EFFECTS OF MANIPULATING AN ANTECEDENT EVENT ON MATHEMATICS RESPONSE RATE¹

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The purpose of this investigation was to assess the effects on performance rate of simply writing the answers to mathematics problems *versus* verbalizing the problems before making a written response. The subject was an 11-yr-old boy whose response accuracy on mathematics problems was very erratic. Three experiments were conducted, each consisting of three phases. In each first phase, the subject was requested to write the answers to sets of mathematics problems. In the second, he was required to verbalize the problem before writing the answer. In the third phase, the subject was told to write the answer again without prior verbalization. The results indicated that the subject's correct answer rate increased and his error rate decreased as a result of his verbalizing the problems before making a written response. Results further revealed that in the final phase of each experiment, the return to the original conditions, his correct answer rate continued to increase.

Recent investigations have reported that certain academic behaviors have been increased as a result of manipulating specific subsequent events—those happenings that follow academic performance. McKenzie, Clark, Wolf, Kothera, and Benson (1968) studied the effects of grades and allowances contingent upon the academic behaviors of a class of children with learning disabilities. They reported that when such subsequent events were used within a response-contingent framework, the rate of task completion was positively affected. Lovitt, Guppy, and Blattner (1968) sought to determine the functional relationship between spelling accuracy and contingent leisure time. The results of this study, conducted with a class of fourth graders, revealed that spelling performance improved when leisure time was systematically employed as a subsequent event.

Currently, many teachers attend to the arrangement of subsequent events in their efforts to alter certain academic behaviors of children. Although the scheduling of subsequent happenings is often rather random and unsystematic, classroom teachers commonly

withhold such prized activities as recess or free time until the children have completed specified academic tasks.

Other teachers, however, particularly those attempting to encourage more accurate academic performance, manipulate antecedent events—those happenings that occur before the pupils respond. Many of these antecedents are in the form of instructions such as "Be more careful", or "Don't make so many mistakes". Another antecedent alteration, sometimes used by teachers attempting to affect more accurate performance, is requesting children to use mnemonic devices. Children are given such aids as the "alphabet song" and the "30 days hath September" poem to recite before they write the letters of the alphabet or the number of days in each month.

Many of these antecedent alterations, such as instructions or memory aids, could positively affect academic performance. However, evaluations of their function are generally casual; rarely have these common classroom teaching aids been subjected to an experimental analysis.

The current study was prompted by a student who exhibited extreme variability in responding to mathematics materials. His teacher had noted that at times he could answer certain problems correctly, but at other times would err when presented the same facts. The teacher had further observed that occasionally, when the subject verbalized

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the problem before writing the answer, the probability of correct responding was increased. The purpose of the present investigation was to assess experimentally the function of a popular remediation suggestion of teachers and parents, that children "think before they do". More specifically, this study was designed to determine the effects of simply writing the answers to mathematics problems *versus* verbalizing the problems before making a written response.

METHOD

Subject and Conditions

The subject was an 11-yr-old boy attending a class for children with behavior disorders at the Experimental Education Unit of the University of Washington.

Procedures

Three individual experiments comprised the investigation. For each session the subject was placed in a small room furnished with a table, chair, and additional seat. Each day he was provided a pencil and a sheet of math problems by the experimenter. Sessions were timed by the experimenter, who sat next to the subject with a stopwatch.

During the 26 sessions of the first study, the experimenter presented the subject daily with a set of 20 mathematics problems of the class $\square - 2 = 6$ where the minuend and subtrahend < 10 . A pool of 121 problems of this class was available. From this collection, 26 separate sets were constructed, composed of 20 randomly selected problems. The basic considerations in making up each set were that all problems on a single set would be different and that identical problems would not appear in two consecutive sets. Throughout this experiment, each problem reappeared from four to seven times.

