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EFFECTS OF MODELING VERSUS INSTRUCTIONS ON SENSITIVITY TO REINFORCEMENT SCHEDULES

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This study examined the effects of modeling versus instructions on the choices of 3 typically developing children and 3 children with attention deficit hyperactivity disorder (ADHD) whose academic responding showed insensitivity to reinforcement schedules. During baseline, students chose between successively presented pairs of mathematics problems associated with different variable-interval schedules of reinforcement. After responding proved insensitive to the schedules, sessions were preceded by either instructions or modeling, counterbalanced across students in a multiple baseline design across subjects. During the instruction condition, students were told how to distribute responding to earn the most reinforcers. During the modeling condition, students observed the experimenter performing the task while describing her distribution of responding to obtain the most reinforcers. Once responding approximated obtained reinforcement under either condition, the schedules of reinforcement were changed, and neither instruction nor modeling was provided. Both instruction and modeling interventions quickly produced patterns of response allocation that approximated obtained rates of reinforcement, but responding established with modeling was more sensitive to subsequent changes in the reinforcement schedules than responding established with instructions. Results were similar for students with and without ADHD.

DESCRIPTORS: attention deficit hyperactivity disorder, concurrent schedules, history effects, instructions, matching, modeling, verbal behavior

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According to the matching law, the distribution of behavior across response alternatives tends to be proportional to the reinforcement derived from those alternatives (Baum, 1974; Herrnstein, 1961). This has been demonstrated repeatedly in basic research with nonhuman subjects (see Davison & McCarthy, 1988). That is, in a symmetrical concurrent-schedules arrangement in which identical response options produce identical reinforcers correlated with independent schedules (e.g., pecks on one key are reinforced with access to food on a variable-interval [VI] 30-s schedule, and pecks on another are reinforced with access to food on a VI 60-s schedule), the rate of responding to each of the two keys tends to occur in the same proportion as the relative rate of reinforcement (e.g., on a 2:1 ratio).

Although the matching law has clear implications for the study of choices among multiple response options available to humans (see Fisher & Mazur, 1997; Pierce & Cheney, 2004), deviations from matching often occur. Responding by some individuals may be insensitive to relative rates of reinforcement. Neef, Mace, Shea, and Shade (1992), for example, found that the choices of participants (special education students) between mathematics problem alternatives did not show sensitivity to features of the VI reinforcement schedules until countdown timers (which nonverbally described the

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schedules) were used. In a related investigation of the influence of reinforcer rate, quality, delay, and response effort on choice, only 1 of 11 students showed sensitivity to differences in the rates of reinforcement relative to the other dimensions, even though participants were first required to sample the response alternatives associated with the different schedules (Neef & Lutz, 2001).

Horne and Lowe (1993) also observed schedule insensitivity in adults' choices under a series of multiple concurrent VI schedules. In each of the six experiments, different geometric shapes or lights signaled the VI schedules in effect. Nevertheless, 8 of the 30 participants showed undifferentiated responding, 9 showed proportionally more responding to the leaner schedule (undermatching), and 6 showed overmatching (e.g., exclusive responding to the richer schedule). Participants' reports about their response strategies indicated that their responding conformed to rules they had formulated about how to respond, even though their self-generated rules did not always accurately reflect the schedules in effect. These results suggest that human choice may be controlled by self- or other-generated verbal behavior that changes the likelihood of subsequent verbal and nonverbal behavior, as well as by direct contact with reinforcement contingencies operating in the environment (see also Catania & Shimoff, 1998; Catania, Shimoff, & Matthews, 1989).

Therefore, one way to establish performance that is sensitive to current reinforcement contingencies might be to provide instructions that accurately describe those contingencies. Instructions are a ubiquitous and efficient means of influencing behavior in the natural environment, and are one form of priming (the presentation of a stimulus that affects responding after the stimulus is removed; Catania, 1998). However, research indicates that instructed performance is not always sensitive to subsequent changes in reinforcement (Bicard & Neef, 2002; Catania et al., 1989; Michael & Bernstein, 1991). One possible reason is that, because compliance with instructions may restrict the range of responding, it limits the extent to which behavior contacts, and can be affected by, altered nonverbal contingencies (e.g., Chase & Danforth, 1991; Galizio, 1979).

Some authors have suggested that certain populations differ in sensitivity of instructed performance to reinforcement changes (e.g., Barkley, 1997; Wulfert, Greenway, Farkas, Hayes, & Dougher, 1994). Barkley, for example, asserted that children with attention deficit hyperactivity disorder (ADHD) are likely to display greater response variability and sensitivity to nonverbal contingencies relative to instructions, and that their responding "may be less rigid or more flexible when the rule in effect is later shown to have been incorrect, since ADHD individuals are not governed by the rule as much in the first place" (p. 248). Bicard and Neef (2002) demonstrated that the type of instructions provided might differentially affect the sensitivity of responding to changes in reinforcement with children who had a diagnosis of ADHD. Tactical instructions (which specified an optimal response pattern for the reinforcement schedules in effect) established behavior that was slower to adapt to changing contingencies than did strategic instructions (which provided a strategy to determine the optimal response pattern for the reinforcement schedules).

