*MODIFICATION OF ARITHMETIC RESPONSE RATE
AND ATTENDING BEHAVIOR IN A
SEVENTH-GRADE STUDENT¹*

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An adjusting fixed-ratio schedule of praise and immediate correctness feedback produced increases in a seventh-grade student's arithmetic response rate. Percentage of time spent in attending behavior also increased collaterally. Removal of the treatment led to decreases in both arithmetic response rate and collateral attending behavior. Reinstatements of the procedure again produced increases in both types of behavior. It was suggested that the present procedure of directly modifying arithmetic response rate requires less time and effort than working indirectly through modifying attending behavior.

Recent studies have shown that operant conditioning techniques can be useful in improving children's classroom behaviors. Several of these studies have focused on either increasing study behavior or increasing academic response rate. Hall, Lund, and Jackson (1968) demonstrated that study behavior is subject to teacher attention contingencies. Bushell, Wrobel, and Michaelis (1968) modified study behavior utilizing a token system and group contingencies. Walker and Buckley (1968) conditioned attending behavior by providing points for increasing intervals of attending behavior. The points could be exchanged for a model of choice at the end of the treatment period. Surrat, Ulrich, and Hawkins (1969) utilized an elementary student to monitor the study behavior of a group of students. A light on the student's desk was on during study behavior and off during non-study behavior. Using back up rein-

forcers for light-on time, they increased time spent in study.

The main purpose of increasing study behavior is to achieve collateral increases in academic performance. The forementioned studies modified attending or study behavior but did not systematically measure changes in academic response rate or accuracy. One of the problems in attempting to increase academic response rate indirectly by modifying study behavior is the time and effort involved in monitoring study behavior. Someone must monitor the behavior of the child almost constantly. A more direct approach to academic performance may be more efficient.

Academic response rate has been directly modified by Lovitt and Curtiss (1968, 1969). These studies demonstrated increases in academic response rate as a result of verbalizing in addition to writing correct answers and of self-imposed as opposed to teacher-imposed reinforcement contingencies. Changes in percentage of study behavior were not systematically measured.

The present study was designed to measure the combined effects of an adjusting fixed-ratio schedule of immediate praise and immediate correctness feedback on the arithmetic response rate of a seventh-grade student and to measure

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possible collateral changes in study behavior. The subject was rewarded for increasing units of arithmetic work in a manner similar to the procedure used by Walker and Buckley (1968) wherein the subject was rewarded for increasing intervals of time spent in study.

METHOD

Subject

Tom, a 13-yr-old boy enrolled in the seventh grade at Humboldt State College Elementary School, was of average intelligence as measured by the Wechsler Intelligence Scale for Children, receiving a Full Scale Score of 96. Before the study, Tom was observed for a period of two weeks. During this time, he exhibited a great deal of non-attending behavior and his arithmetic work was poor. Tom frequently exhibited non-attending behavior until his teacher reminded him to work or went over to his desk and watched him. Tom would then work for a few minutes, but if his teacher left, he would become easily distracted. Tom seldom completed class assignments and tended to make many errors, especially with arithmetic problems.

Procedure

After consultation with Tom's teacher, it was decided to use a 20-min time block each day in an experiment designed to help Tom increase his arithmetic achievement and attending be-

havior. The study was conducted in Tom's normal classroom every day from 11:30 to 11:50 a.m. During this time the experimenter presented Tom with a worksheet consisting of 20 multiplication problems to compute. Examples of the types of problems used are shown in Table 1. Complexity order #1 represents a one digit number times another one digit number (1×1) *etc.*

Random selection was used to determine the content for each worksheet. The problems were placed on individual cards and placed in one of nine boxes, each box contained problems of the same complexity. Two problems were drawn from each box for each of the 24 worksheets used during the study, giving each worksheet 18 problems. The remaining problems were then placed in one box and two more problems were selected for each of the 24 worksheets, so that each worksheet contained 20 problems. The problems were arranged in order of increasing complexity for each worksheet, *i.e.*, 1×1 , 1×2 , 1×3 , 2×1 , 2×2 , *etc.*

