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SELF-INSTRUCTION: AN ANALYSIS OF THE DIFFERENTIAL EFFECTS OF INSTRUCTION AND REINFORCEMENT

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This study investigated the impact of training 9 first- and second-grade children to use a full self-instructional regimen, and then differentially reinforced the use of self-instruction only, accuracy only, or both self-instruction and accuracy. Three comparison children received no training in self-instruction and were reinforced for accuracy only. Children improved dramatically in academic accuracy subsequent to self-instructional training, independent of the use of self-instruction and of the specific behavior consequated. Children who were reinforced for using self-instruction did use self-instruction, and those who were not, did not. Comparison group children showed little improvement until training in problem-solving strategies was given after 9 days of reinforcement for accuracy. Self-instructional training is discussed as one type of event that increases the likelihood of accurate performance. Its effectiveness may be explained in terms of a teaching strategy rather than in terms of modifying cognitive processes.

DESCRIPTORS: self-instruction, academic behavior, reinforcement

The efficacy of self-instructional procedures with children has frequently been demonstrated (Craighead, Wilcoxon-Craighead, & Meyers, 1978; Kendall, 1977). Learning to use self-instruction at appropriate times in the problem-solving process has been seen as the critical component in improved performance (e.g., Douglas, Parry, Marton, & Garson, 1976; Meichenbaum & Goodman, 1971). Previous studies, however, have used varying procedures. In some studies, children have been reinforced for stating their verbal strategies (e.g., Bornstein & Quevillon, 1976). In others, outcome has been reinforced independent of the overt use of the specifically taught strategy (e.g., Friedling & O'Leary, 1979; Varni & Henker, 1979). Both of these studies found self-instructional training to be ineffective until a subsequent token system was introduced. Thus, the treatment effect may have been the cumulative result of the combined programs.

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We viewed the use of self-instruction to develop academic skills as a process that involved several chains of behaviors which could be taught through reinforcement and feedback. Steps in the chains included the appropriate sequences of verbal and motor components that ended with accurate performance and subsequent reinforcement. The degree to which the verbal components of self-instruction, once trained, retained cue properties that enhanced the likelihood of task accuracy and subsequent reinforcement was examined. Specifically, the following conditions were tested using a multiple baseline within each of four groups: first, reinforcing the overt use of self-instruction independent of accuracy; second, reinforcing accuracy independent of the overt use of self-instruction; third, reinforcing both the use of the overt self-instruction and the accuracy; and fourth, reinforcing accuracy without the benefit of self-instructional training.

METHOD

Subjects

Subjects were 6 first graders and 6 second graders from two private schools in Greensboro, North Carolina. The intelligence test scores of these children fell largely in the average range ($M = 105$; range, 83 to 120) on the Slosson Intelligence Test

(Slosson, 1977). Although these children were at grade level on the Key Math Diagnostic Arithmetic Test (KMDAT) (Connolly, Nachtman, & Pritchett, 1976), they were referred by their teachers as experiencing difficulties with addition and subtraction problems compared to their classmates.

Quartets of children were formed, based on their grade, gender, IQ score, and KMDAT score. The four children from each quartet were randomly assigned to the four experimental conditions, with the restriction that no experimental condition would have only first- or only second-grade children.

Setting

The study was conducted in a quiet, unused area outside the classroom. In one school, the school library was used; in the other, the gymnasium was used. Both sites were well ventilated and well lit with a minimum of distracting noise.

Experimental Design

There were four between-subject experimental conditions (described below), with 3 subjects assigned to each condition. Within each condition, a multiple baseline across subjects design was used, with baselines consisting of four, six, or eight sessions.

After baseline sessions were completed, children in the first three experimental conditions were trained individually to use a standard set of self-instructions to assist them in correctly completing the arithmetic problems. Because the self-instruction contained a problem-solving strategy, children in these groups actually received training both in the use of the overt self-instruction and a strategy necessary to accurately complete the problems. Following training, there were 10 treatment sessions for each child in which receipt of tokens and social praise was contingent either on the use of self-instructions, accuracy of the arithmetic problem, or both.

After baseline, children in the comparison condition received tokens and social praise contingent on accurately completing the problems without the benefit of training in the use of self-instruction. After eight or nine treatment sessions, children in this condition were trained on the use of the strategy without being taught to use any overt self-instruction. Children continued to receive tokens and social praise only for accuracy. Depending on individual children, this condition lasted from one to three sessions.

Experimental Conditions

Self-instruction training plus reinforcement for using self-instruction. During treatment sessions, the child was given a token after each arithmetic problem if he or she overtly verbalized all self-instructions regardless of the correctness of their answers.

