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VARIABLE-TIME REINFORCEMENT SCHEDULES IN THE TREATMENT OF SOCIALLY MAINTAINED PROBLEM BEHAVIOR

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Noncontingent reinforcement (NCR) consists of delivering a reinforcer on a time-based schedule, independent of responding. Studies evaluating the effectiveness of NCR as treatment for problem behavior have used fixed-time (FT) schedules of reinforcement. In this study, the efficacy of NCR with variable-time (VT) schedules was evaluated by comparing the effects of VT and FT reinforcement schedules with 2 individuals who engaged in problem behavior maintained by positive reinforcement. Both FT and VT schedules were effective in reducing problem behavior. These findings suggest that VT schedules can be used to treat problem behavior maintained by social consequences.

DESCRIPTORS: developmental disabilities, fixed-time schedules, functional analysis, noncontingent reinforcement, variable-time schedules

Treatment with noncontingent reinforcement (NCR) typically consists of delivering the reinforcer that maintains inappropriate behavior on a response-independent fixed-time (FT) schedule while the behavior is placed on extinction. Noncontingent reinforcement has been used to treat a variety of problem behaviors, including self-injury (Vollmer, Iwata, Zarcone, Smith, & Mazaleski, 1993), aggression (Marcus & Vollmer, 1996; Vollmer et al., 1998), and disruption (Hagopian, Fisher, & Legacy, 1994). Noncontingent reinforcement has also been used to treat behavior maintained by social-positive reinforcement in the form of attention or leisure materials (Marcus & Vollmer, 1996; Vollmer et al., 1993) and social-negative reinforcement in the form of escape from tasks and social proximity (Vollmer, Marcus, & Ringdahl, 1995; Vollmer et al., 1998).

Research findings have shown that NCR has a number of advantages over other common behavior-reduction procedures. For example, results of Vollmer et al. (1993) indicated that NCR was associated with higher rates of reinforcement than was differential reinforcement of other behavior (DRO). Noncontingent reinforcement also has been found to lessen extinction-induced behavior (i.e., response bursts, increases in other inappropriate behavior) relative to DRO or extinction alone (Vollmer et al., 1993, 1998). Potential disadvantages of NCR also have been explored in the literature. For example, it is possible that free and frequent access to reinforcers might decrease motivation to engage in adaptive behavior to acquire those reinforcers. Results of one study in which NCR and differential reinforcement of alternative behavior (DRA) were combined showed that an alternative response was acquired when the same reinforcer was delivered noncontingently (Marcus & Vollmer, 1996). However, Goh, Iwata, and DeLeon (2000) further evaluated this question by superimposing DRA on a continuous NCR

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schedule using the reinforcer found to maintain self-injury for 2 participants. Results showed that the alternative response was not acquired until the NCR schedule was thinned beyond FT 60 s for 1 participant and beyond FT 120 s for the 2nd participant. This finding suggests that NCR can reduce motivation to engage in a competing response when the reinforcer is delivered on relatively rich time-based schedules.

Another limitation of NCR is the possible occurrence of adventitious reinforcement. For example, in Vollmer, Ringdahl, Roane, and Marcus (1997), noncontingent delivery of magazines (the functional reinforcer) was not effective in reducing aggression. Results showed that during NCR, aggression often occurred during the 10-s interval preceding the scheduled reinforcer delivery. This apparent adventitious reinforcement maintained high levels of problem behavior, necessitating the addition of a momentary DRO procedure to reduce aggression.

Research on procedural variations of NCR has focused primarily on the initial NCR schedule and methods to systematically thin the time-based interval across treatment. Research findings indicate that initial treatment with NCR is more effective in reducing behavior when reinforcement is delivered on relatively dense FT schedules (Hagopian et al., 1994). In most studies, the maintaining reinforcer was delivered either continuously (Marcus & Vollmer, 1996; Vollmer et al., 1993) or following brief FT intervals (e.g., every 40 s) during initial treatment sessions (Fisher, Ninness, Piazza, & Owen-DeSchryver, 1996). Other studies found that an initial FT schedule based on either the mean interresponse time (IRT) in baseline sessions (Kahng, Iwata, DeLeon, & Wallace, 2000) or the latency to the first target behavior in baseline sessions (Lalli, Casey, & Kates, 1997) was effective in reducing problem behavior.

