JOURNAL OF APPLIED BEHAVIOR ANALYSIS 2000, **33,** 223–231 NUMBER 2 (SUMMER 2000)

A COMPARISON OF PROCEDURES FOR PROGRAMMING NONCONTINGENT REINFORCEMENT SCHEDULES

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We compared two methods for programming and thinning noncontingent reinforcement (NCR) schedules during the treatment of self-injurious behavior (SIB). The participants were 3 individuals who had been diagnosed with mental retardation. Results of functional analyses indicated that all participants' SIB was maintained by positive reinforcement (i.e., access to attention or food). Following baseline, the effects of two NCR schedule-thinning procedures were compared in multielement designs. One schedule (fixed increment) was initially set at fixed-time 10-s reinforcer deliveries and was also thinned according to fixed-time intervals. The other schedule (adjusting IRT) was initially determined by participants' baseline interresponse times (IRTs) for SIB and was thinned based on IRTs observed during subsequent treatment sessions. Results indicated that both schedules were effective in initially reducing SIB and in maintaining response suppression as the schedules were thinned.

DESCRIPTORS: functional analysis, noncontingent reinforcement, reinforcement schedules, self-injurious behavior

Noncontingent reinforcement (NCR), which involves the delivery of reinforcers according to a schedule that is independent of responding, has been shown to be an effective means for reducing the frequency of severe problem behavior (e.g., Fischer, Iwata, & Mazaleski, 1997; Hanley, Piazza, & Fisher, 1997; Vollmer, Iwata, Zarcone, Smith, & Mazaleski, 1993; Wilder, Draper, Williams, & Higbee, 1997). Interest in NCR as a therapeutic technique may be partly due to the fact that NCR is often easier to implement than other reinforcement-based interventions, such as differential reinforcement of other behavior (DRO). Typical DRO schedules require continuous monitoring by a therapist to determine whether the criterion

This research was supported in part by a grant from the Florida Department of Children and Families and was part of a dissertation submitted by the first author in partial fulfillment of requirements for the PhD degree from the University of Florida. We thank Juliet Conners, Han-Leong Goh, Jana Lindberg, and Eileen Roscoe for their assistance in conducting the study.

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for reinforcement (no responding throughout the DRO interval) has been met. This requirement is eliminated under NCR schedules because reinforcer deliveries are unaffected by the individual's behavior (Vollmer et al., 1993).

Studies (Hagopian, Fisher, & Legacy, 1994; Vollmer et al., 1993) have shown that NCR schedules can be effective when reinforcers are delivered rather infrequently (e.g., according to fixed-time [FT] 5-min schedules). However, in most applications of NCR, the initial schedule of reinforcement has been extremely dense (continuous or nearly continuous), and the data presented by Hagopian et al. suggest that dense NCR schedules are more effective in reducing the frequency of behavior than are thinner schedules, at least initially. Hagopian et al. compared the effects of dense (FT 10 s) and thin (FT 5 min) NCR schedules on the destructive behavior of 4 participants and observed lower rates of problem behavior for all participants under the dense schedule. Thus, procedures used to determine the initial NCR schedule, as well as those used during schedule thinning, may influence the outcome of intervention.

A common practice (Hagopian et al., 1994; Vollmer et al., 1993) has been to set the initial NCR schedule at an arbitrarily determined dense value (e.g., FT 10 s). It is possible, however, that this value may not be ideal under certain conditions, leading to either the absence of a therapeutic effect (if the schedule is too thin) or some inefficiency (if the schedule is unnecessarily dense). Lalli, Casey, and Kates (1997) used mean latency to the first occurrence of problem behavior to determine the NCR schedule while treating 2 children who engaged in aggression and self-injurious behavior (SIB). This resulted in initial schedules of FT 90 s for 1 participant and FT 120 s for the other, which were associated with substantial decreases in the problem behavior of both participants. Although these data provide support for the use of initial NCR schedules that are much thinner than the typical FT 10-s schedule, no comparison was conducted between the latency-based schedule and other alternatives. In addition, one possible limitation of the latency-based schedule is that latency to the first response may not provide an accurate index of interresponse times (IRTs) throughout a session.

The most common method for thinning NCR schedules is to increase the interval by fixed increments (e.g., by adding 10 s or 20 s) when responding remains below a preset criterion (Hagopian et al., 1994; Lalli et al., 1997; Vollmer et al., 1993). Although this approach has met with good success, it is possible that other methods, which are more sensitive to changes in the rate of behavior during treatment, may be more efficient by allowing more rapid thinning or may prevent having to back up the schedule if the incremental change is too large.

