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EFFECTS OF NONCONTINGENT REINFORCEMENT ON PROBLEM BEHAVIOR AND STIMULUS ENGAGEMENT: THE ROLE OF SATIATION, EXTINCTION, AND ALTERNATIVE REINFORCEMENT

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This study examined the effects of noncontingent reinforcement (NCR) with and without extinction on problem behavior and stimulus engagement (consumption of reinforcement) of 4 participants. Reductions in problem behavior using NCR have frequently been attributed to both satiation of the reinforcer and extinction. In the current study, aspects of the NCR treatment effects were difficult to explain based solely on either a satiation or an extinction account. Specifically, it was found that stimulus engagement remained high throughout the NCR treatment analysis, and that problem behavior was reduced to near-zero levels during NCR without extinction. The implications of these findings are discussed with respect to the satiation and extinction hypotheses frequently described in the applied literature. Findings from basic studies examining the effects of response-independent schedules are presented, and are used as the basis for a matching theory account of NCR-related effects. It is proposed that reductions in problem behavior observed during NCR interventions may be a function of the availability of alternative sources of reinforcement.

DESCRIPTORS: alternative reinforcement, extinction, matching theory, noncontingent reinforcement, problem behavior, satiation

Since Mace and Lalli (1991) described the use of noncontingent reinforcement (NCR) as a clinical intervention for bizarre speech maintained by attention, over a dozen studies have been published on NCR as a treatment for a variety of socially mediated problem behaviors. NCR usually involves the delivery of the reinforcer responsible for behavioral maintenance on a fixed-time (FT) response-independent schedule. NCR has been used for treating problem behaviors maintained by attention (Derby, Fisher, & Piazza, 1996; Hagopian, Fisher, & Legacy, 1994; Kahng, Iwata, DeLeon, & Worsdell, 1997; Vollmer, Iwata, Zarcone, Smith, & Mazaleski, 1993; Vollmer et al., 1998), escape from instructional demands (Kahng et al., 1997; Vollmer, Marcus, & Ringdahl, 1995; Vollmer et al., 1998), and access to tangible items (Lalli, Casey, & Kates, 1997; Marcus & Vollmer, 1996; Vollmer, Ringdahl, Roane, & Marcus, 1997). Extinction has been used in combination with NCR in the majority of studies, although some investigators have implemented NCR without extinction (e.g., Fisher et al., 1999; Lalli et al., 1997). Although the clinical utility of NCR has been demonstrated by all of these studies, the behavioral mechanisms underlying the effects of NCR are not known.

The two behavioral processes commonly viewed as responsible for the reductive effects of NCR are satiation and extinction (Vollmer et al., 1993). Satiation, an establishing operation that decreases the effectiveness of a reinforcer, occurs as a function of

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prior exposure or access to that reinforcer (Michael, 1982). Satiation has been suspected as being responsible for reductions in responding during NCR because the reinforcer responsible for maintaining problem behavior is presented continuously or for extended periods within and across sessions (e.g., Lalli et al., 1997). That is, NCR is believed to attenuate a state of deprivation, thereby reducing problem behavior.

Another process hypothesized to be responsible for decreased responding during NCR is extinction. Operant extinction, broadly defined, is the elimination of the reinforcement contingency (Catania, 1992). Typically, extinction procedures involve withholding the maintaining reinforcer following the response. With NCR, the contingency between the response and the reinforcer is eliminated because the reinforcer is delivered on a response-independent schedule. Although many researchers have suggested that both satiation and extinction occur during NCR (e.g., Hagopian et al., 1994; Vollmer et al., 1995), the available data do not allow definitive conclusions about the roles of these operant processes.

In order to examine the role of extinction in NCR, Lalli et al. (1997) used NCR without extinction to treat problem behavior maintained by access to tangible items. That is, problem behavior continued to produce reinforcement on a fixed-ratio (FR) 1 schedule, while the FT schedule was in effect for the delivery of that same reinforcer. This treatment was effective for the one case in which it was evaluated. Fischer, Iwata, and Mazaleski (1997) also examined the effects of NCR (using arbitrary reinforcers) without extinction for problem behavior. For both participants in the Fischer et al. study, NCR without extinction was effective in reducing problem behavior (however, for 1 participant, clinically acceptable reductions could not be achieved until extinction was added). These studies showed that, in at least some cases, NCR without extinction can reduce problem behavior. Based on these findings, it has it has been suggested that alteration of the behavior's establishing operation (i.e., attenuation of a state of deprivation) rather than extinction is responsible for the effects of NCR. One potential problem with this interpretation is that it provides only indirect support of the satiation hypothesis on the basis of ruling out extinction.

Marcus and Vollmer (1996) superimposed a differential-reinforcement-of-alternative-behavior schedule (in which mands were reinforced) onto an NCR schedule in an attempt to determine the processes responsible for the suppressive effects of NCR. For 2 of the 3 participants, manding persisted despite the noncontingent delivery of reinforcement (tangible items). The authors argued that if satiation had occurred (and there was a decrease in "motivation" to obtain the reinforcer), mands would not have persisted. It should be noted, however, that manding did not occur until the NCR schedule was thinned. For 1 of the participants, manding increased as the NCR schedule was thinned such that continuous access to reinforcement was maintained. Nevertheless, the fact that manding occurred even when NCR schedules were relatively dense (although not continuous) indicates that the tangible items continued to function as reinforcers. This finding has been interpreted as supportive of the extinction hypothesis, although it provides only indirect support by ruling out satiation.

A number of researchers have speculated that satiation and extinction might be involved to differing degrees over the course of implementing and thinning an NCR schedule (Hagopian et al., 1994; Vollmer et al., 1995). Typically, evaluations of NCR effects involve dense FT schedules, which are later thinned to schedules that are more practical for caregivers to implement. Based on the frequent observation that NCR often results in immediate suppression of behavior, it has been hypothesized that satiation may play a more important role than extinction during the initial sessions when the NCR schedule is dense. It has been suggested that extinction may be operative during later sessions, particularly when the NCR schedule is thinned and satiation seems unlikely.

