported by NIH Biomedical Research Support Grant RR-07055 to the University of Nebraska-Lincoln and by the David Fund, the Warden Fund, and the Stanton Fund of the University of Nebraska Foundation. We thank Trinity Infant and Child Care Center for facilities and cooperation, Suzanne Sollars, Julia Groene, and Cyndi Halpin for assistance in conducting the research, and Jan Jacobs and Gina Green for comments on the manuscript. Correspondence and requests for reprints should be addressed to Renee L. Michael, 209 Burnett Hall, University of Nebraska-Lincoln, Lincoln, Nebraska 68588-0308.

contingencies. During training, they gave subjects rules to master correctly a variety of schedules. Subjects who performed under eight different reinforcement schedules were more sensitive to changes than were subjects who performed under only one of those schedules. Vaughan (1985) provided subjects with instructions about the correct sequence of a chain of responses and found that instructed responding made more effective contact with contingencies than did noninstructed responding. When subjects were tested later without the instruction component, however, performance reverted to pretraining levels. Subjects in Vaughan's experiment demonstrated that instructions can aid in the acquisition of complex behavior, but the procedure can also produce performance dependent on those instructions.

Conceptualization of this area has extended beyond the original premise that rule-governed behavior is more rigid than behavior acquired through shaping and now focuses on the parameters of instruction and how those parameters alter the outcome of an instructional history. The purpose of the current study was to replicate and extend previous work in this area by examining variables not considered by other researchers. First, we selected an experimental task that is more complex than simple schedules of reinforcement, and we expected the general phenomenon to extend to behavior other than responding under reinforcement schedules. The matching-to-sample procedure (Sidman, Kirk, & Willson-Morris, 1985; Sidman & Tailby, 1982; Wetherby, Karlan, & Spradlin, 1985) seems to meet that criterion. Sidman (1986) argued that analysis of stimulus control and stimulus classes provides behavior analysts with a tool for examining linguistic processes, and a demonstration of the effects of various forms of acquisition on stimulus-class formation would expand the generality of the phenomenon to an interesting behavioral domain.

Second, we included an additional form of acquisition in the analysis. Imitation is a method of acquisition often employed in applied behavior analysis but with mixed effectiveness. Baer, Peterson, and Sherman (1967) and Baer and Sherman (1964) demonstrated the utility of modeling in generalized acquisition of behavior. They reinforced children's behavior of imitating a model's bar presses and found that the children imitated the model's other behavior as well. Rogers-Warren and Baer (1976) used imitation as a way of training correspondence between verbal behavior and overt behavior in children. They found that modeling procedures, combined with reinforcement, were an effective method of teaching sharing and praising. Imitative acquisition has been attempted in a matching-to-sample procedure, but modeling alone was not sufficient to create criterion-level performance. MacDonald, Dixon, and LeBlanc (1986) taught retarded adult males an arbitrary matching-to-sample task, but, even after learning direct relations through imitation, performance on emergent stimulus relations remained at chance level. Only when verbal instructions were added did the subjects' performance improve. We expected imitation as a form of acquisition to be effective in establishing stimulus classes in children and would provide a comparison with shaping and instructions when contingencies were changed.

Finally, we wanted to extend the exposure to each form of acquisition to see the effects of an extended history on behavioral rigidity and flexibility. Previous research has been largely conducted in short 1- or 2-hr experiments. Matthews et al. (1977), Shimoff et al. (1981), and Hayes et al. (1986) gave subjects an acquisition history and tested for performance that adapted to contingency changes during only a few short experimental sessions. By the end of those sessions most of their subjects who had acquired responding through instructions had not changed their behavior when contingencies were changed. We wanted to provide subjects with an acquisition history that extended over several sessions. Bernstein (1988) suggested that the results of human operant research may vary as a function of the length of time devoted to experimental sessions, and we wanted the responses to be stable and representative of the repertoire studied. In general, sessions continued as long as each subject needed to overcome a specific acquisition history and adapt to new contingencies. It is possible that the level of rigidity or sensitivity may differ from previous findings if subjects are given longer histories and exposed to the changed contingencies for a longer period of time.

To maximize the potential effect of the experimental histories, we chose children as sub-

jects in this research. Whereas college students are likely to have extensive natural histories of interacting with instructions (which may compete with the experimental variables), experimental variables might have a larger impact on younger subjects who bring less history into an experiment. Vaughan (1985) also chose children as subjects for the same reason. In summary, the current study was designed to compare three forms of acquisition within the context of a complex operant procedure studied for an extended period.

METHOD

Subjects

The subjects were 12 children (3 female, 9 male) aged 4.5 to 5.5 years old. Four children (1 female, 3 male) participated in the instructed condition, 3 children (1 female, 2 male) were in the contingency-shaped condition, and 5 children (1 female, 4 male) were in the imitation condition. All children were enrolled in the same room of a day-care center and were recruited by letters sent to their parents. Children participated only if both a written consent form was signed by the parents and a child assent form was completed by the child. Independent of performance, children received a page of stickers at the completion of each session. Toys and books were donated to the subjects' room at the day-care center at the completion of the experiment.

