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EFFECTS OF TASK DIFFICULTY AND TYPE OF CONTINGENCY ON STUDENTS' ALLOCATION OF RESPONDING TO MATH WORKSHEETS

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This study investigated students' allocation of responding as a function of task difficulty and type of reinforcement contingency (i.e., accuracy based or time based). Four regular education fourth-grade students were presented with two identical stacks of easy and then difficult math worksheets using a reversal design. Regardless of condition, completing problems from each stack of worksheets was reinforced according to a different contingency; one required correct completion of math problems (accuracy based) and one required on-task behavior (time based). Results suggested that 3 of the 4 students preferred the accuracy-based contingency when given easy material and the time-based contingency when given difficult material. One student allocated more responding to the accuracy-based contingency when given easy problems but did not show a clear preference for either contingency with difficult problems. The implications of these findings for designing reinforcement-based programs for tasks of varying difficulty are discussed.

DESCRIPTORS: academic behavior, reinforcement contingency, task difficulty, response allocation

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One way to increase the effectiveness of reinforcement-based programs is to assess preferences for potential reinforcers (e.g., edible items, tangible items, activities) or reinforcer dimensions (e.g., rate, quality, delay). Children's reinforcer preferences have been examined in the literature using a variety of methods including single-stimulus approach, paired-stimulus choice, pictorial choice, and multiple-stimulus choice procedures (Fisher et al., 1992; Northup, George, Jones, Broussard, & Vollmer, 1996; Pace, Ivancic, Edwards, Iwata, & Page, 1985). This research has shown that identifying preferred items for use as reinforcers increases the likelihood that such stimuli will actually increase responding (e.g., Pace et al.).

Researchers have also examined children's preferences for various reinforcer dimensions (e.g., Hoch, McComas, Johnson, Faranda, & Guenther, 2002). In a series of investigations, Neef and her colleagues presented students with two sets of math problems, each corresponding to a specific value of different reinforcer dimensions or task difficulty (e.g., rich vs. lean schedule of reinforcement, high- vs. low-quality reinforcers, immediate vs. delayed access to reinforcers, and easy vs. hard problems) (Neef, Mace, & Shade, 1993; Neef, Mace, Shea, & Shade, 1992; Neef, Shade, & Miller, 1994). Although individual differences were observed in students' allocation of responding across the various dimensions, preferences for higher quality reinforcers were frequently shown. Task difficulty was not evaluated until the Neef, Shade, and Miller study and was assessed only in tandem with reinforcer dimensions.

Task difficulty is an important variable in classroom instruction, and is based on an interaction between the material presented and the skill level of students. Often, however, students are not presented with material at an appropriate or instructional skill level. Difficulty of the material has been shown to affect students' on-task behavior, thus potentially decreasing opportunities for reinforce-

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ment. For example, Gickling and Armstrong (1978) found that when students were engaged in instructional-level material, they displayed more on-task behavior than when engaged in material that was either too difficult or too easy. Lee, Sugai, and Horner (1999) examined this issue further by using an instructional intervention while presenting students with both easy and difficult material. Following intervention, students exhibited fewer occurrences of off-task and other problem behaviors and completed difficult problems with greater accuracy.

In addition to task difficulty, the relation between on-task behavior and academic performance has also been examined following the use of varying task-related contingencies. Research involving different intervention targets has typically found collateral increases in on-task and decreases in off-task or disruptive behavior when reinforcement was contingent only on academic performance (Ayllon & Roberts, 1974; Lentz, 1988). Hay, Hay, and Nelson (1977) demonstrated that children were on task more and performed at higher rates and with greater accuracy when teacher attention was contingent on academic performance rather than on-task behavior.

Rosenberg, Sindelar, and Stedt (1985) explored the impact of different contingencies and difficulty of material on task acquisition. Students in this study were assigned to one of two tasks (simple or difficult) and one of two contingencies (for both on-task behavior and correct academic performance or for correct academic performance only). Students who were assigned to the contingency based on correct academic performance were off task more during the difficult task than were children assigned to the contingency for both attention and correct academic performance. There were no such differences in the acquisition of the simple task.

Previous research involving the reinforcement of on-task behavior and academic performance has shown inconsistent effects suggestive of an interaction between task difficulty and reinforcement contingency. In previous studies, however, students were not allowed to choose among reinforcement contingencies but rather were assigned to them. Given this fact, it would be important to directly examine children's preferences for different types of reinforcement contingencies as a function of task difficulty. As task difficulty increases, students are likely to have fewer opportunities to obtain reinforcement contingent on correct work, because they respond at lower rates than on easier material. In such instances, children may prefer a reinforcement contingency for on-task behavior because it potentially results in richer obtained rates of reinforcement.