During the first phase the experimenter told the subject to write the answers. When the subject finished a page, the experimenter made a comment such as "Thank you, that's fine", calculated the total time of the session, then returned the pupil to the classroom. The examiner then totalled the correct and error responses and converted these figures to rates per minute by dividing each total by the time of the session.

In the second phase, the manipulation

phase, the subject was told to say each problem aloud before writing the answer. He was first given a practice problem, with the instructions: "Read the problems aloud like this: 'Some number minus two equals six.' Then write the answer. Say this problem first to practice: $\square - 2 = 6$." After starting the page, neither the subject's verbalizations nor his answers were corrected; he was, however, reminded to say a problem aloud if he failed to do so. After the third day, the practice problem was no longer required, since no examiner prompts were necessary during the third session.

During Phase 3, the subject was told that he no longer needed to say the problem aloud before writing the answers. If he did verbalize the problem, the experimenter reminded him merely to write the answer, not recite the problem.

After the first study was completed, Exp. II was conducted. This investigation, which consisted of 30 sessions, with 20 problems presented per session, was designed to replicate the previous experiment by again assessing the subject's performance as a function of either reciting or not reciting the problem before his written response. During Exp. II, a collection of 60 problems was available of the class $\square - 20 = 40$, where the minuend and subtrahend were of the tens class from 0 to 100. From this pool, six sets of 20 problems each were constructed. The problems within the sets were all different, and although each problem was included more than once in the series, identical problems did not appear in two consecutive sets. These sets were then presented on consecutive days, beginning with the first set and continuing through the sixth, then beginning again with the first. Throughout Exp. II, each problem was thus presented 8 to 12 times.

In Phase 1, the subject was told simply to write the answers to the problems. During Phase 2, he was instructed to verbalize "Some number minus 20 equals 40", before making a written response. Finally, in Phase 3, the subject was instructed not to verbalize the problem before writing his response. All other procedures remained identical to Exp. I.

Experiment III consisted of 32 sessions. Throughout this experiment, 10 problems, of a class more complex than those of the 2 preceding experiments, were offered each session.

Seven sets, each containing 10 problems, were constructed from a pool of 70 items of the class $4 - 3 = 9 - \square$. These sets were then scheduled on consecutive days, sets one through seven, then beginning again with the first. The sets were arranged so that the problems within and between each set were different. During the 32-day experiment, then, the same problems reappeared each seventh session or about four times throughout the experiment. All procedures remained identical to those in Exp. I and II.

RESULTS

Experiment I

As can be seen in Fig. 1, during the initial phase, where no verbalization was required of the subject, his correct answer rate ranged from 0.6 to 12.0 with a mean of 3.0 responses per minute. His mean error rate at this time was 13.4 with scores ranging from 1.8 to 21.0. When the subject was required to verbalize the problem before responding in Phase 2, his correct answer rate increased to a mean of 7.1 with a range of 3.0 to 9.0. At the same time, his error rate decreased to a mean of 0.2, with a range of 0 to 1.2. In the final phase, although verbalization was no longer required, the subject's correct answer rate continued to increase, reaching a mean of 17.4 and ranging from 6.6 to 22.2. His error rate during this latter phase

continued to be low (mean = 0.6, range = 0 to 1.2).

Experiment II

The results of this study paralleled those of Exp. I. During the manipulation phase, the subject's correct answer rate rose and his error rate decreased from the nonverbal initial phase, as shown in Fig. 2. The subject's correct answer rate increased still further, as in Exp. I, in the final nonverbal period. Mean correct answer rates were 2.2 for Phase 1 (range = 0 to 6.0); Phase 2, 4.3 (range = 3.6 to 4.8); and Phase 3, 6.7 (range 3.6 to 9.0). As indicated by Fig. 2, the mean error rates in the second experiment decreased from 9.8 (range 1.8 to 18.0) in Phase 1, to 1.1 (range = 0.6 to 1.8) in Phase 2, the manipulation period. In the final phase, Phase 3, the mean error rate rose slightly to 2.4 with a range of 1.2 to 3.6.

