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ANALYSIS OF THE REINFORCEMENT AND EXTINCTION COMPONENTS IN DRO CONTINGENCIES WITH SELF-INJURY

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Previous research has shown that self-injurious behavior (SIB) maintained by positive reinforcement may be reduced under differential-reinforcement-of-other-behavior (DRO) contingencies. In this study, we conducted an analysis of the reinforcement and extinction components of DRO while treating the self-injury of 3 women with developmental disabilities. A functional analysis revealed that each subject's SIB was maintained by positive reinforcement in the form of attention. Subsequent reinforcer assessments identified preferred and nonpreferred stimuli for later use in conjunction with DRO. Results showed high rates of SIB for all 3 subjects during baseline, which persisted when DRO was implemented without the relevant extinction component (withholding of attention for SIB) for 2 of the subjects. Low rates of SIB were observed for all subjects when DRO plus extinction was implemented or when extinction was implemented alone, suggesting that extinction may be a critical component of DRO schedules.

DESCRIPTORS: differential reinforcement, extinction, functional analysis, self-injurious behavior

Self-injurious behavior (SIB), a serious problem exhibited by many persons with developmental disabilities, has been described frequently in the literature (e.g., Carr, 1977; Favell et al., 1982; Lovaas & Simmons, 1969). Although some self-injury has been correlated with medical disorders (e.g., Nyhan, 1972), most SIB appears to be learned behavior maintained by specific reinforcement contingencies whose properties can be identified through systematic experimental analysis (e.g., Carr, Newsom, & Binkoff, 1976; Iwata, Dorsey, Slifer, Bauman, & Richman, 1982). Once the maintaining variable(s) of an individual's SIB are identified, a therapeutic procedure aimed at modifying the relevant reinforcement contingencies may be developed (e.g., Day, Rea, Schussler, Larsen, & Johnson, 1988; Iwata, Pace, Cowdery, Kalsher, & Cataldo, 1990).

One variable known to play a significant role in the development and maintenance of SIB is positive reinforcement delivered by parents, teachers, and other caregivers (Brawley, Harris, Allen, Fleming, & Peterson, 1969; Lovaas, Freitag, Gold, & Kassorla, 1965; Lovaas & Simmons, 1969). Access to reinforcing stimuli often is restricted for many developmentally disabled individuals, and behavior problems such as SIB may develop when these stimuli are presented contingent on such behaviors. For example, Lovaas et al. (1965) demonstrated that social interaction (the experimenter saying "I don't think you are bad") contingent on head and

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arm banging increased the frequency of a child's SIB. Similar results with nonhumans were reported by Schaefer (1970), who demonstrated that head hitting in 2 monkeys could be shaped and maintained by food and social interaction (the experimenter saying "poor boy") delivered contingent on SIB.

One method used to reduce SIB maintained by social–positive reinforcement is differential reinforcement of other behavior (DRO), in which reinforcement is delivered contingent on the absence of a target behavior for a predetermined amount of time. Reynolds (1961) first demonstrated the use of DRO in a nonhuman experiment, and an early application of DRO to human behavior was reported by Allen and Harris (1966). Since the publication of these early studies, DRO has emerged as one of the most frequently used treatment procedures for behavior disorders in general and SIB in particular (e.g., see reviews by Homer & Peterson, 1980; Poling & Ryan, 1982; Vollmer & Iwata, 1992).

A typical DRO contingency actually involves two components. Although not often described as such, the *reinforcement* component involves a time-based schedule of noncontingent stimulation (i.e., reinforcement is contingent on interresponse time), and the *extinction* component consists of withholding reinforcement contingent on occurrences of the target behavior. When considering the therapeutic use of DRO to reduce problem behavior, there are two common variations of both components. The reinforcement component can include (a) delivery of the reinforcer maintaining the problem behavior or (b) delivery of arbitrary reinforcers (i.e., reinforcers other than those maintaining the problem behavior). Likewise, the extinction component of DRO can take the form of (a) withholding the reinforcer maintaining the problem behavior or (b) withholding the arbitrary reinforcer.

Even though it has been demonstrated that DRO may be successful in reducing SIB (e.g., Cowdery, Iwata, & Pace, 1990; Frankel, Moss, Schofield, & Simmons, 1976; Vollmer, Iwata, Zarcone, Smith, & Mazaleski, 1993), the procedure frequently has been found to be ineffective. For example, Corte, Wolf, and Locke (1971) compared the effects of punishment, time-out, and DRO as treatments for SIB in 4 profoundly retarded adolescents, and found DRO to be only slightly effective. Foxx and Azrin (1973) examined the effects of DRO, noncontingent attention, punishment, and overcorrection as procedures to reduce mouthing of hands and objects, and found DRO to be one of the least effective treatments. In these and other examples in which DRO was not effective in reducing SIB, it is not clear that the reinforcer maintaining SIB was incorporated into the DRO contingency.

Several potential problems may hamper the effectiveness of DRO. Failure to identify the maintaining variable(s) of an individual's maladaptive behavior, thus limiting the extinction component of the DRO, is one difficulty. Previous research (e.g., Lovaas & Simmons, 1969; Rose, Sloop, & Baker, 1980) has indicated that one way to reduce the frequency of behavior is to discontinue its reinforcing consequences, but in order to withhold delivery of these reinforcers, they must first be known.

A second potential problem in using DRO is that reinforcers may not have been previously identified for the individual. Arbitrarily selected stimuli may be effective when used in DRO programs, but only to the extent that they can compete with reinforcers maintaining the target behavior. Systematic attempts to identify "preferred" stimuli prior to treatment (e.g., Datillo, 1986; Pace, Ivancic, Edwards, Iwata, & Page, 1985; Wacker, Berg, Wiggins, Muldoon, & Cavanaugh, 1985) may increase the likelihood that arbitrary reinforcers might be substitutable for relevant reinforcers in a DRO contingency.