One alternative to instructions, which also is used frequently in the natural environment, is modeling. In the process of demonstrating responding that is effective in producing reinforcement, modeling can also make apparent the strategy used to establish optimal responding. In this way, modeling might function in a manner similar to the strategic instructions used by Bicard and Neef (2002). On the other hand, modeling can differ from instructions in several key ways. For example, modeling demonstrates both the response and the consequences of that response, whereas instructions only describe that presumed relation. Thus, modeling might make more prominent the desired response (which is shown rather than described) as well as its relation to reinforcement (which is illustrated rather than requiring a presumption as to its accuracy). Instructions are simple and efficient; however, initial compliance with another's instructions is likely to depend on an individual's history of reinforcement for following them. Thus, instructions and modeling might differ in the extent to which each establishes responding that is sensitive to reinforcement contingencies initially, and when they are altered subsequently.

In the present investigation, we examined the effects of two types of priming procedures—prior instructions and modeling—on the choices of students whose academic responding showed insensitivity to reinforcement schedules, and we compared the performance of students with and without ADHD. With instructions, students were told how to allocate their responses across academic tasks to obtain the most reinforcers; with modeling, students observed the experimenter choosing and performing the tasks as she verbalized her distribution of responding to obtain the most reinforcers. We then examined the history effects of responding established through instructions or modeling on schedule sensitivity (matching) when the reinforcement schedules changed. Finally, we examined the students' verbal behavior to determine the extent to which it described effective patterns of time allocation and its relation to the students' nonverbal performance.

METHOD

Participants and Setting

Two girls and 4 boys served as participants. Maude (11 years old), Ling (11 years old), and Ann (10 years old) were typically developing children in the fifth grade of a public elementary school. The other 3 participants (Del, Matt, and Gene) had been diagnosed with ADHD according to the criteria of the *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.; American Psychiatric Association, 2000). Del (10 years old) attended fifth grade at the same public elementary school as Maude, Ling, and Ann. He had been prescribed 40 mg of Metadate CD® in the morning, which he took throughout the study. Matt and Gene attended the same private school as one another. Matt (12 years old) was in the sixth grade and was not receiving any medication. Gene (13 years old) was in seventh grade and had been prescribed Adderall® (15 mg in the morning and 10 mg in the afternoon). His medication remained unchanged throughout the study.

The students originally had been enrolled in another study to examine reinforcer dimensions affecting response allocation; however, they did not meet criterion for continued participation because their choices did not show discrimination between high and low rates of reinforcement during baseline conditions similar to the no-instruction condition described below. The current study was conducted in a small room of the school with only the experimenter and the student present (Matt and Gene), in a quiet corner of a classroom, or in an empty hallway (Maude, Ling, Del, and Ann).

Apparatus and Stimuli

The experimental task was conducted on a Dell computer (Inspiron® 3800 or 5000c) using a software program identical to one described by Neef, Bicard, and Endo (2001) and Bicard and Neef (2002). The program provided a menu from which the experimenter selected mathematics problems (e.g., levels of addition, subtraction, and multiplication) and VI schedules of reinforcement for task completion. Mathematics problems of moderate difficulty were selected for each student based on preexperimental assessment of performance on samples of different types of problems. All students completed at least 75% of the problems correctly at the identified level during a pretest. The target problems consisted of single-digit (0 to 9) subtraction (Ann), one-digit from two-digit subtraction without regrouping (Maude), double-digit subtraction without regrouping (Ling), multiplication with single digits (Matt and Del), and addition with sums to 18 (Gene). The computer program was equipped to record the number of problems attempted, the number of problems completed accurately and inaccurately, the number of points obtained, and the cumulative time spent completing problems for each problem set.

During experimental sessions, two different-colored problems appeared on the left (Set 1 problems) and right side (Set 2 problems) of the monitor (choice screen). The cumulative number of reinforcers (points) obtained from each problem set, and the "store" (A or B) containing items that could be purchased with points earned for problem completion, were displayed under the respective problems. Once the student selected a mathematics problem by pointing and clicking with a mouse, only the selected problem appeared on the screen along with a small clock that showed how much time was left to complete the problem, and the VI timer began. The problem remained on the screen until the student entered the correct answer from the keyboard or the preset time of 30 s elapsed without a response (the student could reset the clock by pressing any key). The choice screen appeared with two new problems after a correct response was entered, if the time ran out before the student entered a response, or if the student chose not to complete either of the problems displayed and pressed the reset button. Following an incorrect response, the words "try again" appeared on the screen, and the computer presented the same problem with the clock reset. Differential auditory stimuli signaled reinforcer delivery for Set 1 and Set 2 problems. Problems completed correctly (initially or after re-presentation following an error) were reinforced on a VI schedule as described below. Problems continued to be presented in this manner for the duration of the session.

