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BRIEF RESEARCH REPORT

THE EFFECTS OF EXPLICIT TIMING ON MATH PERFORMANCE[1]

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Many elementary school teachers rely on the clock to start and stop academic assignments, thus periods, or portions of periods, are usually allotted for completion of a set amount of work. This contingency is much like a fixed-interval schedule of reinforcement, in which the child has a fixed amount of time either to finish an assignment or complete as much work as possible. Although such timing is present in most classrooms, children are rarely aware of it, and teachers often extend or reduce the length of an activity period as a function of student performance.

In several studies, students have been told that their work was being timed as part of an experimental package designed to improve reading or writing performance (Van Houten, Hill, and Parson, 1975; Van Houten, Morrison, Jarvis, and McDonald, 1974). However, the effects of explicitly timing student's behavior were not independently evaluated in these studies.

Semb and Semb (1975) reported a study where fixed-page assignments produced higher work levels in reading than fixed-time assignments. During the first fixed-page condition, children were rewarded with free time for completing 12 pages of work at an accuracy level of 90% correct. During the fixed-time phase, children continued to be rewarded for their accuracy but were no longer rewarded for their work rate. To keep overall time constant between both conditions, the duration of the fixed-time condition was determined by calculating the average time children worked during the fixed-page assignment condition.

It is not possible to conclude from Semb and Semb's (1975) results whether fixed-page assignments would always be superior to fixed-time assignments, because other variables may influence the effectiveness of fixed-time assignments. One such variable is whether or not the children are explicitly timed. In the Semb *et al.* (1975) experiment, students were not explicitly timed, but were told by the teacher when to start and when to stop working. In addition, the length of the timed period may also be an important factor. For example, dividing a long period into several short timed intervals may improve performance. The present experiment examined the effects on math performance of explicitly timing students for short intervals.

METHOD

Subjects and Setting

Twenty children in a second-grade classroom located in Dartmouth, Nova Scotia, were selected for this class on the basis of poor school performance. Eight had repeated one grade. Apart from the occasional presence of the first author and the school principal, the teacher (who was also the second author) was the only adult present during experimental sessions. At the onset of the experiment, the teacher was unaware of the purpose and design of the research; however, as the experiment progressed, she became cognizant of its purpose due to the easily discernable performance increase associated with the timing condition.

General Procedure

Each day, the children worked for 30 min on addition and subtraction worksheets. Alternate worksheets contained either 100 basic addition or subtraction facts of the following type: $3 + 5$, $7 + 8$, $9 - 3$, $4 - 2$, *etc.* These facts were arranged on each sheet, the only restriction being that each of the basic facts be used once. Problems were printed on one side of 21 by 35 cm paper. Work sheets were alternately arranged (addition sheet followed by a subtraction sheet, *etc.*) and stapled together into a booklet of approximately 10 sheets. When a student had completed one sheet, that sheet was turned back and the next sheet begun. Each student printed his name on the first sheet of each booklet and entered the date next to the first problem worked each day. At the end of the period, each student drew a line across the sheet under the last row of problems completed.

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If a student finished his booklet during the math period, he was instructed to take a new booklet from the teacher's desk.

At the end of the school day, the teacher carefully graded the booklets and returned the corrected booklets the following morning. The children then made all corrections in ink and returned the booklets to the teacher.

The reliability of the teacher's count was checked for two days during each condition by a second scorer, who was unaware of the purpose of the experiment. Rescoring agreement was calculated by totalling the problems marked correctly by each scorer for each child and dividing the lower of the two scores by the higher score. The reliability on all days checked was 97% or better.

Measures

Three measures were taken. First, *overall correct rate* was defined as the number of problems worked correctly during the 30-min period divided by 30 min (problems per minute). *Local correct rate* was defined as the number of problems worked correctly during the 30-min period divided by the actual time that children had available to work. These two measures were always the same during the baseline phase. However, local rate was always higher than overall rate during experimental phases because children could not work between timings. *Accuracy* was defined as the number of problems worked correctly, divided by the number of problems worked correctly plus the number of problems worked incorrectly.