Recently, Fisher et al. (1999) proposed that the effects of NCR may be a function of choice responding. During NCR without extinction, responding occurred almost exclusively between reinforcer access periods (i.e., during the NCR interreinforcer intervals; NCR IRIs). The authors suggested that had satiation been in effect, then responding would have been suppressed to an equivalent degree during both the NCR IRIs and the NCR reinforcer intervals. It was also demonstrated that reductions in contingent responding during the NCR IRI did not change within or across sessions as a direct function of the density of the NCR schedule. It was argued that if the reductions in behavior were a function of satiation, then greater reductions would have been observed during the dense rather than the lean schedules. Fisher et al. proposed that the effects of NCR are better explained by the participants choosing free reinforcement when it is available and contingent reinforcement when free reinforcement is unavailable. It should be noted, however, that their conclusions were based on patterns of problem behavior, and data were not collected on consumption of reinforcement.

The Marcus and Vollmer (1996) study represents the first attempt to determine whether the process of satiation is in effect during NCR by examining the effects of NCR on a behavior (manding) other than targeted problem behavior. Another behavior independent of problem behavior that may provide useful information about whether satiation is in effect is engagement with the maintaining reinforcer. That is, data on consumption of reinforcement may provide an indirect means of determining the role of satiation, independent of the rate of problem behavior itself. Decreased levels of stimulus engagement during NCR would support the satiation hypothesis, whereas high levels of stimulus engagement might suggest that satiation is not in effect.

The purposes of the present study were (a) to record participants' engagement with the freely provided reinforcer (i.e., consumption) as a means of examining the role of satiation; (b) to evaluate the role of extinction by implementing NCR with and without extinction; and (c) to identify factors that influence behavior over the course of thinning the NCR schedules. Based on our previous work with NCR, it was hypothesized that stimulus engagement would remain high throughout the analysis. It was also hypothesized that NCR without extinction would be effective until the FT schedule was thinned; extinction would need to be added to NCR to maintain low rates of problem behavior.

METHOD

Participants and Setting

The participants were 4 individuals who had been admitted to an inpatient behavioral unit for the assessment and treatment of severe behavior problems. Jack was a 4-year-old boy who had been diagnosed with autism and severe mental retardation. He was ambulatory and used gestural communication. Rex was a 13-year-old boy who had been diagnosed with profound mental retardation and a seizure disorder. He was ambulatory and communicated only by pointing to objects or pulling an adult toward an object. Alex was a 7-year-old boy who had been diagnosed with severe mental retardation, cerebral palsy, and microcephaly. He was ambulatory and had limited gestural communication. Emily was a 4-year-old girl who had been diagnosed with severe to profound mental retardation and a seizure disorder. She was able to ambulate with a walker. Emily was able to reach for desired objects but did not point or verbalize. All sessions were 10 min long and were conducted in a session room (3 m by 3 m) equipped with a one-way mirror.

Data Collection and Interobserver Agreement

Frequency data were collected on target problem behaviors during Phases 1 (functional analysis) and 2 (treatment analysis) and are presented as number of responses per minute. Jack's problem behaviors included *aggression*, defined as hitting, kicking, hair-pulling, grabbing, scratching, biting, and pinching; and *self-injurious behavior* (*SIB*), defined as head banging, face slapping, hand biting, head hitting, self-scratching, and eye poking. Rex's problem behaviors included *aggression*, defined as hitting, kicking, throwing an object within 0.7 m of a person, pinching, grabbing, and scratching; *disruption*, defined as throwing, swiping, ripping, breaking, tearing, shredding, and banging on surfaces from more than 4 cm; *SIB*, defined as eye poking, self-scratching, and head hitting; *dangerous behavior*, defined as tipping over furniture, standing on furniture, and so on; and *dropping to the floor*, defined as falling to the floor from a standing or sitting position. Alex's problem behaviors included *SIB*, defined as head banging, self scratching, and arm or hand biting; *aggression*, defined as grabbing, scratching, and hair pulling; and *screaming*, defined as any vocalization louder than conversational level. Emily's problem behaviors included *SIB*, defined as head hitting, head banging, and hair pulling; *aggression*, defined as hitting others; and *disruption*, defined as throwing, ripping, or breaking objects.

During Phase 2, duration data were collected on *stimulus access*, defined as the tangible items being available to the participant. The tangible items used were plastic fruit keys and a Slinky® for Jack, plastic building blocks and plastic straws for Rex, music played from a portable cassette player for Alex, and a spaceship toy and pacifier for Emily. During Phase 2, duration data were also collected on *stimulus engagement,* defined individually for each participant. For Jack, stimulus engagement was defined as being in physical contact with the toys. For Rex, stimulus engagement was defined as manipulating, playing with, or orienting toward the toys. For Alex, stimulus engagement was defined as touching or being oriented toward the cassette player or rocking back and forth. For Emily, stimulus engagement was defined as looking at or touching the toy or sucking on a pacifier. Percentage of stimulus engagement (i.e., the amount of time the participant interacted with the stimuli relative to the amount of time that the stimuli were available) was calculated by dividing the duration of stimulus engagement by the duration of stimulus access and multiplying by 100%.

Two observers recorded target behaviors on laptop computers, and interobserver agreement was collected during 46%, 56%, 51%, and 54% of sessions during Phase 1 (functional analysis) for Jack, Rex, Alex, and Emily, respectively. For frequency measures, exact agreement was calculated by dividing the number of exact agreements per 10-s interval by the number of exact agreements plus disagreements and multiplying by 100%. An exact agreement was defined as both observers recording the same frequency of a target response during a 10-s interval. Average exact agreement coefficients for target problem behaviors during Phase 1 were 99.7% (SIB) and 96.1% (aggression) for Jack; 99.9% (SIB), 99.1% (aggression), 95.6% (disruption), 100% (dropping), and 100% (dangerous behaviors) for Rex; 94.6% (aggression), 99.1% (SIB), and 95.1% (screaming) for Alex; and 99.6% (SIB), 99.9% (aggression), and 99.9% (disruption) for Emily.

Interobserver agreement was assessed during 35% of sessions for Jack, 61% of sessions for Rex, 35.8% of sessions for Alex, and 46% of sessions for Emily during Phase 2 (treatment analysis). Exact agreement coefficients for problem behaviors targeted during Phase 2 averaged 99.9% (SIB) and 98.1% (aggression) for Jack; 98.9% (aggression) for Rex; 98.1% (aggression) for Alex; and 98.4% (SIB), 99.8% (aggression), and 100% (disruption) for Emily. For duration measures, duration-per-interval agreement was calculated by dividing the smaller duration by the larger duration for each 10-s interval, obtaining the average across intervals, then multiplying by 100%. Duration-per-interval coefficients for stimulus access averaged 92.2% for Jack, 95.7% for Rex, 96.4% for Alex, and 93.1% for Emily. Duration-per-interval coefficients for stimulus engagement averaged 96.0% for Jack, 94.8% for Rex, 91.9% for Alex, and 87.3% for Emily.