Self-instruction training plus reinforcement for accuracy. The child was given a token each time he or she correctly completed an arithmetic problem, regardless of whether or not the self-instructions were stated.

Self-instruction training plus reinforcement for self-instruction use and accuracy. The child was given a token after each arithmetic problem only if he or she both overtly stated all self-instructions and correctly answered the arithmetic problem.

Reinforcement for accuracy. The three children in the comparison condition did not receive training in self-instruction. During treatment sessions, the children were given tokens after each instance of correctly completing an arithmetic problem.

Reinforcement for accuracy plus instructions. After children in the comparison condition had received nine, eight, and nine treatment sessions, respectively, they were trained individually in the use of the appropriate strategies but not in the overt verbal repetition of the strategies. Three, three, or one more treatment sessions followed, respectively, for the three children, in which the child received a token and social praise after each arithmetic problem if his or her answer was correct.

Treatment and Training Materials

Treatment materials consisted of sheets of paper (8½ by 11 inches), each containing 20 grade-appropriate addition and subtraction problems. Problems were of the form $8 + \square = 15$ for first-grade subjects and $\square - 28 = 19$ for second-grade subjects. The position of the missing value, indicated by the block, was varied throughout the 20 problems. Each sheet contained an equal number of addition and subtraction problems. A different set of problems was constructed for each day of baseline and treatment. The problems were presented in the same order to all 6 first- and second-grade subjects, respectively.

During the individual self-instruction training, the experimenter used a training sheet consisting of three addition and three subtraction problems to demonstrate the use of self-instruction while problem-solving. A second training sheet consisting of three different addition and three different subtraction problems was used by the child following the experimenter's example. The problems used during training were of the same form as those used during treatment.

Dependent Measures

There were two primary dependent measures collected by the experimenter during each session. The first measure was the number of correctly answered arithmetic problems, with the maximum correct being 20. The second measure was the number of arithmetic problems during which the child overtly stated all self-instructions that had been taught in training, with the maximum being 20. Children were not required to state the self-instructions verbatim but were required to include all components on a checklist monitored by the trainer.

Reliability of Dependent Measures

Accuracy of arithmetic problems. After the study was completed, a random sample of 20 arithmetic sheets selected across conditions and subjects was independently rescored by an individual who was not otherwise involved in the study and was blind to the experimental conditions. She compared her scores for each sheet to those recorded by the individual experimenters. Interscorer agreement was 100%.

Use of overt self-instruction. No data on interobserver agreement were recorded on this measure. However, to reduce variability among experimenters during treatment, each experimenter was provided with cards that listed the verbalizations that the children had been trained to say.

Procedure

Baseline. During baseline sessions, each subject met individually with one of the experimenters for 20 to 30 min. Each subject was presented with the problem sheet and was instructed by the experimenter to complete the problems. The experimenter sat across from or next to the subject and waited until the subject indicated that he or she had completed all of the problems. The subject was not given any feedback on his or her performance either during the task or after the task was completed. Upon completion of the task, each subject was thanked and returned to the classroom.

Self-instruction training sessions. After completion of the baseline phase, each experimental subject was introduced to the self-instruction to be used in solving the arithmetic problems that were regularly employed in the classroom. First, the experimenter modeled the use of self-instruction to solve the problems. For a problem such as $8 + \square = 15$, the modeled self-instruction would be: "First, I have to read the problem. Eight plus some number equals 15. This is an addition problem so I have to circle the sign. I circle the plus. Now I put eight sticks over the 8 and put sticks over the box until I get 15. 1, 2, 3, 4, 5, 6, 7, 8 and 9, 10, 11, 12, 13, 14, 15. Now I count the sticks over the box. 1, 2, 3, 4, 5, 6, 7. There are seven sticks over the box. Seven is my answer so I write it in the box. Eight plus seven equals 15." The subject was then given a similar problem to solve and was prompted in the use of self-instruction. Verbal praise was used to reinforce the subject for correct verbalizations and solutions. These prompts and social reinforcers were faded over the course of the training session. By the end of the training session, subjects were able to state all necessary self-instruction without prompting.

Following the training sessions, each subject was given an explanation of the reinforcement system and was taken to the store, set up in a vacant room, to look over the prizes they could purchase with the tokens they earned. Prizes consisted of various inexpensive toys or school-related items, such as marbles, trinkets, or pencil erasers. Their point value in tokens varied from 8 points to 50 points. The children were told they could either spend their tokens each day or save for a larger prize of their choice.

Treatment sessions. Each treatment session began with the experimenter modeling the self-instructional approach taught during the training session. Different problem types were modeled at the beginning of different sessions.

