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SENSITIVITY OF CHILDREN'S BEHAVIOR TO PROBABILISTIC REWARD: EFFECTS OF A DECREASING-RATIO LOTTERY SYSTEM ON MATH PERFORMANCE

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Probabilistic reward has been shown to affect children's choice behavior in game-like activities. We examined the effects of a lottery system containing progressively lower exchange ratios on children's completion of math problems. Two of the 3 children completed problems above baseline levels until the chance of exchange dropped to 25%. This study describes a potentially useful method for examining reinforcement schedules in applied settings and extends previous research on probabilities of reinforcement.
DESCRIPTORS: probabilistic reward, lottery systems, academic behavior

Intermittent schedules of reinforcement can be effective at promoting high levels of appropriate responding in children (e.g., Hanley, Iwata, & Thompson, 2001; McGinnis, Friman, & Carlyon, 1999). One way to provide intermittent reinforcement is to arrange situations in which children have various probabilities of earning rewards (Witt & Elliott, 1982). To date, however, little research has examined the effects of probabilistic reward on children's behavior. Cuvo, Lerch, Leurquin, Gaffaney, and Poppen (1998) presented children with a choice of lower and higher effort behaviors in the context of game-like activities (e.g., tossing bean bags from two distances). In each experiment, the reinforcement schedule was thinned for the lower effort alternative while the higher effort alternative resulted in continuous reinforcement. Results suggested that the children's choices in behavior were sensitive to different probabilities of reinforcement which resulted from a combination of variables: the success of their attempts, their *obtained* schedules of reinforcement, and their within-session reinforcement histories. In this study, we developed a procedure for examining probabilistic reward based on a lottery system in which children earned tokens that were entered into a drawing for the opportunity to obtain back-up reinforcers. In so doing, we sought to replicate and extend the work of Cuvo et al. by examining the effects of progressively lower exchange ratios on children's completion of math problems.

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METHOD

Participants and Setting

Participants were 3 fourth-grade female Caucasian students, ages 9 years (Stephanie)

and 10 years (Jenna and Kate), who had been identified by their teachers as having difficulties in math. Experimental sessions took place at a desk and chair located in an alcove outside the students' classrooms.

Materials

Multiple versions of difficult and easy math computation worksheets were developed from curriculum-based screening probes. Difficult worksheets consisted of 30 four-digit by four-digit addition problems without regrouping arranged in vertical format. Easy worksheets consisted of four single-digit addition problems with sums 0 to 5 placed on small slips of paper.

Preferred back-up reinforcers for which students could exchange points earned during each session were identified using a pictorial-choice preference assessment. Picture cards representing items were presented in pairs to each child, and she was asked to choose the preferred item from each pair. Preferred items for Jenna and Kate included candy, shopping at the school store, and file folders. Preferred items for Stephanie included candy, shopping at the school store, and a "good work" certificate.

Experimental Design and Procedure

Sessions occurred two to four times a week and lasted approximately 15 min. Regardless of session type, each child was given 8 min to complete difficult problems, exchanged these for slips of easy problems, and then completed the easy problems (i.e., a chain schedule). The number of correct difficult problems required to earn an easy problem slip was determined at screening and was 10 for Jenna and Kate and 5 for Stephanie. No reinforcement was provided for completing problems correctly during baseline. Before attempting problems on lottery days, students were told the exchange rate, watched the experimenter place the required number of red and white chips in a canvas bag, and restated the chances of drawing a red chip that day (e.g., three of four, or 75%). After completing the easy problem slips, each child drew a colored plastic chip from the bag. If the chip drawn was red, the student was able to exchange every two easy problem slips for her choice of a back-up reinforcer. Any remaining slips were carried over to the next session that a red chip was drawn. If a white chip was drawn, the student was not allowed to exchange slips, was told that maybe next time she would draw a red chip, and returned to class. On no-lottery days, students were able to earn and complete easy problem slips, but there was no drawing or exchange for rewards.

During the 4:0 condition that followed baseline, the ratio of red to white chips was 4 to 0 (i.e., 100% chance of exchanging easy problem slips for back-up reinforcers). The ratio of red to white chips was systematically lowered (e.g., 4:0, 3:1, 2:2, 1:3) until a decrease was observed in the number of difficult problems completed correctly by each student. The experimental condition that previously produced the highest level of responding was then reinstated, forming a multielement design with a reversal (e.g., A-B1-B2-B3-B4-B1). The dependent measure was the number of difficult problems completed correctly during each 8-min session.

Procedural integrity for the number of steps correctly completed by the experimenter and interscorer agreement for the number of difficult math problems completed correctly by the children were computed for 38% of the sessions across all students and conditions. Mean procedural integrity was 99% (range, 93% to 100%), and mean interscorer agreement was 99% (range, 97% to 100%).