Two measures of behavior were recorded: the number of correct problems solved per minute and the percentage of total time spent in attending behavior. The number of correct problems solved was recorded by the experimenter each time Tom turned in a unit of work. The amount of time spent in problem solving included only the time he spent at his desk while completing the 20 problems and did not include

Table 1
Examples of the Multiplication Problems Used in the Present Study

Complexity Order	No. of Digits	Examples	Number
1.	1×1	2×6 , 4×8	56
2.	1×2	3×12 , 5×43	56
3.	1×3	8×754 , 9×362	56
4.	2×1	54×7 , 32×5	56
5.	2×2	34×65 , 75×12	56
6.	2×3	23×143 , 59×641	56
7.	3×1	645×4 , 781×3	56
8.	3×2	893×34 , 619×15	56
9.	3×3	156×723 , 916×416 ...	56

the time he took to bring his work to the experimenter for correction, be assigned a new set of problems to solve, and return to his desk. Tom completed the entire worksheets of 20 problems each day of the experiment.

An independent observer was used to record Tom's attending behavior. The observer was seated in the classroom, approximately 18 ft from Tom's right-hand side, out of the way, but with an unobstructed view of the subject. From this position the observer recorded Tom's behavior every 10 sec, recording only behavior exhibited at the tenth second. The observer used a stopwatch, held in her left-hand, clearly marked, to determine the intervals. Attending behavior included: looking at or writing on the assigned page, looking at the teacher or experimenter when appropriate, talking to the teacher or experimenter, walking from his desk to the experimenter's desk and back to his own, and standing at the experimenter's desk while his paper was being corrected and a new assignment given. All other behavior was recorded as non-attending. If Tom completed the worksheet before the end of the assigned 20 min, the observer noted the time and stopped recording. This procedure was used throughout the study. The reliability of the observer was checked 10 times with another observer, three times before the start of the study and seven times during the study. The two observers sat in opposite corners at the rear of the room during reliability checks. The results showed a 98% agreement between observers, with a range from 95% to 100%. Percentage of agreement was determined by dividing the number of agreements by the total number of observations.

Design

The study was conducted over a period of 24 school days and was divided into four phases.

PHASE	DAYS
Baseline	1-5
Treatment 1	6-13
Reversal	14-19
Treatment 2	20-24

Baseline. During the baseline phase, Tom was presented each day with a different arithmetic worksheet of 20 problems. His instructions were as follows:

"Here is your arithmetic worksheet for today, you have 20 minutes to complete it, then I will collect it."

The problems were corrected and returned the following day with the number correct at the top. No praise was given Tom, by either the teacher or the experimenter during the 20-min period.

Treatment 1. During this phase, Tom was presented each day with a different arithmetic worksheet of 20 problems. The instructions given Tom during this phase were as follows:

"Here is your arithmetic worksheet for today, when you have completed — problems, bring your paper over to my desk and I will check your answers. You have 20 minutes to complete the worksheet."

Tom was given praise and the correct answers marked subsequent to the correction of each unit of work using an adjusting fixed-ratio schedule. Initially this involved reinforcement for every two problems completed. Then, the experimenter gradually increased the units of work or number of problems completed by Tom before delivering reinforcement. Correct answers were designated but Tom was not shown how to work any problems or where he had made errors.

Examples of praise used by the experimenter included:

1. "Good work"
2. "Excellent job"
3. "Great, you got 14 right today"
4. "All right, you didn't do too well today, but tomorrow you will do better"
5. "Since you did so well today it won't be necessary to have your work checked as often tomorrow"

6. "And keep up the good work; you can work more problems at a time now"

For the first two days of Treatment 1, Days 6 and 7, Tom was given praise and the correct answers each time he completed two problems. During Days 8 and 9, the number of problems completed at one time was increased to four. Then, for Days 10 and 11, the number was increased to eight. Finally, for Days 12 and 13, no reinforcement was given until Tom had completed 16 problems.