After the problem was modeled, the subject was given a problem sheet. Before beginning work, the child was reminded what set of behaviors was required to earn a token; that is, he or she was told that a token would be earned contingent on either stating all of the appropriate self-instructions and/or answering the problem correctly.

The subject was instructed to complete all 20 problems. If the subject engaged in the target behavior, he or she was given a token, praised, and provided with a statement of the contingencies ("Good job, you get a token because you told yourself what you had to do"; and/or "you got the right answer"). If the subject did not engage in the target behavior, the experimenter explained why a token was not given. Subjects who received tokens contingent on their use of self-instruction received feedback on the correctness of the arithmetic answer only after tokens had been delivered or withheld and the contingencies had been restated. When the subject completed the worksheet, he or she counted the tokens that had been earned and was taken to the store to exchange tokens for prizes.

RESULTS

The first dependent measure to be considered is the number of arithmetic problems that the children completed correctly during each session. As shown in Figure 1, the children's accuracy in solving the arithmetic problems was generally quite low during baseline. After the baseline session, the children in the three experimental conditions were trained in self-instruction and were exposed to the differing reinforcement contingencies. It is important within the logic of the multiple baseline design to note that improvement in accuracy began when, and only when, the training and rewards were instituted. The only exception is Kathy in the experimental condition who was rewarded for overt use of self-instruction only; it took her a few sessions after training to improve her arithmetic accuracy.

Self-instruction training plus reinforcement for using self-instruction. The data for the children who were trained in, and rewarded for, overtly verbalizing are depicted in the upper left panel of Figure 1. All three children increased the number of problems answered correctly during treatment.

Self-instruction training plus reinforcement for accuracy. The data for children who were trained in self-instruction and who were rewarded for correctly answering the problems are depicted in the upper right panel of Figure 1. All three children improved their accuracy in solving the arithmetic problems during treatment.

Self-instruction training plus reinforcement for self-instruction use and accuracy. The data for children who were trained in self-instruction and who were rewarded when they both overtly verbalized the self-instructions and produced correct answers are depicted in the lower left panel of Figure 1. All three children improved their accuracy in solving the arithmetic problems during treatment.

Reinforcement for accuracy. The children in the comparison group did not receive training in self-instruction following baseline; but, during treatment sessions, they did receive tokens for each