Several strategies to thin the initial NCR schedule also have been examined. Vollmer et al. (1993) thinned the initial schedule to FT 1 min by systematically decreasing the amount of time that the reinforcer was available within each minute (e.g., FT 10 s with 50-s access to reinforcement; FT 20 s with 40-s access to reinforcement). The FT interval then was lengthened by 30-s increments, and the reinforcement interval remained at 20 s, until the terminal schedule (FT 5 min) was reached. In other studies, the schedule was increased by arbitrary fixed amounts of time ranging from 30 s to 120 s (e.g., Lalli et al., 1997). Results of a recent study also suggested that FT schedules could be successfully thinned across treatment sessions by basing the NCR schedule in each session on responding in previous sessions (Kahng et al., 2000). The FT schedule in each treatment session was equal to the mean IRT of problem behavior in the previous three sessions. As a result, the FT interval either increased or decreased across treatment as behavior decreased or increased. Results showed that this schedule-thinning method was as effective as that used by Vollmer et al. (1993) and that the terminal FT schedule (i.e., 5 min) was reached more quickly. The consistency of treatment effects across these procedural variations suggests that NCR is a robust intervention for problem behavior.

One procedural variation of time-based schedules that has not been systematically evaluated is the use of variable-time (VT) schedules. In contrast to FT schedules, which consist of unchanging interreinforcement-interval lengths, VT schedules include a range of time intervals that vary around a predetermined average length. Variable-time schedules should be systematically evaluated because caregivers often are unable to implement FT schedules with a high degree of integrity in the natural environment. Noncontingent reinforcement schedules may approximate programmed VT schedules more closely than programmed FT schedules when NCR is used in clinical settings. However, the lengthier intervals associated with VT schedules may increase deprivation for the reinforcer and, hence, cause an increase in problem behavior.

Mace and Lalli (1991) evaluated several VT schedules with 1 participant as part of treatment for bizarre speech maintained by attention. Results suggested that VT 30-s, 60-s, and 90-s schedules were effective in reducing bizarre speech. However, procedural details about the VT schedules (e.g., the programmed ranges for the interval lengths, the method for thinning the schedule) were not provided, and the efficacy of VT schedules beyond 90 s was not evaluated.

Basic research findings indicate that VT schedules may be extremely effective in reducing problem behavior in clinical settings. Results of several studies showed that VT schedules were associated with lower response rates than FT schedules (e.g., Lattal, 1972; Ono, 1987; Zeiler, 1968). Some authors have suggested that the higher level of responding observed under FT schedules relative to VT schedules was partially due to superstitious behavior or adventitious reinforcement (Lachter, Cole, & Schoenfeld, 1971; Lattal, 1972; Neuringer, 1973; Ono, 1987). For example, Neuringer (Experiment 3) found that FT schedules were associated with a "break-and-run" pattern of responding in pigeons similar to that typically produced by fixed-interval (FI) reinforcement schedules. The predictability or invariant nature of FT schedules may increase the likelihood of response maintenance via adventitious reinforcement.

Although results of basic studies indicate that VT schedules would be more effective than FT schedules in reducing problem behavior, these findings may have limited application. Certain procedural components specific to basic studies on NCR may account for the greater efficacy of VT over FT schedules. For example, intermittent reinforcement schedules (i.e., FI and variable-interval [VI] schedules) typically were used in baseline, and the initial NCR schedule was matched to the baseline schedule (e.g., an FT 3-min schedule followed an FI 3-min schedule). Thus, the transition from contingent to noncontingent reinforcement may have been relatively indiscriminable, increasing the likelihood that the positively accelerated temporal pattern of responding established under the FI schedule would continue to occur under the matched FT schedule and to precede reinforcer delivery with a high degree of consistency. In contrast, adventitious reinforcement was less likely to occur under the VT schedule because VI schedules typically did not establish this type of temporal response pattern (Lattal, 1972). Noncontingent reinforcement schedules also were not thinned across time in basic studies. Thus, adventitiously maintained responding likely would persist across multiple FT sessions.

The purpose of the present study was to evaluate whether VT schedules of reinforcement would be effective in reducing problem behavior maintained by social consequences in individuals with developmental disabilities. As a basis for evaluating treatment effects under VT schedules, treatment under FT schedules also was conducted with each participant.

METHOD

Participants and Settings

Participants were 2 individuals who had been diagnosed with moderate to severe mental retardation and who had been referred by teachers and parents for the assessment and treatment of severe behavior problems. Roger was a 13-year-old boy who had been referred for aggression, and Rachel was a 21-year-old woman who had been referred for aggression and self-injury. Neither participant had expressive language skills, both had very limited receptive language skills, and Rachel used a wheelchair. Neither participant was taking medication during the course of the experiment. The participants attended separate self-contained classrooms for individuals with developmental disabilities. Sessions were conducted in unused rooms at the participants' schools. The rooms contained several chairs, tables, and desks, and a variety of items necessary to conduct the sessions (described below). Three to five sessions were conducted 2 to 5 days per week.