Experimental Design

The functional analysis for each participant was conducted using a multielement design. The treatment analyses were conducted using reversal designs. For Rex and Alex, an ABABCAC design was used, and for Jack, an ABABC design was used. (A was a nontreatment baseline, B was FT without extinction [EXT], and C was FT differential reinforcement of other behavior [DRO] with EXT. The C phase was not replicated in Jack's analysis due to time constraints.) For Emily, an ABAB design was used (A was a nontreatment baseline, and B was FT DRO with EXT).

Phase 1: Functional Analysis

Procedure

A functional analysis was conducted for each participant, based on procedures described by Iwata, Dorsey, Slifer, Bauman, and Richman (1982/1994). The functional analysis for Jack consisted of tangible, attention, demand, alone, and toy play conditions. The functional analysis for Rex consisted of attention, demand, ignore, tangible, and toy play conditions. For Alex, the functional analysis consisted of attention, demand, toy play, tangible, and divided attention conditions. For Emily, the functional analysis included demand, alone, tangible, toy play, and attention conditions.

For each participant, all behaviors described above were targeted during the functional analysis. During the attention condition, participants were given adult attention in the form of a brief reprimand contingent on the occurrence of a target behavior. For Emily, the attention condition included holding her (while giving the reprimand) for 30 s. During the divided attention condition, the participant was in a room with two therapists. The therapists talked to each other for the duration of the session, and provided attention contingent on target behavior. The attention and divided attention conditions were designed to evaluate the role of attention in the maintenance of problem behavior. During the tangible condition, participants were given 30-s access to a highly preferred item (food or toy) contingent on the occurrence of a target behavior. The purpose of this condition was to evaluate the role of tangible items in the maintenance of problem behavior. The demand condition consisted of providing instructional demands to each child using a three-step guided compliance prompting sequence. Compliance resulted in praise. Participants received a 30-s escape from demands contingent on the occurrence of a target behavior. This condition was designed to evaluate the role of escape from demands in the maintenance of problem behavior. During the ignore condition, the participant and a therapist remained in a padded session room for the entire session without the presence of items or social interaction; target behaviors were ignored. During the alone condition, the participant was alone in the room with no toys present. The purpose of the ignore and alone conditions was to evaluate problem behavior in the absence of social consequences. During the toy play condition, each participant had access to toys and adult attention, and no instructional demands were given. This condition was designed to serve as a control against which the other conditions could be compared.

Results

The top panel of Figure 1 depicts the results of Jack's functional analysis. Stable rates of aggression were observed during the tangible condition (M = 0.71). Data on aggression only are presented because Jack displayed zero or near-zero rates of SIB throughout the analysis. These results suggest that aggression was maintained by access to preferred toys.

The second panel of Figure 1 depicts the results of Rex's functional analysis. Rex displayed the highest rates of aggression in the tangible condition (M = 1.46) and near-zero rates of aggression in all other conditions. Data on aggression only are presented because Rex displayed near-zero rates of SIB, dropping, and dangerous behavior; and because disruptions were extremely high in conditions with little external stimulation (i.e., possibly maintained by automatic reinforcement). These results suggest that aggression was maintained by access to preferred items.

The third panel of Figure 1 depicts the results of Alex's functional analysis. Alex displayed efficient rates of aggression (M = 1.32) in the tangible condition, particularly during the last four sessions (i.e., he maintained high levels of access to toys with few behaviors and emitted few behaviors during the reinforcement interval). Higher rates of aggression were observed in the attention and divided attention conditions (M = 6.23 and 7.82, respectively). Alex displayed some aggression in the demand condition, although it should be noted that aggression occurred frequently during the escape intervals (when no demands were presented). Data on aggression only are presented because SIB occurred at near-zero rates (M = 0.14) across all conditions, and because screaming occurred consistently across all conditions, suggesting that it was maintained by automatic reinforcement. These results suggest that aggression was maintained by access to adult attention and preferred items.

The bottom panel of Figure 1 depicts the results of Emily's functional analysis. Data on SIB, aggression, and disruption are presented. Data from the demand condition are not presented because it contained a potential confounding effect (i.e., Emily engaged in high rates of what appeared to be attention-seeking problem behavior during the escape interval). That is, high rates of problem behavior were observed in the demand condition; however, most of it occurred when demands were not being presented. Problem behaviors were highest in the attention (M = 1.09) and tangible conditions (M = 0.71), and were low in the toy play condition. Although relatively low rates of behavior were observed in the tangible condition, Emily's problem behaviors were believed to be maintained by access to tangible items based on the observation that they ceased once reinforcement was delivered (this hypothesis was also consistent with informal observations and parental report). Therefore, results of Emily's functional analysis suggest that SIB, aggression, and disruption were maintained by both attention and access to preferred items.

Phase 2: Treatment Analysis

For all participants, treatment of problem behaviors maintained by access to tangible