The goal of the present study was to examine students' allocation of responding across identical stacks of worksheets as a function of task difficulty and type of reinforcement contingency. Students were presented with two stacks of math worksheets, each associated with a different reinforcement contingency: reinforcement for accurate work completion or reinforcement for time on task. In one condition, both stacks of worksheets were comprised of easy material, and in the second condition worksheets were comprised of difficult material. Differences in response allocation between the stacks of worksheets were interpreted as indicating an interactive effect of task difficulty and type of reinforcement contingency.

METHOD

Participants and Setting

Four boys in a fourth-grade regular education classroom served as participants in the study. All the students were 9 years old at the beginning of the study. Parental consent and student assent were obtained prior to commencement of the study. In addition, student assent was obtained before each session.

To provide additional information about the participants, students' scores from the Terra Nova achievement test, a group-administered test that the students had taken during third grade, were reviewed. The math scale contained subtests that assessed number and number relations, computation, measurement, and other related areas. The students performed as follows: Enrique at the 52nd percentile, Quincy at the 19th percentile, Rick at the 55th percentile, and Brent at the 28th percentile.

A three-item self-report scale was given to the students to assess how much they liked the subject of math. The scale contained the following questions, "Do you enjoy math?," "Do you find math useful?," and "How well can you do math?" Students responded to each item using a 5-point Likert scale ranging from 0 = *not at all* to 4 = *very much.* The students' mean ratings on the three questions indicated positive perceptions of math (M = 3.75, 3.75, and 3.0, respectively).

Each student was removed from his classroom after lunch three times a week. Each session was 5 min in length and was conducted in a tutoring classroom down the hall from the students' classroom. The student sat at a long rectangular table with a pencil, math probes, and two chairs so that the examiner could sit across from the student during all sessions.

Materials

Worksheets containing computation problems were used to identify students' skill levels in math. The first set of math probes contained one-digit addition problems with sums to 5. The second set of math probes contained two-digit addition problems with regrouping with sums to 99. Each probe contained 30 math problems per page, with five columns and six rows of problems. Materials for the reinforcer preference assessment included picture cards depicting the available reinforcers and a recording sheet. During each experimental session, the student was given a pencil and two sets of math probes from which to choose. A plastic cup was placed behind each set of probes. White poker chips served as tokens that were placed in the cup during the session.

Materials for momentary time sampling included an audio cuing tape, earphone, and a recording sheet. The tape contained tones at 30-s intervals. The recording sheet was divided into 10 intervals. Thirty seconds was chosen as the interval length because it has been found to be an accurate estimate of behavior occurrences (Kearns, Edwards, & Tingstrom, 1990).

Preliminary Assessments

Each student was assessed using a curriculum-based assessment screening procedure (Shapiro, 1996). Students were presented with math probes containing different types of computation problems (i.e., different difficulty levels) and were instructed to complete as many math problems as they could in 2 min. Students were given math probes at each of several difficulty levels, and the digits correct per minute (DCM) on the probes was calculated. This score was used to identify easy and difficult probes based on the following criteria for fourth grade: 0 to 19 DCM is difficult, 20 to 39 DCM is instructional, and 40+ DCM is easy (Shapiro, 1996). The results of the CBA assessment revealed that easy material was addition sums to 5 and difficult material was two-digit addition with regrouping with sums to 99. Although difficult material has been characterized in previous research by low accuracy and rate (Neef et al., 1994), students in the current study completed the difficult math problems with a high degree of accuracy but at a low rate.

For the reinforcer preference assessment, the students' teacher was administered the Reinforcer Assessment Survey, which lists possible reinforcers (e.g., attention, edible items, stickers) (Northup et al., 1996). The teacher then indicated the reinforcers from the list that she felt were appropriate for the classroom. The teacher-approved reinforcers were then presented to the students on picture cards. Each reinforcer represented on the picture card was paired with every remaining reinforcer in a counterbalanced order until all possible pairs were presented. At the conclusion of the preference assessment, the students' choices for each reinforcer were tallied to determine the top three reinforcers. The pool of reinforcers included snack cakes, juice, reward certificates, pencils, erasers, time to play a game with a friend, and a note home to parents and was individualized according to each student's endorsements.

Behavior Definitions and Measurement

DCM, as determined through performance on math probes, served as an index of academic behavior in this study. DCM is an indicator of fluency and accuracy that is sensitive to instructional intervention and can be taken as an estimate of a student's skill level in mathematics (Shapiro, 1996). DCM is scored as the number of correct digits in their proper place value divided by time spent working on math probes.

On-task behavior was defined as active math computation, as evidenced by counting on one's fingers, drawing objects, or writing on the worksheet. The student was also required to be seated in the chair and have his eyes oriented towards the math problems in order to be scored as on task. On-task behavior was measured using 30-s momentary time sampling. A team of graduate and undergraduate students was trained to use an audio cuing tape and recording sheet to record on-task behavior. The audio cue was audible only to the observers.

