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AN ANALYSIS OF ERROR-CORRECTION PROCEDURES DURING DISCRIMINATION TRAINING

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Mechanisms involved in error-correction procedures during behavioral acquisition were examined. Seven developmentally delayed subjects participated in match-to-sample discrimination training, consisting of three conditions arranged in a multielement design. Correct responses in all conditions were followed by praise and either food or pennies. In the baseline condition (differential reinforcement), an error produced no consequences. In the practice condition, an error was followed by repetition of the trial until a correct response occurred. In the avoidance condition, an error was followed by additional trials consisting of irrelevant stimuli; this condition separated the effects of repeated exposure to the same task from those of negative reinforcement, both of which existed in the practice condition. All 7 subjects made noticeable progress in the baseline condition. However, 5 of the 7 performed better in one of the error-correction conditions: 2 performed better in the practice condition, and 3 performed better in the avoidance condition. These data indicate that error-correction procedures may serve multiple functions and suggest that the practice requirement in this study included both avoidance and stimulus control components. More generally, the data indicate that additional control procedures should be included in acquisition studies to identify the relevant behavioral mechanism(s).

DESCRIPTORS: acquisition, avoidance, error-correction procedures, practice

Teachers use a number of behavioral techniques to motivate students, and several procedures have become so common that they are considered basic elements of instruction. One is the delivery of rewards (e.g., praise, materials, and other stimuli presented contingent on correct performance), which, if effective, function as positive reinforcement. A second procedure often used is some type of correction technique to reduce the frequency of errors. Considerable variation is seen among these error-correction procedures; as a result, their underlying behavioral mechanism is not as clear as in the case of positive reinforcement.

Four general strategies are followed when a student makes an incorrect response. The first is characterized by the absence of a programmed consequence and is equivalent to the extinction component of differential reinforcement. For example, Bennett (1974) taught 2 4-year-old girls to articulate phonemes using only positive reinforcement for correct responses.

A second method for reducing errors also does not entail the delivery of consequences per se, and differs from extinction in that, following an incorrect response, a delay is imposed prior to the next learning trial. These time-out periods are typically brief (e.g., 10 s to 30 s in Barton, 1970, and McReynolds, 1969) and are thought to be effective because they establish an even less favorable density of positive reinforcement for incorrect responses than that found with extinction.

Teacher presentation of discrete events following errors comprises the third approach to error correction. A common feature of this approach is that no response is required of the student; the teacher responds to an error while the student remains relatively passive. Beyond that, the procedures can be quite varied and have incorporated punishment (stimulus presentation in Tawney, 1972, and McMorrow & Foxx, 1986) or response cost (stimulus removal in Panyan & Hall, 1978) for errors,

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which may include negative reinforcement if the procedures are applied for nonoccurrence of correct responses (Iwata, 1987).

The fourth type of error-correction procedure involves presentation of a remedial trial contingent on errors. A common behavioral requirement consists of repeating the trial until some criterion is met, defined by either number of repetitions or correct responses. For example, Schumaker and Sherman (1970) repeated error trials four times; Ollendick, Matson, Esveldt-Dawson, and Shapiro (1980) had five repetitions of error trials; and Nutter and Reid (1978) repeated trials until a subject made three consecutive correct responses.

A thorough analysis of instructional processes would include a description of the relative contributions made by various procedural components. With respect to error-correction procedures, very little research has attempted to isolate the effects of extinction and time-out, punishment, response cost, negative reinforcement, or enhanced stimulus control. Altman, Hobbs, Roberts, and Haavik (1980) compared two variations of remedial trials (easier tasks and harder tasks) by systematically implementing two different procedures contingent upon errors. This study represents one of the few analyses of the effects of correction procedures. Although the primary interest for Altman et al. was the effects on disruptive behavior, they noted that correct responses were higher when the presentation of harder tasks was contingent upon errors.