RESULTS AND DISCUSSION

Figure 1 shows the number of difficult problems completed correctly by each stu-

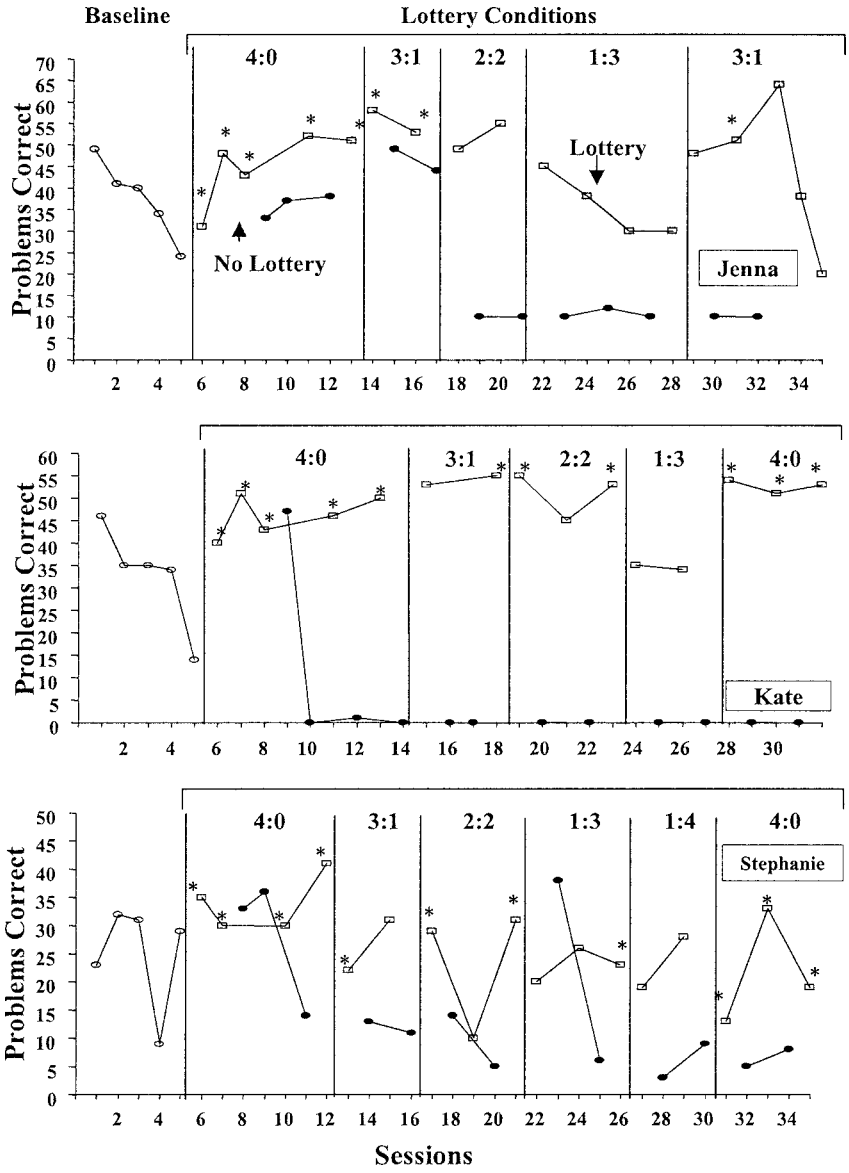

Figure 1. Number of problems completed correctly by Jenna, Kate, and Stephanie on lottery and no-lottery days throughout all phases of the study. Sessions marked with an asterisk indicate that the student drew a red chip and exchanged it for back-up reinforcers.

dent on lottery and no-lottery days throughout all phases of the study. Problem-completion rates for all 3 children on lottery days increased over baseline following implementation of the 4:0 condition (100% chance of exchange). Responding remained high for Jenna and Kate during the 3:1 (75% chance) and 2:2 (50% chance) conditions, with the obtained schedule exceeding the programmed schedule in two instances (3:1 for Jenna and 2:2 for Kate). Jenna did not draw a red chip during the 2:2 condition. The children also completed more problems initially during no-lottery days, but then levels decreased well below baseline after only a few sessions, providing additional evidence

for the reinforcing effects of the lottery procedure.

When the exchange ratio dropped to 1:3 (25% chance), neither Jenna nor Kate drew a red chip and problem-completion rates returned to baseline levels. Moreover, both students experienced an obtained schedule of extinction in this phase. A similar effect was observed during the last two sessions of the 3:1 condition for Jenna, in which she drew no red chips and problem completion decreased. Both students showed a reversal upon return to more favorable exchange ratios. Unlike Jenna and Kate, Stephanie returned to baseline levels of problem completion following implementation of the 3:1 (75% chance) condition and remained at this level throughout subsequent phases.

The present findings are consistent with those reported by Cuvo et al. (1998) in suggesting that children's behavior is sensitive to different probabilities of reinforcement. This study extends previous research in three ways. First, we examined probabilistic reward within the context of a token lottery system. This procedure may be useful in future research for studying various reinforcement and schedule effects (e.g., conditioned reinforcement, probabilistic reward, risky choice behavior). Second, this study extends research on probabilistic reward to an educationally relevant behavior (i.e., completing math problems). Third, although lottery systems can be effective at maintaining work completion while reducing reinforcer costs, consecutive days without the opportunity to exchange for back-up reinforcers may result in extinction effects. The present results are limited by the small number of sessions per condition, failure to replicate the 1:3 condition for Jenna and Kate and the 4:0 condition for Stephanie, and the possibility that behavior was controlled both by the obtained schedule values and instructions about the chance for exchange on lottery days. Conditions should be extended in future research to give students additional exposure to the schedules and to determine if obtained schedule values more closely approximate programmed values.

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