A third difficulty in using DRO may arise when the same stimulus is presented repetitively, which may result in satiation. Egel (1981) demonstrated that repeated presentation of a reinforcer, which originally maintained on-task behavior when used during a small number of trials, resulted in a decrease in responding. By contrast, presentation of a variety of reinforcers in the same procedure maintained high rates of on-task behavior. Access to a variety of reinforcing stimuli in a behavior-reduc-

tion program such as DRO may also prove to be more effective than excessive use of the same reinforcer.

The original purpose of this investigation was to examine the reinforcement component of DRO procedures applied as treatment for SIB. Preferred and nonpreferred arbitrary stimuli were to be compared to reinforcers maintaining SIB. Initial results indicated that variations in the reinforcement component, which included the delivery of preferred or nonpreferred stimuli, produced similar decreases in SIB. Because the extinction component was a constant across all treatment conditions, the study was modified to clarify the role of the extinction component of DRO. More specifically, we examined the effects of DRO, with and without an extinction component, using preferred, a variety of preferred, or nonpreferred stimuli as reinforcers, in the treatment of self-injury maintained by positive reinforcement in the form of attention.

EXPERIMENT 1: REINFORCER ASSESSMENT

Method

Subjects and Setting

Three women, all living in a state residential facility, participated. Diane was 32 years old, with diagnoses of Down syndrome and profound mental retardation. She had a long history of SIB (body hitting, head hitting, head banging), but exhibited few other behavior problems. As a result of her SIB, Diane had a large wound on her forehead and wore a protective helmet throughout the study. She had an expressive vocabulary of two manual signs and good receptive language (she could follow instructions, such as "put on the jacket"). Diane received no psychotropic medication during the course of the study. Brenda was a 42-year-old woman with profound mental retardation whose SIB included head banging against hard objects, head hitting, and body slapping. Her head banging and hitting posed a moderate risk of tissue damage, whereas her body slapping was benign in nature. Brenda could follow a number of instructions, but her expressive skills were limited to two manual signs. Brenda received a constant dose of haloperidol (Haldol®, 6 mg per day) throughout the course of the study. Bonnie, a 40-year-old woman with severe mental retardation, engaged in chronic hand mouthing. There was evidence of tissue breakdown on both hands and chapping around the mouth. She had very good receptive language and limited expressive skills (she could utter simple phrases). Bonnie received no psychotropic medication during the study.

Prior to this investigation, all 3 subjects had participated in another study in which a functional analysis of their SIB was conducted (Vollmer et al., 1993). The length of time from the completion of the functional analysis to the start of the current investigation was approximately 2 months. The assessment was based on that described by Iwata et al. (1982), and for all 3 individuals the highest rate of SIB was observed in the attention condition, indicating that attention was a source of positive reinforcement for each subject's SIB.

All sessions were conducted at a day program for the treatment of SIB. Couches and chairs were provided in the therapy rooms, along with a variety of materials that varied according to experimental conditions.

Response Measurement and Reliability

Data collection and reliability assessment were conducted in the following manner. During reinforcer assessment sessions, an observer sat across from the subject and recorded an approach or a nonapproach to a stimulus item. *Approach* was defined as the subject reaching for, moving towards, or activating the stimulus within 5 s of presentation; *nonapproach* was defined as the absence of movement toward a stimulus within 5 s of the item presentation. To assess interobserver reliability, a second observer simultaneously but independently collected data during 50% of the sessions. Agreement percentages were based on trial-by-trial comparisons of the data, using the formula of agreements divided by agreements plus disagreements and multiplied by 100%. Agreement for approach

averaged 99.7% overall and exceeded 95% for each subject.

Based on results of the reinforcer assessment, preferred and nonpreferred stimuli were designated for each subject. A *preferred* stimulus was defined as one selected on 80% or more of all trials, and a *nonpreferred* stimulus was defined as one selected on fewer than 20% of all trials.

Procedure

The stimulus pool consisted of 27 items, from which 20 were selected for presentation to each individual. Items were selected because of ease of presentation, the ability of each subject to manipulate objects, and because the items represented a variety of categories of sensory stimulation. Session length ranged from 5 to 7 min. Each session consisted of 20 trials, during which four stimuli were presented five times each in a rotating order, similar to that described by Pace et al. (1985). Ten assessment sessions were conducted, in which each of 20 items was presented a total of 10 times. Preference was assessed by measuring approach to each of the items, and a subject was given two opportunities to exhibit a response. If the individual approached the item, access was permitted for 5 s. If after two presentations the subject had not approached the stimulus, the observer recorded a nonapproach.

Results and Discussion

Table 1 shows the results of the reinforcer assessment, in which percentage approach to each of 20 stimuli is reported for each individual. Diane approached 19 of the items on 100% of the trials. For Brenda, only four items were defined as preferred stimuli, and 13 were defined as nonpreferred. Sixteen items were defined as preferred for Bonnie, and three were defined as nonpreferred. For Brenda and Bonnie, the total of preferred and nonpreferred items does not sum to 20 because some items were defined as neither (e.g., perfume for Brenda and electric piano for Bonnie). The results also show more between-subject consistency in preference than was observed by Pace et al. (1985). Diane and Bonnie approached all food items presented on 80% or more of the trials, and Brenda approached two of the three food items on 80% or more of the trials. One possible explanation for the consistent approach to the food items by Diane and Bonnie is that they were generally quite responsive to most items presented.

EXPERIMENT 2: REINFORCEMENT AND EXTINCTION COMPONENTS OF DRO

General Method

Subjects and Setting

The subjects and setting for Experiment 2 were the same as in Experiment 1, and treatment sessions were conducted in the same location. Each session lasted for 15 min, and two to four sessions were conducted daily with each individual, usually 5 days a week.