Response Measurement, Reliability, and Treatment Integrity

Aggression was defined as hitting, pinching, kicking, or pushing the therapist. *Self-injury* was defined as forceful contact between one or both hands and any part of the head. Data on self-injury and aggression were collected using frequency recording, and the data were expressed as number of responses per minute. Therapist behaviors (attention, escape, and toy delivery) were collected using duration recording. Data were collected on laptop computers by observers seated in the room in all conditions except the alone condition of the functional analysis. Observers did not interact with the participants during the sessions.

A second observer simultaneously and independently collected data on target behaviors for 32% to 77% of all sessions. Interobserver agreement for each target behavior was calculated by dividing each session into consecutive 10-s intervals. Agreement was computed by dividing the number of exact agreements by the number of agreements plus disagreements, and multiplying by 100%. Mean interobserver agreement for problem behavior was 98% (range, 88.4% to 100%) for Roger and 97% (range, 44.3% to 100%) for Rachel.

Treatment integrity was assessed by calculating the difference (in seconds) between the scheduled time of each reinforcer delivery and the actual time of each reinforcer delivery. For example, the difference was set at 10 s if attention was scheduled to be delivered at 200 s and was delivered at 210 s. Each difference score was subtracted from the scheduled reinforcer delivery time (e.g., 10 s was subtracted from 200 s). The result was divided by the scheduled time (e.g., 190 s was divided by 200 s) and multiplied by 100% to express treatment integrity for that reinforcer delivery (e.g., 95%). Treatment integrity for each session was determined by calculating the average integrity across reinforcer deliveries. For example, if a session under the FT 200-s schedule had a treatment integrity of 95%, the FT schedule varied by an average of 10 s. Treatment integrity was calculated for 34% of treatment sessions for each participant. Treatment integrity for Roger was 93.6% (range, 79.7% to 99.3%) for the FT sessions and 98.1% (range, 94% to 99.3%) for the VT sessions. Treatment integrity for Rachel was 96.1% (range, 77% to 100%) for the FT sessions and 95.6% (range, 78% to 99.8%) for the VT sessions.

Preference Assessment

Leisure items used during functional analysis and treatment sessions were selected via a stimulus choice preference assessment similar to that described by Fisher et al. (1992). Eight to 10 items were presented in pairs until each item was paired with every other item at least once. Each pair was presented for 10 s, and the therapist instructed the participant to choose one item. The first item touched by the participant was made available for 20 s. Items chosen at least 80% of the time were selected for the functional analysis and treatment sessions. These items were a dish scrubber for Roger and a ball and a switch that produced recorded voices and sounds for Rachel.

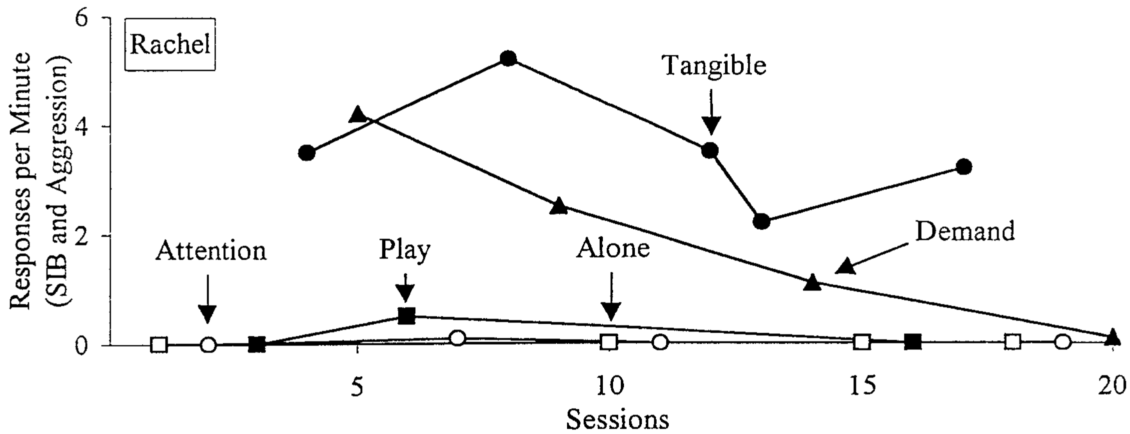


Figure 1. Number of responses per minute of problem behavior in the functional analysis for Rachel.

