EFFECTS OF INTERMITTENT PUNISHMENT ON SELF-INJURIOUS BEHAVIOR: AN EVALUATION OF SCHEDULE THINNING

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Although the use of punishment often raises ethical issues, such procedures may be needed when the reinforcers that maintain behavior cannot be identified or controlled, or when competing reinforcers cannot be found. Results of several studies on the effects of intermittent schedules of punishment suggest that therapists must use fairly rich schedules of punishment to suppress problem behavior. However, residential caretakers, teachers, and parents often have difficulty implementing programs that require constant monitoring of the client's behavior. In this study, we examined the feasibility of gradually thinning the delivery of punishment from a continuous schedule to an intermittent schedule during the course of treatment for self-injurious behavior (SIB). Results of functional analyses for 5 individuals who had been diagnosed with profound mental retardation indicated that their SIB was not maintained by social consequences. Treatment with continuous schedules of time-out (for 1 participant) or contingent restraint (for the other 4 participants) produced substantial reductions in SIB. When they were exposed to intermittent schedules of punishment (fixed-interval [FI] 120 s or FI 300 s), SIB for all but 1 of the participants increased to levels similar to those observed during baseline. For these 4 participants, the schedule of punishment was gradually thinned from continuous to FI 120 s or FI 300 s. For 2 participants, SIB remained low across the schedule changes, demonstrating the utility of thinning from continuous to intermittent schedules of punishment. Results for the other 2 participants showed that intermittent punishment was ineffective, despite repeated attempts to thin the schedule.
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Punishment procedures, such as time-out from positive reinforcement and the delivery of aversive stimulation (e.g., electric shock, water mist), have been effective in reducing a variety of severe behavior disorders (see Matson & DiLorenzo, 1984, for a review). These interventions can be useful adjuncts

to treatment when the reinforcers that maintain problem behavior cannot be identified or controlled, or when competing reinforcers cannot be found because, compared to reinforcement-based treatments, punishment may be more effective in overriding the variables that maintain problem behavior (Paisey, Whitney, & Hislop, 1990; Vollmer & Iwata, 1993).

Nevertheless, caregivers often may find the use of punishment undesirable because they believe that it is too intrusive or time consuming (O'Brien & Karsh, 1990). Some of these concerns might be alleviated if punishment could be applied infrequently yet still produce substantial treatment effects. For example, intermittent schedules of punishment could permit infrequent delivery of punishment as well as discontinuous monitoring of behavior.

Basic studies with both humans and nonhumans have examined the effects of a variety of intermittent punishment schedules on behavior exposed to concurrent schedules of reinforcement. Results indicate that amount of response suppression depends on such factors as the type of punishment schedule, the intensity of the punishing stimulus, and the particular schedule of reinforcement that maintains the target response (e.g., Azrin, 1956; Bradshaw, Szabadi, & Bevan, 1979; Scobie & Kaufman, 1969; Zimmerman & Ferster, 1963). In a review of this literature, Azrin and Holz (1966) concluded that punishment should be delivered on a continuous (or fixed-ratio [FR] 1) schedule to be most effective.

Results of applied studies, however, seem to indicate that under some conditions, intermittent punishment schedules may be as effective as FR 1 (e.g., Acker & O'Leary, 1988; Calhoun & Lima, 1977; Cipani, Brendlinger, McDowell, & Usher, 1991; Kircher, Pear, & Martin, 1971; Romanczyk, 1977). For example, Clark, Rowbury, Baer, and Baer (1973) conducted one of the first

systematic investigations of intermittent punishment after successfully treating an 8-year-old girl's disruptive behavior with an FR 1 schedule of time-out. Using a reversal design, they examined three different variable-ratio (VR) schedules (VR 3, 4, and 8) and a schedule that specified delivery of time-out for any response that followed the previous one by less than 10 min (i.e., differential punishment of high rates [DPH]). Results indicated that when the punishment schedule was no leaner than about VR 4, treatment was nearly as effective as it was when time-out was delivered on an FR 1 schedule.

Although most studies on intermittent punishment did not involve attempts to identify the sources of reinforcement that maintained the target responses, delivery of punishment is almost always confounded with the termination of reinforcement in applied research (see Iwata, Pace, Cowdery, & Miltenberger, 1994, for a discussion of this issue). Thus, studies examining intermittent schedules may have combined punishment with extinction, a procedure that probably would increase the efficacy of intermittent punishment (Azrin & Holz, 1961).

As such, the utility of punishment as treatment for severe behavior disorders maintained by unknown or uncontrolled sources of reinforcement may be limited unless every instance of the target response is punished. However, treatment programs that require close, constant monitoring of behavior may be difficult to implement in settings with low staff-to-client ratios (e.g., schools and residential facilities). It would be beneficial if caregivers could use intermittent schedules of punishment, yet still obtain clinically significant reductions in behavior. Although several authors have suggested that punishment schedules might be gradually thinned to increase the efficacy of intermittent punishment (e.g., Cipani et al., 1991;

Kazdin, 1994), only one study has examined such a procedure.

Barton, Brulle, and Repp (1987) implemented a DPH schedule of time-out to decrease the aggression of 3 children in a classroom. The initial DPH schedule was determined for each child by calculating the mean baseline interresponse time (IRT) of aggressive behavior. On the first day of treatment, the interval used for the DPH schedule was equal to the mean baseline IRT, and this interval was adjusted daily throughout treatment to reflect the mean IRT from the previous day. The DPH was implemented as follows: If the mean IRT was 2 min, the first target response that occurred during every 2-min interval did not produce time-out. All subsequent responses that occurred prior to the end of the interval were followed by the time-out procedure (contingent observation for 2 participants and exclusion time-out for the 3rd). The interval did not reset following each time-out; at the start of every consecutive 2-min interval, the first instance of aggression was not followed by time-out. Results showed substantial reductions in aggression for all participants as the DPH interval was lengthened across several weeks.