Procedure

One to two 10-min sessions were conducted per day, 3 to 5 days per week. Each experimental session was preceded by a 5-min period of either practice or modeling (depending on the condition) as described below. Five prizes that included a variety of preferred tangible items and activities (e.g., small toys and novelty items, comic books, snack items, juice boxes, tattoo stickers, 5 min of free time, a certificate for good work, etc.) were selected each session. The prizes were based on a brief preference assessment conducted before each session; the student selected an item from among 10 that he or she wanted to earn, the item was removed, and the student selected again, until the five most preferred items were identified. The experimenter placed duplicates of each of these items in stores designated as "Store A" and "Store B," indicating the stores from which items could be purchased with points earned from the two sets of problems. Students could elect to have more than one of the same item placed in the stores. The experimenter explained to the students that the points they earned for doing the mathematics problems from the different sets could be used to purchase items from the respective stores, that each item cost 4 points, and that they could choose to work on problems from either set at any time. The concurrent schedules programmed for each experimental condition are described in the Results section.

No instruction. Immediately before each experimental session, the student completed a 5-min practice during which he or she was required to sample the response alternatives and respective rates of point delivery for problem completion. This ensured that students contacted both of the reinforcement schedules prior to the experimental sessions. Correct completion of problems from the two sets was reinforced on concurrent VI VI schedules ranging from 15 s to 240 s (e.g., VI 15 s VI 90 s). The concurrent VI schedules in effect during the practice were the same as those used during the subsequent experimental session (however, points earned during practice could not be used to purchase prizes). No information was provided concerning the schedules other than through direct exposure to the contingencies in effect.

Modeling. Before each experimental session, the student sat next to the experimenter while she modeled allocation of responding to obtain the most points and "talked out loud." The experimenter described her actions because previous research has indicated that modeling is enhanced when it is accompanied by verbal behavior (e.g., Coates & Hartup, 1969; Jahr & Eldevik, 2002; Werts, Caldwell, & Wolery, 1996). The experimenter said, for example, "I'll try problems from this set to see how the computer is giving me points. . . . Now I'll try the other set to see if I get points more often. . . . No, it's taking more time to get points, so I'll go back to Set 1. . . . I'll check out Set 2 again. . . . Good, I got a point . . . but now it's been a while, so it looks like I should spend more time on Set 1 and then after a minute see if a problem on Set 2 will give me a point." The experimenter distributed her responding between the problem alternatives to correspond with the schedules in effect. At the end of 5 min, she announced the number of points she had earned. The concurrent schedules in effect during the subsequent practice and experimental session were the same as those in effect during modeling.

Instructions. Conditions were the same as in the no-instruction condition except that the experimenter gave the participant specific instructions for earning the most points with the concurrent schedules in effect: "The best way to earn the most points is to spend about — seconds doing problems from Set 1, and then about — seconds doing problems from Set 2, going back and forth."

Postsession Verbal Reports

At the end of each experimental session, the experimenter asked the student, "What's the best way to earn the most points?" The experimenter also asked, "How did you decide which problems to do?" in the event that the student's response to the first question was ambiguous. The experimenter recorded the student's responses verbatim, without comment.

Experimental Design

The design used for this study was a counterbalanced multiple baseline design across subjects within two groups (those for whom the first intervention was modeling or instructions, respectively). Each student was first exposed to a no-instruction baseline, which was implemented under a concurrent VI 15-s VI 90-s schedule for all students except Matt. A concurrent VI 15-s VI 240-s schedule was used with Matt (and Gene in subsequent baseline sessions) to determine whether sensitivity could be established by making the schedules more discriminable.

The no-instruction baseline was followed by the staggered introduction of a priming intervention consisting of either modeling (Maude, Del, and Ling) or instructions (Ann, Matt, and Gene). Because Ann's responding was highly variable in the instruction condition, a modification was made in which she was required to repeat the experimenter's instruction to ensure that she had attended to it. Either concurrent VI 15-s VI 240-s or concurrent VI 15-s VI 90-s schedules were used during intervention. The schedules were the same as those used during the preceding no-instruction baseline, except for Maude (modeling) and Ann (instruction); different schedules were used with them as an additional control for prior exposure. For all participants, the modeling or instruction intervention was continued until schedule-sensitive responding occurred (based on visual analysis, but with no more than 20% difference in the percentage between time allocation and reinforcement for at least two consecutive sessions).

The priming intervention was followed by a change in the reinforcement schedules with no instructions and no modeling, to assess the effects of the histories on adaptation to changing contingencies. Because sensitivity to the changed schedules occurred with modeling for Maude, Del, and Ling, ceiling effects prohibited subsequent comparison with instructions. Sensitivity to the changed schedules did not occur following the initial intervention (instructions) for Ann and Matt; therefore, the change in reinforcement schedules with no instruction and no modeling also provided a baseline for assessing the subsequent effects of modeling (after which the schedules were again changed, with no instructions and no modeling provided). Instructions also did not result in sensitivity to the changed schedules for Gene, but the school year ended before modeling could be implemented with him.