Experimental Design

A reversal design was employed to assess the effect of timing on work rate and accuracy.

Baseline 1. During this condition, students were given their booklets and told to begin work. The teacher timed the 30-min session surreptitiously with a wall clock. During this period, and throughout all subsequent conditions, the teacher spent most of her time sitting or standing at the front of the room. Occasionally, however, she would walk around the classroom and look at student's work. During this time, she did not interact with the children unless a question was asked; this occurred quite infrequently. At the end of the 30-min period, the teacher would instruct the class that it was time to begin the next activity and that they must pass in their booklets.

One-Minute Timings 1. During this condition, the teacher instructed the children that the math period was 30 min and that the period was being timed. The teacher timed the period with a General Electric spring-wound interval timer. At the end of the 30-min interval, the timer would ring and all work would stop. Subjects were also instructed that they would be timed with a stopwatch for 1-min timings. At the beginning of each timing, the teacher would say "Pencils up, ready, begin". The children would then work until the 1-min interval was up. The teacher would then tell the students to stop and to draw a line after the last problem answered. This procedure would be repeated throughout the 30-min period until the bell rang. When the bell rang, all work stopped, even if the children were in the middle of a timed period. Since it was not possible to get 30, 1-min timings in the 30-min period, the actual time available to work problems was always less than 30 min during this condition.

Baseline 2. During this condition, the children were told that they were no longer being timed with the stopwatch and the alarm clock, but that they should try to get as much work done as possible.

One-Minute Timings 2. This condition was identical to the first 1-min timing condition.

RESULTS

The mean number of problems worked per minute and percentage correct during each of the different experimental conditions are presented in Figure 1 for the entire class. It can be seen that accuracy remained high throughout the experiment. During the first baseline condition, the class averaged approximately three and a half correct problems per minute.

Introduction of 1-min timings increased overall rate to 6.8 correct problems per minute. However, local rate increased to 10.5 problems correct per minute. At the start of this condition, the teacher gave fewer timings than at the end. This is shown in the data by the relative stability of the local rate and the gradual increase in overall rate as the number of timings per period increased.

The return to baseline decreased overall rate to a mean of 5.5 correct problems per minute. The second baseline rate was slightly above the initial baseline rate, but below the rate evidenced during the 1-min timings condition. Reintroduction of the 1-min timings condition increased overall and local rates to 8.2 and 11.5 correct problems per minute respectively.

Because students marked when they started and stopped each timing in their workbooks, it was possible to analyze their performance during each minute of each experimental condition. This analysis showed the mean performance to be consistent, with a slight drop during the last several minutes of the period. However, individual performance showed a good deal of variability throughout the period, with different children showing marked variability.

DISCUSSION

The results demonstrated that explicitly timing student's math performance increased the rate of problems worked correctly per minute while maintaining very high baseline levels of accuracy.

The failure to obtain a complete return to the first baseline levels of performance during baseline 2 is very similar to the results reported by Van Houten