Results of this study must be interpreted with caution for a number of reasons. First, all instances of aggression were followed by a verbal reprimand during treatment, a procedure that may have established the reprimand as a conditioned punisher and increased the efficacy of the DPH time-out schedule. In actuality, an FR 1 schedule may have been in effect throughout the study because all responses appeared to be followed by some type of potentially punishing event. Second, it is possible that gradual adjustment, or thinning, of the intermittent schedule was unnecessary to obtain significant reductions in aggression. That is, the terminal DPH schedule implemented for each subject may have been effective at the outset of treatment. Finally, the utility of the DPH

schedule was somewhat limited because, like FR 1, it required continual monitoring of behavior.

Additional research should determine if intermittent punishment schedules can be gradually thinned after behavior has been reduced by an FR 1 schedule. The intermittent schedule should be relatively easy to implement and, if possible, allow discontinuous monitoring of behavior. For example, fixed-interval (FI) schedules, which have not yet been examined in applied research on intermittent punishment, seem particularly well suited for this type of procedure. Monitoring the passage of time is probably less effortful than counting responses. In addition, interval schedules may be more effective than ratio schedules during the course of a thinning procedure because a high proportion of responses will be followed by punishment if response rates remain low (i.e., the behavior has a lengthy IRT). Although punishment delivery under FI schedules is more predictable (and hence potentially less effective) than punishment delivery under variable-interval (VI) schedules, FI schedules are probably easier to arrange in the natural environment than VI schedules, which require planned, systematic variations in the interval length following each punishment delivery.

In this study, we examined the efficacy of intermittent punishment with individuals who engaged in self-injurious behavior (SIB) that was maintained by unknown or uncontrolled sources of reinforcement. For all participants, alternative procedures, such as differential reinforcement of other behavior (DRO), differential reinforcement of alternative behavior (DRA), and noncontingent access to reinforcement (NCR), were found to be ineffective in reducing SIB. Thus, the effects of FR 1 punishment on SIB were examined by exposing participants to baseline and treatment conditions within a reversal design. After subsequently identifying an in-

Table 1
Mean Levels and Ranges of SIB Across Functional Analysis Conditions

Condition	Paul	Wendy	Wayne	Melissa	Candace
Alone	74% (48–91)	69% (22–87)	12% (2–23)	25% (5–51)	22 (14–32)
Attention	5% (4–6)	7% (0–15)	4% (0–13)	4% (0–19)	26 (16–42)
Demand	2% (0–5)	9% (0–19)	6% (0–15)	66% (43–80)	22 (0–44)
Play	12% (0–23)	19% (0–48)	6% (0–20)	4% (0–7)	29 (0–54)

Note. Data are expressed as percentage of intervals for Paul, Wendy, Wayne, and Melissa, and as responses per minute for Candace.

effective FI punishment schedule, the FR 1 schedule was reimplemented and gradually thinned every few sessions as long as responding remained low.

METHOD

Participants and Setting

Five individuals who had been diagnosed with profound mental retardation participated. All participants lived in a public residential facility for individuals with developmental disabilities and had been referred to a specialized program for assessment and treatment of SIB based on histories of chronic SIB. None of the participants had visual or auditory impairments, and all but 2 (Melissa and Wayne) could walk independently. The participants displayed no expressive language skills; however, all but 2 (Melissa and Wayne) were responsive to simple instructions.

Paul was a 39-year-old man with a long history of hand mouthing that produced redness, swelling, and tissue damage on several fingers. Paul received clonopin for "agitation," but no medication changes occurred during the course of the study. Melissa was a 31-year-old woman who engaged in chronic hand mouthing that had produced extensive tissue damage and frequent infection on both hands. At the time of this study, Melissa wore rigid arms splints at home (as prescribed by her physician) to prevent hand mouthing and reoccurrence of infection. Melissa used a wheelchair and re-

ceived medication (Dilantin®) to control seizures during the course of the experiment. Candace was a 35-year-old woman who had a long history of head and face hitting. Her SIB, which was of mild intensity but high frequency, had resulted in extensive bruising, swelling, and tissue damage on her cheeks and chin. Wendy, a 25-year-old woman who had been diagnosed with Cornelia de Lange syndrome, engaged in hand mouthing that had resulted in redness, swelling, and tissue damage on both hands. At the time of this study, Wendy's caregivers had requested rigid arm splints to prevent hand mouthing. Wayne was a 31-year-old man who engaged in chronic hand mouthing that had produced extensive swelling and tissue damage on both hands. He used a wheelchair and received medication (Dilantin®) to control seizures.

Prior to the study, all participants were exposed to a functional analysis of SIB, based on procedures described by Iwata, Dorsey, Slifer, Bauman, and Richman (1982/1994). Mean levels and ranges of SIB during the four conditions of the functional analysis are presented in Table 1. For Paul, Wendy, and Wayne, the highest levels of SIB occurred in the alone condition, suggesting that their hand mouthing was maintained by automatic reinforcement. Results for Candace showed high rates of SIB in all conditions, an undifferentiated pattern that also suggested that her behavior was maintained by automatic reinforcement. For Melissa, the highest levels of hand mouthing occurred in

the alone and demand conditions, suggesting that her behavior was sensitive to negative reinforcement as well as automatic reinforcement. A series of 15 consecutive alone sessions was conducted following her functional analysis to further determine if hand mouthing would be maintained in the absence of social consequences. Levels of hand mouthing were moderate ($M = 33\%$) and stable across alone sessions. Due to the extensive tissue damage and risk of infection produced by engaging in SIB, it was important to treat Melissa's automatically maintained SIB prior to developing treatments for the escape-motivated component of her behavior.