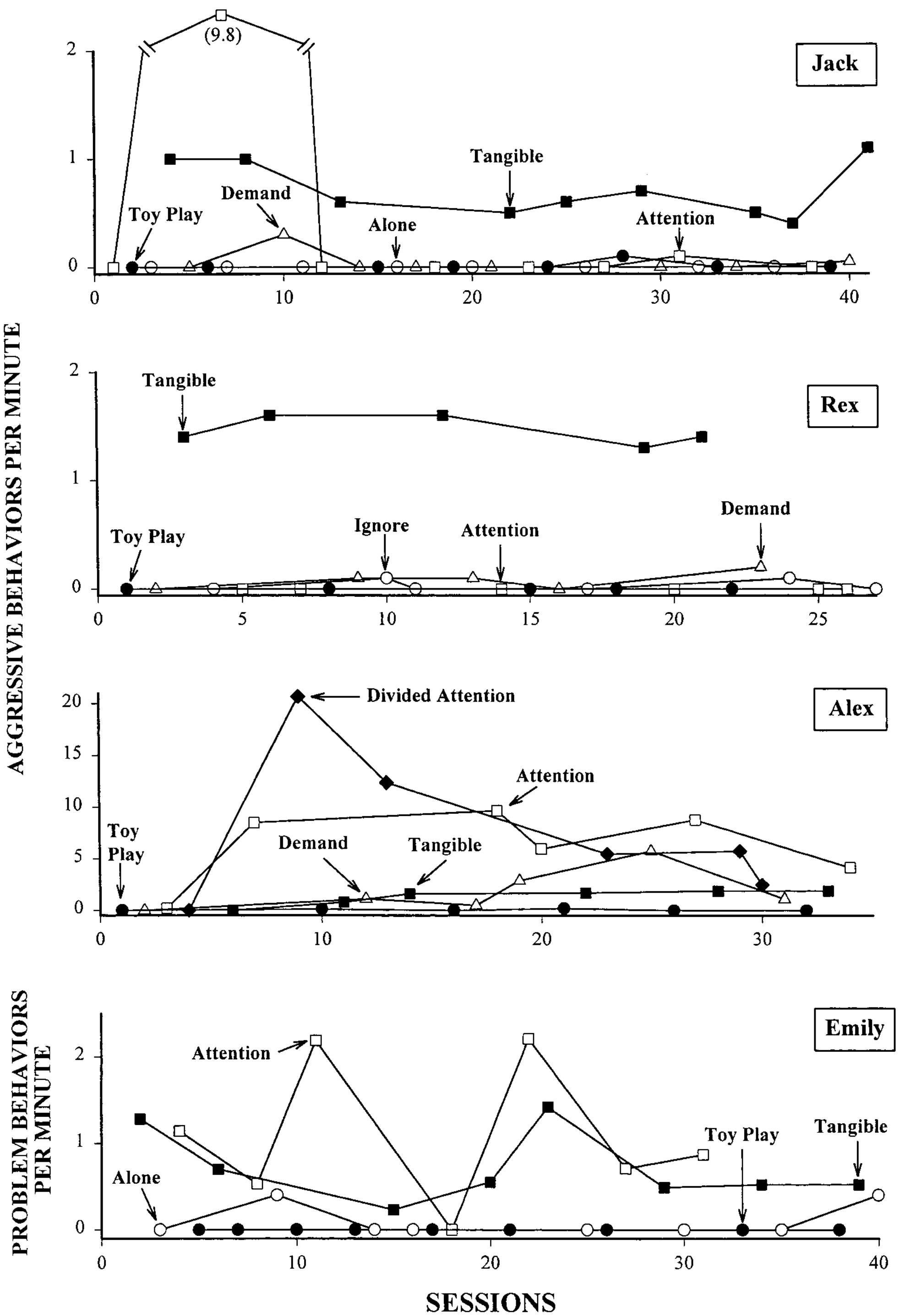

Figure 1. Functional analysis results for each participant.

items were treated using NCR-based interventions. Aggression was targeted for Jack, Rex, and Alex; aggression, SIB, and disruption were targeted for Emily. Treatment of behaviors maintained by other reinforcers are not described in the current study.

Procedure

Baseline. The baseline conditions were identical to the tangible condition of the functional analysis. That is, each participant received 30 s of access to tangible items contingent upon the occurrence of the target behaviors listed above.

FT without EXT. During the first phase of the treatment analysis for Jack, Rex, and Alex, access to the preferred items was provided for a 30-s period on an FT 30-s schedule (i.e., continuous access) and contingent upon the occurrence of a target behavior. That is, if the participant was not interacting with the preferred item, the therapist would deliver it contingent upon a target behavior. The therapist sat in a chair or on the floor during the entire session and did not interact with the participant.

FT without EXT and schedule thinning. The FT schedule was thinned by increasing the IRI. For example, during the FT 45-s schedule, Jack had noncontingent access to the items for 30 s every 45 s. At the end of the reinforcer interval, the materials were removed and then redelivered after 15 s (i.e., the IRI was 15 s). Target behaviors continued to result in access to the items for 30 s.

Tandem FT DRO with EXT. During this phase, target behaviors no longer produced access to the items. A 5-s DRO component was added to the FT schedules to prevent adventitious reinforcement of problem behaviors (with Rex, the DRO component was changed from 5 to 10 s after Session 45). That is, delivery of the preferred items was delayed if the participant engaged in a problem behavior within 5 s of the scheduled delivery time. Thus, the schedule arrangement was a tandem FT DRO with EXT schedule (all schedule values are presented in seconds). This is similar to the momentary DRO schedule described by Vollmer et al. (1997); however, a resetting DRO was used in the current study, whereas Vollmer et al. used a nonresetting DRO. Access to the preferred items was provided for a 30-s period on a tandem FT DRO schedule for all participants. For Emily, the initial schedule was FT 25 DRO 5.

Tandem FT DRO with EXT and schedule thinning. The FT component of the schedule was thinned by increasing the IRI during this phase (the DRO component was not altered). For Jack and Emily, the terminal FT component was FT 115. For Rex the terminal FT component was FT 110. For Alex, the reinforcer interval was increased from 30 to 120 s at Session 31 to reduce the number of times his preferred item was removed (the FT component was changed accordingly to keep the IRI at 10 s). The terminal FT component for Alex was FT 415. For all participants, the criterion for thinning was two to three consecutive sessions at or below 0.2 target behaviors per minute.

Results

Baseline. The results of the treatment analyses are depicted in Figure 2 for Jack and Rex and in Figure 3 for Alex and Emily. Relatively stable rates of problem behavior were observed during the initial baselines for Jack (M = 1.07), Rex (M = 1.37), and Alex (M = 1.67). Increasing trends were observed during the baseline phases for Emily (M = 0.83).