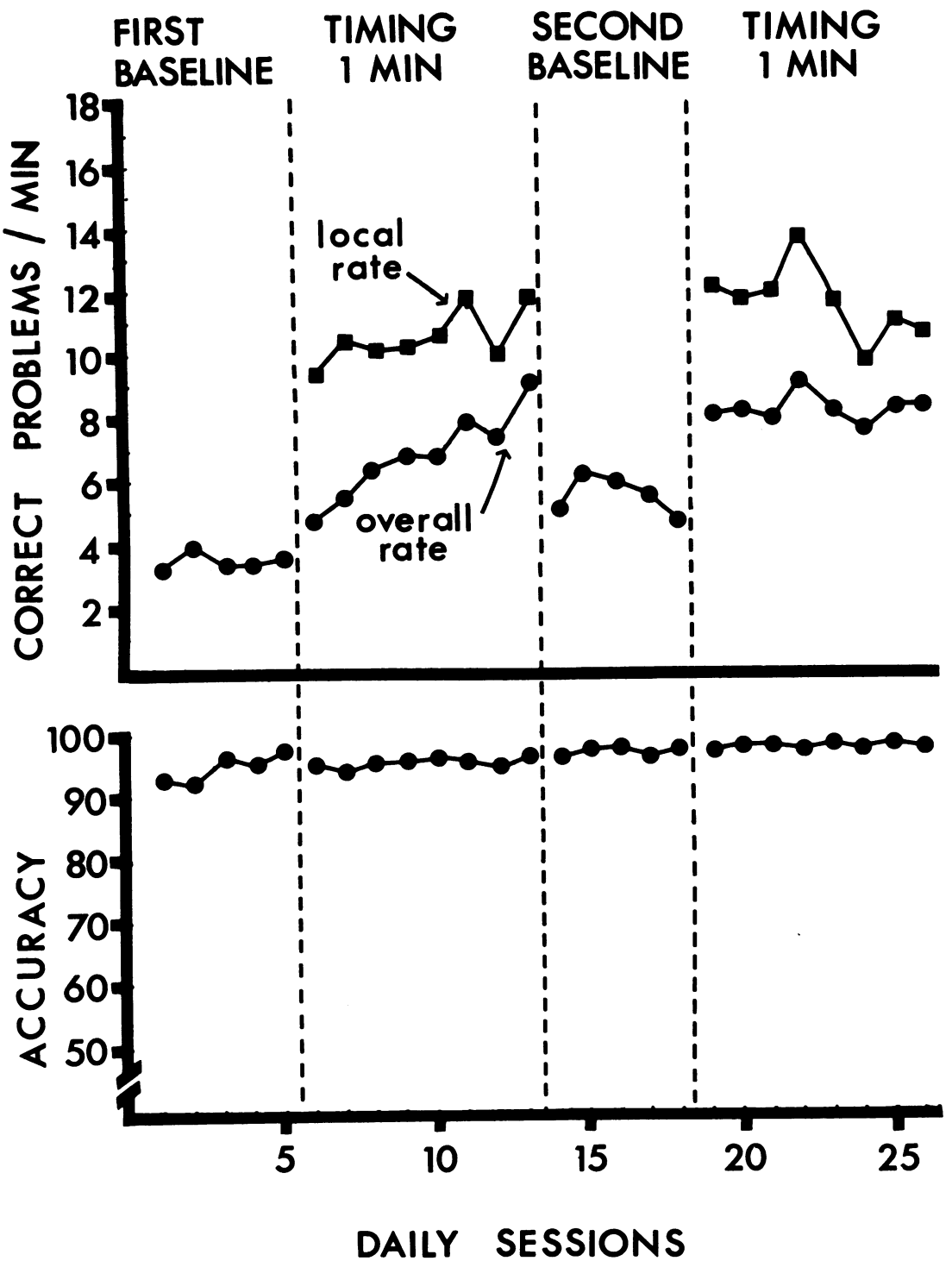

Fig. 1. The mean local and overall response rates and accuracy in each daily session across all conditions. The broken vertical lines represent introduction of the experimental conditions.

et al. (1974) with writing behavior, and may represent a tendency for some children to behave as if they are still being timed.

The teacher's major reason for drilling children on addition and subtraction problems was that many children could not work basic addition and subtraction problems without the aid of counters, a number line, marking slashes on scrap paper, or counting on their fingers. The purpose of the drill was to help them to memorize these number facts, and thereby make them more proficient in using them. As the experiment progressed, the teacher noticed that children were not counting on their fingers as frequently as before and that the use of scrap paper had decreased until it was no longer necessary to hand it out. It is unfortunate that the scrap paper was not saved, so that an empirical analysis of these data could have been made. This procedure represents a more efficient use of drill time because students worked or attempted more problems in a set period of time.

The teacher also noted that children often made comments such as: "I got two rows done", or I got _____ done" during the experimental phases. These types of comments were never noticed during the baseline condition and it is possible that they may have effected performance.

Another reason why timing children for short intervals may be effective is that it tends to make performance changes more salient. The usefulness of this procedure lies in its simplicity. Timing students is technically a simple procedure. It would be interesting to determine whether timing alone would produce similar changes in other academic behaviors. Until more data are available, one should be cautious about the generality of these effects.

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