In the present study, we extended the research of Lalli et al. (1997) by evaluating an alternative method for both determining and thinning NCR schedules. We derived initial NCR schedules from participants' baseline IRTs, such that initial rates of noncontingent reinforcement during treatment were about equal to rates of contingent reinforcement prior to treatment. We subsequently modified the NCR schedule during a given session based on observed IRTs during previous sessions. Thus, as rates of problem behavior decreased during treatment, IRTs increased, resulting in a thinner schedule of NCR. The effects of this adjusting-IRT method for programming NCR were compared with those based on the more common fixed-increment method (Hagopian et al., 1994; Vollmer et al., 1993).

GENERAL METHOD

Participants and Settings

The participants were 3 individuals who lived in a state residential facility and who

had been diagnosed with severe to profound mental retardation. None of the participants emitted vocal speech, although they did use idiosyncratic gestures to indicate some of their needs. All participants were referred to a day treatment program, located on the grounds of the residential facility, for assessment and treatment of their SIB. Julia was a 43-year-old woman who had a seizure disorder, for which she received phenytoin and phenobarbitol throughout the study. Her SIB consisted of skin picking. Lisa was a 27-year-old woman whose SIB consisted of head and body hitting and hand biting. Nancy was a 50-year-old woman whose SIB consisted of head and body hitting. Julia and Lisa had previously participated in a study on noncontingent and contingent reinforcement (Goh, Iwata, & DeLeon, 2000). Nancy had no such history.

Sessions were conducted in therapy rooms located in the clinic, which contained several chairs, a table, and other materials necessary to conduct assessment and treatment sessions (e.g., leisure or work materials). All sessions lasted for 15 min and were conducted three to five times per day, 4 to 5 days per week.

Response Measurement and Reliability

Target behaviors were defined as follows: (a) skin picking (Julia): scraping of a finger against the skin or closure of fingers on any part of the skin combined with a pulling motion; (b) head and body hitting (Lisa and Nancy): forceful contact of a hand against the head or any part of the torso; and (c) hand biting (Lisa): closure of teeth while in contact with any part of the hand.

Trained observers recorded occurrences of SIB during continuous 10-s intervals on handheld computers (Assistant Model AST102). Data were summarized as the number of SIB responses per minute. Observers also collected data on experimenters' implementation of assessment and treatment procedures (e.g., delivery of instructions, prompts, and consequences) as a means of assessing procedural integrity; these measures always exceeded 90% accuracy.

Interobserver agreement was assessed by having a second observer simultaneously but independently collect data. Agreement percentages were then calculated based on an interval-by-interval comparison of observers' records. The smaller number of responses in each interval was divided by the larger number of responses in each interval. These fractions were averaged across all intervals and multiplied by 100% to obtain the percentage agreement between the observers.

Interobserver agreement was assessed for 20.0% of Julia's sessions, 47.6% of Lisa's sessions, and 37.5% of Nancy's sessions during their functional analyses. Mean agreement scores for Julia, Lisa, and Nancy, respectively, were 99.7% (range, 98.9% to 100.0%), 95.4% (range, 69.0% to 100.0%), and 96.9% (range, 94.9% to 97.8%). Interobserver agreement was assessed for 35.3% of Julia's sessions, 51.8% of Lisa's sessions, and 33.3% of Nancy's sessions during baseline and treatment. Mean agreement scores for Julia, Lisa, and Nancy, respectively, were 98.7% (range, 95.6% to 100.0%), 95.9% (range, 72.1% to 100.0%), and 95.9% (range, 89.2% to 100.0%).

Experimental Sequence

A functional analysis was initially conducted to identify the sources of reinforcement that maintained participants' SIB. Results of the functional analyses were then used to develop NCR procedures in which participants received these maintaining reinforcers according to schedules that were independent of occurrences of SIB.

Phase 1: Functional Analysis

Each participant was exposed to four assessment conditions (attention, demand, alone, and play) in a multielement design

according to procedures described by Iwata, Dorsey, Slifer, Bauman, and Richman (1982/1994). One participant, Lisa, was exposed to a fifth condition (tangible) based on informal observations and on reports from caretakers that her SIB seemed to increase in the presence of food.