Following the functional analysis, preference assessments were conducted for each participant using the procedures described by Pace, Ivancic, Edwards, Iwata, and Page (1985). Results were used to develop reinforcement-based treatments for SIB, including DRO (Melissa), DRA (Wayne), and NCR (all participants). These interventions did not reduce SIB below baseline levels for any participant except Melissa. Although noncontingent access to toys (e.g., plastic rings) nearly eliminated Melissa's hand mouthing, Melissa chewed the toys continuously under this treatment. As a result, her hands contacted large amounts of saliva, placing her at risk for infection, and her caregivers requested an alternative procedure. More intrusive interventions were then developed for all participants due to the chronic nature of their SIB, severity of tissue damage, risk of infection caused by engaging in the behavior, and ineffectiveness of the reinforcement procedures.

All sessions were conducted in therapy rooms of a day program located on the grounds of the residential facility. Rooms contained tables, chairs, and materials necessary for conducting certain conditions (see Procedure). At least one observer was present during all sessions.

Response Measurement and Reliability

Response definitions were developed on the basis of staff interviews and informal observations of the participants prior to the study. *Hand mouthing* (Paul, Melissa, Wendy, and Wayne) was defined as contact of the tongue with any part of the hand or wrist, or insertion of any part of the hand or wrist between the lips without biting. *Head hitting* (Candace) was defined as forceful contact of a closed hand with any part of the face or head. Event data also were collected on experimenters' delivery of punishment.

Observers collected data using a hand-held computer (Assistant Model A102) that audibly signaled 10-s intervals. Observers were graduate and undergraduate students who had previously demonstrated proficiency with this type of data collection by attaining a 90% agreement criterion for three consecutive sessions. Data were collected using frequency or partial-interval recording, and the data were expressed as responses per minute (Candace) or percentage of 10-s intervals scored (Paul, Melissa, Wendy, and Wayne).

Interobserver agreement was assessed by having a second observer simultaneously but independently record data during 30% of all sessions. Agreement percentages were calculated on an interval-by-interval basis. For partial-interval recording, the percentage agreement between the two observers was calculated by dividing the number of agreements by the number of agreements plus disagreements and multiplying by 100%. For frequency recording, the smaller number of responses in each interval was divided by the larger number of responses. These fractions were then summed across all intervals, divided by the total number of intervals in the session, and multiplied by 100%. Mean percentage of agreement for SIB across all participants was 98% (range, 97% to 99%).

Procedure

Three to four sessions were conducted daily for each participant, 4 to 5 days per week. All sessions lasted 15 min except for Candace's sessions, which lasted 10 min. Session time was stopped when the therapist delivered the punishing consequence (20-s time-out for Paul, 15-s manual restraint for Melissa and Wayne, 30-s manual restraint for Wendy, and 30-s manual restraint plus protective equipment for Candace). These intervals were not included in the total session time. The effects of intermittent punishment on SIB were examined in the absence of alternative procedures (e.g., DRO, DRA) so that changes in responding could be directly attributed to changes in the punishment schedule rather than to some other variable. However, throughout the course of the study, all participants engaged in habilitation programs in their residences for about 5 hr each day as specified in their individual habilitation plans. Self-care skills (e.g., eating, toothbrushing, toileting, propelling wheelchair) and on-task behavior (e.g., participating in work or leisure activities) were targeted in the programs. Adaptive behaviors were taught via prompting and reinforcement by therapy aides, behavior program specialists, and rehabilitation therapists. Typically, each staff member was responsible for implementing daily habilitation programs with two to three residents.

Baseline. During these sessions, the participant was seated in a chair, and no one interacted with him or her. Paul had continuous access to a hand-held massager.

Time-out (FR 1). Paul was exposed to the time-out procedure. During these sessions, he had continuous access to a hand-held massager; however, the therapist removed the massager for 20 s contingent on each occurrence of hand mouthing. If Paul engaged in hand mouthing during the last 10 s of the time-out period, the interval was extended until he had not engaged in hand mouthing for 10 s.

Contingent restraint (FR 1). Melissa, Candace, Wendy, and Wayne were exposed to the manual restraint procedure. Contingent on each occurrence of SIB, the therapist held the participants' arms to their sides for 15 s (Melissa and Wayne) or 30 s (Candace and Wendy), using the minimum force necessary to keep their hands stationary near their laps. The amount of force necessary to apply the restraint was never sufficient to cause bruising on the participants. The therapist also placed a soft collar brace around Candace's neck at the start of each restraint interval to prevent chin hits against her shoulder, an SIB topography that occurred when her arms were restrained during treatment probes. None of the participants was ever observed to self-restrain.

Time-out or contingent restraint (FI 120 s, FI 300 s, or FI 600 s). The time-out and contingent restraint procedures were implemented as described above. However, the therapist delivered punishment contingent on the first occurrence of SIB after 120 s (all participants), 300 s (Paul, Wendy, and Wayne), or 600 s (Wayne) had elapsed since the last application of punishment (or the start of the session). If the individual was already engaging in SIB at the end of the 120-, 300-, or 600-s interval, the therapist immediately delivered the consequence. Thus, a maximum of one (for FI 600 s), three (for FI 300 s), or seven (for FI 120 s) punishment deliveries was possible during these sessions.