Response Measurement and Reliability

Data collection and reliability assessment were conducted in the following manner. Topographies of SIB were defined as follows: *head banging*—contact of the head against a solid object; *head or face hitting*—audible contact of a hand, knee, shin, or foot with any part of the head or face; *hand mouthing*—any contact of the fingers with the mouth that broke the plane of the lips; and *slapping*—any audible contact of one body part against another (other than the head or face) or contact against a stationary object such as furniture, walls, or floor. Occurrences of SIB during each session were recorded by observers on a hand-held computer (Assistant, Model AST 102). Data were converted into number of responses per minute.

To assess interobserver reliability, a second observer simultaneously but independently collected data during 31.7% of sessions. Reliability was calculated by dividing session time into consecutive 10-s intervals, and agreement percentages were based on interval-by-interval comparisons of the data. For each interval, the smaller number of responses was divided by the larger number of re-

sponses. These fractions were summed across all intervals and divided by the total number of intervals in the session. During baseline sessions, agreement for SIB averaged 91.8% overall and exceeded 83.0% for each subject. Agreement for SIB during treatment sessions averaged 96.0% overall and exceeded 84.0% for each subject.

Data on additional categories of behavior also were collected. Other inappropriate behaviors (aggression and disruption) were observed in order to note any correlation between these behaviors and SIB. *Aggression* was defined as striking or biting the therapist or observers, and *disruption* was defined as tipping over furniture, throwing materials, and removing clothes. The second category included therapist behaviors: delivery of attention for SIB and the delivery of items for completed DRO intervals. The data from each session were converted to responses per minute of SIB, attention, disruption, and aggression.

Table 1
Percentage of Approach Responses to Stimuli Presented During Reinforcer Assessment

Stimulus	Percent approach		
	Diane	Brenda	Bonnie
Juice	100	100	100
Pudding	100	40	100
Fruit chews	N/A	80	100
Applesauce	100	N/A	N/A
Coffee grounds	100	20	10
Perfume	100	30	0
Massager	100	20	100
Ice block	100	10	100
Wet cloth	100	40	100
Wet sponge	N/A	0	N/A
Lotion	N/A	100	100
Electric piano	100	N/A	70
Cassette player	100	0	90
Music box	N/A	0	100
Water game	100	0	100
Flashlight	100	0	100
Pinwheel	100	0	N/A
Wind-up-fish	100	N/A	N/A
Wheel-O	100	N/A	90
Top	100	N/A	90
Toy car	90	N/A	100
Electric fan	N/A	0	100
Paper fan	100	0	90
Pats on back	100	100	0
Hand claps	100	N/A	N/A
Comb	N/A	20	N/A
Rocking chair	N/A	0	N/A

Experimental Designs

Each subject was exposed to a series of DRO conditions in which reinforcement and extinction components were varied in individual reversal designs. Because of differences across subjects in both the content and sequence of conditions, each subject's procedures are described separately.

Diane

Originally, Diane was to participate in a series of conditions examining the effects of DRO when preferred versus nonpreferred stimuli were delivered in the reinforcement component. Because she showed approach to all stimuli tested, the same preferred stimulus was presented repeatedly to examine the sustained as well as the initial effects of arbitrary reinforcement. Two experimental conditions were implemented in a reversal design.

Experimental Conditions

REINF (attn). This condition was identical to the original assessment condition in which SIB was shown to be maintained by attention; it was used to establish an initial baseline for all subjects. Diane received 5 s of attention contingent on the occurrence of SIB. Attention took the form of statements of concern, such as "Don't hit yourself, you'll get hurt." Behaviors other than SIB were ignored.

DRO (music) plus EXT (attn). A previously identified preferred stimulus (music) was delivered in a DRO contingency. The music was selected from portions of the same two pop-music songs presented during the reinforcer assessment, and was delivered through an experimenter-operated cassette player. Access to music was provided for 5 s if Diane did not engage in SIB for 15 s. Following occurrences of SIB, the DRO interval for music delivery was reset. Thus, the DRO contingency was based on access to an arbitrary reinforcer, and necessarily contained both a reinforcement and an extinction component with respect to music. In addition, the therapist did not deliver attention