FT without EXT. With the introduction of FT without EXT, problem behaviors were reduced to zero for Jack and Rex (Figure 2) and to near-zero levels (M = 0.08) for Alex (top panel of Figure 3). After behavior rates recovered during a reversal to baseline (Jack, M = 1.27; Rex, M = 1.30; Alex, M =

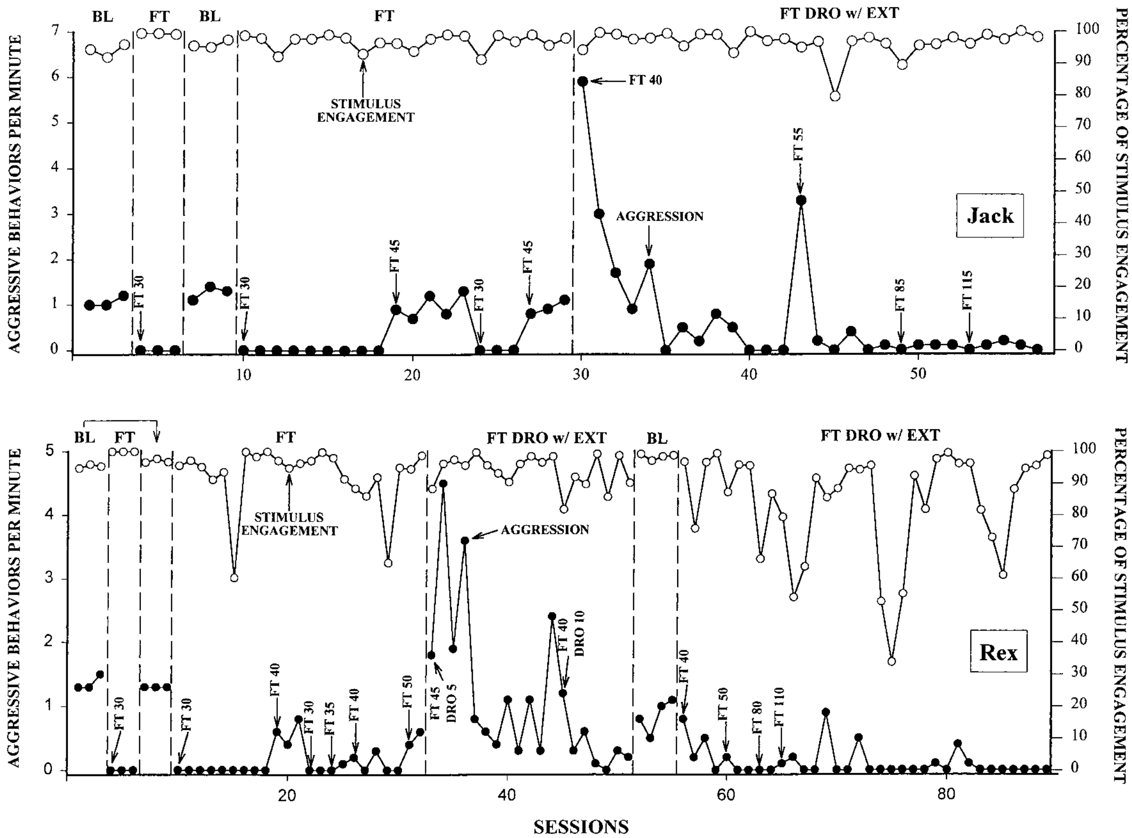

Figure 2. Treatment analysis results during baseline (BL), FT without extinction (FT), and FT DRO with extinction (FT DRO w/ EXT) for Jack (top panel) and Rex (bottom panel). Aggressive behaviors are depicted on the left axis, and percentage of stimulus engagement is on the right axis. Arrows and values indicate changes in the FT component.

1.63), FT without EXT was reimplemented and behavior was reduced to zero or near-zero levels for Jack, Rex, and Alex.

FT without EXT and schedule thinning. With the introduction of an IRI to thin the FT schedule, increases in behavior were observed with Jack, Rex, and Alex during FT without EXT. For Jack, the FT schedule was initially thinned to FT 45 (i.e., a 15-s IRI was introduced). Aggression increased to baseline levels for five sessions, until the FT component was returned to FT 25, at which time aggression rates returned to zero. Aggression increased again when the FT schedule was thinned to FT 40. With Rex and Alex also, aggression increased whenever the IRIs were increased during FT without EXT.

Tandem FT DRO with EXT. For Emily, FT DRO with EXT was implemented after baseline and resulted in zero rates of problem behavior. After a reversal to baseline, during which problem behavior increased, treatment was reimplemented and problem behavior returned to zero until the FT component was thinned.

Tandem FT DRO with EXT and schedule thinning. With the introduction of EXT (with schedule thinning), a temporary increase in problem behavior characteristic of an extinction burst was observed with Jack, Rex, and Alex. Emily, for whom FT DRO with EXT was implemented directly after baseline, also displayed a burst when the schedule was thinned. For Rex, the FT com-