In another comparison of error-correction procedures, Axelrod, Kramer, Appleton, Rockett, and Hamlet (1984) attempted to determine whether the function of spelling practice exercises was educational (relevant task) or aversive (irrelevant task). The relevant task, presented contingent upon misspelled words, was writing the misspelled word, its part of speech, and phonetic spelling, and writing the word in five sentences. The task was the same for the irrelevant condition, except that the root words of the misspelled words were substituted for the actual misspelled words. Both procedures produced improvement in spelling test scores, with the irrelevant task resulting in slightly more improvement. Axelrod et al. concluded that the two procedures were so similar that a determination of different functions was not possible.

The purpose of this study was to provide a preliminary analysis of behavioral mechanisms operating in one of the strategies described above, the remedial-trials procedure. Specifically, do correction trials improve performance? If so, what is the function of the correction trials? Do they merely provide exposure to the stimuli and practice for the correct response, or do they set up an avoidance contingency for the correct response?

This study compared the effects of a control condition, in which only correct responses received a consequence, with two other conditions involving repetition of a trial contingent on errors. These two conditions separated the effects of repeated practice (stimulus control) and avoidance (negative reinforcement) from those of avoidance alone.

METHOD

Subjects

Seven developmentally delayed adults, 5 males and 2 females, participated in the study. Roger was 41 years old, Robert was 32 years old, Carl was 28 years old, Fred was 32 years old, Kevin was 26 years old, Amy was 42 years old, and Lola was 43 years old. All subjects scored in the severe to profound range of mental retardation and displayed limited communicative repertoires. All of the subjects were residents of a large state institution for the mentally retarded, and at the time of the study none participated in sheltered workshops or vocational training.

Apparatus

The training context was a matching-to-sample task consisting of stimuli printed on paper (8 in. by 11 in.) and arranged in a three-ring binder (see Figure 1). The stimuli included geometric shapes, Greek letters, and computer-generated graphic symbols (Macintosh®). These unconventional stimuli were selected to ensure that correct responding was the result of the training procedures rather than the result of some unknown history of the subject with the stimuli. The matching task was either identity (sample stimuli and the correct comparison were the same stimuli) or nonidentity (the correct comparison was an arbitrarily assigned stimulus that did not resemble the sample). On any trial, the correct comparison stimulus could be located in the middle, right, or left position for each sample. Each stimulus set was randomly assigned to one of three conditions, with different assignments for each subject. A data sheet was specifically designed to record the order of stimulus presentation and correct or incorrect responses on each trial.

The experimenter was the first author or one of eight research assistants trained by the first author. Experimenter assignment varied across subjects; the first author observed the first 2 weeks of training with each assistant to ensure procedural integrity.

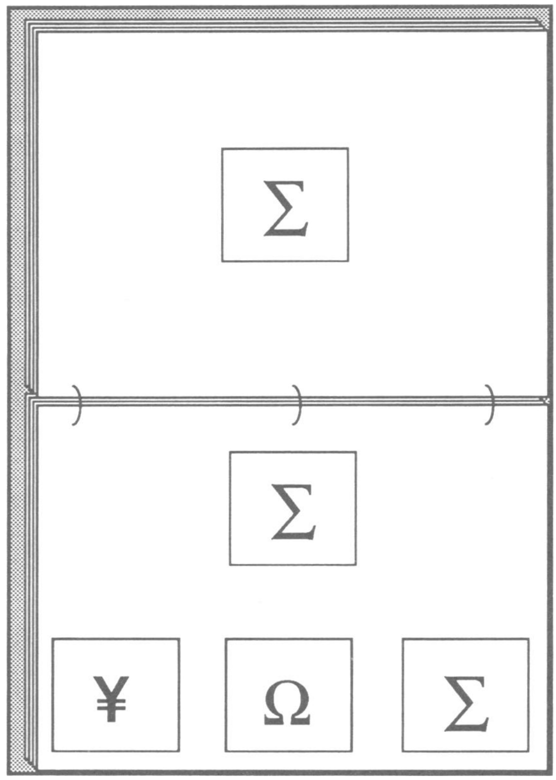

Figure 1. An example of the stimulus display for identity matching. The sample is presented on the top page, and the sample and the comparison stimuli are presented on the page below. During a trial, an observing response to the sample, when presented alone, produced the sample and comparison stimuli.