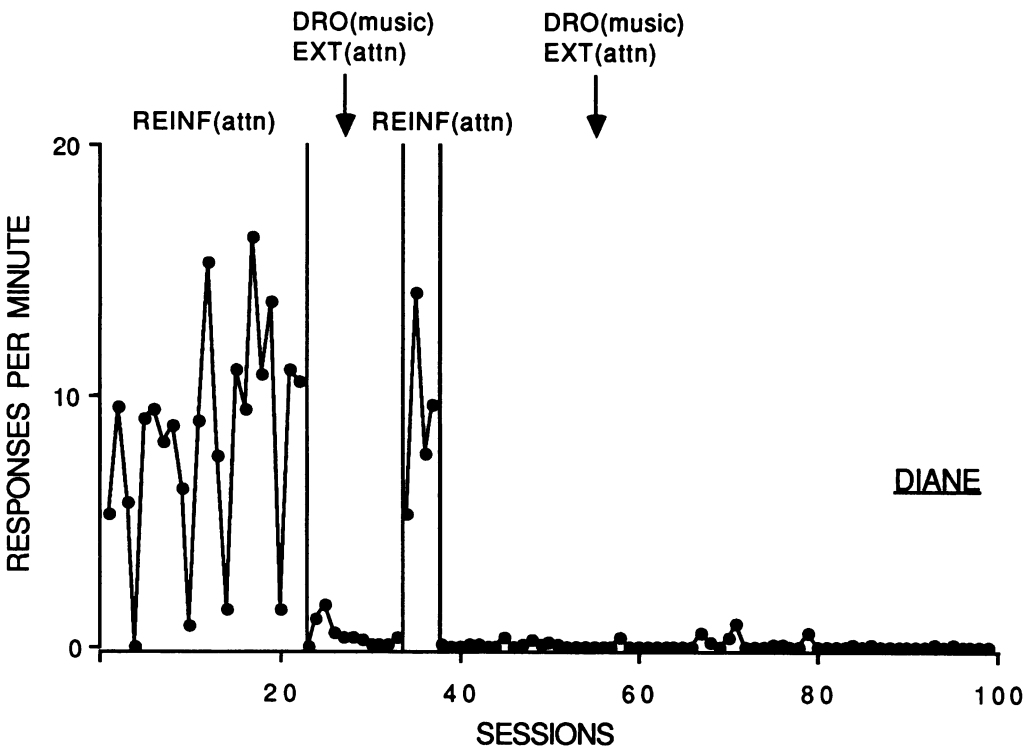

Figure 1. Responses per minute of SIB for Diane across experimental conditions.

contingent on occurrences of SIB; thus, the condition also contained an extinction procedure in which the behavior's relevant reinforcer was no longer delivered.

Results and Discussion

Results for Diane are shown in Figure 1. Variable but high rates of SIB, averaging 8.9 responses per minute, were observed during the REINF (attn) baseline. Diane's SIB decreased rapidly to a mean rate of 0.5 responses per minute during the first treatment condition [DRO (music) plus EXT (attn)]. A brief return to baseline resulted in an increase in SIB to a mean rate of 9.2 responses per minute, comparable to that observed in the original baseline. When the DRO (music) plus EXT (attn) combination was reinstated, the rate of SIB decreased and remained low, averaging 0.1 responses per minute throughout the condition.

Although previous research has shown satiation effects after 32 sessions with presentation of the same reinforcer (e.g., Egel, 1981), there did not appear to be any satiation due to repetitive stimulus presentation in the DRO procedure conducted with Diane. Because no increase was observed in Diane's SIB across 62 sessions in the DRO (music) plus EXT (attn) condition, a question arises about basic process: Which aspect(s) of the contingency produced and/or maintained the decrease in SIB? Was the reinforcement component based on the delivery and withholding of an arbitrary reinforcer (music) sufficiently potent to reduce attention-maintained SIB? Or was the extinction component based on the withholding of the relevant reinforcer (attention) primarily responsible for the observed treatment effects? Component analyses of differential-reinforcement-of-alternative-behavior (DRA) contingencies have indicated that extinction may be an integral part of that procedure. For example, Wacker et al. (1990) demonstrated that when the extinction component of "functional communication training" was not in effect, rates of hand biting maintained by positive reinforcement increased. Thus, Diane's results, when considered in light of

other research on reinforcer satiation and DRA, suggest the need to conduct further analyses of the role of extinction in DRO contingencies. These analyses were undertaken when evaluating the effects of DRO with Brenda and Bonnie.

Brenda

The sequence of DRO manipulations implemented with Brenda was designed to clarify results obtained for Diane by varying both the reinforcement and extinction components of the DRO procedure. Brenda participated in a series of conditions examining the effects of a nonpreferred stimulus delivered in a DRO contingency, with and without the relevant extinction component, on the rate of SIB. These comparisons were made within a reversal design.

Experimental Conditions

REINF (attn). The first condition was a baseline identical to that used for Diane. Brenda received 5 s of attention (e.g., "Don't hit yourself, you'll get hurt") contingent on occurrences of SIB, whereas other behaviors were ignored.

DRO (music) plus EXT (attn). Brenda's next condition also was procedurally similar to one used with Diane; there was, however, an important difference. The stimulus delivered in the reinforcement component (music) was a preferred stimulus for Diane (100% approach to the cassette player during assessment) but not for Brenda (zero approach during assessment). Music was delivered through an experimenter-operated cassette player and consisted of portions of the same two pop-music songs presented in the reinforcer assessment. Access to music was made available for 5 s if Brenda did not emit a self-injurious response for 15 s. Occurrences of SIB reset the DRO timer. In addition, attention was withheld contingent on SIB.

REINF (attn). Because SIB decreased during the DRO (music) plus EXT (attn) condition, a return to baseline was implemented next.

EXT (attn). This condition consisted of an extinction component only, in which the stimulus withheld (attention) was the functionally relevant reinforcer for SIB (i.e., the maintaining reinforcer). The therapist was in the room, and all responses emitted by Brenda, self-injurious or otherwise, were ignored.

DRO (music) plus REINF (attn). In this condition, a nonpreferred stimulus (music) was delivered in the reinforcement component, while the relevant reinforcer (attention) was not withheld. Access to music (same as above) was delivered for 5 s contingent on a 15-s absence of SIB, and each self-injurious response was followed by attention from the therapist.

EXT (attn). As in the previous EXT (attn) condition, no attention was delivered to Brenda throughout the session.

DRO (attn). Brenda's final condition involved a DRO contingency in which attention (the relevant reinforcer) was the stimulus both delivered and withheld. Access to attention was delivered for 5 s contingent on a 15-s absence of SIB. Self-injurious responses were ignored and reset the DRO interval. Attention took the form of positive statements, such as "Good job, you didn't hit yourself."