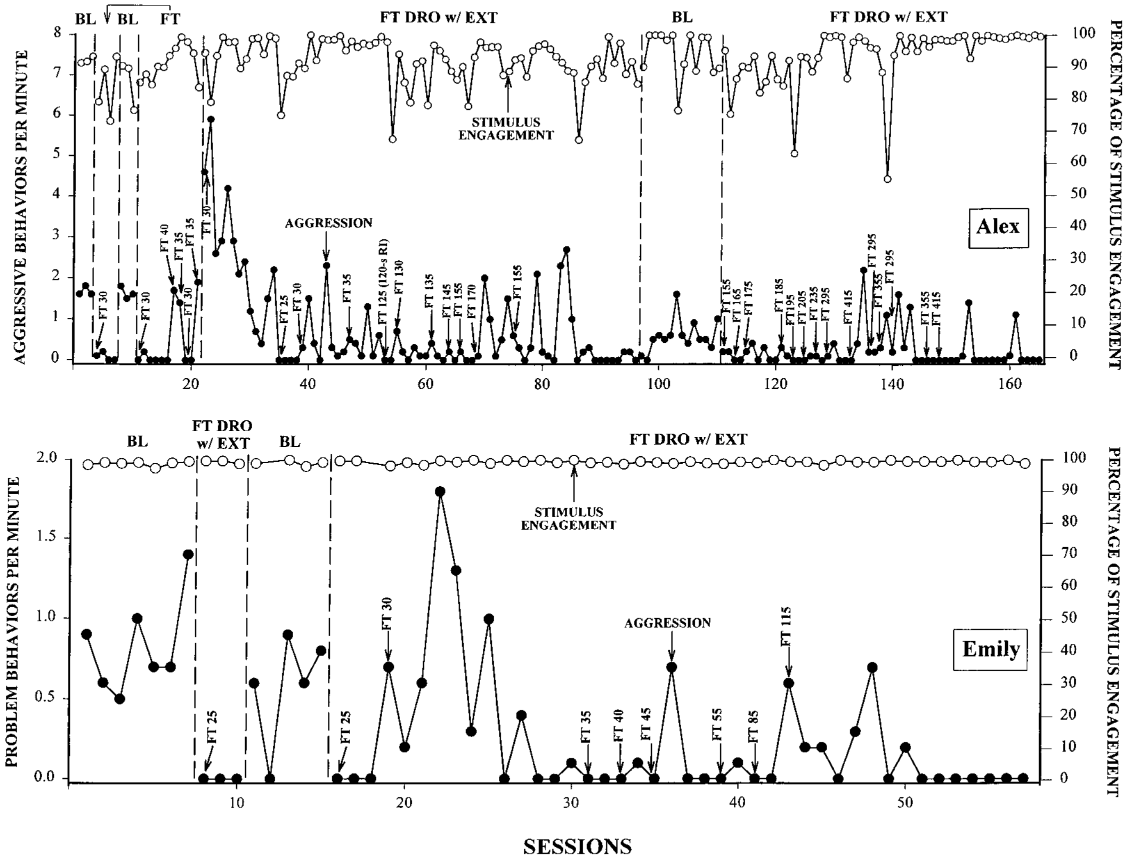

Figure 3. Treatment analysis results for Alex across baseline (BL), FT without extinction (FT), and FT DRO with extinction (FT DRO w/ EXT) conditions (top panel); and for Emily during BL and FT DRO w/ EXT. Problem behaviors are depicted on the left axis, and percentage of stimulus engagement is on the right axis. Arrows and values indicate changes in the FT component.

ponent was held at FT 45 until after a reversal to baseline, when rates of aggression increased, and then were reduced once FT DRO with EXT was reimplemented. The FT component for Alex was successfully thinned to FT 155 before reversing to baseline. Although aggression increased, it did not return to original baseline levels. Treatment was reimplemented, and aggression returned to previously low levels. The FT components were faded to FT 115 for Jack and Emily, to FT 110 for Rex (10-s DRO), and to FT 415 for Alex during FT DRO with EXT.

It was observed that Alex engaged in some aggression during the IRIs that were not directed at obtaining the tangible reinforcer. In an attempt to address what appeared to be problem behavior resulting from the lack of attention and structured activities during the IRI, some temporary modifications were made to his treatment. Alex was provided attention during the IRI during Sessions 80 through 92 and tasks to complete during Sessions 144 through 149. Alex's problem behaviors decreased when these modifications were introduced, but his problem behaviors did not increase when the modifications were withdrawn. Therefore, neither of the modifications were implemented in subsequent treatment sessions.

Percentage of stimulus engagement is also depicted for each participant in Figures 2 and 3. For Jack, stimulus engagement remained high and stable across all treatment phases (baseline, *M* = 95.1%; FT without EXT, *M* = 97.2%; and FT DRO with EXT, *M* = 96.6%). For Rex, stimulus engagement was high and stable throughout the baseline conditions (*M* = 97.1%). During the FT without EXT and the FT DRO with EXT conditions, Rex's stimulus engagement was variable but remained high (*M* = 93.3% and 87.3%, respectively). An increase in seizure activity (associated with lethargy and sleepiness, and which appeared to be negatively correlated with stimulus engagement) was observed starting with Session 52 and continued throughout the remainder of the final FT DRO with EXT phase. For Alex, stimulus engagement was variable but high across all treatment phases (baseline, *M* = 88.7%; FT, *M* = 89.1%; and FT DRO with EXT, *M* = 92.7%). For Emily, stimulus engagement was high and stable across both conditions (baseline, *M* = 98.5%; and FT DRO with EXT, *M* = 99.0%).

Figure 4 depicts cumulative records of responding during representative baseline sessions, higher rate sessions during FT with schedule thinning (FT 40), and FT DRO with EXT and schedule thinning (FT 115 DRO 5). In all conditions, problem behavior occurred rarely during the reinforcer intervals, whether the reinforcer was delivered contingently or noncontingently. In addition, problem behavior occurred most frequently during IRIs. Similar patterns of responding were observed throughout all conditions of the treatment analyses across all participants.

DISCUSSION

In this study, it was demonstrated that problem behavior rates were low and stimulus engagement was high for all participants during the initial phases of treatment. As the FT schedules were thinned, however, problem behavior increased. With the addition of extinction, a temporary increase in problem behavior characteristic of an extinction burst was observed with all participants. The FT schedules were successfully thinned only with the addition of an extinction component. For all participants, stimulus engagement remained high across every phase of the treatment analysis, regardless of whether extinction was in effect or whether the FT schedule was dense or lean.

Applied researchers have suggested that satiation and extinction (or a combination of the two) may be the processes responsible for the reductions observed in problem behavior during NCR (e.g., Lalli et al., 1997; Vollmer et al., 1993). In the current study, NCR was implemented both with and without extinction in order to determine the role of extinction. In addition, the effects of NCR on consumption of reinforcement were examined to provide an indirect means of determining whether reinforcer effectiveness was influenced (and, hence, the role of satiation), independent of the rate of problem behavior.

Determining the possible role of extinction in the treatment analyses presented in the current study is relatively straightforward. Extinction could not have been responsible for the initial reductions in problem behavior observed because problem behavior continued to produce reinforcement. The bursts of responding observed for all participants when extinction was added to NCR further suggests two things: The process of extinction was not in effect during the initial NCR without extinction phases, and extinction was in effect once it was added to NCR. Therefore, the finding that NCR without extinction all but eliminated problem behavior provides evidence suggesting that the initial reductive effects were not due to extinction, at least for these participants. Extinction, however, appeared to be a