Experimental Design and Procedure

A concurrent-schedule design with a reversal was used to compare the students' allocation of responding to each type of reinforcement contingency when working easy and difficult problems. Phase changes were based on a stable rate of math performance or a clear separation of the data series. More specifically, when a stable data path of four data points was established or when one contingency was never chosen, a phase change was initiated. If neither of these conditions were met due to variability in the data, additional sessions were conducted until the degree of variability was apparent.

Baseline. During baseline, the students completed math worksheets containing 30 math problems with single-digit addition sums to 5 or two-digit addition with regrouping for 5 min. The type of problems completed alternated across sessions. No reinforcers were given during baseline. For each session, the students were instructed to complete as many math problems as they would like or none at all until the experimenter said stop. These same directions were given across conditions.

Easy problems (easy) condition. During this condition, students were asked to complete math problems for 5 min at an easy, or mastery, skill level (i.e., single-digit addition sums to 5). Students were able to choose from two identical stacks of 30-problem worksheets, each associated with a different reinforcement contingency. The first contingency (accuracy based) reinforced correct completion of a certain number of math problems with a token. The student could exchange every four tokens earned for one preferred item at the end of the 5-min session. The second contingency (time based) reinforced on-task behavior with a token. Specifically, the student received one token each time he was observed to be on task through 30-s momentary time sampling. As with the accuracy-based contingency, the student had the opportunity to exchange every four tokens earned for one preferred item at the end of the session. The students were able to alternate between the two stacks of worksheets at any time during the session. Colored paper served as a discriminative stimulus for the two contingencies (probes for the accuracy-based contingency were on blue paper and probes for the time-based contingency were on yellow paper). The left–right placement of the probes was alternated across sessions.

Difficult problems (difficult) condition. During this condition, students were asked to complete math problems for 5 min at a difficult, or frustrational, skill level (i.e., two-digit addition with regrouping). Students again were able to choose from two sets of probes. The reinforcement contingencies were the same as for the easy condition.

Before introducing the easy and difficult conditions, two forced-choice sessions were conducted to ensure that the students were exposed to each reinforcement contingency. Just prior to the easy condition, the students experienced the accuracy-based contingency for one session and then the time-based contingency for a second session. Before the difficult condition, the students were again exposed to one session each according to the accuracy-based and the time-based contingencies. No other information was provided to the students regarding the contingencies. During the initial easy condition, Brent alternated between the two contingencies with no clear pattern, so a training session was conducted. The training session was comprised of the same forced-choice exposure that all students received initially, with the addition that explicit feedback was provided by pointing out to the student the number of problems completed under each contingency and the resulting tokens earned.

Calibration of the Reinforcement Schedules

Schedules were designed to provide identical rates of reinforcement between each type of contingency if students worked at the same average rate under each schedule. This was accomplished in three steps. We yoked the accuracy-based contingency to the time-based contingency by first calculating the number of tokens that could be earned in the time-based contingency (10). Second, we calculated the average number of problems correct per session across easy and difficult worksheets at screening for each student. Third, this average was divided by 10 to identify the number of correct problems required for one token in order for the student to receive 10 tokens during each 5-min session under the accuracy-based contingency. The number of correct problems required to earn one token was nine for Enrique and Brent, seven for Quincy, and eight for Rick. Because the accuracy-based and time-based contingencies were equated based on average number of problems correct per session, students were able to earn more tokens when completing easy problems by allocating their responding exclusively to the accuracy-based contingency. In contrast, when completing difficult problems, the students were able to earn more tokens by allocating their responding exclusively to the time-based contingency.

Interobserver Agreement, Treatment Integrity, and Acceptability

Interobserver agreement was calculated during 37% of sessions across all students and conditions. Percentage agreement for DCM was calculated on a problem-by-problem basis by dividing the number of agreements by the number of agreements plus disagreements and multiplying by 100%. Percentage agreement for on-task behavior was calculated by dividing the number of agreements by the number of agreements plus disagreements and multiplying by 100%. Mean agreement across students and conditions was 99.9% (range, 99.7% to 99.9%).

For treatment integrity, scripted protocols were devised to ensure adherence to the instructions. During 37% of the sessions, an independent observer recorded whether the experimenter gave all the instructions and the order in which they were given. Treatment integrity was assessed to be 100% for each session sampled.

To assess students' perceptions of the intervention, the students completed the Children's Intervention Rating Profile (CIRP; Witt & Elliott, 1985) after each condition. The CIRP is a seven-item one-factor scale assessing the acceptability of the intervention with an average coefficient alpha of .86 (Turco & Elliott, 1986). The items of the measure were modified slightly to reflect the intervention in the present study. The CIRP was given after each condition to reduce students' confusion between the contingencies (as might occur if it was given at the completion of the study). In addition, the students were asked two open-ended questions to determine acceptability and their understanding of the intervention. The first question was, "If you had a friend do this tomorrow, what colored set of math problems would you tell him to pick and why?" The second question was, "Which colored set of math problems did you like to do best and why?"