Procedure

Attention. The purpose of this condition was to determine if SIB was maintained by social-positive reinforcement in the form of attention. An experimenter was present, and the room contained various leisure materials to which the participant had free access throughout the session. The experimenter did not interact with the participant during the session, except to deliver approximately 5 s of attention (e.g., "Don't do that; you'll hurt yourself") and light physical contact (e.g., touching an arm) following each occurrence of SIB.

Tangible. This was implemented only with Lisa and was a variation of the attention condition. Procedures were similar to those in the attention condition, except that the experimenter delivered a small piece of food instead of attention following each occurrence of SIB.

Demand. The purpose of this condition was to determine if SIB was maintained by social-negative reinforcement in the form of escape from task demands. The experimenter and participant were seated at a table on which various task materials were placed. The experimenter presented instructional trials on an FT 30-s schedule using a three-step graduated prompting procedure (verbal instruction followed by a demonstration, and, if necessary, physical guidance). The experimenter delivered praise if the participant complied and delivered prompts at 5-s intervals if the participant did not comply. If the participant emitted SIB at any time during a trial, the experimenter terminated the trial by turning away from the participant.

Alone. The purpose of this condition was to determine if SIB persisted in the absence of social reinforcement, which would suggest that the behavior was maintained by automatic reinforcement. The individual was observed while alone in a therapy room. An experimenter was not present, nor were any leisure materials available.

Play. This condition served as the control. The participant had free access to leisure items throughout the session (as in the attention condition). An experimenter delivered noncontingent attention on an FT 30-s schedule and ignored occurrences of SIB.

Results

Figure 1 shows results obtained during functional analyses expressed as rates of SIB across assessment conditions. Julia's and Nancy's SIB occurred most often during the attention condition, indicating that their SIB was maintained by contingent attention. By contrast, Lisa engaged in little or no SIB during the attention condition. Instead, her highest rates of SIB were observed during the tangible condition, indicating that her SIB was maintained by contingent access to food. Thus, all participants' SIB appeared to be maintained by positive reinforcement, although the specific reinforcer differed somewhat across participants.

Phase 2: Comparison of NCR Schedules

Following completion of the functional analyses, two baselines were implemented for each participant. Experimenters conducted each baseline in different therapy rooms painted different colors to enhance discrimination between the two NCR conditions. Following baseline, the NCR intervention was introduced according to a multiple baseline across subjects design. The two NCR schedule-thinning procedures were compared using a multielement design.