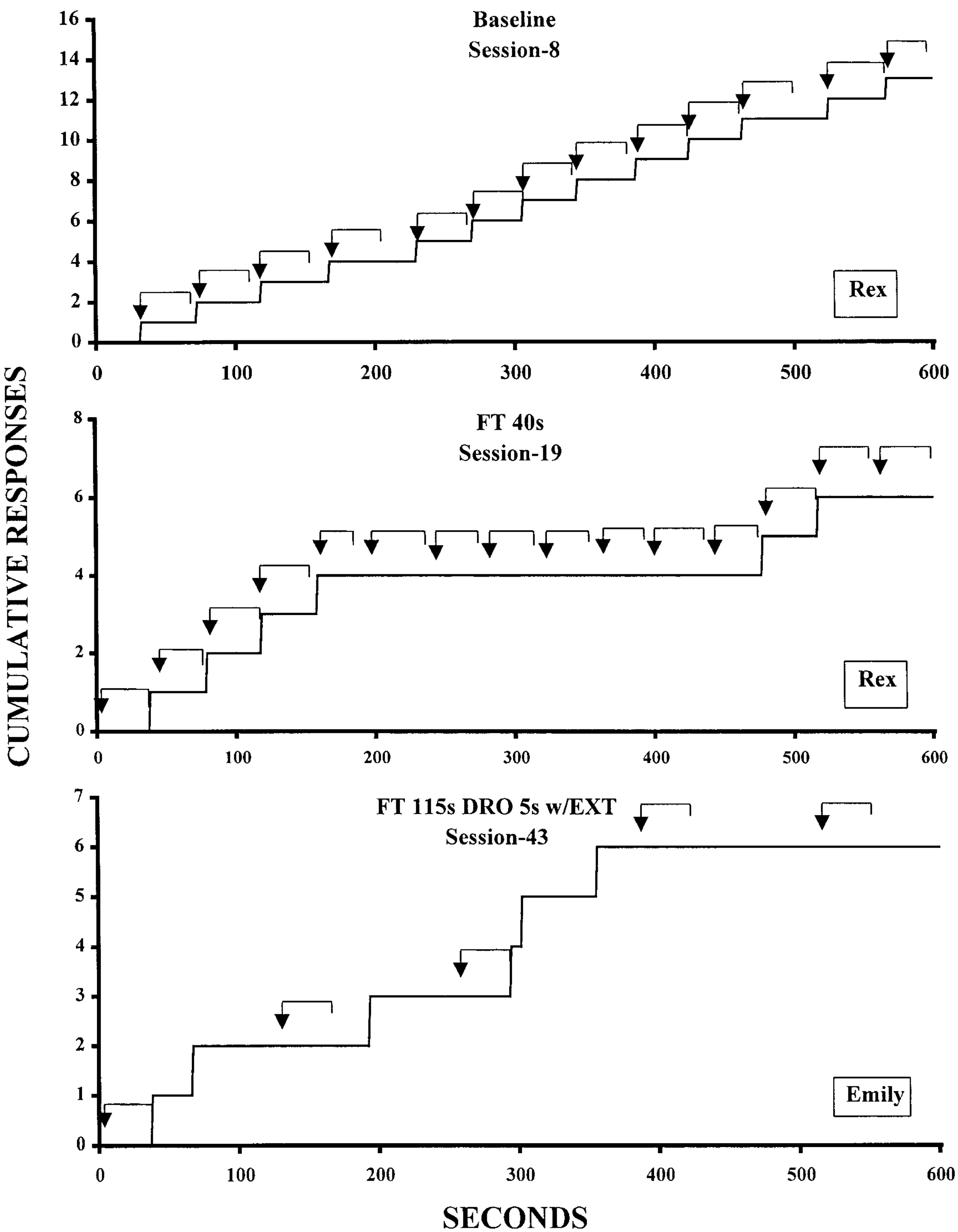

Figure 4. Cumulative records of responding for three sessions. A representative session during baseline (Rex, Session 8) is presented in the top panel. Higher rate sessions during FT without extinction (FT) and schedule thinning (Rex, Session 21), and FT 115 DRO 5 with extinction and schedule thinning (Emily, Session 43) are presented in the middle and bottom panels, respectively. Brackets indicate reinforcer intervals, with arrows on the left of the brackets indicating reinforcer delivery.

necessary component of NCR to thin the FT schedules successfully.

Conclusions regarding the role of satiation during NCR without extinction are somewhat more elusive (and, in part, depend on what sort of processes one is willing to term *satiation*). Satiation has been defined as a type of establishing operation (EO), more specifically an abolishing operation, in which access to a reinforcer reduces the effectiveness of that stimulus as a reinforcer (Catania, 1992). An EO has been defined as an event that alters both the effectiveness of other events as reinforcers and the frequency of responding that produces those events as consequences (Michael, 1993). Therefore, the more specific question, with respect to the present findings, is whether the observed reductions in problem behavior were a function of decreased reinforcer effectiveness (i.e., satiation) or some other process.

In the current study, stimulus engagement (i.e., consumption of reinforcement) during reinforcer access time remained high during every phase of NCR for all cases presented. One interpretation of these findings is that they indicate that satiation was not in effect. If these stimuli were less effective as reinforcers (and satiation was in effect), then one would not expect such high and stable levels of engagement. Thus, the validity of the interpretation that satiation was not in effect hinges on whether the level of stimulus engagement provides a measure of their effectiveness as reinforcers.

Alternatively, one could argue that the high level of stimulus engagement observed in the present study does not directly inform us about the relative effectiveness of these stimuli as reinforcers for problem behavior. A reinforcer cannot be fully described in absolute terms, but must be considered in the context of other variables, including the schedule requirements (e.g., DeLeon, Iwata, Goh, & Worsdell, 1997) and availability of other reinforcement (e.g., Roscoe, Iwata, & Kahng, 1999). That is, the stimuli may have been valuable enough to consume, but not effective as reinforcers in maintaining problem behavior. Therefore, it is possible that the *relative* effectiveness of these stimuli as reinforcers for problem behavior was indeed reduced during access time (i.e., satiation).

Another finding that should be considered is that problem behavior reemerged immediately once brief IRIs were introduced during NCR schedule thinning. The stream of behavior observed during NCR without extinction with schedule-thinning sessions was highly similar across all participants. Throughout these sessions, problem behavior ceased whenever free reinforcement was available, participants engaged with the materials when they were available (i.e., consumed reinforcement), and problem behavior reoccurred during most of the IRIs (when free reinforcement was not available) (see Figure 4). If satiation was responsible for the observed reductions in behavior, it appears to have been a transient process that occurred only during times when free reinforcement was available. It may be useful, however, to distinguish between operations that produce decrements in responding because that behavior is obviated while the reinforcer is being consumed from those in which decrements in responding occur because the value of the reinforcer is decreased as a function of prior exposure (i.e., satiation). Consider the potential effects of removing the reinforcer once it is accessed in both situations. In the first case, removing the reinforcer may be more likely to quickly occasion responding to regain access than in the latter case. With the participants described in the current study, problem behavior typically reemerged once the reinforcers were withdrawn at the end of the reinforcer interval during NCR without extinction.