Fig. 1. Correct answer and error rates for the subject during the three phases of Exp. I, where the mathematics problems were of the class $| \quad | - 2 = 6$.

Fig. 2. Correct answer and error rates for the subject during the three phases of Exp. II, where the mathematics problems were of the class $| \quad | - 20 = 40$.

Experiment III

In the final study, the subject again increased his rate of correct responding during and after the manipulation phase. As can be seen in Fig. 3, the subject's mean rate of correct responding in the initial phase was 1.4 (range = 0 to 3.0). In Phase 2, this correct answer rate increased to an average of 3.9 with a range of 2.6 to 5.4; and in Phase 3, it increased still farther to a mean of 8.7 with a range of 5.6 to 11.1. Error rates decreased, as illustrated by Fig. 3, between Phases 1 and 2, declining from 11.1 (range 4.8 to 27.0) to 0.2 (range = 0 to 0.6). The subject's error rate in Phase 3 in-

creased slightly to a mean of 0.8 (range = 0 to 5.6).

Fig. 3. Correct answer and error rates for the subject during the three phases of Exp. III, where the mathematics problems were of the class $4 - 3 = 9 -$.

DISCUSSION

Throughout the three experiments of this study, the subject's pattern of responding was relatively consistent. During the initial phase of each experiment, when the subject simply wrote the answer to the problem without verbally stating the problem, his error rate was much higher than his correct rate of response. During the second, or verbalization, phase of each experiment, his error rate dropped considerably, generally near zero, while his rate of correct responding increased. When the subject no longer verbalized the problem (Phase 3 of each experiment), his rate of correct responding increased by a large amount while his rate of committing errors increased only slightly. Furthermore, the subject's variability was much lower during the verbal phase of each experiment. This may be noted by comparing the subject's range of correct and error rates during the second phase of each study with Phases 1 and 3.

Since the same problems were used repeatedly within each experiment, and since the pupil's rate of correct responding actually increased from the verbal second phase to the nonverbal third phase, it could be said that the effect of verbalization generalized. Gen-

eralization was, however, restricted to mathematics problems of the same class; when different problems were introduced during subsequent experiments, the student's accuracy was again low. This is evidenced by a comparison of the pupil's correct rate of responding in the final phase of Exp. I with the first phase of Exp. II, and the final phase of Exp. II with the initial phase of Exp. III.

Cases such as this, where generalization does not occur from one situation to another, pose problems for teachers. In such instances, the teacher must systematically arrange and develop each sequential step; for as Baer, Wolf, and Risley (1968) pointed out, generalization "should be programmed, rather than expected or lamented."

The current study, which experimentally assessed the function of a popular remediation theory—that verbalizing a problem aids in solving it—revealed data supporting this theory. These results may be due to one of a number of factors. One possible explanation is that the subject's increased accuracy when the problem was verbalized was a function of adding a second stimulus dimension to the mathematics problem—orally reciting the problem as well as seeing it. The theoretical basis for such a thesis, that learning proceeds at a more rapid rate under multisensory conditions, has historically been supported by numerous educators.

An alternate explanation for the subject's more accurate performance during and after periods of verbalization could be that he simply became more deliberate. A pupil, when required merely to write an answer to a problem, could regard the cost of making a pencil mark as extremely minimal. However, when required to state a problem verbally, then write the solution, the increase in cost and/or complexity could have functioned to make the pupil more deliberate.

Whether saying the problem before making a written answer served to increase the pupil's accuracy because of multisensory involvement, or whether the pupil became more deliberate as the process became more complex, are questions which these data do not presume to answer. What is important is the fact that, in this study, when the variable—a verbal statement of the problem—was manipulated, it was found to improve arithmetic performance. Furthermore, this report demonstrates that the

individual effects of various remediation theories and maxims might be determined through the use of experimental analysis procedures.

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