Functional Analysis

Functional analyses were conducted using procedures similar to those described by Iwata, Dorsey, Slifer, Bauman, and Richman (1982/1994). In the alone condition (Rachel only), observers were in an adjacent room looking through a one-way mirror; no attention, leisure materials, or demands were provided; and self-injury was ignored. The purpose of this condition was to evaluate whether self-injury would persist in the absence of social consequences. In the attention condition, 20 s of attention was delivered contingent on each occurrence of aggression or self-injury, and the participant had noncontingent and continuous access to leisure items. This condition was designed to identify behavior maintained by social-positive reinforcement in the form of attention. In the tangible condition, 20 s of access to leisure materials was delivered contingent upon each occurrence of aggression or self-injury, and the participant had noncontingent continuous access to attention. This condition was designed to identify behavior maintained by social-positive reinforcement in the form of access to leisure materials. In the demand condition, 20 s of escape from continuous tasks was delivered contingent upon each occurrence of aggression or self-injury, and no leisure items were available. This condition was designed to identify behavior maintained by social-negative reinforcement in the form of escape from tasks. In the play condition, the participant had continuous access to attention and preferred items, no demands were delivered, and all problem behavior was ignored. This condition served as the control for comparison with the test conditions. Conditions were presented in a multielement design, and all sessions were 10 min.

Results of Rachel's functional analysis are displayed in Figure 1. High levels of self-injury and aggression were observed during the tangible and demand conditions (M = 3.5 and M = 2.0, respectively). We concluded that Rachel's problem behavior was maintained by access to leisure materials and possibly by escape from tasks (the tangible function was addressed prior to further evaluation of a possible escape function). For Roger, mean levels of aggression in the functional analysis were 0.5 responses per minute in the tangible condition, 0.4 in the demand condition, 0.02 in the attention condition, and 0.1 in the play condition.[1] High levels of aggression were observed consistently during the tangible condition of Roger's func-

[1] Results of Roger's functional analysis can be found in Roane, Lerman, Kelley, and Van Camp (1999).

tional analysis, indicating that his behavior was maintained by access to leisure materials. Although the overall mean for the demand condition was similar to that for the tangible condition, aggression occurred only during the first session of the five total demand sessions.

Design and Procedure

The relative treatment effects of FT and VT schedules of noncontingent reinforcement were examined in a multielement design for Roger. However, responding under the VT schedules may have been influenced by exposure to the FT schedule because of the rapidly alternated conditions. Thus, for Rachel, a reversal design was used, and the VT condition was implemented during the first treatment phase so that the effects of VT schedules could be examined without prior exposure to FT. Procedures for the 2 participants are discussed separately.

Roger. Two therapists, each associated with either the VT or the FT schedule during treatment, conducted baseline sessions. Baseline sessions were identical to the tangible condition of Roger's functional analysis. Baseline sessions were 15 min. During the treatment analysis, FT and VT sessions were conducted each day, and the order of the conditions alternated across days. During both FT and VT sessions, the reinforcer (i.e., the dish scrubber) was delivered for 20 s, and aggression no longer produced access to the reinforcer. The initial schedules and the schedule thinning procedure were similar to those described by Kahng et al. (2000). Initial schedules were determined by calculating the mean latency to the first target behavior that followed each reinforcer removal during baseline sessions, and these mean latencies were averaged across the last three baseline sessions with either the FT or the VT therapist. For Roger, the mean latency to the first occurrence of aggression following each reinforcer removal was 14 s with the FT therapist and 22 s with the VT therapist; thus, his initial FT and VT schedules were set at 14 s and 22 s, respectively. Subsequent schedules for each treatment session were determined by calculating the mean latency of responding during the three preceding sessions. The FT and VT schedules were adjusted individually based on responding that occurred under the corresponding treatment condition. If no aggression occurred between reinforcer deliveries, the latency for that interval was set at twice the length of the interval. Thus, occurrences of aggression between scheduled reinforcer deliveries served to decrease the schedule for the following sessions, whereas nonresponding between scheduled reinforcer deliveries increased (i.e., thinned) the schedule. For each VT schedule, the range of the interreinforcement intervals was set at 50% above and below the mean VT interval. The random number generator tool in Excel® was used to select the interreinforcement intervals, which fit a normal distribution around the mean.

Table 1
Number of Reinforcer Deliveries Across VT and FT Schedules

Schedule	Reinforcer deliveries
FT/VT 30 s or below	25
FT/VT 31 s to 60 s	15
FT/VT 61 s to 120 s	10
FT/VT 121 s to 180 s	7
FT/VT 181 s to 240 s	5
FT/VT 241 s to 300 s	4

Each session consisted of a preset number of reinforcer deliveries as shown in Table 1. This resulted in session lengths ranging from 8 min to 21 min. This strategy insured that Roger contacted each schedule numerous times within a single session (e.g., if the session length was preset at 15 min, Roger would have received less than three exposures to the FT or VT 5-min schedule in each session). This seemed to be particularly important because the FT and VT schedules were derived from Roger's latency to respond during interreinforcement intervals. The terminal FT or VT schedule was 5 min, and the treatment sessions terminated when responding remained 80% below mean baseline levels for three consecutive sessions in each condition (0.3 responses per minute).