Although not conclusive, the data on consumption obtained in the current study should raise questions about whether the reductions in problem behavior were a function of decreased reinforcer effectiveness. The data on consumption also inform us about what the participants were doing when the reinforcers were available. Instead of engaging in problem behavior, they interacted with the stimulus materials. Considering that behavior could have been allocated between different response options, namely stimulus engagement and problem behavior, it is also possible to explain the effects of NCR in terms of matching theory. Although the formal mathematical matching equation has been shown to be inadequate in describing behavior in complex asymmetrical choice environments (e.g., Baum, 1974), there is widespread acceptance of the principle that responding is distributed across alternatives in proportion to how reinforcement is distributed across those alternatives (Herrnstein, 1970; McDowell, 1989). Stated another way, responding associated with reinforcement from one source is inversely related to the value of reinforcement from alternative sources (McDowell, 1988). In the case of NCR, the introduction of a concurrently available alternative source of reinforcement (provided noncontingently) produces a shift in the allocation of responding from problem behavior to stimulus engagement, which directly competes with problem behavior.

The relation between operant responding and alternative sources of response-independent reinforcement has been demonstrated empirically in a number of basic studies. Rachlin and Baum (1972) showed that when response-independent reinforcement was delivered while a response-dependent schedule was in effect, responding on the response-dependent schedule decreased. The larger the amount of response-independent reinforcement, the greater the reductions in responding. Other basic studies superimposing response-independent reinforcement on a response-dependent schedule have obtained similar results (e.g., Burgess & Wearden, 1986; Edwards, Peek, & Wolfe, 1970; Lattal & Boyer, 1980; Lattal & Bryan, 1976; Mace et al., 1990; Zeiler, 1976). It should be noted that these basic studies differed from clinical applications of NCR in a variety of ways. For example, they typically involved leaner schedules of response-independent and response-dependent reinforcement, the delivery of small quantities of edible items that were quickly consumed, and the omission of behaviors during consumption time in the data analysis. Nevertheless, a preponderance of data shows that as the amount of response-independent reinforcement increases in the context of a concurrent response-dependent schedule, the rate of the response maintained by the latter schedule decreases. In contrast to the applied research on NCR, none of these basic studies explain the reductive effects of response-independent reinforcement in terms of satiation or EOs. In fact, in the basic literature these findings have often been conceptualized in terms of matching theory.

Using matching theory as a conceptual framework, the noncontingent delivery of reinforcement can be described as the provision of reinforcement from an alternative source. Indeed, McDowell (1982) suggested, in an article on the applicability of matching theory to behavior therapy, that increasing alternative reinforcement (including noncontingent reinforcement) could be a clinical intervention for decreasing problem behavior. These formulations are similar to what was recently proposed by Fisher et al. (1999), who suggested that the reductive effects of NCR may be a matter of the individual consuming free reinforcement when it is available and responding to obtain the reinforcer when free reinforcement is unavailable. More precisely, the provision of an alternative source of reinforcement produces a shift in the allocation of responding from problem behavior to engagement with the reinforcers.

The observation that the rate of behavior to obtain the functional reinforcer varies inversely with the density of the FT schedule reported in this and other NCR studies (e.g., Fisher et al., 1999; Marcus & Vollmer, 1996) is also consistent with a matching conceptualization. Also, using matching as a framework for describing NCR effects may also explain some of the findings of previous studies on NCR that are inconsistent with the satiation or extinction hypotheses. In particular, this would explain how the response-independent delivery of arbitrary reinforcers that are not responsible for behavioral maintenance can reduce problem behavior (Fischer et al., 1997; Hanley, Piazza, & Fisher, 1997). In terms of matching, which does not specify type of reinforcement, the interventions described in those studies produced reductions in behavior by increasing alternative reinforcement. In addition, this conceptualization provides an explanation of how NCR without extinction can be effective in reducing problem behavior (Fisher et al., 1999; Lalli et al., 1997). That is, if the alternative sources of free reinforcement are adequately dense, problem behavior can be reduced despite the fact that it continues to produce reinforcement. It should be noted that the hypothesis that NCR reduces problem behavior as a function of the provision of alternative reinforcement is not inconsistent with an EO account. Clearly, the amount of available alternative reinforcement is a type of EO. As noted earlier, whether one chooses to label the EO in this case as satiation depends on how satiation is defined.

The generalizability of the findings obtained in the current study is limited because it reports on the use of NCR only with behaviors maintained by access to tangible items. The findings, therefore, need to be replicated with other participants who exhibit problem behavior maintained by other reinforcers. It should be noted that it is entirely possible, if not likely, that the processes responsible for the reductive effects of NCR and related treatments may vary across individuals. Therefore, the primary contribution of this study may be that it describes a methodology for better elucidating the role of different processes in effect during NCR-related interventions. In addition, it presents the availability of alternative reinforcement as one way to account for NCR effects.

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STUDY QUESTIONS

1. What were the purposes of the study?

2. Alex's aggression occurred at the highest rates during the two attention conditions of his functional analysis; however, the authors concluded that his aggression was also maintained

by access to preferred items. What feature of Alex's data provides support for this interpretation?

3. Describe the procedures in effect during the FT DRO with EXT condition. What characteristic of the procedure qualified it as a tandem schedule?

4. Summarize the results obtained during the FT without EXT condition (prior to thinning) with respect to both problem behavior and stimulus engagement. How were these results inconsistent with both an extinction and a satiation interpretation?

5. Problem behavior increased temporarily for all participants when the NCR schedules were thinned. What do these results suggest about the roles of satiation versus extinction under dense and thin NCR schedules?

6. What patterns of responding are depicted in Figure 4, and what do these data suggest about the role of satiation during NCR?

7. If satiation is defined as a change in reinforcer efficacy, what is the potential limitation of using reinforcer consumption (i.e., stimulus engagement) as a measure of satiation?

8. What is matching theory, and in what way are the results of this study consistent with the general predictions made by matching theory?

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