General Procedure

The subject sat at a table facing the experimenter. The experimenter presented the stimulus page for that trial with only the sample stimulus exposed. After the subject made an observing response by touching the sample stimulus, the experimenter showed both the sample and comparison stimuli. The subject was instructed to "find the same one" (for identity matching) or to "find the one that gets you the treat" (for nonidentity matching), and was prompted to respond if he or she did not initiate a response within 5 s of the instruction. The prompt consisted of the minimal amount of physical assistance necessary for the subject to raise a hand toward the comparison stimuli. A correct response was not prompted; the hand was only moved so that it was above the comparison stimuli.

For all conditions, a correct response on the first presentation of a stimulus pair was immediately followed by the experimenter presenting a food item or penny and saying, "Good, that's right," or some similar statement. Food items (small candies, pieces of sugar-coated cereal, marshmallows, pieces of cookies) or pennies that could be exchanged for glasses of diet coke after a session were presented following correct answers. The reinforcing consequences for each subject were determined prior to training by presenting items and observing for repeated approach and consumatory responses.

A response designated as incorrect always was followed by a statement to the effect, "No, that's wrong." Intertrial intervals were 3 to 5 s, and sessions were approximately 15 to 20 min long.

The criterion for mastery was set, prior to training, at two consecutive sessions of 90% or better correct responses for identity matching and at three consecutive sessions of 90% or better correct responses for nonidentity matching. Both criteria are well within the range set in other behavioral acquisition studies (Guevremont, Osnes, & Stokes, 1988; McGee, Krantz, & McClannahan, 1986; Yamamoto & Mochizuki, 1988). When criterion was met for a stimulus, it was replaced so that a constant number of training stimuli was kept in each condition.

All subjects began the study working on identity matching. When subjects met criterion on new stimuli within the first five sessions in all training conditions, they were switched to nonidentity matching. This occurred with only 3 subjects (Fred, Rob, and Roger).

Experimental Design

Three conditions with differing error contingencies were presented in a multielement design (Sidman, 1960). Each session consisted of each of these conditions presented in a random order.

Differential reinforcement (baseline). During this condition, the matching task was presented as described previously. Praise and food items or pennies followed a correct response, whereas an incorrect response was followed by a statement that an error was made. Then the next trial was presented. This condition was designed as a baseline control condition and demonstrated the effect of positive reinforcement for correct responses.

Practice. The same procedures as those used during differential reinforcement were used, with the following exception: When a subject made an incorrect response, the error trial was repeated until a correct response occurred. Initially, all correct responses, including those made on remedial trials, were followed by the reinforcement procedure. After several stimuli had been acquired by each subject, only praise followed correct responses on remedial trials. This ensured that the practice condition did not result in a denser schedule of reinforcement than the differential reinforcement condition because of the opportunity for reinforcement during remedial trials.

This condition was designed to determine the effects of stimulus control via practice and repeated exposure to the error trial. However, necessarily combined with the stimulus control process is negative reinforcement of correct responses; this occurs because correct responses during training avoid remedial trials. Therefore, any differences in acquisition during this condition, when compared to the differential reinforcement condition, could be attributed either to the effects of improved stimulus control via repeated presentations or to negative reinforcement of correct responses through avoidance of repetitions by correct responding.

Avoidance. This condition also was identical to differential reinforcement with respect to consequences for correct responses. However, when a subject made an incorrect response, color-matching stimuli were presented in a configuration identical to that used for presenting the learning stimuli. The number of color-matching trials presented was yoked to the average number of repetitions for the practice condition from the previous session. Reinforcement density (praise) during this condition was maintained at approximately the same rate as during the practice condition.

This condition was designed to separate the effects of negative reinforcement from stimulus control by repeated presentation of trials. Improved stimulus control could not account for acquisition during this procedure because the repeated trials contained irrelevant stimuli.