Setting and Apparatus

Sessions were conducted 3 days per week in a quiet conference room of the subjects' day-care center, and the length of each session varied from 10 to 15 min. Each subject was alone with the experimenter during sessions. A Sanyo color videomonitor (22 cm by 28 cm) displayed stimuli generated by an Apple II+® or a Laser 128® computer. The monitor and computer were on a table, and the subject sat facing the monitor at a distance of 30 cm. The monitor was fitted with a touch screen (manufactured by Personal Touch) to make responding easy for the child, and the occurrence and location of each touch on the screen were recorded by the computer. Programs that controlled stimulus presentation and allowed automatic data recording were written by the experimenters. During the session, the experimenter sat 1.5 m from the child to minimize interaction.

Nature of the task. Subjects performed a two-choice matching-to-sample task with stimuli consisting of ordinary numbers, letters, and shapes. On each trial, a sample stimulus was presented in the center of the screen with two choices presented on either side of the sample. To ensure that the child attended to the task, he or she was required to touch the sample when it appeared on the screen. Only after the subject touched the sample did the two comparison stimuli appear, one of which the child was also required to touch as an indication of a selection.

Phases of the Experiment

There were six phases of training and testing, which lasted as many sessions as were required for each subject to reach a mastery criterion. Within each session, all trials were part of a single phase of the experiment. In each session, a subject responded to a programmed sequence of 12 to 14 match-to-sample items made up of two or four stimulus combinations, repeated three, four, or six times each. Feedback for correct selections consisted of computer-generated figures and music, and feedback for incorrect selections was a low buzzing tone. During all phases that included feedback, each incorrect response was followed immediately by a correction trial (repetition of the same stimuli), so sessions varied in length as a function of performance. All descriptions of session length will specify the number of correct trials planned. The mastery criterion for each sequence was 90% correct responses. If criterion was reached during one session, a child encountered the next phase of the experiment at the next session. If criterion was not reached, a sequence from the same phase was repeated at the next session. The primary focus of the study was the number of sessions each child required to reach criterion for each phase of the experiment, especially as a function of acquisition history.

Phase I: identity matching and generalized identity matching. Subjects first had sessions of identity matching in which selection of an identical comparison stimulus was a correct match and selection of a comparison stimulus different from the sample was an incorrect match. Contingencies were in effect on a continuous reinforcement schedule. Once criterion

was reached for the initial identity matching, an entirely new set of stimuli was substituted into the same program. To determine whether the initial training would generalize to new stimuli, this phase was conducted in extinction. Subjects continued with generalized identity-matching sequences until the accuracy criterion was met. Figure 1 (top) shows the stimuli used for identity matching and for generalized identity matching.

Phase II: training arbitrary direct relations in Stimulus Sets 1 and 2. After learning to select stimuli identical to the sample, the subjects next learned to select an arbitrary stimulus designated to match the sample. First subjects learned two pairs of arbitrarily matched stimuli. For example, a subject might learn that the number "5" matched the letter "V" and that the number "6" matched the letter "T" (see Figure 1). These trial types are designated as AB trials in standard matching-to-sample terminology. During all AB trials, numbers were sample stimuli, letters were comparison stimuli, and there was continuous reinforcement. Each of the two stimulus combinations was presented six times. After reaching criterion on these stimulus relations, subjects were introduced to relations in which letters were sample stimuli paired with shapes as comparison stimuli. For example, a subject might learn that the letter "V" matched a rectangle and that the letter "T" matched a triangle (see Figure 1). These trials are designated as BC trials in standard matching-to-sample terminology, and these letter–shape relations were acquired under continuous reinforcement. The letter–shape trials were mixed in with number–letter trials such that eight trials were new direct relations under continuous reinforcement and four trials were previously trained relations under intermittent reinforcement.

Phase III: probes for formation of stimulus classes. After reaching criterion on all sequences of direct relations, a series of probe sessions tested for formation of two number–letter–shape stimulus classes. The probes determined whether a subject who matched "5" with "V" and "V" with a rectangle would make selections consistent with the untrained relation of "5" and rectangle (see Figure 1). The untrained relation is part of a stimulus class that emerges when stimulus relations are both transitive and symmetric. In other words, we tested for the emergence of AC and CA relations (as described by standard matching-to-sample terminology). The unreinforced probe trials were interspersed among intermittently reinforced trials using the already trained number–letter and letter–shape pairs, such that 10 trials were probes and four trials were tests of directly trained relations. Subjects who did not meet criterion on the probes for emergent relations were required to repeat the letter–shape training sequence at criterion level before performing in another probe session.