Data Analysis

Nonverbal responding. According to matching theory, schedule sensitivity occurs when behavior is allocated across response alternatives in proportion to the reinforcement obtained from those alternatives (Pierce & Cheney, 2004). Data on nonverbal responding were analyzed according to the proportion of time allocation in relation to the proportion of obtained reinforcement during each session. The former represent $T_1/(T_1 + T_2)$ (where T_1 and T_2 reflect the total amount of time spent on the task alternative subject to the respective reinforcement schedules), and the latter represent $r_1/(r_1 + r_2)$ (where r_1 and r_2 represent obtained rates of reinforcement on those alternatives). We analyzed time allocation rather than distribution of discrete responses because the former related more directly to the interval reinforcement schedules used.

Verbal behavior. The student's postsession verbal report was categorized as an accurate, inaccurate, or ambiguous description. An accurate description was recorded if the student described time-based responding that corresponded to the contingencies in effect (e.g., "To spend more time on Set 1 problems than Set 2 problems") or a way to determine how to allocate responding to conform to the schedules (e.g., "Try both sides first to see which one gives points more often"). An inaccurate description was recorded if the report did not describe time-based responding or if it did not specify an effective way to determine how to allocate responding to conform to the schedules (e.g., "Do the same number of problems on each side," "Work on one side until I get a point and then switch"). The verbal report was recorded as ambiguous if the description was unrelated to the schedules. These reports usually referred to subjective events and included responses such as "Look at the problems really carefully to see if I wanted to do them," "Try hard and pay attention," "Try your best," "Go fast," "Look at the problem, pay attention to the number, make sure of the right number," "I just always put the right answer," and "Pick whatever you want." Data on the verbal reports were summarized as the percentage of accurate and inaccurate reports (ambiguous responses were not included in the analysis).

Verbal–nonverbal correspondence. The experimenter compared the student's verbal description with the computer-generated data for the number of problems completed and time allocation from each set (Bicard & Neef, 2002). Positive correspondence was recorded if the student's verbal description closely approximated his or her nonverbal responding for the session. For example, if the student said, "to do the same number of problems on each side" and data showed that responding occurred in approximately equal proportions, positive correspondence was recorded (even if the description was not an accurate depiction of the reinforcement schedules). Negative correspondence was recorded if the student's verbal description did not reflect his or her nonverbal responding during the session (e.g., if the student gave the verbal description above but allocated 100% time to one set of problems). These scores were converted to ordinal data in which positive correspondence equaled 1 and negative correspondence equaled 0, for the purpose of a contingency space analysis (Matthews, Shimoff, & Catania, 1987). This analysis is a set of conditional probabilities described as the interaction between $p(y/x_1)$ and $p(y/x_0)$, where p is probability, y is nonverbal responding, x_1 is an accurate verbal description of responding, and x_0 is an inaccurate description of responding. Data approximating 1 indicate high correspondence; data at .5 or below indicate low correspondence.

Procedural Integrity and Interobserver Agreement

One of the other experimenters observed or listened to tape recordings of implementation of the procedures and completed a checklist on 25% of the modeling sessions across participants. The observer recorded whether or not the experimenter completed specified nonrecurring steps (e.g., programming the appropriate schedules for the condition in effect), and marked each time the experimenter completed a recurring step of the procedure during the session (e.g., describing actions and response–reinforcer relations while demonstrating optimal response patterns during the modeling condition). Procedural integrity (the percentage of steps on the checklist completed as specified) was 100% for all sessions (except for one step during one session for Maude).

On 33% of the experimental sessions across all conditions and participants, two of the experimenters compared the student's postsession verbal responses with the computer-generated data for nonverbal responding and independently categorized each verbal response as accurate, inaccurate, or ambiguous. Agreements for description categories occurred if the two observers scored the same category of description. Point-by-point agreement was 100%. Two of the experimenters independently scored correspondence data during 33% of the sessions across all conditions. An agreement was scored if the two experimenters recorded the same type of nonverbal–verbal correspondence. The observers agreed on all but one of the assessed verbal reports.

RESULTS

Nonverbal Responding

Figure 1 shows the extent of time-allocation matching across conditions for each of the 3 students (1 with and 2 without ADHD) who first received the modeling intervention following the no-instruction baseline. Figure 2 shows results for the 3 students (2 with and 1 without ADHD) who first received the instruction intervention following the no-instruction baseline. The data for all 6 students are portrayed as the percentage of time engaged in responding to