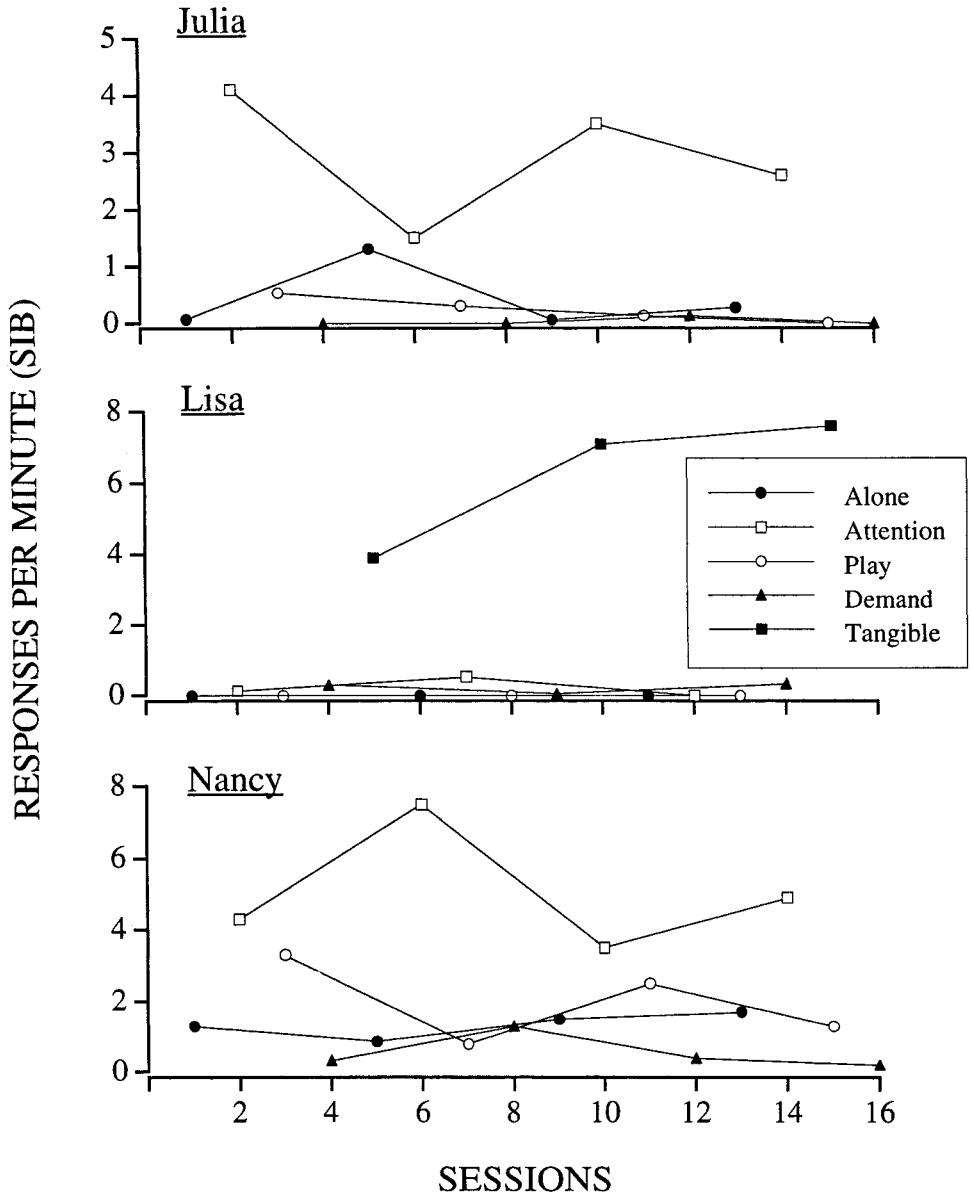

Figure 1. Responses per minute of SIB during functional analyses for Julia (top panel), Lisa (middle panel), and Nancy (bottom panel).

Procedure

Baseline. An experimenter was present, and the participant had free access to leisure materials throughout the session. The baseline contingencies were identical to those of the functional analysis condition in which SIB occurred most frequently. That is, Julia and Nancy both received brief attention, and Lisa received a small amount of preferred food, contingent on each occurrence of SIB.

Noncontingent reinforcement. During both NCR conditions, the experimenter delivered the same reinforcers as in baseline. However, reinforcers were not delivered following occurrences of SIB and instead were delivered according to FT schedules. The fixed-incre-

Table 1
NCR Schedule Values (Fixed-Increment Condition)

Number of reinforcers (per minute)	NCR schedule	Number of reinforcers (per minute)	NCR schedule
6	FT 10 s	1	FT 1 min
5	FT 12 s	0.5	FT 2 min
4	FT 15 s	0.33	FT 3 min
3	FT 20 s	0.25	FT 4 min
2	FT 30 s	0.2	FT 5 min

ment NCR schedule was based on procedures described by Vollmer et al. (1993). The initial schedule was always set at FT 10 s. If SIB occurred at or below 0.5 responses per minute during a given session, the schedule was increased in the subsequent session by adding a fixed amount of time to the NCR interval (see Table 1). Thus, all fixed-increment NCR schedules began with reinforcers delivered at a rate of six per minute (FT 10 s) and ended with reinforcers delivered at a rate of 0.2 per minute (FT 5 min). Under the adjusting-IRT NCR schedule, initial rates of reinforcer delivery were the same as each participant's mean IRT for SIB during the last three baseline sessions. For example, Julia's mean rate of SIB during her last three baseline sessions was four responses per minute, yielding a mean IRT of 15 s and an initial NCR schedule of FT 15 s. Before each subsequent NCR session, the schedule was determined by calculating the mean IRT of the previous three sessions. To prevent large, sudden decreases in responding from dramatically altering the NCR schedule, the increase in the NCR schedule for a given session was limited to a 100% increase from the previous session's NCR schedule. Thus, the initial and subsequent adjusting-IRT schedules varied across both participants and sessions as a function of changes in IRT. The criterion for terminating treatment under both NCR conditions was five consecutive sessions during which SIB remained below 0.5 responses per minute at an NCR value of FT 5 min.