Time-out or contingent restraint (thinning). All participants but Wayne were exposed to the thinning procedure. During this phase, delivery of time-out or restraint was thinned from FR 1 to either FI 120 s (Melissa and Candace) or FI 300 s (Paul and Wendy). The initial intermittent schedule was FI 15 s (Melissa and Candace) or FI 30 s (Paul and Wendy). The interval was lengthened by a

prespecified amount (see Results) when SIB was below 1.5 responses per minute (Candace) or occurred in 10% or less of the intervals (Melissa, Paul, and Wendy) for four or five consecutive sessions. The individual's performance under the current schedule and the length of the terminal interval schedule were considered when adjusting the interval length across the course of the schedule-thinning procedure.

RESULTS

Paul. Paul (Figure 1) engaged in moderate but variable levels of hand mouthing during baseline ($M = 33\%$), which appeared to increase across sessions. Treatment with time-out (FR 1) produced an immediate reduction in the behavior to low levels ($M = 4.2\%$). With the removal of time-out in the next phase, Paul's hand mouthing rapidly increased and, although variable, occurred at a moderate level ($M = 44.2\%$). These findings indicated that the FR 1 schedule of time-out was effective in treating Paul's hand mouthing. When the FI 120-s schedule was implemented, hand mouthing decreased to levels just slightly greater than those under FR 1 ($M = 9.4\%$). The FI 300-s schedule was then implemented, and hand mouthing increased again to near baseline levels ($M = 26\%$). The reintroduction of time-out (FR 1) again produced a reduction in hand mouthing ($M = 4.4\%$), and responding remained low as the time-out schedule was gradually thinned to the FI 300-s schedule. Across the 57 sessions of the thinning procedure, hand mouthing occurred in an average of 3.4% of the intervals. Hand mouthing also remained low when Paul was exposed to the final FI 300-s schedule of time-out ($M = 2.4\%$), suggesting that the thinning procedure increased the efficacy of an initially ineffective intermittent punishment schedule.

Melissa. During baseline, Melissa's levels of hand mouthing were variable and moderate ($M = 46\%$) (Figure 1). Treatment with contingent restraint FR 1 resulted in an immediate decrease in SIB to low levels ($M = 6.6\%$). Hand mouthing then increased and was maintained at moderate levels with the return to baseline ($M = 55.7\%$). These findings indicated that contingent restraint on an FR 1 schedule was effective in treating Melissa's hand mouthing. When contingent restraint on an FI 120-s schedule was implemented, however, levels of hand mouthing were similar to those in baseline ($M = 58.7\%$). The reintroduction of contingent restraint on an FR 1 schedule again produced significant decreases in responding ($M = 7.9\%$). Hand mouthing remained relatively low as the schedule was thinned to FI 45 s, at which time responding became more variable and increased to baseline levels. FR 1 was then implemented to reestablish treatment effects before attempting to thin a second time. Hand mouthing decreased to low levels under FR 1; however, responding increased sharply during the first session of intermittent punishment (FI 15 s) and was maintained at moderate levels for the next few sessions. As a result, FR 1 was again introduced before thinning the schedule more gradually using 5-s increments. During the third attempt to thin the schedule, levels of hand mouthing remained low until the FI 25-s schedule, under which responding became more variable and was maintained at moderate levels across seven sessions. These findings suggested that contingent restraint would not effectively treat Melissa's hand mouthing unless nearly every response was followed by punishment. Instead of attempting to thin the schedule any further, FR 1 was reimplemented as Melissa's final treatment condition. Across the final 14 sessions with FR 1, levels of hand mouthing remained low ($M = 3.3\%$).