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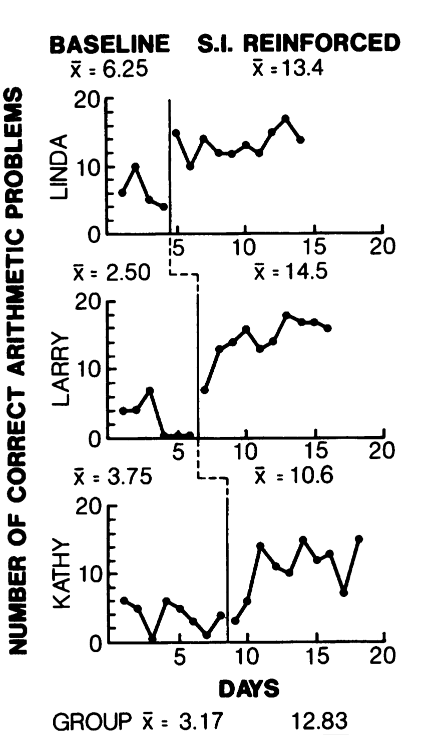
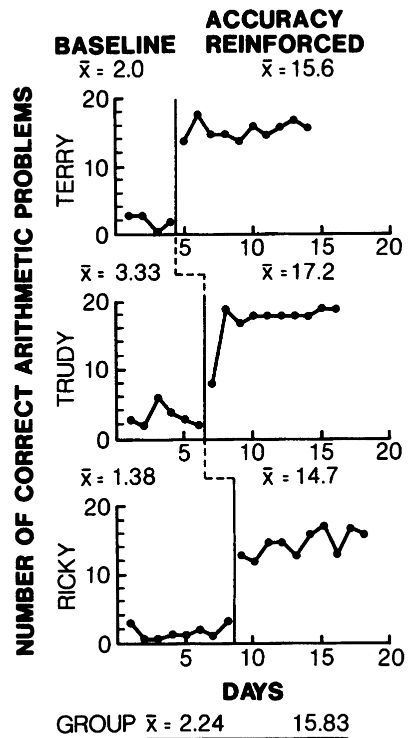
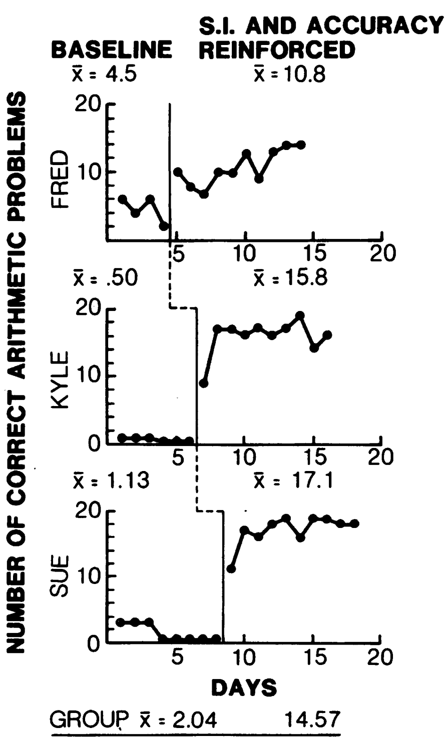
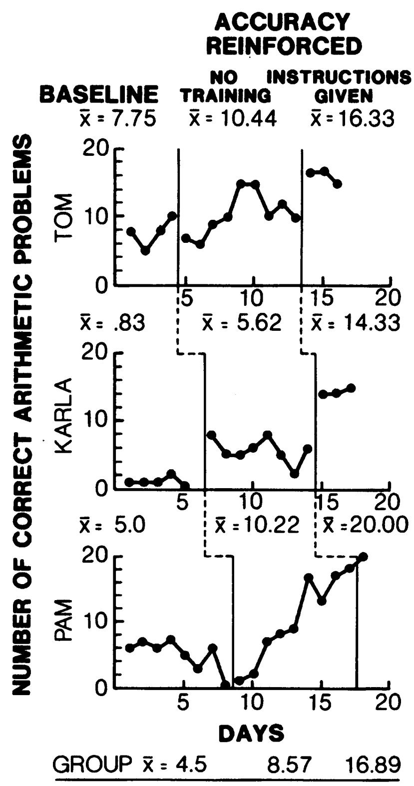
Figure 1. Number of problems answered correctly for each baseline and treatment session (maximum = 20). The group in the upper left was reinforced for use of self-instruction; the group in the upper right was reinforced for correct arithmetic problems; the group in the lower left was reinforced for both the use of self-instruction and correct arithmetic problems; the group in the lower right was the comparison group, who were first reinforced for correct arithmetic problems and then taught a problem-solving strategy.


BASELINE
S.I. REINFORCED
x̄ = 6.25
x̄ = 13.4
NUMBER OF CORRECT ARITHMETIC PROBLEMS
LINDA
x̄ = 2.50
x̄ = 14.5
LARRY
x̄ = 3.75
x̄ = 10.6
KATHY
0 10 20
5 10 15 20
DAYS
GROUP x̄ = 3.17 12.83


BASELINE
ACCURACY REINFORCED
x̄ = 2.0
x̄ = 15.6
NUMBER OF CORRECT ARITHMETIC PROBLEMS
TERRY
x̄ = 3.33
x̄ = 17.2
TRUDY
x̄ = 1.38
x̄ = 14.7
RICKY
0 10 20
5 10 15 20
DAYS
GROUP x̄ = 2.24 15.83


BASELINE
S.I. AND ACCURACY REINFORCED
x̄ = 4.5
x̄ = 10.8
NUMBER OF CORRECT ARITHMETIC PROBLEMS
FRED
x̄ = .50
x̄ = 15.8
KYLE
x̄ = 1.13
x̄ = 17.1
SUE
0 10 20
5 10 15 20
DAYS
GROUP x̄ = 2.04 14.57


ACCURACY REINFORCED
BASELINE
NO TRAINING
INSTRUCTIONS GIVEN
x̄ = 7.75
x̄ = 10.44
x̄ = 16.33
NUMBER OF CORRECT ARITHMETIC PROBLEMS
TOM
x̄ = .83
x̄ = 5.62
x̄ = 14.33
KARLA
x̄ = 5.0
x̄ = 10.22
x̄ = 20.00
PAM
0 10 20
5 10 15 20
DAYS
GROUP x̄ = 4.5 8.57 16.89

arithmetic problem that was correctly answered. Their data are depicted in the lower right panel of Figure 1. Each child showed a somewhat different pattern of results. The implementation of the reward contingencies had an immediate effect only on Karla, who went from a baseline mean of 0.83 problems correct to a treatment mean of 5.62 problems correct. The reward contingencies did not appear to have an effect on Tom's performance but did produce a gradual improvement in the accuracy of Pam's performance with her attaining near perfect performance by the end of this condition.