Results and Discussion

Results for Brenda are shown in Figure 2. Self-injury averaged 10.5 responses per minute during the REINF (attn) baseline and decreased to a mean rate of 2.1 responses per minute during the first treatment condition, DRO (music) plus EXT (attn). These results were unusual because Brenda never exhibited approach to the cassette recorder when it was presented during the reinforcer assessment. Thus, the data from this condition suggested that a nonpreferred stimulus functioned as a reinforcer in a DRO contingency. An alternative explanation is that the low rates of SIB were a result of the extinction component of the DRO (withholding attention) and not the reinforcement component. This possibility was examined following a brief return to baseline, in which a mean rate of 16.0 self-injurious responses per minute was observed. The EXT (attn) condition produced a mean rate of 1.9 responses per minute, comparable to that observed in the DRO (music) plus EXT (attn) condition. These results suggest that the extinction procedure alone might have produced the low rates

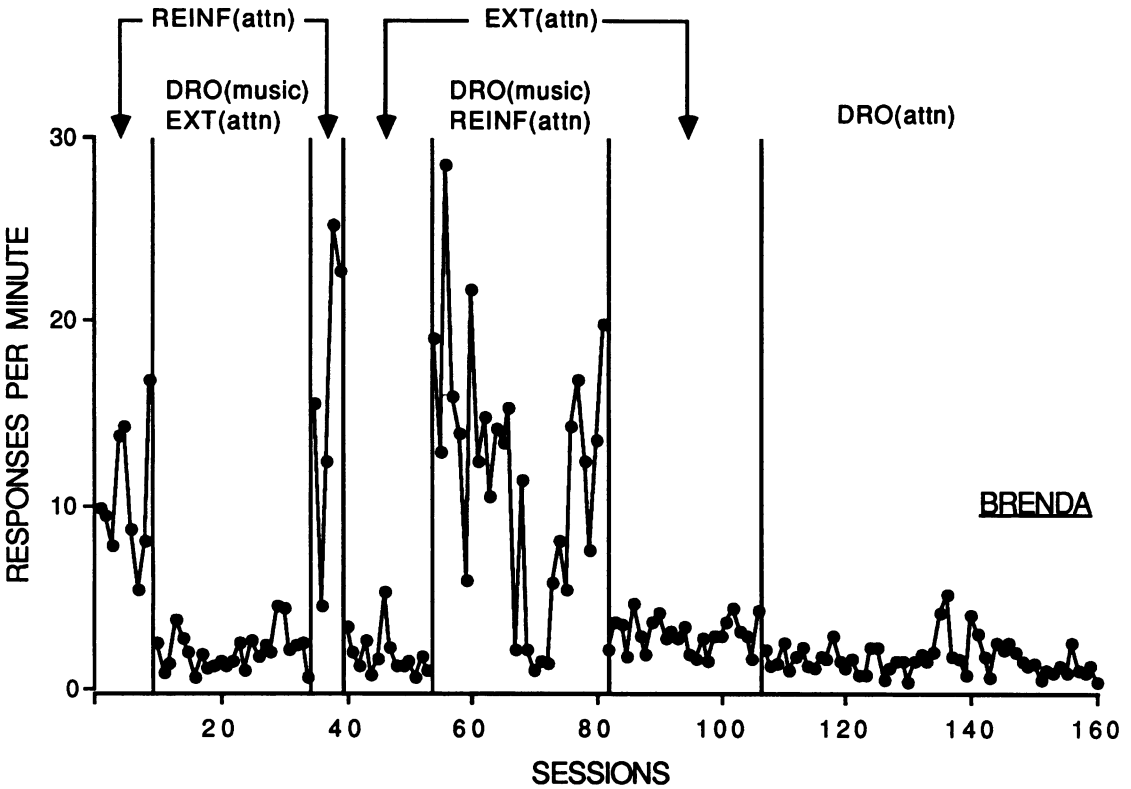

Figure 2. Responses per minute of SIB for Brenda across experimental conditions.

of SIB observed during the first treatment condition but are tentative because the reinforcement component alone might have produced similar results.

The next condition, DRO (music) plus REINF (attn), examined the effects of nonpreferred stimulus delivery in the absence of the extinction component. Music was delivered as the reinforcer for completed DRO intervals, and attention was delivered contingent on SIB. Although five low data points occurred in the middle of this condition, the rate of SIB did not remain suppressed, averaging 11.5 responses per minute throughout the condition. These data were comparable to those obtained in previous baseline conditions during which attention was delivered contingent on SIB, indicating that the nonpreferred item (music) did not serve as a reinforcer and strengthening further the conclusion that extinction was the functional component of the DRO contingency. The extinction-only condition was implemented a second time, producing a mean SIB rate of 2.9 responses per minute. The final condition exemplified what might be considered an optimal DRO contingency, in which the reinforcer maintaining SIB (attention) was delivered for nonoccurrences of the behavior and was withheld following occurrences. A mean SIB rate of 1.8 responses per minute was observed in this condition. These results are not appreciably different from those observed in the DRO (music) plus EXT (attn) and the EXT (attn) conditions and suggest that delivery of the relevant reinforcer in the DRO (attn) condition did not substantially enhance the therapeutic effects obtained with extinction alone.

Bonnie

We attempted to extend the results obtained for Brenda by examining an additional parameter of arbitrary reinforcement with Bonnie. An important control condition during Brenda's treatment was one in which a nonpreferred stimulus (music) was included in the reinforcement component of the DRO, while the relevant extinction component was

absent (i.e., SIB produced attention). Although results indicated that the *nonpreferred* stimulus did not compete successfully with attention, there may be little generality of this finding with respect to other reinforcers because it is possible that a highly *preferred* arbitrary stimulus delivered for the absence of SIB might suppress SIB maintained by a different reinforcer. In an attempt to maximize the potential efficacy of the arbitrary-reinforcement component of DRO, we included a variety of preferred stimuli as reinforcers and evaluated their effects when implemented with and without the relevant extinction component.

Experimental Conditions

REINF (attn). A baseline was conducted in which Bonnie received 5 s of attention contingent on occurrences of SIB in a manner identical to that used for Diane and Brenda.

EXT (attn). An extinction-only condition was conducted next, in which a therapist was in the room and ignored all responses emitted by Bonnie, self-injurious or otherwise.