Candace. Candace's rates of SIB were high and variable during baseline ($M = 32$ re-
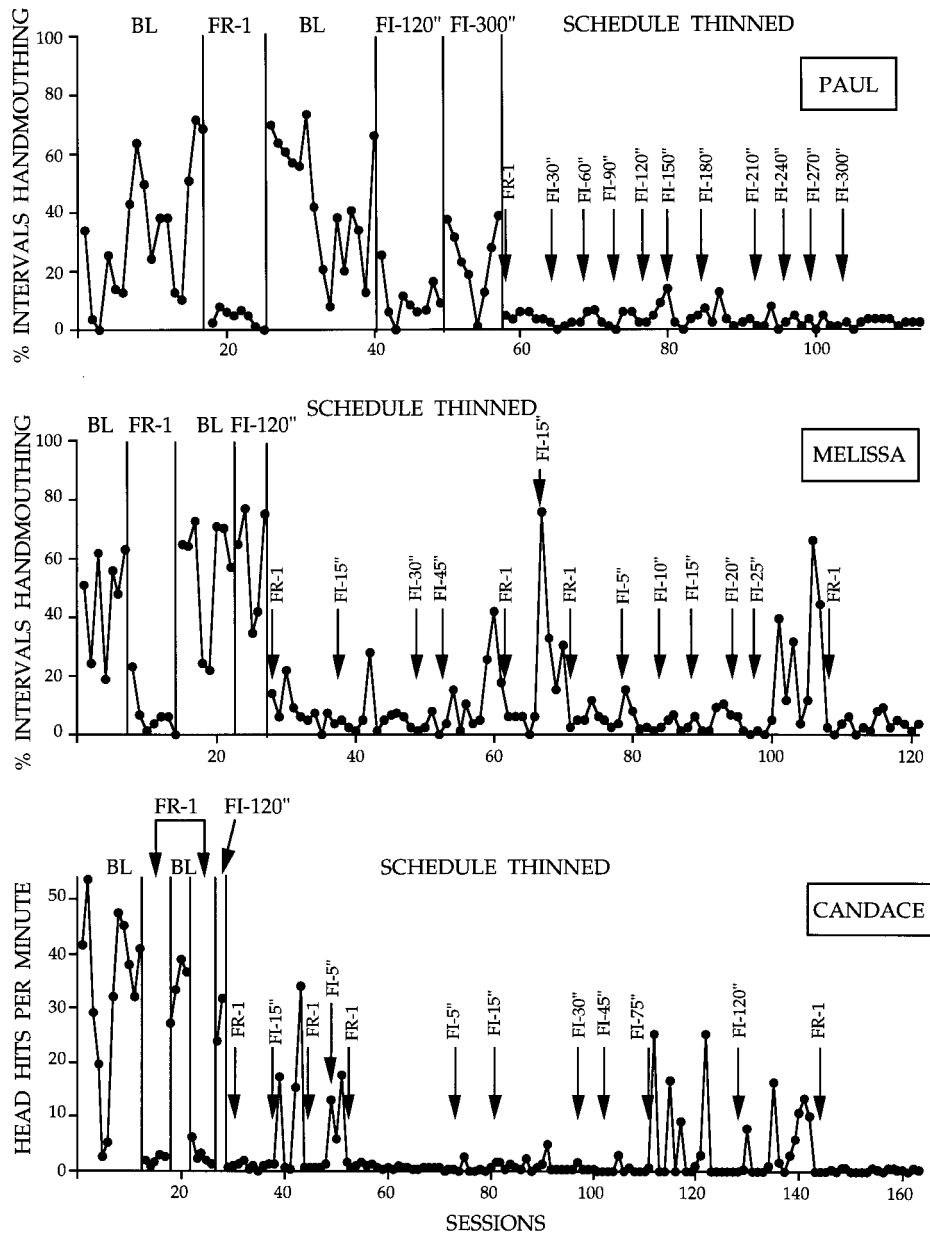
Figure 1. Percentages of intervals of hand mouthing for Paul and Melissa and responses per minute of head hitting for Candace across baseline and treatment sessions (time-out for Paul, manual restraint for Melissa, and manual restraint plus protective equipment for Candace).

sponses per minute) (Figure 1), and the introduction of contingent restraint on an FR 1 schedule produced an immediate decrease in responding to low levels ($M = 2$). These findings, which were replicated during additional baseline and contingent restraint FR 1 phases, indicated that the combined manual and mechanical restraint FR 1 procedure was an effective treatment for Candace's SIB. When the FI 120-s schedule was then implemented, rates were similar to those in baseline ($M = 28$). SIB again decreased with
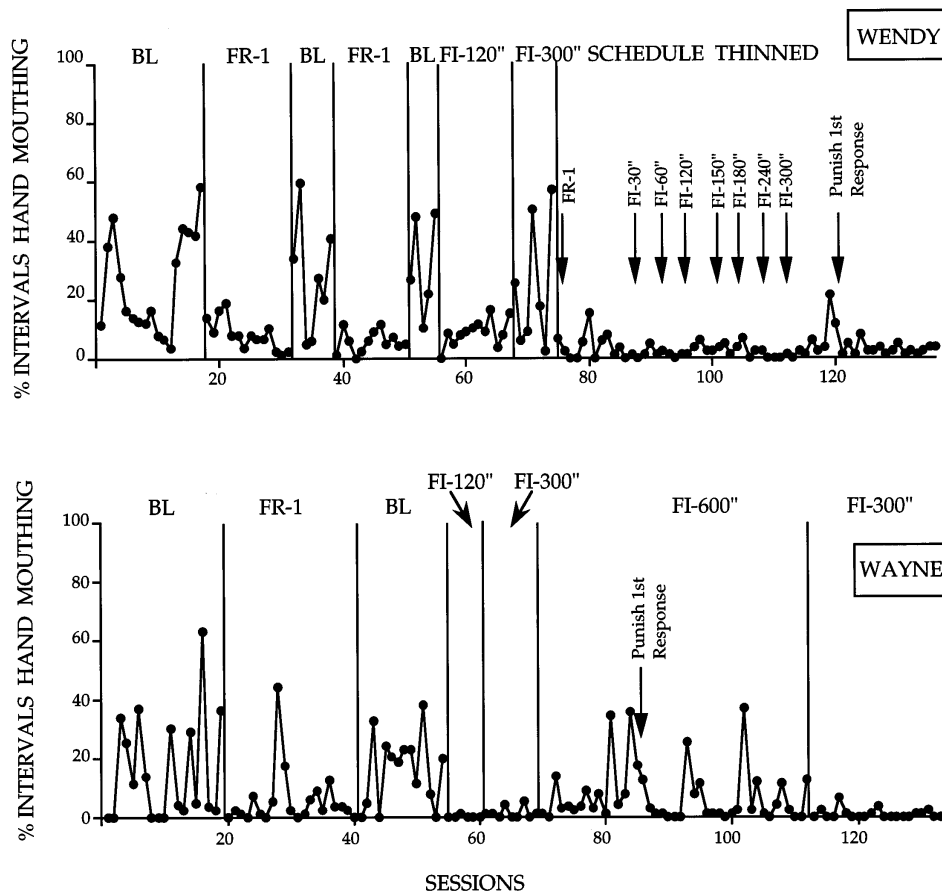
Figure 2. Percentages of intervals of hand mouthing across baseline and treatment with contingent manual restraint for Wendy and Wayne.