RESULTS

The top panels of Figures 1 through 4 display the total number of digits correct per session for the students during baseline, easy, and difficult conditions. In each condition, the total number of correct digits was calculated by summing the digits completed correctly on both stacks of worksheets (i.e., accuracy and time based) to evaluate reinforcement effects relative to baseline. The total number of digits correct per session for all students was lower in difficult conditions than in easy conditions. In comparison to baseline, 2 students (Quincy and Rick) completed similar numbers of correct digits during the easy conditions. Enrique completed more total digits correct in comparison to baseline during the second but not the first easy condition. Brent showed an increasing trend across both easy conditions and completed more total digits correct compared to baseline. Enrique and Quincy also completed similar numbers of total digits correct during both difficult conditions in comparison to baseline. Rick and Brent completed more total digits correct during the difficult conditions than during baseline.

The bottom panels of the figures show how students allocated their responding across the two types of contingencies during the alternating easy and difficult conditions. During easy conditions, Rick and Quincy allocated their responding exclusively to the accuracy-based contingency. Response allocations by Enrique and Brent were more variable during the initial easy condition, but both students showed a preference for the accuracy-based contingency. Similar to the other 2 students, Enrique and Brent responded exclusively to the accuracy-based contingency during the second easy condition.

During the difficult conditions, Brent and Quincy showed clear preferences for the time-based contingency. Enrique and Rick alternated between the two contingencies during the initial difficult condition, with Rick responding exclusively to the time-based contingency during the final four sessions of this phase. Both Enrique and Rick showed a preference for the time-based contingency during the final difficult phase.

In summary, 3 of the 4 students displayed a clear pattern of responding across conditions by completing more digits correct un-