Measurement and Reliability

The dependent variable was the number of correct responses in each condition for each session. The total numbers of correct and incorrect responses for each comparison stimulus, and for the condition as a whole, were recorded for each session.

A second observer, who received the same training as the experimenters, was present for at least 10% of all training sessions for each subject. Initially, every session during the first 2 weeks was observed by a reliability observer; thereafter, at least one session every other week was observed. The reliability observer independently recorded all responses for the sessions and observed the training for procedural accuracy. Point-to-point reliability for each response was calculated. Reliability scores were 100% for all sessions observed. No procedural variations were reported.

RESULTS

Subjects participated in varying numbers of sessions based on their availability; Amy participated in the fewest (25 sessions × 3 conditions) and Roger the most (134 sessions × 3 conditions). Figure 2 shows the cumulative number of correct responses across blocks of 25 trials for each subject in each condition.

A consistent finding for all subjects was that performance improved noticeably throughout the study during the baseline condition (differential reinforcement), in which no consequences followed errors. In fact, Lola's best performance was in baseline, and Rob's performance was virtually the same across the three conditions. The 5 remaining subjects performed best under one of the error-correction conditions. Amy, Fred, and Carl performed best during avoidance sessions, whereas Kevin and Roger performed best during practice sessions. Although differences were not large in all cases, they were noticeable. Across the 5 subjects (Amy, Fred, Carl, Kevin, and Roger), the smallest difference between the superior error-correction condition and baseline was 15 correct responses across 25 sessions (Amy, avoidance vs. differential reinforcement). This amounts to a difference of 60 correct responses projected across 100 sessions. By way of comparison, the largest actual difference amounted to over 300 correct responses across 134 sessions (Roger, practice vs. differential reinforcement).

DISCUSSION

This study examined mechanisms involved in error-correction procedures during one-to-one matching-to-sample instruction. Procedures were designed such that performance would be affected by three possible variables: differential positive reinforcement alone (baseline condition), positive and negative reinforcement (avoidance condition), or positive and negative reinforcement plus enhanced stimulus control (practice condition). Subjects' performance, measured as number of correct responses, was compared for the three conditions. All subjects improved in the baseline condition, 3 performed best in the avoidance condition, and 2 performed best in the practice condition.

Of particular interest was the fact that all subjects made progress when no consequences were provided for incorrect responses (errors). These results are consistent with data reported by Bennett (1974), indicating that differential reinforcement alone was sufficient to produce learning. In recent years, however, there has been a trend toward developing and refining error-correction procedures; data from the present study indicate that error-correction procedures can enhance performance. The mechanism common to both the avoidance and practice conditions was negative reinforcement, in that correct responses allowed subjects to avoid error-correction trials. This feature accounted for some of the improvement in performance. The additional feature of practice with relevant stimuli was associated with further improvement in 2 subjects' performance.

Common sense suggests the superiority of the practice condition, which included differential positive reinforcement, negative reinforcement, and the repeated presentation of trials establishing stimulus control; the avoidance condition presented only positive and negative reinforcement of correct responses. The fact that there was some between-subject variability across conditions suggests that for error-correction procedures, as in other behavioral procedures and processes, individual history affects performance.

The data presented in this study are also consistent with findings reported by Axelrod et al. (1984) and eliminate a problem they identified—that of the irrelevant-trial stimuli being too similar to the relevant-trial stimuli. Combined with the Axelrod et al. findings, our results support the view that remedial trials contain an aversive element that is avoided through correct performance.