Phases IV and V: extended exposure to the task. Once the mastery criterion was reached for an emergent-relations probe session, new stimuli were introduced into the procedure used in Phases II and III, and each child learned two new number–letter–shape stimulus classes. In other words, Phase IV consisted of each child learning direct arbitrary relations with two new stimulus sets, and Phase V consisted of probes for emergent relations within those new stimulus sets (see Figure 1). This repetition of the design with new stimuli provided subjects with additional exposure to the acquisition method.

Phase VI: sensitivity to contingency change. After each child reached mastery criterion on the emergent-relations probe in the second set of stimulus classes, he or she immediately began another session of trials in which the arbitrary direct relations of those sets were scrambled. This session was begun without a break to avoid obvious hints that the stimulus relations had changed. For the first six trials of this additional session, the relations and contingencies were the same as in the last session. For the next 14 trials, however, some of the correct pairings were changed. Two of the four original direct relations changed and were trained in eight trials; the other two matches remained as they were previously and were trained in six trials. For example, initially the second stimulus class was established by training the following direct relations: "7" goes with "L," "L" goes with plus sign, and "8" goes with "F," "F" goes with diamond. The scrambled stimulus class training, however, consisted of the following: "7" goes with "L," "L" goes with diamond, and "8" goes with "F," "F" goes with plus sign (see Figure 1). The final six trials of each session probed for the emergent relations within the changed stimulus classes. The unreinforced probes were embedded among intermittently reinforced tri-

PHASE I - IDENTITY MATCHING AND GENERALIZED IDENTITY MATCHING

ID	2	H	□	❤	K
GEN ID	3	4	Z	★	○

PHASE II - TRAIN DIRECT STIMULUS RELATIONS-SET 1

TRAIN 5 → V

V → ▭

6 → T

T → △

PHASE III - PROBE FOR STIMULUS CLASSES-SET 1

TEST 5 → ▭

▭ → 5

6 → △

△ → 6

PHASE IV - TRAIN DIRECT STIMULUS RELATIONS-SET 2

TRAIN 7 → L

L → +

8 → F

F → ◇

PHASE V - PROBE FOR STIMULUS CLASSES-SET 2

TEST 7 → +

+ → 7

8 → ◇

◇ → 8

PHASE VI - RULE CHANGE

TEST 7 → L

L → ◇

8 → F

F → +

Fig. 1. The configuration of stimulus sets and the sequence of trained and emergent relations for all phases of the experiment.

als that trained direct relations, such that four trials were probes and two trials were tests of directly trained relations. Sessions with the scrambled direct relations were repeated only until the mastery criterion for direct relations was met, even if the emergent relations were not mastered.

To provide an experimental context comparable to prior research on this topic, half of the direct relations in each stimulus class remained unchanged so that some of the original sample–comparison matches would still be reinforced. Under previous experimental procedures (e.g., Matthews et al., 1977; Shimoff et al., 1981), it would be easy to miss the unannounced changes in the multiple schedule because the pattern of performance acquired under the original schedule would still generate some reinforcers after the schedule components were switched. Having some unchanged direct relations in the present procedure created a context with ambiguous feedback comparable to that received from unannounced changes in the multiple schedules used previously. The scrambling of the stimulus sets was done in the middle of a session because some subjects in pilot procedures picked up the changes immediately when they were accompanied by completely restarting the computer.

Methods of Acquisition

All subjects performed the same task, but there were three different methods of training the stimulus relations in the task.

Instructed condition. The children in the instructed condition were given the following verbal rules about how to use the touch screen and which stimuli were paired:

> You are here to play a computer game. You can do this by touching the screen on the T.V. When the first shape appears, touch it with your finger. Then, two more shapes will come on the T.V. To play the game, you then need to touch the shape that goes with the first one you touched. After a while, another shape will come on the T.V. in the middle again. Keep playing the game by touching the screen until it is over. Please begin.

Children in the instructed condition were also given the following instructions at the beginning of each session that trained direct arbitrary relations:

> This game is a little different from the others you have played so far. To help you play the game, I will show you the shapes that go together. They will appear together on the computer screen. When you think you can remember the two shapes that go together, touch the middle of the screen to see the next ones. After this you can play the game.

At this point all correct stimulus pairs for the session were presented to the child. Each child was able to view the stimulus pair until a touch on the center of the screen brought on the next pair. Each correct pair was displayed twice.

Contingency-shaped condition. A second group of children was given very limited instructions about how to perform the task. Information about matching pairs of stimuli could be gained only through interaction with the contingencies. Children in the shaped condition were told the following at the beginning of each experimental session: "You are here to play a computer game. You can play the game by touching the screen. Please begin." Children in the shaped condition were given no additional information about matching the arbitrary stimulus pairs.