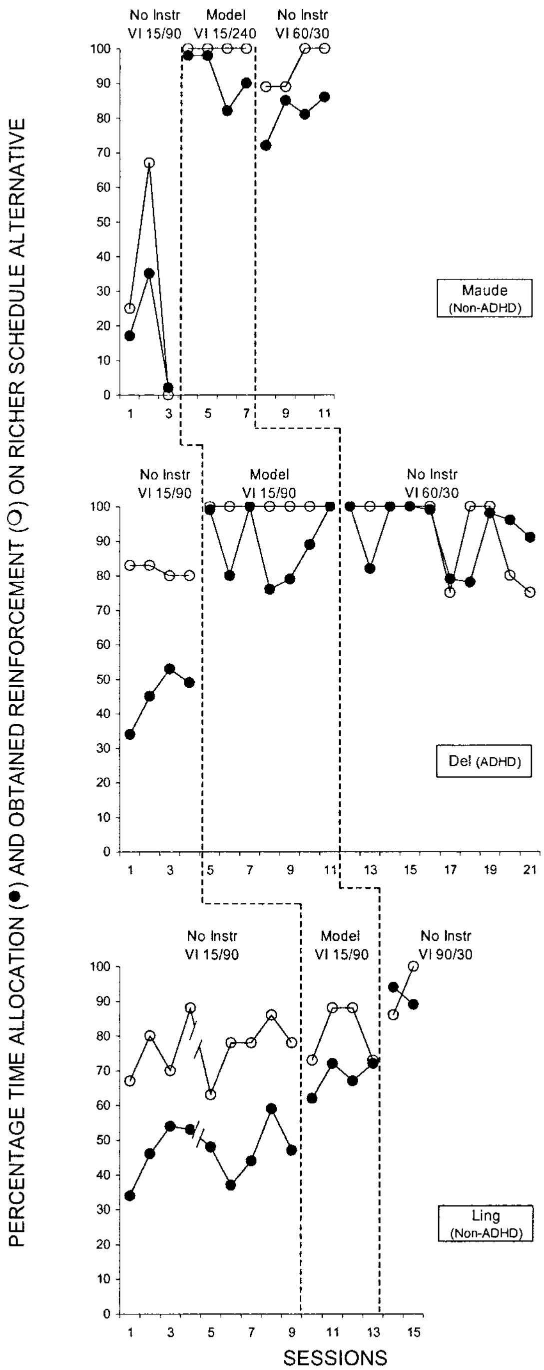

Figure 1. Percentages of time allocation (filled data points) and obtained reinforcement (open data points) on mathematics problems associated with the richer schedule across experimental conditions for Maude, Del, and Ling. Hatch marks in baseline for Ling indicate a discontinuous period of time between Sessions 4 and 5.

the problem alternative associated with the richer reinforcement schedule and the percentage of obtained reinforcement on that schedule.

During the no-instruction baseline condition, all 6 students demonstrated continued schedule insensitivity and undermatching. For Maude, Del, Ling, Ann, and Gene, who were exposed to concurrent VI 15-s VI 90-s schedules, the mean percentage of time allocation to the richer schedule (and the mean percentage of obtained reinforcement on that schedule, not counting the third session for Maude in which the absence of responding precluded reinforcement on the richer schedule) was 18% (46%), 45% (82%), 47% (76%), 40% (78%), and 24% (78%), respectively. Although Matt (and subsequently, Gene) were exposed to concurrent VI 15-s VI 240-s schedules in which the differences between the rates of reinforcement were more pronounced, schedule insensitivity was also evident (mean time allocation, 38% and 45%; mean percentage of obtained reinforcement, 96% and 99%, respectively).

When modeling was implemented for Maude (VI 15 s VI 240 s), Del, and Ling (VI 15 s VI 90 s), time allocation more closely approximated obtained rates of reinforcement. Mean time allocation (and mean percentage of obtained reinforcement) on the richer schedule was 92% (100%) for Maude, 90% (100%) for Del, and 68% (81%) for Ling. A subsequent change in the reinforcement schedules with no instruction or modeling showed continued schedule sensitivity. Maude (VI 60 s VI 30 s) allocated a mean of 81% time to the problems on the VI 30-s schedule (mean obtained reinforcement, 95%). Del (VI 60 s VI 30 s) allocated a mean of 91% to the problems on the VI 30-s schedule (mean obtained reinforcement, 92%). Ling (VI 90 s VI 30 s) allocated a mean of 92% to the problems on