DRO (varied) plus REINF (attn). The third condition consisted of DRO without extinction. The reinforcement component might best be described as a "varied" reinforcement condition, based on the procedure used by Egel (1981). Prior to each session, three stimuli were selected from a pool of 16 items identified as preferred through Bonnie's reinforcer assessment. The only stipulation on items presented during a given session was that each set of three stimuli had to differ from previously selected sets by at least one member. If a set was selected that replicated all three stimuli from a previous set, a second set of three stimuli was selected. During treatment sessions, 5-s access to one of the three preferred stimuli was delivered contingent on a 15-s absence of SIB, and the stimuli were rotated across DRO intervals within the session. Each self-injurious response was followed by attention from the therapist.

DRO (varied) plus EXT (attn). The final condition consisted of DRO plus extinction. As in the previous condition, 5-s access to one of three preferred stimuli was made available if Bonnie did not engage in SIB for 15 s. However, occurrences of SIB were ignored by the therapist and reset the DRO interval.

Results and Discussion

Results for Bonnie are shown in Figure 3. The mean rate of SIB in the REINF (attn) baseline was 6.2 responses per minute. The next condition, EXT (attn), was associated with a decrease in SIB to a mean rate of 1.2 responses per minute. This finding was consistent with results obtained during DRO (music) plus EXT (attn) for both Diane and Brenda and EXT (attn) and DRO (attn) for Brenda. Bonnie's next condition was one in which the reinforcement component of DRO contained a variety of preferred stimuli, yet SIB still produced attention. A mean rate of 7.2 responses per minute was observed, indicating that an optimally designed DRO comprised of arbitrary reinforcers did not reduce the rate of SIB when the relevant extinction component was missing. In spite of the fact that eight of Bonnie's highly preferred stimuli were used in the reinforcement component, rates of SIB observed during this condition were comparable to those obtained in baseline, when no reinforcers were delivered for the absence of SIB. A DRO-plus-extinction condition, using the same reinforcers as in the DRO-without-extinction condition, was conducted next and produced a mean rate of 1.2 responses per minute, similar to rates observed in the extinction-only condition conducted with Bonnie and Brenda and the DRO-plus-extinction conditions for Diane and Brenda.

Follow-Up

At the conclusion of the study, each subject was taught alternative responses for obtaining reinforcers from others in her environment. The procedures used were DRA contingencies, similar to those described for functional communication training (Carr & Durand, 1985). Selected target responses produced specific reinforcers delivered by caretakers, whereas SIB was placed on extinction. Diane was taught to ask for four items (eat, drink, music, and lotion) through the use of manual signs. Signing was ignored if Diane was engaging in SIB. Obser-

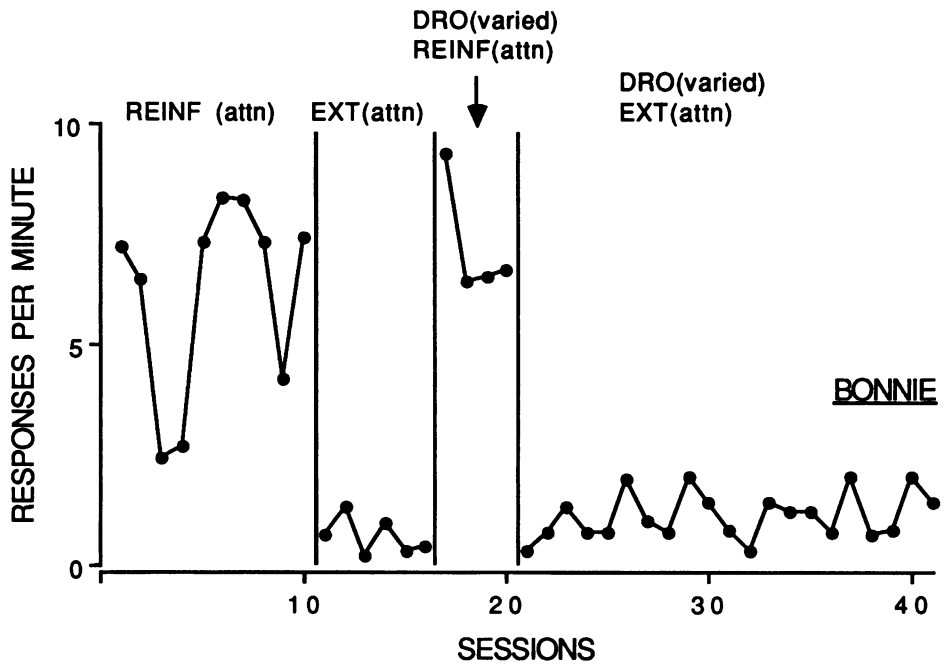

Figure 3. Responses per minute of SIB for Bonnie across experimental conditions.

vations conducted in Diane's home revealed that she engaged in little SIB and occasionally produced manual signs. Brenda was taught to mand for attention by extending her arm toward nearby individuals. If Brenda engaged in SIB while extending her arm to someone, the individual ignored Brenda until SIB ceased. In-home observations revealed that Brenda engaged in little SIB and occasionally produced arm extensions. Bonnie was taught to mand for attention by saying "hello" to nearby individuals. If Bonnie was not engaging in SIB at the time of the interaction, the individual to whom Bonnie spoke would say "hello" and initiate a brief social interaction. If Bonnie was engaging in SIB, the individual would not respond until Bonnie discontinued the SIB. Observations during visits to Bonnie's home showed that she engaged in a low rate of SIB and a high rate of saying "hello" to nearby individuals.