Imitation condition. Finally, a third group of children was provided with an adult model who correctly performed the task while the child watched. Very limited verbal instructions were provided to these children. Children in this group were told the following: "You are here to play a computer game. Watch me and I will show you how the game works." Children in the imitation condition were alerted to watch as the adult model made correct matches on two experimental trials per pair of arbitrarily matched stimuli. These matched trials contained the same correct information as the verbal instructions given to instructed children. There was no other verbal interaction in this condition.

RESULTS

Regardless of acquisition history, all of the children successfully learned both the direct relations trained for all stimulus classes and all emergent relations for stimulus classes trained through Phase V. There were differences in the number of sessions required to learn the direct relations, with instructed and imitated relations being acquired faster than

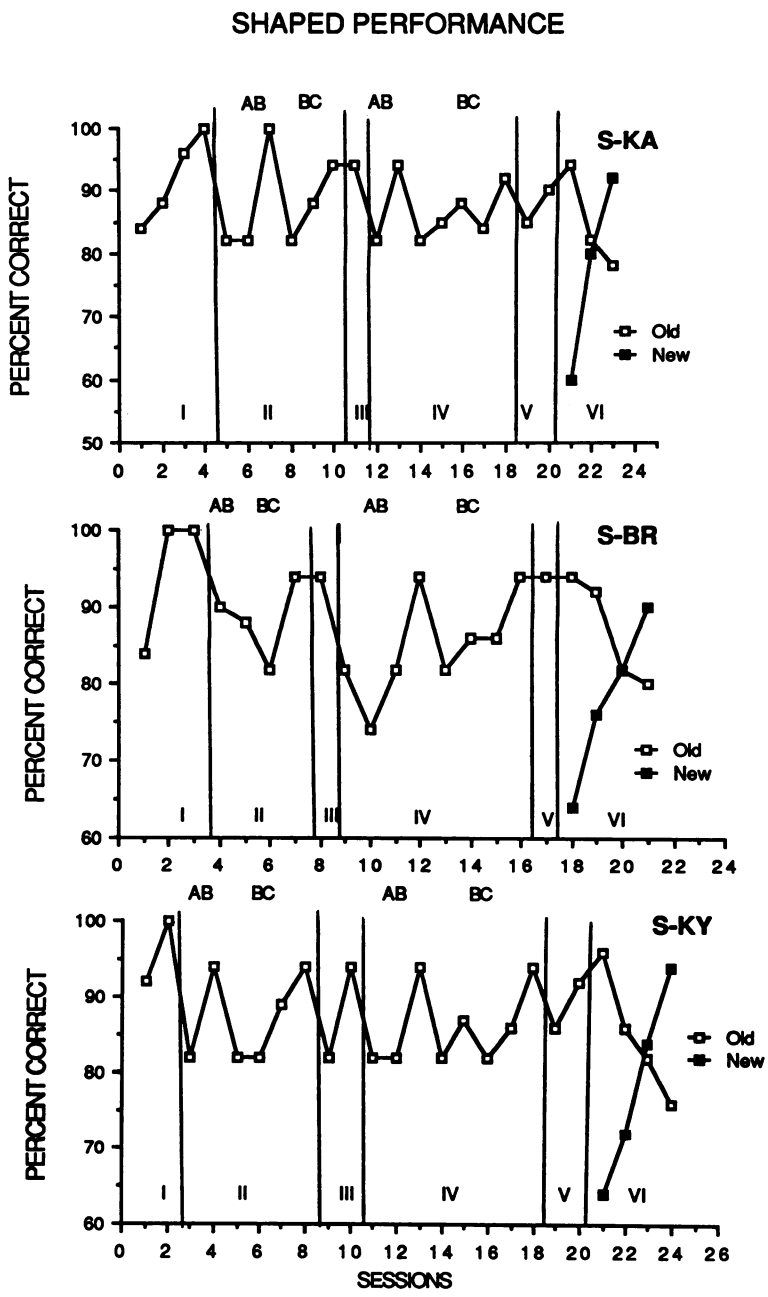

Fig. 2. Percentage correct in each experimental session for individual subjects in the noninstructed group. Experimental phases are separated by solid lines. The rule-change sessions show percentage correct on both the changed (new) and the unchanged (old) stimulus relations. Roman numerals indicate phases of the experiment. Capital letters in upper right of each graph are subject identifiers.

shaped relations. All subjects also learned the new relations following the scrambling of the stimulus classes in Phase VI, although there was some variability in the number of sessions needed to recognize the new contingencies. This is an especially important finding for those cases in which the change was in conflict with the instructions and model provided during acquisition. Details of the results are presented separately for direct relations, emergent stim-