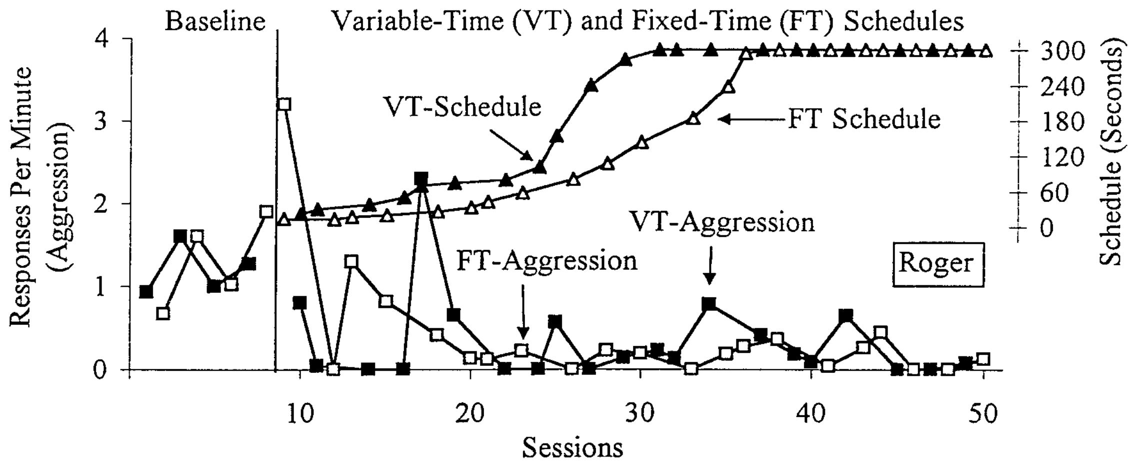
Rachel. A single therapist conducted the treatment analysis for Rachel, and all sessions were 10 min. Baseline and treatment conditions were alternated in a reversal design (ABAC). Baseline sessions were identical to those in the tangible condition of the functional analysis. Unlike the baseline conditions for Roger, Rachel's two baseline phases were conducted at different points in time. Thus, similar mean latencies to the first problem behavior following each reinforcer removal could not be insured during the VT and FT baselines. As such, we used predetermined schedules that were not dependent on responding in baseline. The initial schedule and schedule thinning procedure were identical to those described by Vollmer et al. (1993). The VT schedule was implemented during the first treatment phase.

The initial schedule was 100% reinforcement (i.e., Rachel had access to her toys for the entire session). The schedule was then thinned from 100% to VT 1 min by systematically decreasing the amount of time the reinforcer was available within each minute from 100% to 33.3%, producing the following schedules: VT 10 s (50-s access to reinforcement), VT 20 s (40-s access to reinforcement), VT 30 s (30-s access to reinforcement), VT 40 s (20-s access to reinforcement), and VT 1 min (20-s access to reinforcement). The schedule then was increased by 30-s increments, and the reinforcement access time remained at 20 s, until the terminal schedule of 5 min was reached. For each VT schedule, the range of the interreinforcement intervals was set at 50% above and below the mean VT interval. The random number generator tool in Excel® was used to select the interreinforcement intervals, which fit a normal distribution around the mean. The criterion for increasing the schedule was two consecutive sessions with responding below 0.7 responses per minute (this represented an 80% decrease below mean baseline levels). The criterion for decreasing the schedule was three consecutive sessions with responding at or above mean baseline levels (3.5 responses per minute), but this never occurred. The VT phase terminated when three consecutive sessions with responding at or below 0.7 responses per minute were observed under VT 5 min. Following a return to baseline, the FT schedule was implemented in the final phase. The initial schedule and schedule thinning procedure were identical to those used in the VT condition; however, the reinforcer was delivered at regular (unchanging) intervals. The criteria to thin the schedule and terminate treatment were identical to those in the VT condition.

RESULTS

Treatment analysis results are depicted in Figure 2. Similar levels of aggression were observed with both therapists during Roger's baseline sessions. An increase in aggression relative to baseline was observed in the first FT session, followed by a gradual decrease in responding. A more immediate decrease in aggression was observed during the first four VT sessions, followed by an increase in the fifth session and relatively low levels thereafter. The terminal schedule of 5 min was reached in 21 and 20 sessions under the FT and VT conditions, respectively.