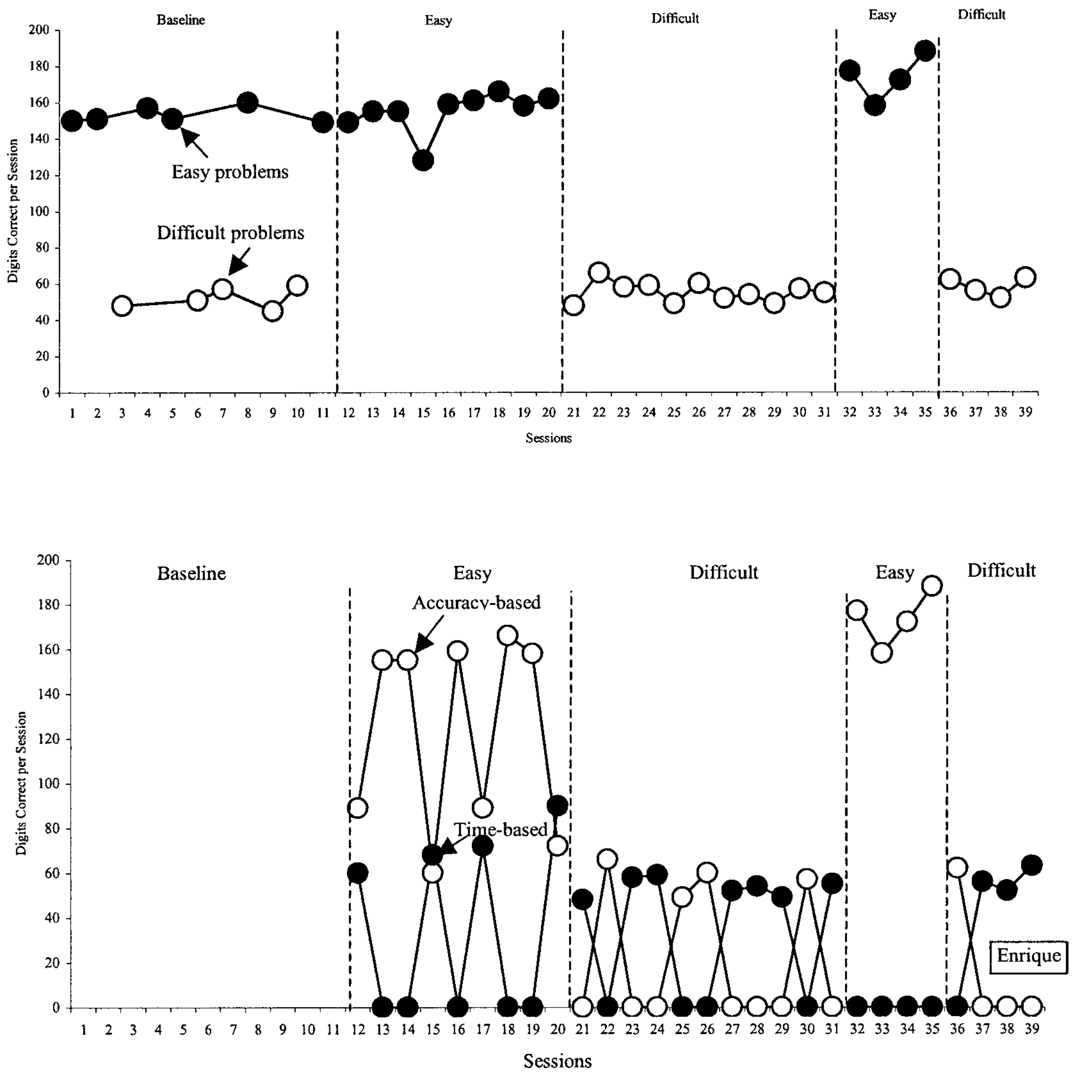

Figure 1. The top panel shows the total number of correct digits completed per session during the baseline, easy, and difficult conditions by Enrique; the bottom panel shows how he allocated his responding between the math sheets associated with the accuracy- and time-based contingencies during the easy and difficult conditions.

der the accuracy-based contingency with easy problems and more digits correct under the time-based contingency with difficult problems. The mean number of tokens earned by each student across conditions and type of contingency (Table 1) suggest that the students' response allocations served to increase their obtained rates of reinforcement in each condition.

Results of the CIRP indicate that the students rated the intervention to be highly acceptable across conditions (M = 5.75, 5.61, 5.82, and 5.57, respectively). In response to the two open-ended questions, "If you had a friend do this tomorrow, what colored set of math problems would you tell him to pick and why?" and "Which colored set of math problems did you like to do best and why?" following the easy conditions, all the students chose the problems associated with