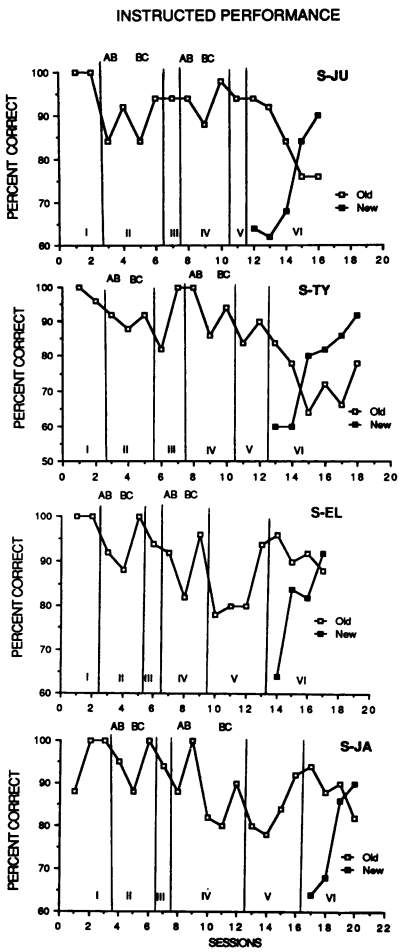

Fig. 3. Percentage correct in each experimental session for individual subjects in the instructed group. Experimental phases are separated by solid lines. The rule-change sessions show percentage correct on both the changed (new) and the unchanged (old) stimulus relations. Roman numerals indicate phases of the experiment. Capital letters in upper right of each graph are subject identifiers.

ulus classes, and the changed stimulus relations.

Acquisition of Direct Relations

The method of acquisition had a clear effect on how many sessions were required to learn the direct relations. Figure 2 shows the performance of individual children in the contingency-shaped condition. Four to eight sessions were needed to acquire the two sets of direct arbitrary relations in the primary training periods (Phases II and IV), with most children needing at least six sessions to reach the mastery criterion. Individual performances of the 4 children in the instructed condition are shown in Figure 3. Three to five sessions were needed to acquire the direct relations, with most children needing only three sessions to advance to the probe for emergent relations. Given that acquisition of the direct relations requires at least two sessions, the performance of this group demonstrates that instructions fostered rapid acquisition of direct relations. Figure 4 shows the individual performances of children in the imitation condition. For the Phase II and IV direct arbitrary relations learned by these 5 children, two to five sessions were needed before advancing to the probes, with most children needing no more than three sessions to reach criterion. These children quickly learned the direct relations through a history of imitation. Table 1 summarizes the number of acquisition sessions needed to reach criterion for all subjects.

Given that the distributions of performance by the groups were overlapping, statistical comparisons were made between conditions for the acquisition of the direct relations. A Mann-Whitney U test for distribution overlap showed a significant difference in sessions to criterion between the children in the shaped condition and the children in the instructed condition, $z = 2.12$, $p < .05$. A significant difference in performance was also found between subjects in the shaped condition and subjects in the imitation condition, $z = 2.24$, $p < .05$.

Formation of Stimulus Classes

Once the direct relations were mastered, all subjects demonstrated the emergent stimulus relations within a few sessions, regardless of their acquisition history. For the 3 children whose direct matching was shaped, one or two sessions of probe trials mixed with training trials (Phases III and V) were needed to demonstrate emergent stimulus relations (see Figure 2). The 4 instructed children needed one to four sessions to demonstrate emergent relations, with two or fewer sessions needed in six of the eight probe phases (Phases III and V combined, see Figure 3). The 5 children who acquired the relations through imitation needed one to four sessions to reach criterion on the Phase III and V probes, with three or fewer sessions needed in nine of the 10 probe phases (see Figure 4). Table 1 provides summary data for all subjects on probes for emergent stimulus relations, and it shows there were no major differences among the groups.