After the three children in the comparison group experienced nine, eight, and nine treatment sessions, respectively, they were individually trained in the appropriate strategies. The children then participated in three, three, or one more treatment session, respectively, in which the children were rewarded after each arithmetic problem if his or her answer was correct. The training in strategy use produced an immediate improvement in the accuracy of two of the children.

The observations of self-instruction use indicated that children whose self-instruction use was reinforced used the procedure, whereas children whose self-instruction use was not reinforced tended not to use it. Only one child in the comparison group was ever observed to use self-instruction. This occurred only during one session of the no-training condition. Moreover, when the degree of association between arithmetic accuracy and overt use of self-instruction was assessed by means of a phi coefficient, the resulting phi was .1934. This shows a very weak association between arithmetic accuracy and the use of overt self-instruction.

The combination of self-instructional training and rewards produced more improvements in arithmetic accuracy than did rewards alone. This conclusion is supported by the following data. First, all three experimental groups that received self-instructional training and rewards improved more from baseline to treatment than did the comparison group who received rewards without self-instructional training. Second, when the children in the comparison group finally did receive training in problem-solving strategy in addition to rewards, their accuracy improved markedly.

A second conclusion is that all three experimental groups that received self-instructional training and rewards showed comparable improvements in arithmetic accuracy. Thus, comparable improvements were produced when rewards were given for correct answers, for the overt use of self-instruction, or both.

DISCUSSION

Children's arithmetic accuracy improved after exposure to self-instruction independent of whether they were subsequently rewarded for using the self-instruction, for accuracy only, or for a combination of the two. Thus, the first conclusion of this study was that the actual use of self-instruction after training was not critical to obtaining the correct answer. These data question the validity of self-instruction in situations in which it is not specifically reinforced or prompted (Roberts & Tharp, 1980). The second conclusion of this study was that, after training, there was no relationship between the children's use of self-instruction on a particular arithmetic problem and the correctness of their answers to that problem.

The importance of the content of the self-instruction during training was examined by contrasting the accuracy of the children in the three experimental conditions with the accuracy of the children in the comparison group. All children in the experimental conditions were more accurate immediately after training than in baseline. Children in the comparison group improved most dramatically after strategy training. It was apparent, however, that self-instruction was no more effective than the strategy training following a straight operant procedure of rewarding arithmetic accuracy.

These data strongly question the assertion in the cognitive behavioral literature that self-instruction is critical to the effects reported in cognitive behavioral training. Moreover, other than the Lurian model of verbal control of motor behavior (Luria, 1961), there are few theoretical models to describe the mechanisms underlying the reported effectiveness of cognitive behavioral training packages (Roberts & Nelson, 1983). The effectiveness of self-instruction instead may be explained in terms of setting events. In Bijou and Baer's (1961) terms, "a *setting event* is a stimulus–response interaction which, simply because it has occurred, will affect other relationships which follow it" (p. 21). Wahler and Fox (1981) suggested that setting events are more complex than discrete stimulus events and represent both the environmental event and the person's response to it.

In this instance, the setting event involved the instruction by another to perform the verbal and motor components of an activity as well as the child's verbal and motor responses to those instructions. All were paired with verbal reinforcement during training and the arithmetic problems used as training materials. However, each component in these complex chains of behavior was still responsive to reinforcement and extinction. After training, the continued use of self-instruction and/or accuracy in the task was differentially reinforced. The components of the setting event that continued to be reinforced remained in the repertoire; those which were not, did not.

Although this study did not address whether or not good instructions alone were the active ingredient in self-instruction training, other studies (e.g., Roberts & Mullis, 1980) suggest this may indeed be the case. In the present study, self-instruction training provided the setting in which good clear instructions, reinforcement for memorizing those instructions, or reinforcement for accuracy in problem completion were each potent variables in task outcome.

Although the overt use of self-instruction did not facilitate arithmetic performance after the task was learned, it was apparent from these data that they also did not interfere with task performance. Results of this study are in agreement with other studies (e.g., Roberts, 1979) that showed no inhibitory effect for the use of overt self-verbalizations once an academic task had been learned. Rather, this study demonstrates that they had no utility once training was complete.

When children have poor skills in an academic area, reinforcement alone will gradually increase accuracy, but anecdotal data from this study suggest that it is a painful and difficult process. The three children in the comparison group showed improvement once they were provided specific strategy training and were then reinforced for outcome. Other studies (Kendall & Braswell, 1982; Roberts & Mullis, 1980) showed that self-instruction training was one of several effective ways to teach a given academic skill. Its utility seems to lie in providing step-by-step, clear instructions rather than its contribution to cognitive processes.

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