In conclusion, this study demonstrated that error-correction procedures improve performance through negative reinforcement and that, for some subjects, trial repetition enhances stimulus control over correct responding. Further studies to isolate the necessary and sufficient processes operating within different error-correction procedures are needed. Furthermore, future research should extend this analysis to additional error-correction procedures in order to specify the component behavioral mechanisms and to determine which are most effective for acquisition. Analyses should be extended

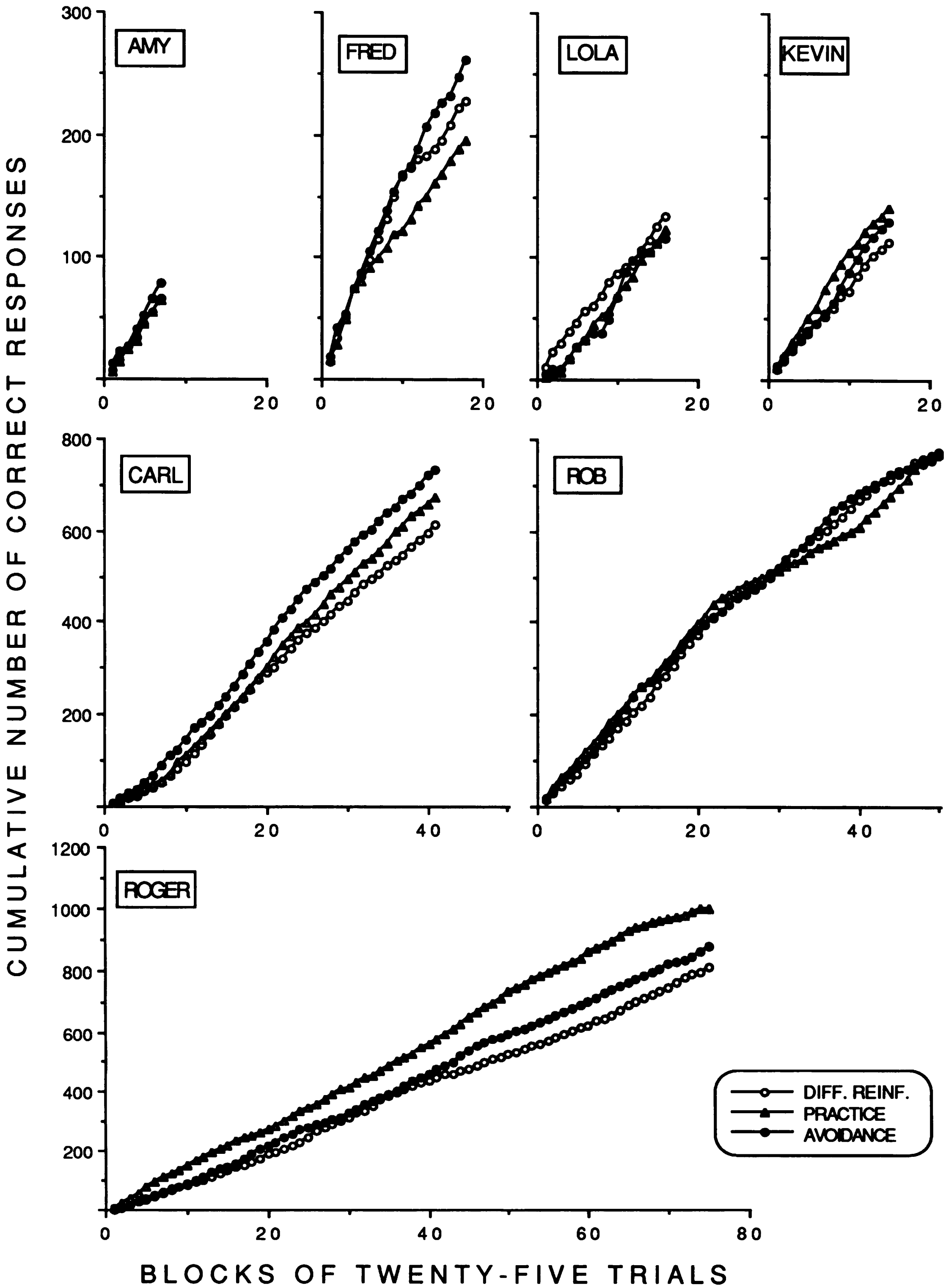

Figure 2. The cumulative number of correct responses across blocks of 25 trials for each subject and each experimental condition.

to learning tasks other than matching to sample to determine whether certain error-correction procedures are more effective for some tasks than for others, or whether each subject responds to one error-correction procedure better than to others.

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