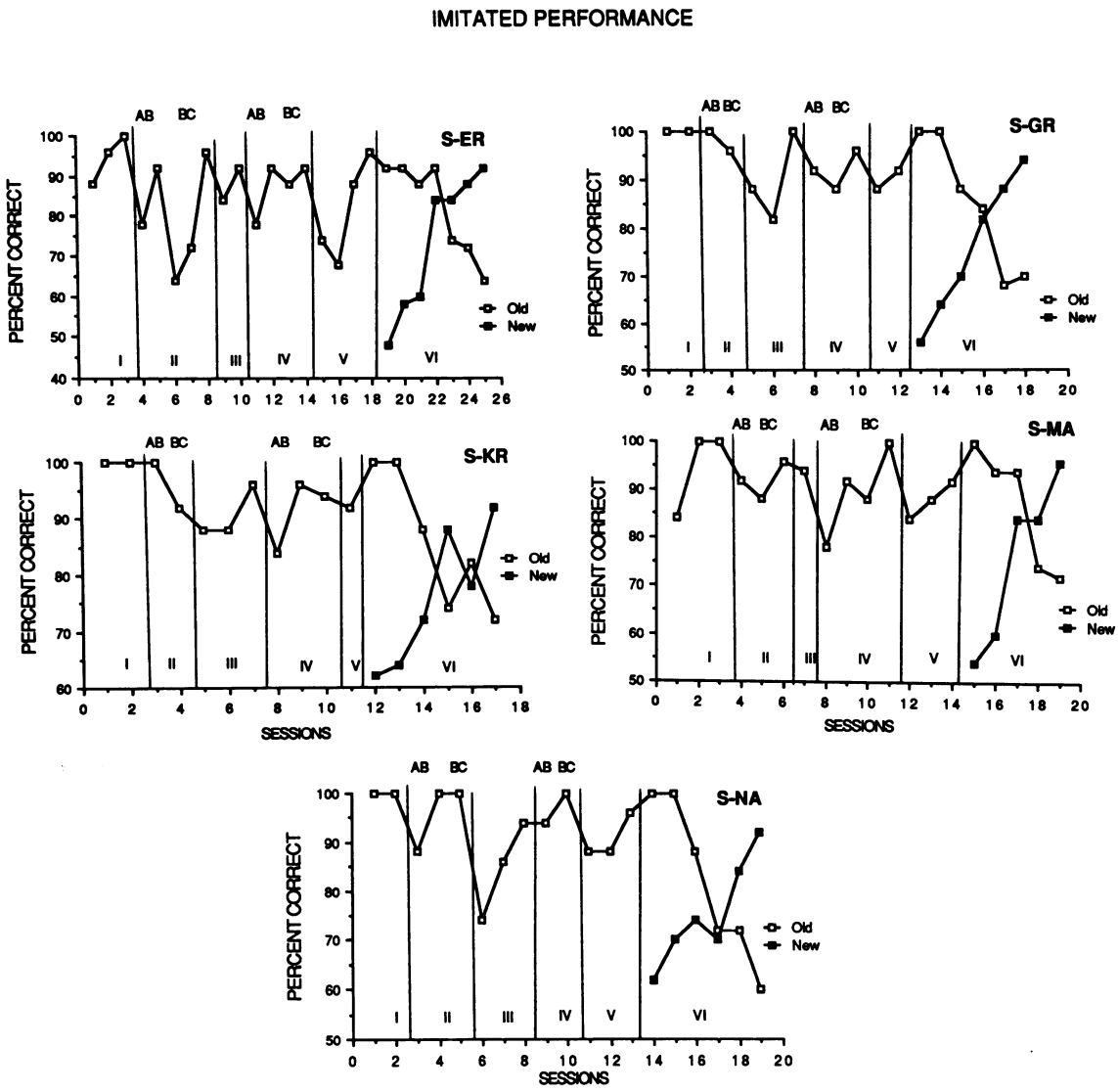

Fig. 4. Percentage correct in each experimental session for individual subjects in the imitation group. Experimental phases are separated by solid lines. The rule-change sessions show percentage correct on both the changed (new) and the unchanged (old) stimulus relations. Roman numerals indicate phases of the experiment. Capital letters in upper right of each graph are subject identifiers.

Sensitivity to Rule Change

All subjects, regardless of their acquisition history, performed at criterion level on the changed direct stimulus relations (Phase VI). Even though all subjects acquired the new relations, there were differences in the number of sessions each group needed for acquisition. Those subjects who learned stimulus relations through imitation were slower to change than the children whose performance was either instructed or shaped. The children in the imitation condition needed between five and seven sessions to master the new relations (see Figure 4). Three of these children needed six sessions, 1 child needed five sessions, and 1 needed seven sessions to reach criterion. In contrast, the 3 children who learned through contingencies needed only three or four sessions before reaching criterion on the changed direct relations (see Figure 2). One of these children needed three sessions, and the other 2 children each needed four sessions before reaching criterion. The instructed children showed some overlap

Table 1

Number of sessions to criterion (90% correct) for each stimulus set and for the rule change; final percentage correct on probes for emergent relations following rule change.

	Method of acquisition											
	Shaping			Instructions				Imitation				
	Subjects			Subjects				Subjects				
	Br	Ky	Ka	Ju	Ty	El	Ja	Na	Ma	Gr	Kr	Er
Acquisition of direct relations												
Set 1	4	6	6	4	3	3	3	3	3	2	2	5
Set 2	8	8	7	3	3	3	5	2	4	3	3	4
Acquisition of emergent stimulus relations												
Set 1	1	2	1	1	2	1	1	3	1	3	3	2
Set 2	1	2	2	1	2	4	4	3	3	2	1	4
Acquisition of rule change												
New rules	4	4	3	5	6	4	4	6	5	6	6	7
Percentage correct on emergent relation probes following rule change												
	67	67	50	67	67	50	83	50	67	67	50	50

in performance with the children who learned through contingencies, needing from four to six sessions to master the new relations (see Figure 3). Two of these children needed four sessions, 1 needed five sessions, and 1 needed six sessions before reaching criterion.