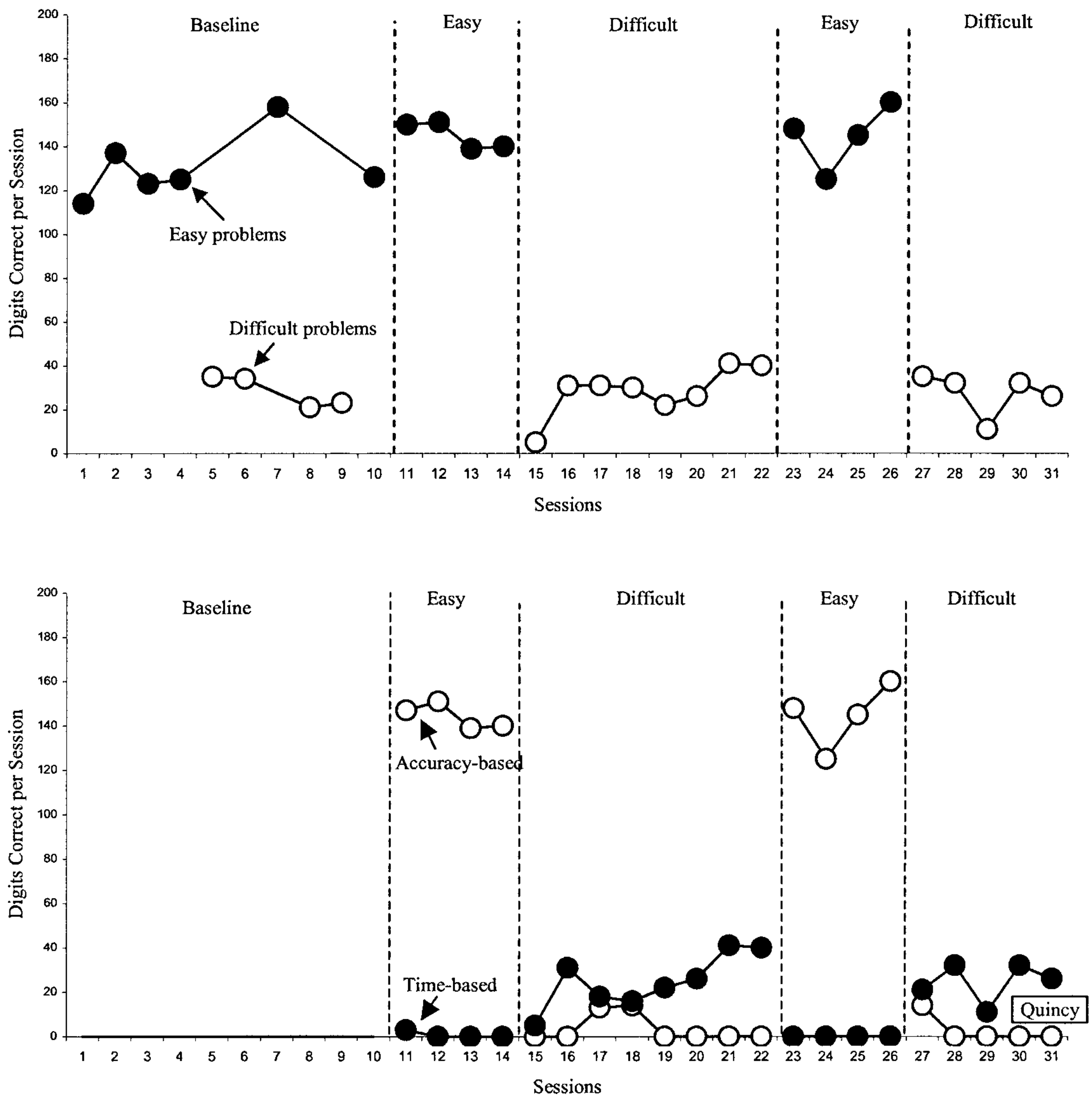

Figure 2. The top panel shows the total number of correct digits completed per session during the baseline, easy, and difficult conditions by Quincy; the bottom panel shows how he allocated his responding between the math sheets associated with the accuracy- and time-based contingencies during the easy and difficult conditions.

the accuracy-based contingency, indicating that they earned more tokens when completing these problems. Following the difficult conditions, the students' responses differed in their choices and reasons given. Quincy endorsed the accuracy-based contingency for a friend because he reported that it would help with math schoolwork. However, he chose the time-based contingency for himself and was unable to explain his reasoning. Brent endorsed the time-based contingency for both a friend and himself, because it would yield tokens even though the problems were difficult. However, following the initial easy condition, Brent endorsed both contingencies because they would help him to perform better in math. Rick chose the problems associated with the time-based contingency for both questions, indicating that it was easier to earn tokens