the reintroduction of FR 1 but became more variable under the FI 15-s schedule, increasing to baseline levels. FR 1 was implemented to reestablish treatment effects before thinning the schedule more gradually in 5-s increments. However, SIB immediately increased under the first intermittent schedule (FI 5 s), and FR 1 was then implemented across the next 20 sessions before initiating the third (and final) attempt to thin the schedule. SIB remained low across the lengthy exposure to FR 1 ($M = 0.7$). During the final schedule-thinning phase, rates of SIB remained low until the FI 75-s schedule, under which responding increased but became quite variable (sessions alternated between very high and very low rates). The

schedule eventually was thinned to FI 120 s; however, the variable pattern of responding continued. Instead of examining any additional thinning procedures, FR 1 was reimplemented as Candace's final treatment condition. Across the final 21 sessions with FR 1, SIB was consistently low ($M = 0.3$).

Wendy. Wendy's levels of hand mouthing were moderate and variable during baseline ($M = 25.6\%$) (Figure 2) and decreased gradually under contingent restraint on an FR 1 schedule ($M = 8.2\%$). These findings were then replicated in additional baseline and contingent restraint FR 1 phases, indicating that manual restraint was an effective treatment for Wendy's hand mouthing. During contingent restraint on an FI 120-s schedule,

hand mouthing remained low across 12 sessions ($M = 8.7\%$); therefore, the FI 300-s schedule was implemented and responding became more variable, increasing to baseline levels ($M = 23.9\%$). Contingent restraint on an FR 1 schedule again produced a reduction in responding, which was maintained as the schedule was thinned to FI 300 s across 25 sessions ($M = 2\%$). However, hand mouthing increased during the ninth session of FI 300 s. Subsequently, the therapist punished the first response in each session (regardless of when it occurred), and levels of hand mouthing remained low across the final 17 sessions of FI 300 s ($M = 3.3\%$).

Wayne. During baseline, Wayne's levels of hand mouthing were moderate but highly variable ($M = 15\%$) (Figure 2). Contingent restraint on an FR 1 schedule produced an immediate reduction in the behavior ($M = 5\%$). With the return to baseline, levels of hand mouthing increased ($M = 16\%$), indicating that contingent restraint was effective in treating Wayne's SIB. Contingent restraint on FI 120-s and FI 300-s schedules was associated with a reduction in hand mouthing that was below that observed during contingent restraint on FR 1 ($M = 0.2\%$ for FI 120 s and $M = 1\%$ for FI 300 s); thus, the FI 600-s schedule was implemented. Hand mouthing remained low across 12 sessions of contingent restraint on the FI 600-s schedule, then gradually increased to baseline levels. To recapture treatment effects with the FI 600-s schedule, the therapist punished the first response in each session regardless of when it occurred, a strategy that had been effective for Wendy. Although this procedure was associated with an initial decrease in hand mouthing, responding increased and became more variable after eight sessions. Contingent restraint on an FI 300-s schedule was then reimplemented as Wayne's final treatment condition, without punishment of the first response unless it occurred at least 300 s after the start of the session,

and hand mouthing remained low across 21 sessions ($M = 0.9\%$).

Results showed that FR 1 punishment was effective for all participants. For Wayne, treatment with intermittent punishment on FI 120-s and FI 300-s schedules was also immediately effective, and for Paul and Wendy, hand mouthing remained low across a lengthy schedule-thinning procedure. By contrast, Melissa's hand mouthing and Candace's head hitting increased when the punishment schedule was thinned slightly. Even after extended exposure to FR 1 and a final attempt to thin the schedule, Candace's SIB rates were not consistently low under a practical intermittent punishment schedule (i.e., FI 120 s). A closer examination of the participants' response patterns during punishment could provide at least one explanation for these discrepant outcomes. Under the FI schedules, occurrences of SIB were not punished when their interresponse times were relatively short (i.e., shorter than the interval used in the FI schedule). If the responses of Melissa and Candace often immediately followed the delivery of punishment, FI punishment schedules, and hence schedule thinning, probably would be ineffective. That is, levels of SIB would likely increase as the schedule interval was lengthened, and the delivery of manual restraint eventually could function as a discriminative stimulus for the temporary discontinuation of the punishment contingency.

Data on the relative frequency or distribution of various IRTs from selected treatment sessions were compared for the 5 participants. Specifically, amount of time that had elapsed since the previous punishment delivery (or the start of the session if no punisher had been delivered) was calculated for each occurrence of SIB. Data from the last five sessions of FR 1, immediately prior to the first schedule-thinning procedure, and from the final five treatment sessions were included in the analysis. For Candace, data

Table 2
Proportion of Responses that Followed Punishment Delivery Within Specified Time Periods