Given that the distributions of performance by the groups were overlapping, statistical comparisons were made between conditions using the Mann-Whitney U test for distribution overlap. The comparison showing the imitation group to be slower than the group exposed to shaping was significant, $z = 2.24$, $p < .05$, and the comparison showing the imitation group to be slower than the instructed group was also significant, $z = 1.71$, $p < .05$ (one-tailed only). Although subjects whose behavior was instructed adapted to the new stimulus relations slightly more slowly than subjects whose behavior was shaped, the difference was not statistically significant, $z = 1.41$, $p > .05$. Subjects in the present study were most resistant to change when their behavior was acquired by watching a model.

Following the rule change, all three groups of subjects performed equally on the probes for emergent relations in the changed stimulus classes. At the point at which the new direct relations were mastered by all subjects, the study was discontinued and no subjects had yet reached criterion-level performance on the changed emergent relations (see Table 1). The percentage of correct trials for emergent relations during the rule-change sessions was lower for all subjects than during those previous sessions that tested for emergent stimulus classes. Because our main interest was in adaptation to changing contingencies, we did not require children to participate in additional sessions to reach criterion on probes for emergent relations following the rule change. In addition, the figures show that, as subjects acquired the new direct relations, their performance on the unchanged relations deteriorated. As the consequences changed for some of the direct relations, performance on all previous relations disintegrated.

Table 1 summarizes, for all subjects, the number of sessions needed to reach criterion on the rule change and the percentage of probe trials consistent with emergent relations within the new established stimulus classes. Given sufficient exposure, subjects with all three histories were sensitive to changes in the contingencies on direct stimulus relations. Subjects provided with imitative and instructional histories generally needed more trials to reach criterion under the new contingencies than did those subjects whose performance was shaped, although there was some overlap between the instructed and shaped groups and the difference was not statistically significant.

DISCUSSION

All of the children in this study learned the changed direct relations regardless of their acquisition history. There were some differences among classes of behavior acquired by rules, by interaction with contingencies, and by imitation, but no class of behavior was insensitive to new contingencies on direct relations. Those children with a history of imitation or instructions acquired the direct relations quickly relative to the children exposed to shaping, and they took longer to adapt to the new contingencies than did those children whose responding was initially shaped to perform the task. The differences in speed of adaptation found in this study are modest, and there is overlap among the groups in the number of trials to mastery. An imitative or rule-governed history may delay acquisition, but in this context it did not completely block a change in behavior.

One practical implication of the present results is that teachers and parents need not avoid the use of rules as part of children's learning histories. If there is sufficient exposure to contingencies, instructed or modeled acquisition of responding need not interfere with making contact with the consequences of behavior. Prior research has suggested that a history of self-generated or instructed rules specifying likely contingencies will compete with an actual history of contingency experience for control of behavior. The present data suggest that the actual history competes effectively with a rule-governed history given sufficient exposure. Although a specific history of rules may delay changes in pattern of performance, the effect is transient and is not sustained when the procedures are continued beyond a few hours.

One possible explanation for the transient effects in the present experiment is that the learning history provided in this experiment was insufficient to have an impact on the subjects. This account is unlikely, however, because the method of acquisition made a clear difference in learning the directly trained relations. In addition, the duration of exposure to the learning history in the present experiment (12 to 20 15-min sessions before the test for sensitivity) is longer than the exposure typically used in research that finds an effect of history. It is more likely that the present procedure yielded a transient effect because subjects were exposed to the changes until they identified the new relation between behavior and consequences. In previous research the amount of exposure to the changed contingency was predetermined and often brief.

Another possible reason for the difference between present and previous results is the age of subjects in this study. Perhaps young children with a shorter history of relying on rules for performance may not demonstrate rigid adherence to those rules. Other researchers in this area have discussed this issue (Matthews et al., 1977; Vaughan, 1985), and it is an empirical question worthy of further research. When age is included as part of a research design, however, the procedures should be kept in force long enough that contingencies can be expected to compete with the recent acquisition history provided by the experiment.

One interesting result of the present study is that the performance of the children in the imitation condition was almost identical to that of the instructed children. One account of this similarity could be the role of self-instruction, such as Lowe's (1983) suggestion that humans often form covert rules about a situation. An account making reference to self-instruction does not, however, explain why children in the contingency-shaped condition would not generate equivalent rules based on their experience of the consequences of responding. A second variable that could contribute to the similarity in performance is the source of the information. Literature in social psychology suggests that compliance increases when the source (in this case, the experimenters) has the power to deliver rewards (Forsythe, 1987), and the experimenter is the source of both instructions and modeled performance. It is possible that instructions or modeled behavior may be less rigidly adhered to if either is provided to subjects by a disliked or unimportant source.