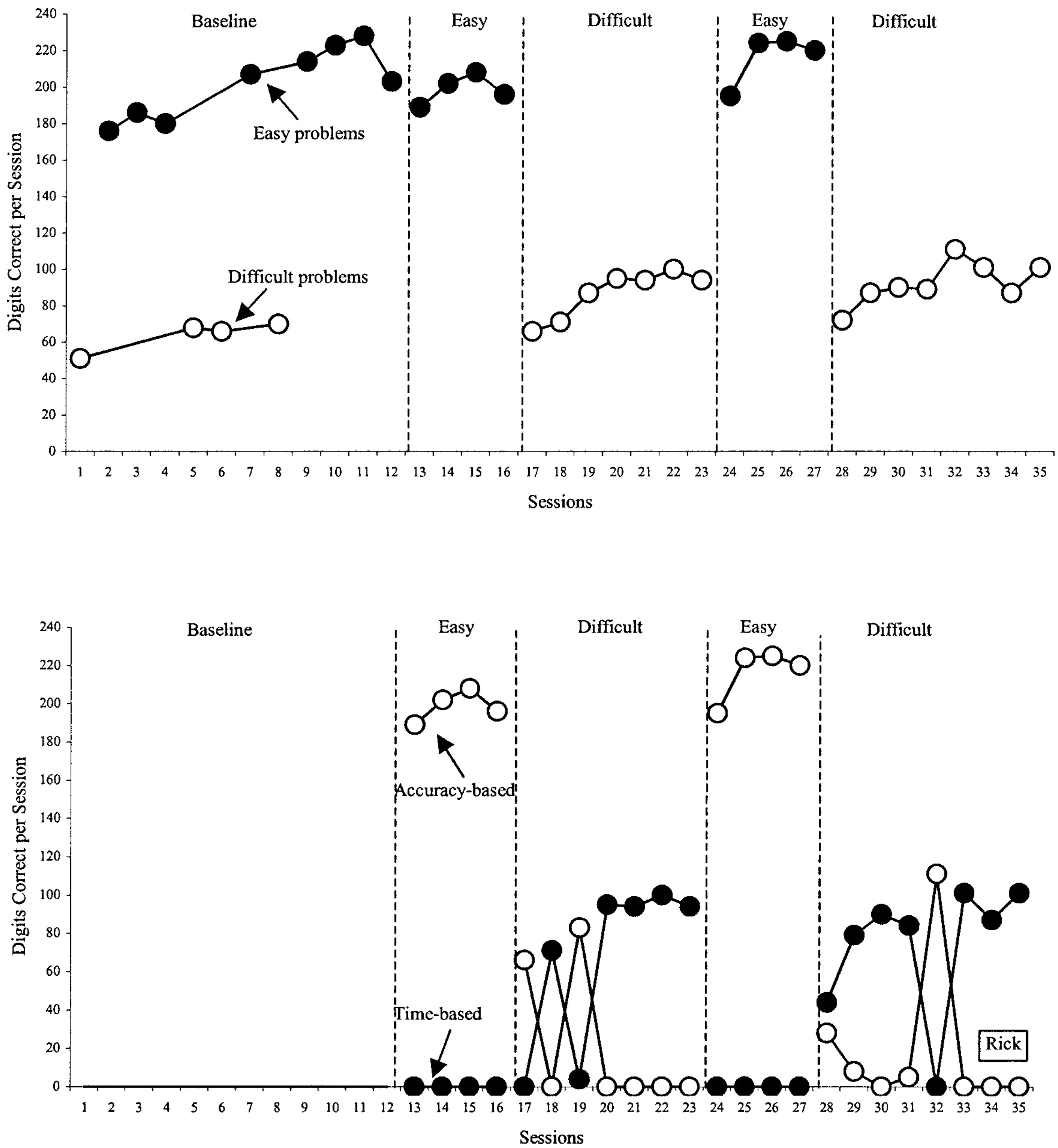

Figure 3. The top panel shows the total number of correct digits completed per session during the baseline, easy, and difficult conditions by Rick; the bottom panel shows how he allocated his responding between the math sheets associated with the accuracy- and time-based contingencies during the easy and difficult conditions.

with these problems. Also following the initial easy condition, Enrique endorsed the problems associated with the time-based contingency for a friend, because one could continue to earn tokens even when the problems were difficult. He chose the problems associated with the accuracy-based contingency for himself because he earned more tokens. Following the final easy condition, Enrique endorsed the accuracy-based contingency for a friend and himself because more tokens could be earned with these problems.

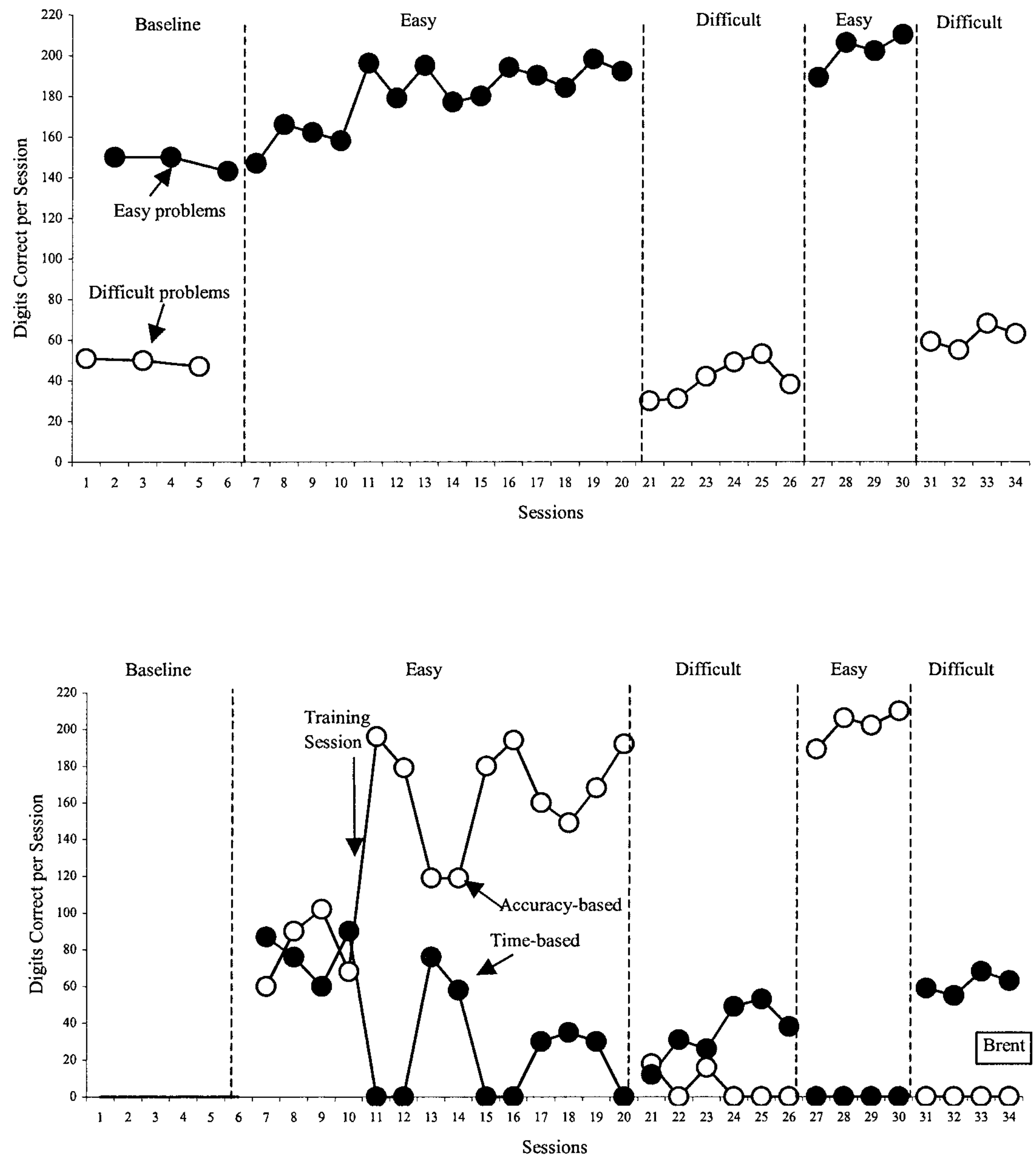

Figure 4. The top panel shows the total number of correct digits completed per session during the baseline, easy, and difficult conditions by Brent; the bottom panel shows how he allocated his responding between the math sheets associated with the accuracy- and time-based contingencies during the easy and difficult conditions.