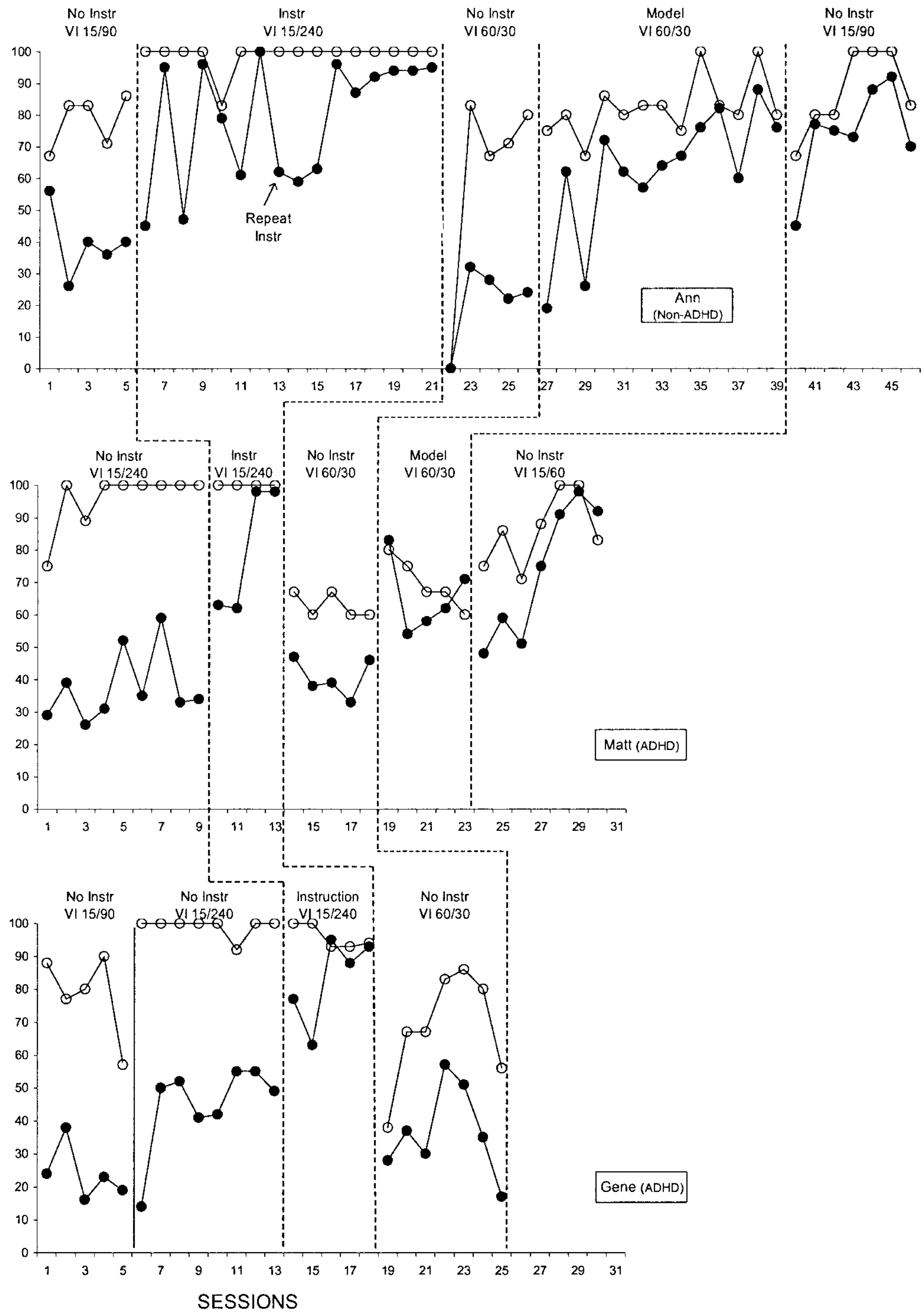

Figure 2. Percentages of time allocation (filled data points) and obtained reinforcement (open data points) on mathematics problems associated with the richer schedule across experimental conditions for Ann, Matt, and Gene.

Table 1
The Percentage of Accurate and Inaccurate Descriptions and the Probability of Correspondence (P of C) for each Participant across Experimental Conditions

Student	Conditions	% accurate	P of C	% inaccurate	P of C
Maude	Modeling	100	1	0	
	No instruction	100	1	0	
Matt	No instruction	11	1	89	1
	Instruction	100	1	0	
	No instruction	0		100	1
	Modeling	80	1	20	0
	No instruction	33	1	67	1
Gene	No instruction	0		100	.8
	Instruction	100	1	0	
	No instruction	0		100	1

the VI 30-s schedule (mean obtained reinforcement, 93%).

Instructions, implemented for Ann, Matt, and Gene (under concurrent VI 15-s VI 240-s schedules) also resulted in time allocation that more closely approximated obtained rates of reinforcement. The mean percentage of time allocation (and obtained reinforcement) for the problem alternatives associated with the 15-s schedule for Ann was 75% (98%) and was 82% (100%) during the same schedule in which she repeated the instructions. The means for Matt and Gene were 80% (100%) and 83% (96%), respectively. However, when the concurrent schedules were changed to VI 60 s VI 30 s in the absence of instructions, undermatching was more pronounced. The mean percentage of time allocation (and obtained reinforcement) on the problem alternatives associated with VI 30-s schedule (not counting the first session for Ann in which no reinforcement was delivered because no responses occurred on the richer schedule) was 27% (75%) for Ann, 41% (63%) for Matt, and 36% (68%) for Gene. When Ann and Matt subsequently received the modeling intervention, time allocation to the problems associated with the VI 30-s schedule (means were 62% for Ann and 66% for Matt) more closely matched the rate of obtained reinforcement (means were 82% for Ann and 70% for Matt). Responding remained relatively sensitive to reinforcement when the concurrent schedules were changed to VI 15 s VI 90 s for Ann and VI 15 s VI 60 s for Matt. The mean percentage of time allocated to the problem alternatives associated with the VI 15-s schedule (and the mean percentage of obtained reinforcement on that schedule) were 74% (87%) for Ann and 73% (86%) for Matt.

Verbal Behavior

Table 1 shows the percentage of accurate descriptions and the probability of verbal–nonverbal correspondence for Maude, Matt, and Gene across experimental conditions. Data for Del, Ling, and Ann are not presented because their postsession verbal reports were almost exclusively ambiguous (see examples described earlier).