High levels of self-injury and aggression were observed during the first baseline phase of Rachel's treatment analysis (Figure 2). An immediate decrease in problem behavior was observed when toys were presented under the continuous VT schedule. Responding remained below baseline levels while the



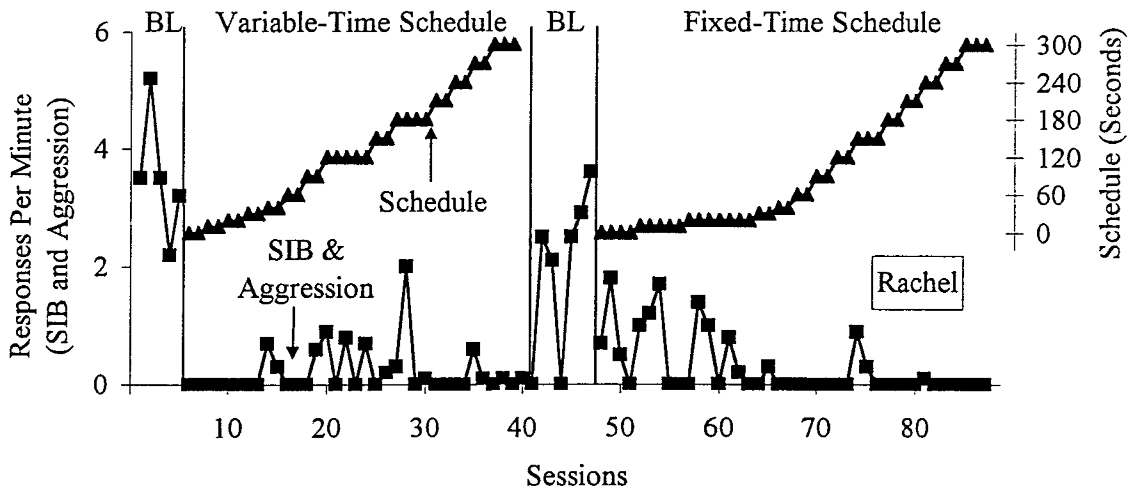


Figure 2. Number of responses per minute of problem behavior and the time-based schedule of reinforcement in seconds across baseline and treatment sessions for Roger (top panel) and Rachel (bottom panel). Responses per minute of problem behavior are plotted on the left axis, and the time-based schedules of reinforcement are plotted on the right axis.

schedule was thinned, with the exception of one session. The terminal schedule (VT 5 min) was reached in 34 sessions. Self-injury and aggression increased during the return to baseline and then decreased somewhat but remained moderately high and variable during the initial FT sessions. Responding decreased as the schedule was thinned, and the terminal schedule was reached in 40 sessions.

DISCUSSION

Previous studies on the use of NCR as treatment for problem behavior have primarily examined FT schedules. Results of this study indicated that VT schedules were as effective as FT schedules in reducing problem behavior. This finding is important because FT schedules are likely to resemble VT schedules when NCR is implemented in clinical settings. The generality of this finding was demonstrated across subjects, experimental designs, and methods to thin the NCR schedule, thus adding to the growing literature on the efficacy of NCR.

Both schedules were similarly effective in treating problem behavior. This outcome probably occurred because the two key components of NCR, termination of the response–reinforcer relation and availability of response-independent reinforcement, were associated with both schedules (Vollmer et al., 1993). However, VT schedules were found to be more effective than FT schedules in basic studies, possibly because VT schedules decreased the likelihood of adventitiously maintained responding (e.g., Lattal, 1972; Neuringer, 1973; Ono, 1987). Thus, we also conducted an analysis of within-session response patterns and reinforcement delivery under NCR for both participants to examine the extent to which adventitious reinforcement may have occurred during treatment. The proportion of problem behavior followed by reinforcement (within 10 s) was calculated to determine the proportion of problem behavior that occurred contiguous to reinforcement. In addition, the proportion of reinforcer deliveries preceded by problem behavior (within 10 s) was calculated to determine the proportion of reinforcer deliveries that was temporally paired with problem behavior. Both analyses were included because adventitiously maintained responding may not have occurred if a large proportion of reinforcer deliveries were made in the absence of problem behavior, even if all occurrences of the problem behavior were contiguous to reinforcer delivery. That is, the behavior may not have been maintained if the probability of reinforcement given the absence of behavior was higher than the probability of reinforcement given the occurrence of behavior (Hammond, 1980).

The top half of Figure 3 depicts the results for Roger. These data show that the proportion of aggression followed by the scheduled reinforcer delivery was approximately .4 or greater during four of the first five FT sessions, whereas instances of aggression were rarely followed by the scheduled reinforcer delivery during the first five VT sessions. However, the proportion of reinforcer deliveries that were preceded by aggression remained fairly low during both conditions. These results indicate that, although a high proportion of aggression was temporally paired with reinforcer delivery in the FT sessions, a higher proportion of reinforcer deliveries occurred in the absence of aggression.