DISCUSSION

The goal of this study was to examine students' allocation of responding across math worksheets as a function of type of reinforcement contingency with easy and difficult problems. For both types of problems, students were given the option of earning rewards based on the number of problems correctly completed (accuracy-based contingency) or for being on task when sampled by the experimenter (time-based contingency). The level of math work was alternated from easy to difficult material. The students increased their obtained rates of reinforcement

Table 1
Mean Number of Tokens Earned per Session by Each Student Across Conditions and Contingencies

	Enrique	Quincy	Rick	Brent
Initial easy condition				
Accuracy based	13.11	19.75	24.5	15
Time based	1.78	0	0	2.14
Initial difficult condition				
Accuracy based	0.9	1	1.29	0.17
Time based	7	6.5	7	7.83
Final easy condition				
Accuracy based	19	20.5	26.25	22
Time based	0	0	0	0
Final difficult condition				
Accuracy based	0.75	0.2	0.88	0
Time based	7.5	8.4	8.13	9.75

by completing more digits with the accuracy-based contingency during easy conditions and by completing more digits with the time-based contingency during the difficult conditions.

Although the students allocated their responses as hypothesized, absolute reinforcement effects were not clearly evident for Enrique, Quincy, and Rick. Two possible explanations exist for this finding. First, the simple act of alternating between worksheets may have reduced the total numbers of problems completed in comparison to baseline. For example, Enrique and Rick showed little or no absolute reinforcement effects, and they were the 2 students who switched most frequently between stacks of worksheets. Second, performance may have reached a ceiling with easy math problems at baseline, and completion rates were unlikely to increase further. Conversely, the difficult math material was, by definition, inappropriately matched to the students' skill levels. This lack of instructional match may have attenuated the effects of reinforcement or required the intervention to be in place for a longer period of time to see increases in performance.

The present findings suggest that students may prefer different types of contingencies depending on their level of skill proficiency, and that these preferences may serve to increase obtained rates of reinforcement when working on a task. Previous research has shown that mastery of a skill is attained through a sequence of stages (e.g., acquisition, fluency, etc.), with learning at each stage best promoted by a different set of instructional procedures (e.g., Daly, Lentz, & Boyer, 1996; Haring, Lovitt, Eaton, & Hansen, 1978). Our results extend research in this area in two ways. First, in addition to instructional procedures, it may also be useful to tailor reinforcement contingencies to a student's proficiency level. Matching the type of contingency to the difficulty of the task (e.g., time based for difficult or acquisition-level material) may increase student motivation by increasing obtained reinforcement rates. Changing contingencies as students progress (e.g., accuracy based for easy or fluency-level material) may be one means of maintaining high rates of reinforcement while promoting practice. Second, despite the importance of matching instructional materials to skill level, teachers are often reluctant to assign students easier work (Martens & Witt, 2004). Using a time-based contingency may be one way for teachers to increase reinforcement for completing difficult tasks.

Although we showed clear effects of task difficulty on students' preferences for type of contingency, it remains unknown to what extent these preferences translate into actual gains in time on task or productivity. It would be important in future research to examine the extent to which matching contingency to task difficulty improves various indexes of student performance. Future research might also assess students' preferences for type of contingency when they work on instructionally matched material, in different content areas (e.g., reading, writing), or with different instructional arrangements (e.g., individual vs. group).

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STUDY QUESTIONS

1. How did the authors define easy and difficult math problems?

2. What were the dependent variables, and how were they measured?

3. Describe the experimental arrangements during baseline, easy, and difficult conditions, and the reinforcement contingencies in effect during each condition.

4. How did the authors design the reinforcement schedules to produce equal rates of reinforcement under the accuracy- and time-based contingencies?

5. Describe how students could earn the most tokens in easy and difficult conditions.

6. Summarize the results with respect to participants' response allocation during the easy and difficult conditions.

7. The authors suggested that the apparent absence of a reinforcement effect (similar response rates across baseline and reinforcement conditions) might have been due to alternating responding between worksheets during reinforcement conditions, which may have reduced the total numbers of problems completed in comparison to baseline. To what extent was this reflected in the data?

8. The authors suggested that participants' response allocation varied as a function of preference for a type of reinforcement contingency. What alternative explanation may be offered to account for the observed patterns of responding?

Questions prepared by Jessica L. Thomason and Jennifer N. Fritz, University of Florida