During the initial no-instruction condition, Gene's verbal descriptions of the "best way to earn the most points" were inaccurate across all sessions, and Matt gave an accurate verbal description only for the first session. (Maude was not asked the question during this condition.) Matt's descriptions were based either on number of problems (e.g., "Work on Store B until 15 problems, then go to Store A and do in the same way") or points that did not reflect differences in obtained reinforcement (e.g., "After I got a point in Store A, I moved to Store B and did some"). Gene's descriptions reflected arbitrary responding after initial failure to obtain points on the leaner schedule (e.g., "Start on Store A then go to Store B. Why does Store B take so long to give points? What should you do?"; "Just go back and forth"). In general, the students' nonverbal responding paralleled the indifference reflected by their verbal descriptions.

During the modeling condition, Maude (first intervention) and Matt (second intervention) gave accurate descriptions on all but one session for Matt. Examples included "To think, try both sides, and choose carefully—I thought Set 1 gave me the most points" (Maude) and "Spending a couple minutes on one side and see what side gives more points and then work there more" (Matt). The descriptions closely corresponded to their nonverbal performance. During the instruction condition, Matt and Gene both gave accurate descriptions of the schedules (e.g., "Work on Set 1 for about 4 minutes, then do a problem on Set 2," "Do Set 1 problems then do Set 2 problems every 4 minutes") that generally characterized their performance.

During the no-instruction condition that followed modeling, Maude provided accurate descriptions during all sessions (e.g., "Try both sides and see and then do which side gives me more points"), which corresponded to her performance. Matt (second intervention) provided accurate descriptions during 33% of the sessions (e.g., "Work on Side A the most"). An example of his inaccurate description was, "Just do Store A." His descriptions characterized his performance, whether or not it reflected the schedules in effect.

During the no-instruction condition that followed instructions, Matt and Gene did not provide accurate descriptions of the schedules during any of the sessions. Examples of Matt's descriptions included "I don't know. It's changed but I don't know how. After I got a point, I moved to the next one on the other side" and "Do some from Store A then some from Store B." Gene typically stated, "Just go back and forth." Although these descriptions were somewhat vague, they reflected the students' unsystematic or undifferentiated patterns of nonverbal responding.

DISCUSSION

Results of this study were similar for the participants with and without ADHD. First, the results indicate that both modeling and instruction were effective priming procedures in establishing responding that approximated the relative rates of reinforcement in the experimental sessions that immediately followed. Because the reinforcement schedules in the experimental sessions were identical to those used in the priming sessions, however, it was unclear at that point whether responding was under the control of the preceding modeling or instructions, or the reinforcement schedules. Data from the subsequent unsignaled change in the schedules are informative in that regard.

Responding established with modeling, irrespective of the schedules, adapted quickly to the unsignaled changes in reinforcement. This was demonstrated with the 3 typically developing students (Maude, Ling, and Ann) and the 2 students with ADHD (Del and Matt) who received the modeling intervention (either initially or after the instruction condition). The results suggest that a modeling history produced responding that was under the control of the reinforcement schedules. Schedule sensitivity may have been facilitated by the particular modeling procedures used. Specifically, the experimenter modeled and described performance that demonstrated a strategy for determining an optimal pattern of choice making. The data suggest that the participants imitated this *strategy* rather than the *tactic* of distributing responses according to the specific reinforcement schedules in that condition.

This is supported by Maude's (and to some extent, Matt's) verbal responses when asked the best way to earn the most points: Both students described the strategy of sampling both response alternatives to determine how points were allocated, and then favoring the alternative that produced the most reinforcement. Imitation of the strategy may have promoted sampling and response variability that enabled contact with and shaping by the reinforcement contingencies. In this way, modeling may have functioned in a manner similar to the strategic instructions used by Bicard and Neef (2002) and Joyce and Chase (1990), which served to increase the variability of responding and its sensitivity to changes in reinforcement schedules. Jahr and Eldevik (2002) also found that modeling (plus verbal description) produced variability in children's cooperative play behaviors indicative of sensitivity to the contingencies of social interactions.

However, increased response variability alone is unlikely to have accounted for the effectiveness of modeling, because the required sampling that preceded each experimental session under no-instruction conditions also served that purpose, yet failed to produce schedule sensitivity during baseline. Thus, it appeared that modeling was important both in demonstrating an effective strategy and in making more prominent the relation between choices and reinforcement, which was not achieved through exposure to the schedules alone.

Neither does restricted response variability associated with the insensitivity of instructed performance suggested in previous research (Bicard & Neef, 2002; Catania et al., 1989; Hackenberg & Joker, 1994; Joyce & Chase, 1990) account for the performance of the students who received instructions in this study. Specifically, Ann, Matt, and Gene did not continue to allocate their responding in the same way as during the prior instruction condition nor in accordance with obtained reinforcement. This suggests that their responding was not under the control of either the prior instructions or the current schedules. It appears that when their first few responses did not produce points in the same manner as during the prior condition (making it evident that conforming to the previous instructions was no longer advantageous) they returned to the same pattern of responding as during the initial no-instruction condition. Therefore, their performance may have been sensitive to the accuracy versus inaccuracy of instructions they received, but not to the features of the reinforcement schedules.