Reversal. During this phase, Tom was given a different arithmetic worksheet of 20 problems each day with the same instructions used during baseline. His paper was corrected and returned the following day with the number correct at

the top. No praise was given Tom by either the experimenter or the teacher.

Treatment 2. Each day, Tom was given a different arithmetic worksheet of 20 problems with the same instructions used during Treatment 1. Praise and correct answers were given Tom in the same manner as in Treatment 1, using an adjusting fixed-ratio schedule. The number of problems completed by Tom before presenting himself to the experimenter to have his work checked was increased from five for Day 20, to 10 for Day 21, 15 for Day 22, and all 20 problems for the last two days.

RESULTS

As can be seen in Figure 1, during baseline Tom's mean correct answer rate was 0.47 per

Fig. 1. The number of correct arithmetic answers per minute achieved by the subject throughout the study.

minute. During Treatment 1, the rate increased to a mean of 1.36 correct answers per minute. During reversal, the rate decreased to 0.98 and during Treatment 2, climbed to a mean of 1.44.

Collateral changes also occurred in attending behavior. Figure 2 shows that during baseline Tom spent a mean of 51% of his time in attending behavior. During Treatment 1, mean percentage of attending behavior rose sharply to 97%. There was a slight decrease during reversal to 82%, followed during Treatment 2 by an increase to 97%. It should be noted that Tom's behavior could not be recorded for Day 18 (reversal) because he left the room and completed the problems in the hallway.

DISCUSSION

The results demonstrate the combined effectiveness of the present adjusting fixed-ratio schedule of praise and immediate correctness feedback in increasing the subject's arithmetic response rate and associated attending behavior. When Tom's rate of correct problem solving was increased through systematic reinforcement, incompatible behaviors of non-attending decreased. It remains to be shown whether or not working directly on increasing attending behavior would have produced comparable improvement in arithmetic response rate.

One advantage of working directly on academic response rate instead of indirectly through

Fig. 2. Percentage of total time the subject spent in attending behavior throughout the study.

increasing attending behavior is the time and effort involved in monitoring the two forms of behavior. Working directly on arithmetic response rate, as in the present study, does not require the teacher constantly to monitor the student's study behavior. The only requirement of the teacher is immediately to correct the paper when presented and supply a short expression of praise upon returning the paper. While the adjusting ratio schedule of reinforcement requires frequent contact with the student during early phases requiring small units of work, it requires no extra effort during later phases when large units of work are assigned. The present study indicates that large units of work can be required rather quickly without deterioration in either academic response rate or related attending behavior. It is interesting to note that during reversal, when all praise and immediate correctness feedback was withheld, the subject maintained a much higher level of arithmetic achievement and attending behavior than before Treatment 1.

Though the praise and immediate correctness feedback were provided by the experimenter in this study, the classroom teacher, a selected pupil from the class (or even from another class), or

a parent volunteer could easily perform the same function.

REFERENCES

- Bushell, Don, Jr., Worbel, Patricia Ann, and Michaelis, Mary Louise. Applying "group" contingencies to the classroom study behavior of preschool children. *Journal of Applied Behavior Analysis*, 1968, 1, 55-61.
- Hall, R. Vance; Lund, Diane, and Jackson, Deloris. Effects of teacher attention on study behavior. *Journal of Applied Behavior Analysis*, 1968, 1, 1-12.
- Lovitt, Thomas C. and Curtiss, Karen A. Effects of manipulating an antecedent event on mathematics response rate. *Journal of Applied Behavior Analysis*, 1968, 1, 329-333.
- Lovitt, Thomas C. and Curtiss, Karen A. Academic response rate as a function of teacher-and self-imposed contingencies. *Journal of Applied Behavior Analysis*, 1968, 1, 49-53.
- Surratt, Paul R., Ulrich, Roger E., and Hawkins, Robert P. An elementary student as a behavior engineer. *Journal of Applied Behavior Analysis*, 1969, 2, 85-92.
- Walker, Hill M. and Buckley, Nancy K. The use of positive reinforcement in conditioning attending behavior. *Journal of Applied Behavior Analysis*, 1968, 1, 245-252.

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