Results

Figure 2 shows results obtained during the baseline and NCR conditions. Julia's SIB decreased immediately from baseline to very low rates under both the adjusting-IRT (initial schedule, FT 15 s) and fixed-increment (initial schedule, FT 10 s) NCR procedures. Her SIB continued to remain low under both NCR schedules as they were thinned. Julia first reached FT 5 min in six treatment sessions under the adjusting-IRT schedule and in 10 treatment sessions under the fixed-increment schedule. The reduction in Lisa's SIB following the introduction of NCR was not as immediate as that observed for Julia. Nevertheless, her SIB decreased to near-zero rates under both NCR schedules and, although an increase was observed when both schedules were thinned, SIB remained generally low throughout treatment. Lisa first reached FT 5 min in 11 sessions under the adjusting-IRT schedule (initial schedule, FT 6 s) and in 15 sessions under the fixed-increment schedule (initial schedule, FT 10 s). Finally, Nancy's SIB decreased to near-zero rates during the NCR conditions, although the duration of her treatment was longer than it was for either Julia or Lisa. Nancy first reached FT 5 min in 15 sessions under the adjusting-IRT schedule (initial schedule, FT 11 s) and in 25 sessions under the fixed-increment schedule (initial schedule, FT 10 s).

GENERAL DISCUSSION

The results of this study replicated those from previous research indicating that dense NCR schedules may be thinned while low rates of problem behavior are maintained. Moreover, schedule thinning based on adjusting-IRT values was shown to be just as effective as thinning based on fixed increments of time. In fact, the adjusting-IRT