Matt's and Gene's verbal descriptions also support this. During the instruction condition, they described the tactic of allocating a specified amount of time on each response alternative. When an unsignaled change in the schedules was subsequently implemented, Matt's verbal description indicated that he discriminated only that a change had occurred ("It's changed, but I don't know how"), and both Matt and Gene returned to the patterns of verbal and nonverbal responding observed during the no-instruction baseline.

Although replications with additional participants are needed, the current results (along with those of Bicard & Neef, 2002) do not support Barkley's (1997) predictions that the responding of children with ADHD "may be less rigid or more flexible when the rule in effect is later shown to have been incorrect, since ADHD individuals are not governed by the rule as much in the first place" (p. 248). Responding consistent with the reinforcement schedules in effect was quickly established with instructions for the students with ADHD, and they did not demonstrate sensitivity to the changed schedules in the subsequent no-instruction condition. The results of a study by Kollins, Lane, and Shapiro (1997) using concurrent schedules suggested that the responding of children with ADHD is actually less sensitive to changes in reinforcement schedules than the responding of children without that diagnosis. The present results similarly indicate that the responding of students with ADHD can be insensitive to reinforcement schedules (albeit not necessarily more so than students without ADHD), but they also suggest conditions under which sensitivity can be enhanced.

For 3 of the participants (Maude, Matt, and Gene), there was high correspondence between their verbal and nonverbal behavior, even though those descriptions did not show sensitivity to critical features of the reinforcement schedules in the no-instruction conditions that preceded either intervention, or that followed the instruction condition. The results for these participants support the hypothesis of Bicard and Neef (2002) and Horne and Lowe (1993) that an individual's behavior might be governed by the performance rules he or she generates, whether or not those rules accurately characterize the environmental contingencies. Nevertheless, that interpretation must be tempered by several considerations.

First, the data that suggest such relations are necessarily correlational, and thus causation cannot be assumed. It is possible that Maude's, Matt's, and Gene's verbal reports did not represent rules that controlled their nonverbal behavior but were only post hoc descriptions of their performance. Furthermore, the verbal behavior of the 3 other participants (Del, Ling, and Ann) was unrelated to the schedules. It may be that the form of the question failed to evoke a description of the performance rules that guided these students' nonverbal responding. On the other hand, it is also possible that the reinforcement schedules did not lead to the formulation of a verbal description of the relation. Del, Ling, and Ann were the youngest participants (ages 10, 10, and 11 years, respectively), and research indicates that the relation between verbal and nonverbal behavior may be related to age. A study by Pouthas, Droit, Jacuet, and Wearden (1990) suggested that the behavior of children younger than 11 is more likely to be controlled directly by reinforcement contingencies than indirectly by their verbal behavior, even when their verbal repertoires are highly developed. It is therefore unclear in the current investigation whether the reinforcement schedules (with modeling) affected responding directly, or whether the reinforcement schedules influenced the participants' (private or public) verbal behavior, which in turn governed their responding.

A limitation of the study is that a within-subjects comparison of the effects of modeling versus instructions was possible for only 2 students (Matt and Ann). To control for sequence effects, we counterbalanced the order of instructions and modeling across students. However, the schedule sensitivity produced by modeling (for Maude, Del, and Ling, who received the modeling intervention first), and the end of the school year (for Gene, who received the instruction intervention first), precluded further analysis. In addition, we did not conduct a component analysis to isolate the effects of nonverbal modeling from the verbal descriptions of the strategy that was modeled.

The study suggests several additional directions for research as well as implications for practice. Because unsuccessful intervention efforts with children may reflect insensitivity to programmed reinforcement schedules, it may be useful to consider the differential effects of priming procedures in establishing sensitivity to reinforcement contingencies in typical classroom or other social contexts, and with different populations. For example, modeling may be indicated for certain populations, such as children with a diagnosis of oppositional defiant disorder, who have a history of poor control by instructions. In addition, the features of what is modeled or instructed appear to be important (e.g., tactics vs. strategies). Of course, sensitivity to reinforcement contingencies may be more desirable in some situations (e.g., interacting with peers) than others (e.g., interacting with strangers), and the procedures and their features might be selected on that basis. Finally, the study underscores a more prominent role for examination of both reinforcement histories and verbal behavior in applied research (see Lattal & Neef, 1996).

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STUDY QUESTIONS

1. In what way might instructions facilitate or inhibit sensitivity of responding to operant contingencies?

2. Briefly describe the no-instruction, modeling, and instructions conditions.

3. How were the effects of modeling and instructions evaluated?

4. Summarize the results following (a) the initial modeling versus instruction evaluation and (b) the subsequent change in reinforcement schedules.

5. How accurately did the students' verbal reports describe (a) their nonverbal behavior and (b) the programmed reinforcement contingencies?

6. What do the results suggest about behavioral characteristics that have been reported to be associated with ADHD?

7. What data suggest that the participants' behavior may have been influenced by self-generated rules?

8. What features of the verbal instructions given during the modeling and instructions conditions might have influenced responding?

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