Future studies comparing rule-based acquisition with other forms of acquisition should also broaden the definition of *sensitivity* in behavior. To date, studies have defined sensitivity as behavior that adapts to changing contingencies. It is possible that behavior that adapts to other kinds of changes could also be construed as sensitive. A person with a history of instructions might be able to detect a change in instructions more quickly than someone whose behavior was initially shaped. There might also be situations in which being sen-

sitive to the changing behavior of a model would be desirable. Attention needs to be given to all possible interactions in this paradigm for a clear conceptual picture to emerge.

In addition, our review of the relevant literature revealed a methodological limitation in this area of research. Although behavior-analytic research typically employs within-subject procedures, most of the studies on this topic used between-group designs, often with relatively few subjects per condition. Only the study by LeFrancois et al. (1988) used a between-group design with enough subjects for statistical analysis. The present study was conducted for a longer period of time, but the basic design is similar to most of the previous research and shares the same methodological problem. Constructing a within-subject design with history as the main independent variable is not easy, but future research should acknowledge this difficulty and either construct appropriate designs or use enough subjects to provide analysis appropriate to the designs used.

In summary, the current study extended research in the area of rule-governed and contingency-shaped behavior. First, the task involved was the formation of stimulus classes rather than schedule performance. Second, the length of the procedure was extended so that the contingencies had more time to have an impact on responding. Finally, imitation was added as a form of acquisition, and it generated behavior closely resembling rule-governed behavior. Further work is needed to examine the limitations of these findings, but this study has broadened the scope of research in this area.

REFERENCES

Baer, D. M., Peterson, R. F., & Sherman, J. A. (1967). The development of imitation by reinforcing behavioral similarity to a model. *Journal of the Experimental Analysis of Behavior,* **10,** 405–416.

Baer, D. M., & Sherman, J. A. (1964). Reinforcement control of generalized imitation in young children. *Journal of Experimental Child Psychology,* **1,** 37–49.

Baron, A., & Galizio, M. (1983). Instructional control of human operant behavior. *Psychological Record,* **33,** 495–520.

Bernstein, D. J. (1988). Laboratory lore and research practices in the experimental analysis of human behavior: Designing session logistics—how long, how often, how many? *Behavior Analyst,* **11,** 51–58.

Forsythe, D. R. (1987). *Social psychology.* Monterey, CA: Brooks/Cole.

Hayes, S. C., Brownstein, A. J., Zettle, R. D., Rosenfarb, I., & Korn, Z. (1986). Rule-governed behavior and sensitivity to changing consequences of responding. *Journal of the Experimental Analysis of Behavior,* **45,** 237–256.

LeFrancois, J. R., Chase, P. N., & Joyce, J. H. (1988). The effects of a variety of instructions on human fixed-interval performance. *Journal of the Experimental Analysis of Behavior,* **49,** 383–393.

Lowe, C. F. (1983). Radical behaviorism and human psychology. In G. C. L. Davey (Ed.), *Animal models of human behavior* (pp. 71–93). Chichester, England: Wiley.

MacDonald, R. P. F., Dixon, L. S., & LeBlanc, J. M. (1986). Stimulus class formation following observational learning. *Analysis and Intervention in Developmental Disabilities,* **6,** 73–87.

Matthews, B. A., Shimoff, E., Catania, A. C., & Sagvolden, T. (1977). Uninstructed human responding: Sensitivity to ratio and interval contingencies. *Journal of the Experimental Analysis of Behavior,* **27,** 453–467.

Rogers-Warren, A., & Baer, D. M. (1976). Correspondence between saying and doing: Teaching children to share and praise. *Journal of Applied Behavior Analysis,* **9,** 335–354.

Shimoff, E., Catania, A. C., & Matthews, B. A. (1981). Uninstructed human responding: Sensitivity of low-rate performance to schedule contingencies. *Journal of the Experimental Analysis of Behavior,* **36,** 207–220.

Sidman, M. (1986). Functional analysis of emergent verbal classes. In T. Thompson & M. D. Zeiler (Eds.), *Analysis and integration of behavioral units* (pp. 213–245). Hillsdale, NJ: Erlbaum.

Sidman, M., Kirk, B., & Willson-Morris, M. (1985). Six-member stimulus classes generated by conditional-discrimination procedures. *Journal of the Experimental Analysis of Behavior,* **43,** 21–42.

Sidman, M., & Tailby, W. (1982). Conditional discrimination vs. matching to sample: An expansion of the testing paradigm. *Journal of the Experimental Analysis of Behavior,* **37,** 5–22.

Skinner, B. F. (1969). *Contingencies of reinforcement.* New York: Appleton-Century-Crofts.

Vaughan, M. E. (1985). Repeated acquisition in the analysis of rule-governed behavior. *Journal of the Experimental Analysis of Behavior,* **44,** 175–184.

Wetherby, B., Karlan, G. R., & Spradlin, J. E. (1985). The development of derived stimulus relations through training in arbitrary-matching sequences. *Journal of the Experimental Analysis of Behavior,* **40,** 69–78.

Received November 27, 1989
Final acceptance January 24, 1991