GENERAL DISCUSSION

The procedures used in this study, when considered for all 3 subjects, provide a systematic analysis of both the reinforcement and extinction components of DRO contingencies. Figure 4 contains a matrix based on the ways in which DRO may be constructed when the reinforcement and extinction components involve manipulation of (a) relevant (maintaining) reinforcers, (b) arbitrary reinforcers, (c) nonreinforcing stimuli, and (d) nothing. Experimental conditions representing each of the feasible combinations of reinforcement and extinction to which subjects were exposed are noted in the matrix. One combination (Cell a) involved no change in the original maintaining contingency and served as the baseline condition for all subjects. Two other types of combinations did not seem relevant to the present analysis. First (Cell b), the complete absence of an extinction component (nothing is withheld) disqualifies a procedure as a DRO contingency because there is no differential reinforcement. That is, a DRO contingency containing any given stimulus in the reinforcement component must, by definition, also contain extinction with respect to that stimulus. Second (Cell c), the withholding of arbitrary reinforcers in the extinction component is irrelevant unless these same

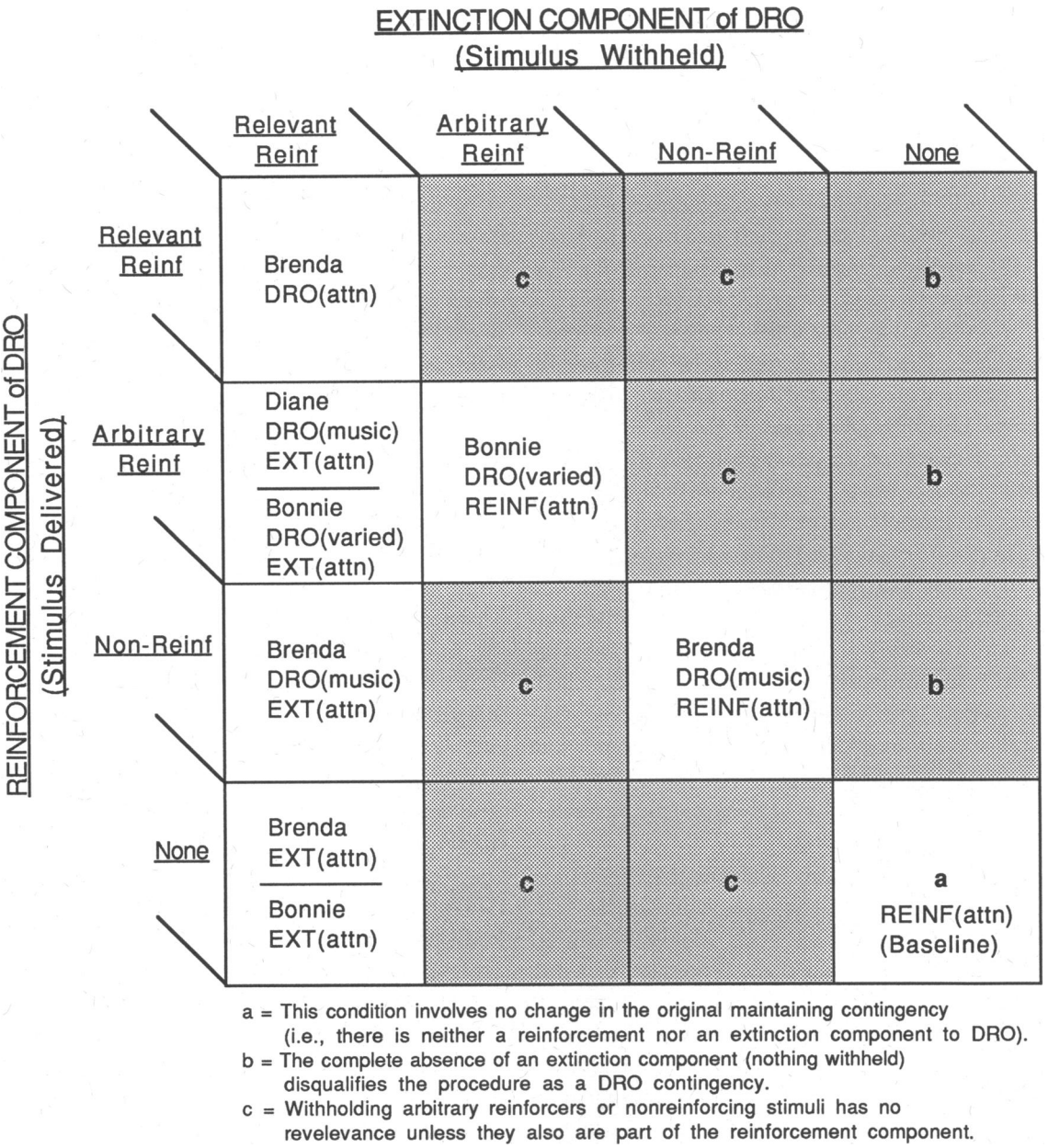

Figure 4. Procedural variations in the reinforcement and extinction components of DRO contingencies to which subjects were exposed.

stimuli are used in the reinforcement component. For example, if SIB is maintained by attention, withholding a specific toy for occurrences of SIB has little significance unless access to that toy is available contingent on the absence of SIB.

Modifications in the reinforcement component, such as delivering a nonpreferred stimulus (nonreinforcer) or a variety of preferred stimuli (arbitrary reinforcers), had little effect on SIB when attention (the relevant reinforcer) was not withheld in the REINF (attn) conditions for Bonnie and Brenda. By contrast, when the relevant reinforcer was withheld in the extinction component, rates of SIB decreased regardless of variations in the reinforcement

component: It made little difference whether the reinforcer consisted of the relevant stimulus (attention for Brenda), arbitrary reinforcers (music for Diane and varied for Bonnie), nonreinforcers (music for Brenda), or no reinforcers whatsoever (extinction only for Brenda and Bonnie). Thus, the results of this study suggest that the effectiveness of DRO contingencies in reducing SIB maintained by socially mediated positive reinforcement is due, in large part, to extinction processes.