Latency (s)	Paul	Wendy	Wayne	Melissa	Candace
Last five FR 1 sessions					
0–20	.10	0	0	.47	.45 (.25)
21–40	.16	.07	.05	.10	.17 (.18)
41–60	.05	.07	.21	.10	.12 (.11)
61–120	.26	.29	.42	.10	.12 (.28)
121–180	.05	.36	.10	.16	.07 (.14)
181–240	.10	0	.10	0	.02 (.03)
241–300	.05	0	.05	0	0 (0)
300+	.21	.21	.05	.05	0 (0)
Last five treatment sessions					
0–20	.18	.09	.25	.38	.33
21–40	0	0	0	.15	.17
41–60	0	0	0	.08	.05
61–120	.09	0	0	.23	.11
121–180	.09	0	0	0	.11
181–240	.09	.18	0	0	.05
241–300	0	.18	0	0	0
300+	.54	.55	.75	.15	.17

from the last five sessions of the lengthy FR 1 phase were also examined. These data are summarized in Table 2, which shows the proportion of responses that followed the previous punishment delivery (or start of the session) by specific amounts of time. Results for the last five sessions of FR 1 (Sessions 59 to 63 for Paul, 81 to 85 for Wendy, 36 to 40 for Wayne, 33 to 37 for Melissa, and 32 to 36 and 67 to 71 for Candace) are displayed at the top of Table 2. Results show that, for Melissa and Candace, large proportions of SIB were distributed among the short IRTs (i.e., 0 s to 120 s) compared to those for Paul, Wendy, and Wayne. In fact, a relatively large proportion of Melissa's and Candace's responses (47% and 45%, respectively) occurred within the first 20 s of the previous punishment delivery. By contrast, small percentages of Paul's, Wendy's, and Wayne's responses (10%, 0%, and 0%) had such short IRTs. Interestingly, data from Candace's extended FR 1 phase, shown in the parentheses, reveal a modest shift toward

longer IRTs when compared to the data from the prior FR 1 sessions.

Data from the last five treatment sessions (Sessions 110 to 114 for Paul, 132 to 136 for Wendy, 129 to 133 for Wayne, 117 to 121 for Melissa, and 159 to 163 for Candace) are displayed at the bottom of Table 2. When compared to the findings from the initial FR 1 sessions, these data show changes in the distribution of responding after exposure to the thinning procedure or, in Wayne's case, extended exposure to intermittent punishment per se. The distributions for Paul, Wendy, and Wayne generally shifted toward the larger values; by contrast, those for Melissa and Candace did not change substantially. As a result, most of Paul's, Wendy's, and Wayne's hand mouthing (54%, 55%, and 75%) followed the previous time-out or restraint delivery by more than 300 s, whereas the majority of Melissa's and Candace's SIB (84% and 66%) continued to occur within 120 s of the previous punishment delivery.

When Paul, Wendy, and Wayne were discharged from the day program, residence staff were taught to implement the interventions using the terminal FI schedule. Informal follow-up observations conducted at the residences indicated that staff members were correctly implementing the procedure and that participants' hand mouthing remained low. Staff members at Melissa's residence were reluctant to implement a treatment that required continuous monitoring of behavior; thus, shortly after her discharge, Melissa was readmitted to the day program, where alternative interventions were being developed. For Candace, treatment effects were not maintained prior to discharge when the procedure was altered to facilitate generalization of the intervention to her residence (e.g., by increasing the distance between Candace and the therapist or attempting to establish a verbal reprimand as a conditioned punisher). Development of alternative treat-

ments for Candace continued at the day program.

DISCUSSION

In this study, we examined the feasibility of gradually thinning schedules of punishment with 4 individuals who engaged in chronic SIB that was not maintained by social consequences. Results for 2 participants (Paul and Wendy) demonstrated that an FI schedule of punishment could be thinned while low levels of responding were maintained. Findings for these individuals further suggested that the thinning procedure increased the effectiveness of an intermittent schedule that had previously failed to suppress behavior. Results for the other 2 participants (Melissa and Candace) indicated that any practical FI punishment schedule probably would be ineffective, despite repeated attempts to gradually thin the schedule beyond FR 1. For a 5th individual (Wayne), thinning the schedule of punishment was not attempted because a practical FI schedule (FI 300 s) produced substantial reductions in hand mouthing.

These conflicting outcomes were not anticipated prior to the thinning procedure because a continuous schedule of punishment was effective for all participants. Results showed that FR 1 punishment with either contingent time-out (Paul) or restraint (Melissa, Candace, Wendy, and Wayne) successfully treated SIB. However, a closer examination of these data indicated that the SIB of Melissa and Candace, when it did occur, often closely followed the delivery of punishment or the start of the session, a pattern of responding that might jeopardize the effectiveness of FI punishment schedules. Thus, an analysis of an individual's IRTs under FR 1 punishment may indicate whether delivery of punishment can be successfully thinned using FI schedules.

Results for Melissa also suggested that her behavior became more sensitive to the FI punishment contingencies with repeated attempts to thin the schedule. Initially, hand mouthing remained low until the FI 45-s schedule. During the second attempt to thin delivery of punishment, levels of hand mouthing escalated under the shortest FI schedule (FI 15 s). When the thinning procedure was then introduced more gradually in 5-s increments, the punishment schedule could not be thinned beyond FI 20 s. Under FI schedules, responses with lengthy IRTs (i.e., those longer than the interval used in the FI schedule) are selectively punished. As a result, the frequency of responses with relatively short IRTs are likely to increase (Galbicka & Branch, 1981). Eventually, delivery of punishment could also function as a discriminative stimulus for punishment-free periods, leading to a gradual overall increase in responding under FI punishment. Basic studies on FI punishment schedules have shown that response rates are often highest immediately following the delivery of punishment and decelerate across the schedule interval (e.g., Azrin, 1956). During FI sessions with high levels of responding (e.g., FI 25 s), Melissa typically hand mouthed continuously through the interval, but response patterns occasionally resembled those obtained in basic studies. On the other hand, Candace's response patterns under FI 120 s showed that the largest proportion of SIB occurred just prior to punishment delivery.