Results for Rachel are shown in the bottom half of Figure 3. Sessions with 100% reinforcement were not included because the reinforcer was delivered immediately at the start of the session and removed at the end of the session. Results show that the proportion of problem behavior followed by the scheduled reinforcer delivery was at or above .8 during the first three FT sessions, whereas instances of problem behavior were never followed by the scheduled reinforcer delivery during the first three VT sessions. Furthermore, the proportion of reinforcer deliveries that was preceded by problem behavior was higher than .5 during these three FT sessions. Although these results suggested that adventitiously maintained responding was more likely to occur under the initial FT sessions than under the VT sessions, responding rapidly decreased under both conditions.

As with previous applied research on NCR, a number of procedural components in this study differed from those found in basic studies. Problem behavior was maintained on a continuous schedule of reinforcement during baseline, and reinforcer delivery under NCR was systematically thinned from relatively rich schedules to lean schedules across treatment. In most basic studies, responding was maintained on relatively thin FI and VI reinforcement sched-

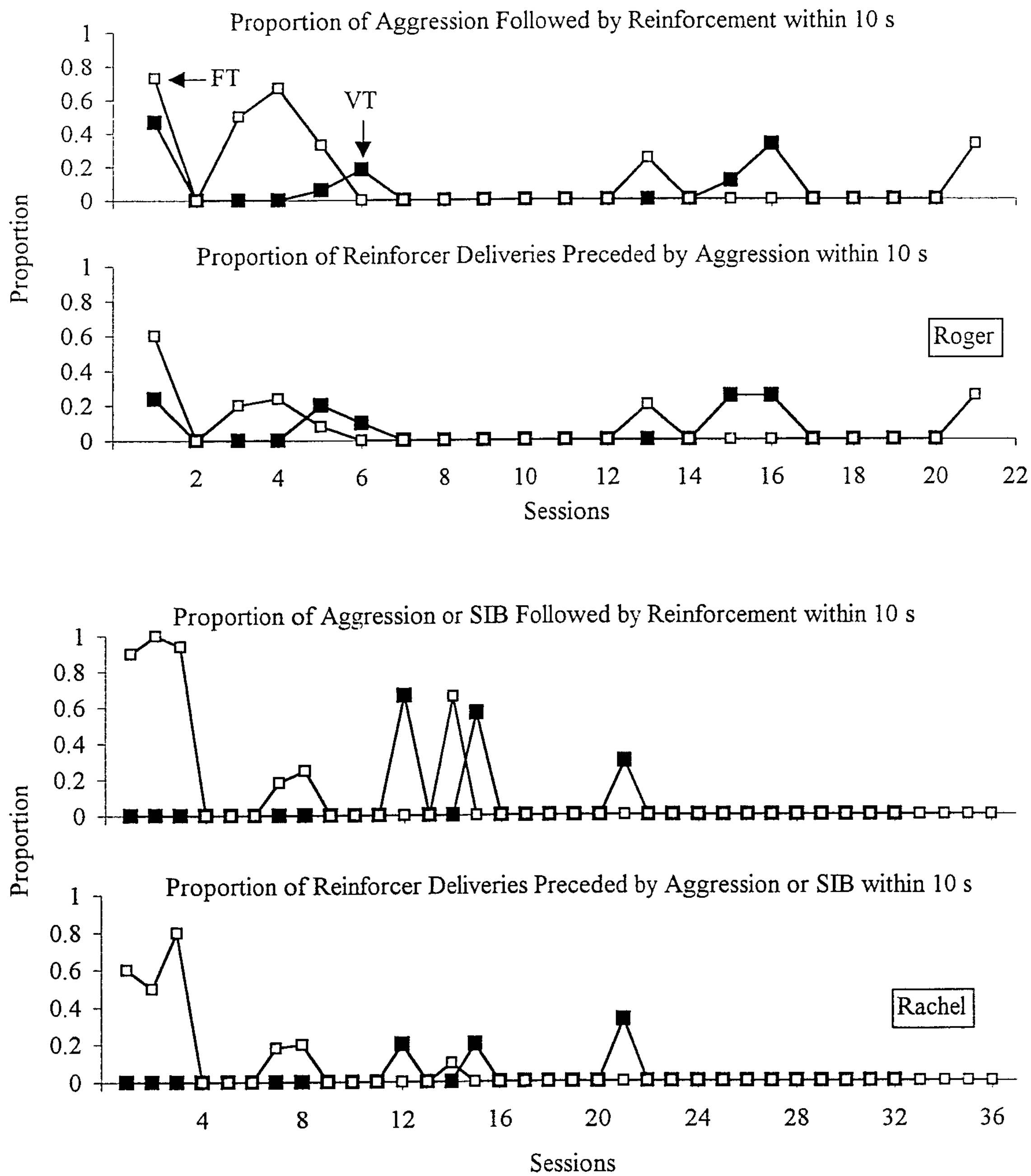


Figure 3. Proportion of aggression followed by reinforcement within 10 s and proportion of reinforcer deliveries preceded by aggression within 10 s for Roger (top two panels); proportion of aggression or self-injury followed by reinforcement within 10 s and proportion of reinforcer deliveries preceded by aggression or self-injury within 10 s for Rachel (bottom two panels).

ules prior to NCR, and the temporal distribution of reinforcers remained unchanged when the FT and VT schedules were introduced. For example, an FI 1-min schedule was followed by an FT 1-min schedule during NCR. Thus, only the response–reinforcer relation was disrupted with the transition from contingent reinforcement to NCR.