An unusual finding in this study was that identifying preferred and nonpreferred stimuli through a reinforcer assessment did not alter the outcome of the DRO manipulations. In fact, unpredictable results were obtained based solely on consideration of the reinforcement component of DRO. For Brenda, the presentation of a nonpreferred stimulus (nonreinforcer) appeared to maintain lower rates of SIB in the DRO (music) plus EXT (attn) condition than those observed in baseline, whereas for Bonnie, access to a variety of highly preferred stimuli in the DRO (varied) plus REINF (attn) condition failed to produce any therapeutic effect. Upon closer examination, the extinction component, and not the reinforcement component, of the DRO appeared to be the critical factor in determining the effectiveness of the procedure.

The present results also illustrate the importance of identifying the variables maintaining SIB when designing DRO contingencies. Manipulations of DRO with Bonnie and Brenda indicated that the procedure was ineffective in reducing the rate of SIB unless the relevant reinforcer (attention) was withheld. Although the use of DRO procedures in which reinforcement is still delivered following occurrences of the target behavior may seem highly unlikely in clinical application and therefore relevant only as an experimental control—the REINF (attn) condition—in this study, it is quite possible that DRO procedures could be implemented without extinction in actual practice if the maintaining variables of SIB are not identified. A situation illustrating this problem would be one in which a caregiver delivers food to an individual contingent on the absence of SIB, but also is required by policy to "attend" to behavior problems through "response interruption," "redirection," or some similar technique. In this situation, if the individual's SIB were maintained by attention, the caregiver would be implementing a DRO procedure without extinction, which was identical to our ineffective REINF (attn) condition.

Although the extent of the above problem is unknown, it probably accounts for a significant proportion of treatment failures attributed to DRO. Moreover, the problem is not limited to "outdated" research conducted prior to the development of functional analysis assessment procedures, as a careful examination of the recent experiment by Bird, Dores, Moniz, and Robinson (1989) illustrates. DRO as a treatment for SIB and aggression was described as ineffective by Bird et al., whereas functional communication training (FCT) was reported to be a highly effective treatment for 2 subjects. However, no functional analysis of the individuals' behaviors was conducted before DRO was implemented; therefore, DRO was applied arbitrarily to reduce the problem behaviors. By contrast, the authors noted that escape from tasks following aberrant behaviors, which was found to be the maintaining reinforcer, was not allowed during the FCT condition. Thus, the DRO was designed improperly, in that the relevant reinforcement and extinction components were both missing, whereas the FCT procedure explicitly contained an extinction component for escape behavior. The authors did not acknowledge the effects of extinction and simply noted that FCT was an effective treatment for problem behaviors, whereas DRO was not. Interpretive problems such as these, which are not uncommon, suggest that future research should begin with a reexamination of the published literature to determine the extent to which pretreatment functional analyses of the target behavior had been conducted. If not, it would be difficult to conclude that DRO is not an effective procedure.

In addition to emphasizing the importance of extinction, the present results suggest that further clarification of the reinforcement component of differential reinforcement contingencies (both DRO and DRA) may be in order. Access to arbitrary reinforcers for completed DRO intervals had no

suppressive effect on SIB that was concurrently reinforced with attention. This finding does not suggest that arbitrary reinforcers could never compete with those maintaining the target behavior, but it does compel us to explore the conditions under which successful competition might occur. At the present time, the basis for determining what types of reinforcers might compete with or substitute for others is not clear, nor is it necessarily related to inherent characteristics of the reinforcer or schedule differences such as those based on the matching law (e.g., Herrnstein & Loveland, 1975). For example, in a recent study on "economic substitutability" of reinforcers with rats (Green & Rachlin, 1991), it was found that electrical brain stimulation was substitutable for both food and water, but that food and water were not substitutable for each other (also see Green & Freed, in press, for a detailed discussion of reinforcer substitutability, complementarity, and independence). Thus, although selection of reinforcers based on systematic assessments of preference is clearly superior to more random processes, it does not necessarily result in identification of stimuli that are substitutable for those maintaining the target behavior.

Finally, the role of the relevant (maintaining) reinforcer in DRO contingencies deserves further consideration in light of Brenda's data indicating that DRO (with attention manipulated in both the reinforcement and extinction components) was no more effective than extinction alone. Perhaps, as suggested by results from a previous study in which all of the present subjects participated (Vollmer et al., 1993), the primary importance of the reinforcement component is to reduce deprivation in a manner similar to that achieved through noncontingent reinforcement (NCR). If so, it may be possible to design DRO schedules that will maximize access to reinforcers while minimizing reinforcement for undesirable behavior. In discussing variations of NCR, Vollmer et al. noted an interesting procedure described by Repp, Barton, and Brulle (1983) as "momentary DRO," which combined NCR with extinction. The procedure did not require subjects to refrain from engaging in the target behavior throughout the DRO interval in order to receive reinforcement. Instead, momentary DRO involved time-based delivery of reinforcement (NCR), which was suspended if the target behavior was occurring at the scheduled time of delivery (extinction). In light of the present data highlighting the importance of extinction processes, the procedure of Repp et al. seems even more attractive as an alternative to traditional DRO and deserves further investigation, even though the procedure was reported to be not highly effective.

There is currently a great deal of interest in how DRO procedures can be modified to enhance their effectiveness in reducing behavior disorders. Much of this research focuses on strengthening the reinforcement component of DRO by increasing the magnitude or variety of reinforcers, or by selecting stimuli based on the results of reinforcer assessment procedures. These approaches may be extremely useful for the development of DRO contingencies in which arbitrary reinforcers are substitutable for those maintaining the behavior problem. The results of this study emphasize the importance of identifying relevant reinforcers so that they may be included, not only in the reinforcement component of DRO but especially in the extinction component, which is often overlooked. Thus, treatment procedures derived from identification of the maintaining variables for behavior disorders may not require identification of an array of powerful reinforcers, but rather identification of and control over the most relevant reinforcer.

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