A number of variables could have influenced the efficacy of intermittent punishment for Melissa and Candace. For example, a different type of punishment schedule may have increased the likelihood of successfully thinning the schedule. Azrin (1956) found that a VI schedule of contingent electric shock produced lower levels of key pecking in pigeons than did an FI schedule. FI schedules were selected for this study because they seem to be easier to arrange in the natural environment than VI schedules

are. Unlike VI schedules, FI schedules permit caregivers to use a constant, time-based schedule when implementing punishment. However, delivery of punishment under VI schedules is somewhat unpredictable and thus less likely to be established as a discriminative stimulus for the temporary discontinuation of punishment. FI schedules may have been ineffective for Melissa and Candace because they often engaged in hand mouthing soon after the delivery of manual restraint (i.e., within 20 s). Some of these responses may have been punished if VI schedules had been implemented throughout the schedule-thinning procedure.

Alternatively, FI schedules may have been more effective if the treatment had been implemented across lengthier time periods. Sessions of such brief duration (10 to 15 min) limited the frequency with which SIB contacted punishment as the schedule was thinned and may have compromised the efficacy of the treatment procedure for Melissa and Candace. Relatedly, lengthier exposure to FR 1 prior to the schedule-thinning procedure may have been beneficial for these 2 participants. Results for Candace suggested that exposure to FR 1 for 20 consecutive sessions increased the efficacy of intermittent punishment. During the initial attempts to thin the schedule, rates of SIB increased under the FI 5-s and FI 15-s schedules. When the schedule-thinning procedure followed the 20-session exposure to FR 1, SIB remained low until FI 75 s. In addition, an analysis of Candace's response patterns during these FR 1 sessions showed a slight shift in the IRT distribution toward values greater than 60 s when compared to the previous FR 1 sessions. For both Melissa and Candace, lengthier exposure to FR 1 (e.g., for 30 to 50 sessions) may have altered the distribution of IRTs even further or increased the efficacy of intermittent punishment in some other manner.

In fact, the criterion for attempting to

thin the schedule could have been based on the pattern of IRTs rather than on overall level of responding. For example, the FR 1 schedule could have been changed for Melissa and Candace when 50% or more of the IRTs were greater than 120 s for five consecutive sessions. In addition, all subsequent steps in the schedule-thinning procedure could have been based on the current distribution of IRTs, a procedure similar to that used by Barton et al. (1987). Such a strategy would ensure that a large proportion of responses is punished even as the schedule is gradually thinned. Although a variety of methods could have been selected to thin the schedule gradually, the particular strategy used (i.e., altering the length of the interval by a prespecified amount based on the participant's current performance and the terminal schedule length) was appealing due to its simplicity.

Results for Melissa and Candace may also be specific to behavior that continues to receive reinforcement during treatment. An extinction component would be likely to increase the efficacy of intermittent punishment or, at the least, enhance the thinning procedure (Azrin & Holz, 1961). Although no studies have compared the effects of intermittent punishment with and without extinction, previous studies obtaining significant reduction of problem behavior with intermittent punishment probably included an extinction component in the treatment program (see Iwata et al., 1994, for a discussion of this issue). If reinforcement for hand mouthing had been eliminated in some manner, the punishment schedule may have been thinned successfully for both participants. In fact, the initial intermittent punishment schedules (FI 300 s for Paul and Wendy, FI 120 s for Candace and Wendy) might have been effective prior to the thinning procedure. However, the primary purpose of this study was to examine the use of intermittent punishment when treatment with

extinction is impractical (as in the case of behavior maintained by automatic reinforcement; Vollmer & Iwata, 1993). Treatment procedures involving intermittent punishment may be unnecessary when the response–reinforcer relationship can be terminated.

Although the utility of punishment as treatment for severe behavior disorders has been firmly established in the literature (see Axelrod & Apsche, 1983, and Matson & DiLorenzo, 1984, for reviews), these findings were likely to depend on the consistent application of punishment procedures. As a result, the robust treatment effects that were demonstrated in these studies may be somewhat difficult to replicate in applied settings, where staff may not have the time or resources to respond to each occurrence of behavior. The intrusive nature of punishment per se also makes it a relatively unpopular treatment option among caregivers and clinicians. Nevertheless, punishment procedures may be useful when the reinforcers that maintain behavior cannot be identified or controlled. In this study, punishment was used infrequently with Paul, Wendy, and Wayne after the schedule was thinned to FI 300 s, and the schedule permitted discontinuous monitoring of behavior. Thus, results of this study have important implications for both the efficacy and the acceptability of punishment in applied settings.

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STUDY QUESTIONS

1. What two practical reasons did the authors cite for determining whether intermittent punishment is effective in maintaining behavioral suppression?

2. Why did the authors select fixed-interval schedules as the basis for schedule thinning?

3. What was the authors' justification for using punishment with the individuals who participated in the study?

4. Following the demonstration that FR 1 schedules of punishment were effective in suppressing behavior, why were the schedules shifted abruptly to relatively lean values prior to systematic attempts to thin the schedule? Whose set of data illustrated the utility of this procedure?

5. What criteria were used to thin the punishment schedules from the original FR 1 value? Also, although the schedule-thinning procedure was not used with Wayne, what additional procedure was used with Wayne and Wendy in an attempt to maintain low rates of SIB under lean schedule values?

6. Summarize the results obtained for each of the participants.

7. What characteristic of the participants' behavior under FR 1 schedules of punishment seemed predictive of the extent to which behavioral suppression would be maintained under lean schedules of punishment?

8. What additional or alternative methods might have been used to enhance the efficacy of intermittent punishment?

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