Furthermore, NCR schedules typically were not altered over time. These factors (baseline schedule, initial NCR schedule, use of schedule thinning) may influence the characteristics of responding under NCR, including the likelihood of responding maintained by adventitious reinforcement. One or more of these procedural differences could account for the inconsistent findings obtained in this study relative to those obtained in basic studies.

Conclusions about the general efficacy of VT schedules must be tempered for several other reasons. First, the initial FT and VT schedules used for Roger were based on his baseline level of responding with separate therapists. As such, the initial FT and VT schedules were not equivalent. Although the schedules were separated by just 8 s, this difference could have influenced the relative effectiveness of treatment under the FT and VT conditions. However, the FT schedule initially was richer than the VT schedule; thus, differences between the schedules should have favored the FT schedule and produced conservative findings. Second, the programmed VT schedules derived for this evaluation may not be analogous to the naturalistic VT schedules that occur in clinical settings. However, compared to programmed FT schedules, these VT schedules provided a close approximation to naturalistic NCR schedules. A third limitation was that only positively reinforced behavior was evaluated. The use of VT schedules with negatively reinforced behavior also should be investigated.

Results of this study also provided further support for the schedule-thinning procedure developed by Kahng et al. (2000). Kahng et al. showed that FT schedules based on responding during previous treatment sessions were as effective as predetermined FT schedules and reached the terminal FT schedule (i.e., 5 min) more quickly than the method developed by Vollmer et al. (1993). Likewise, when a similar procedure was used for Roger in this study, 50% fewer sessions were required to reach the terminal schedule than when the method developed by Vollmer et al. was used (for Rachel).

More extensive evaluation of FT and VT schedules is needed in future research. For example, different baseline schedules (e.g., interval schedules) could precede treatment with FT and VT schedules to evaluate differential effects under conditions often utilized in basic research. Furthermore, the efficacy of NCR with behavior maintained by intermittent reinforcement during baseline should be examined because responding is not likely to be maintained on continuous schedules in the natural environment. The relative efficacy of FT and VT schedules also could be examined when the schedules are not thinned across treatment, as is often the case in basic research. Results of these studies may indicate which procedural variations (e.g., baseline schedule, use of schedule thinning) contributed to the different results obtained in this study.

In addition, future research should investigate the effects of wider or more restricted interreinforcement-interval ranges. For example, the VT schedules evaluated in this study consisted of interreinforcement intervals ranging from 50% below and 50% above a mean value. However, reinforcer delivery in the natural environment, which would be scheduled around competing activities and other factors that influence caregiver behavior, will vary more widely and less systematically. As such, VT schedules with ranges that approximate those that occur in clinical settings should be evaluated. For example, the effectiveness of VT schedules with interreinforcement intervals ranging from 100% below and 100% above a mean value probably should be examined in future studies. Future research also should assess the long-term effectiveness of naturally occurring VT schedules.

In conclusion, results of this study suggest that VT schedules of reinforcement are effective in reducing socially maintained problem behavior. Although researchers may be able to implement NCR with near-perfect integrity, caregivers who implement treatment in the natural environment have numerous demands on their time and, thus, are likely to implement VT schedules even when they were taught to use FT schedules. These findings suggest that noncontingent reinforcement with either FT or VT schedules should be effective.

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STUDY QUESTIONS

1. Describe several advantages and disadvantages associated with NCR relative to other treatments for problem behavior.

2. How are fixed-time (FT) and variable-time (VT) schedules of reinforcement similar and different? Which type of schedule is probably more characteristic of how caregivers are likely to deliver reinforcement in the natural environment?

3. How did the authors estimate reinforcement errors? Indicate the effect of a given discrepancy (e.g., a 5-s delay in delivery) under a rich schedule (e.g., 30 s) versus a thin schedule (e.g., 200 s).

4. Describe the experimental design used with each participant and indicate which conditions were replicated and which were not.

5. Describe the methods used to determine the initial VT and FT schedules and to subsequently thin those schedules.

6. Describe the general patterns of responding observed under the FT and VT schedules.

7. Briefly describe the method used to analyze within-session response patterns. What did the results of this analysis suggest about the probability of adventitious reinforcement under FT and VT schedules?

8. What procedural variables might increase the likelihood of adventitious reinforcement under NCR?

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