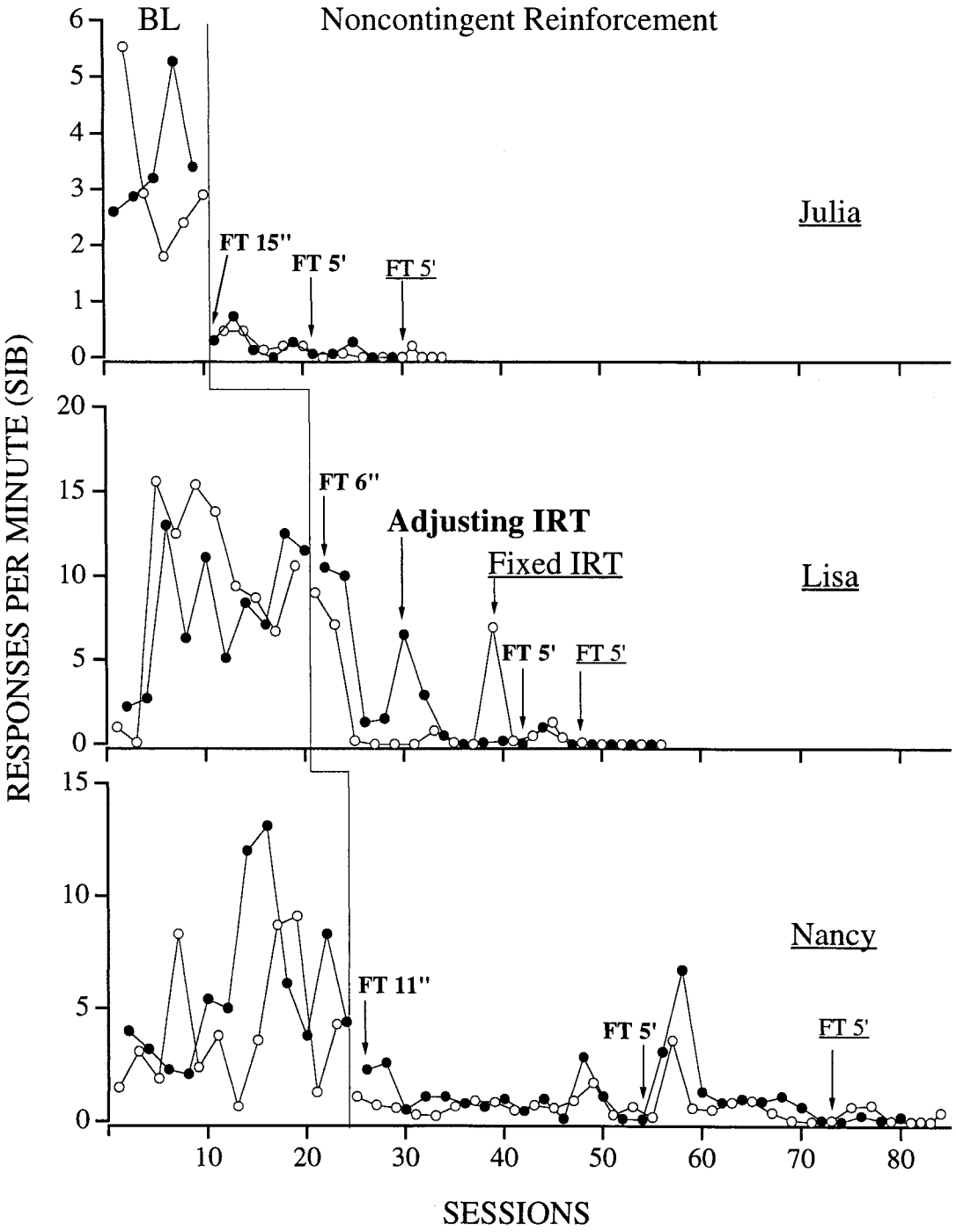

Figure 2. Responses per minute of SIB during baseline and NCR conditions for all participants. Fixed-increment NCR schedules, which always began at FT 10 s, are indicated with underlined type. Adjusting-IRT NCR schedules are indicated in bold type.

procedure allowed all participants to reach the terminal FT schedule in fewer treatment sessions than the fixed-increment procedure. Thus, the adjusting-IRT procedures provides an alternative method for setting initial NCR schedules as well for thinning them.

NCR produced large and immediate decreases in SIB for 2 participants (Julia and Nancy), resulting in increases in the adjusting-IRT schedule that were much greater than those under the fixed-increment schedule. Thus, had we not imposed the restriction of a 100% increase in the adjusting-IRT schedule, it is possible that the terminal FT schedule may have been reached even sooner than was the case in the present study. Of course, it is also possible that very large increases (greater than 100%) in the NCR schedule from session to session may compromise treatment effects by producing increases in SIB.

The fixed-increment procedure used in this study was not entirely based on fixed-time units because initial increments were quite short whereas later increments were longer. In addition, participants were required to progress through all of the thinning steps, which raises the question of whether the fixed-increment procedure was ideally designed. We selected this particular procedure because it was representative of that used in previous studies (e.g., Hagopian et al., 1994; Vollmer et al., 1993). However, it is possible that a different method of fixed-increment thinning (e.g., progressive or proportional schedules) may have been just as effective as the adjusting-IRT procedure. The rate at which NCR schedules can be thinned successfully may depend on a number of factors, such the initial schedule value, the criterion for initiating schedule changes, and the method for determining schedule values. Future research might involve parametric manipulation of these and other variables to identify the most efficient means of thinning NCR schedules.

Another potential limitation of the present investigation is the possibility that results obtained under one of the schedules were in part a function of carryover effects due to the rapid condition changes of the multielement design. However, we attempted to minimize these effects (i.e., enhance discrimination) by correlating the two conditions with different experimenters who conducted sessions in therapy rooms that were painted different colors. In addition, Lisa's responding in the two NCR conditions when the schedules were most similar (near the beginning of the intervention phase) suggested at least a moderate degree of response differentiation.

Given the initial dense schedules of NCR used in almost all research on the treatment of behavior disorders, schedule-thinning procedures such as those illustrated in this study provide a means for maintaining low rates of problem behavior under practical conditions. However, a related issue not addressed in either this or previous research is the criterion used to select the terminal NCR schedule. FT 5-min schedules have been commonly reported in the literature as both practical and effective, yet there are few data to suggest that 5-min schedules have any advantage over schedules that are either denser (e.g., 3 min) or thinner (e.g., 10 min). One problem in evaluating the relative merits of different terminal NCR schedules is that the session length in treatment studies has been very short, typically ranging from 5 to 15 min. Thus, answers to questions about the practicality, efficiency, and effectiveness of thin NCR schedules will require implementation over longer periods of time, so as to better approximate conditions found in the natural environment.

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Received September 9, 1999
Final acceptance February 22, 2000
Action Editor, Robert Stromer

STUDY QUESTIONS

1. How have initial values of noncontingent reinforcement (NCR) schedules typically been determined in previous applied research? What are some potential limitations of those methods?

2. What reinforcers were delivered during NCR, and how were they identified?

3. Describe the key features of the two NCR schedules whose effects were compared.

4. What restriction was imposed on increasing the value of the adjusting-IRT schedule, and what was its purpose?

5. What experimental designs were used during Phase 2, and what was the purpose of each design?

6. Summarize the results of the NCR comparison.

7. The authors noted that the two schedules differed with respect to efficiency. What adjustments could have altered the efficiency of both schedules?

8. What is a potential risk of determining NCR schedules based on IRTs, and how might this problem be prevented?

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