Considerations for Escape Extinction

A Selection of JABA Articles

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ALTERNATIVES TO ESCAPE EXTINCTION

Type	Procedure	More Information
Positive reinforcement of alternative response	Use arbitrary reinforcers for compliance; continue to reinforce problem behavior with a break from demands	Slocum & Vollmer (2015); Carter (2010) - non-food;
NCR breaks	Provide breaks then gradually fade-in demands using a fixed-time schedule; continue to reinforce problem behavior	Waller & Higbee (2010); Fritz et al. (2017) - access
FCT: Concurrent Schedule	Teach an FCR and reinforce it using a higher-quality / longer-duration break; continue to reinforce problem behavior with a lower-quality break	Athens & Vollmer (2010) Kunnavatana et al. (2018)

CONSIDERATIONS FOR MITIGATING THE EFFECTS OF ESCAPE EXTINCTION

Purpose	Procedure	More Information
Minimize extinction bursts	Use of most-to-least prompting to teach FCR	Fisher et al. (2018)
Minimize extinction bursts	Use NCR with escape extinction	e.g., Fisher et al. (2004)
Minimize resurgence	Provide competing activities while using a multiple schedule to thin FCR	Fuhrman et al. (2018)
Minimize resurgence	Contingency-based progressive delay to delay delivery of the reinforcer	Ghaemmaghami, Hanley & Jessel (2016)
Minimize extinction burst and resurgence	Application of behavioral momentum theory which uses a thin schedule of reinforcement for the problem behavior prior to treatment and uses a thin schedule to teach alternative response during FCT.	Fisher et al. (2018)

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A COMPARISON OF POSITIVE AND NEGATIVE REINFORCEMENT FOR COMPLIANCE TO TREAT PROBLEM BEHAVIOR MAINTAINED BY ESCAPE

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Previous research has shown that problem behavior maintained by escape can be treated using positive reinforcement. In the current study, we directly compared functional (escape) and nonfunctional (edible) reinforcers in the treatment of escape-maintained problem behavior for 5 subjects. In the first treatment, compliance produced a break from instructions. In the second treatment, compliance produced a small edible item. Neither treatment included escape extinction. Results suggested that the delivery of a positive reinforcer for compliance was effective for treating escape-maintained problem behavior for all 5 subjects, and the delivery of escape for compliance was ineffective for 3 of the 5 subjects. Implications and future directions related to the use of positive reinforcers in the treatment of escape behavior are discussed.

Key words: autism, compliance, differential reinforcement, escape behavior

Functional analysis methodology has led to an increase in the use of function-based treatments rather than arbitrarily selected treatments (Pelios, Morren, Tesch, & Axelrod, 1999). Typically, results of the functional analysis provide information for developing a treatment that both weakens the relation between problem behavior and its maintaining consequences and strengthens the relation between appropriate behavior and those same consequences (Mace, 1994). Function-based treatments have been developed for both socially reinforced behavior (e.g., Carr & Durand, 1985; Lalli, Casey, & Kates, 1995; Vollmer, Marcus, & Ringdahl, 1995) and automatically reinforced behavior (e.g., Fisher, Lindauer, Alterson, & Thompson, 1998; McCord, Grosser, Iwata, & Powers, 2005; Reid, Parson, Phillips, & Green, 1993). These treatments frequently involve using the reinforcer that had previously maintained problem behavior to subsequently strengthen appropriate behavior, such as communication or compliance.

Escape-maintained problem behavior is commonly treated with noncontingent escape (NCE; Vollmer et al., 1995), differential reinforcement (DR; Carr & Durand, 1985; Lalli et al., 1995), or escape extinction (EE; Iwata, Pace, Cowdery, & Miltenberger, 1994). Although a potential intervention itself, EE is often used in conjunction with other procedures. Previous research suggests that extinction is sometimes a necessary component for treatment of escape behavior to be maximally effective (e.g., Fisher et al., 1993; Hagopian, Fisher, Sullivan, Acquisto, & LeBlanc, 1998; Patel, Piazza, Martinez, Volkert, & Santana, 2002; Shirley, Iwata, Kahng, Mazaleski, & Lerman, 1997). However, the use of EE has several limitations, including the potential necessity of physical guidance in the context of three-step prompting. Physical guidance might be undesirable in some cases, or perhaps dangerous or impossible (e.g., in cases in which the subject is larger or stronger than practitioners or family members). In response to these limitations, researchers have sought to develop classes of alternative interventions that do not require physical interaction.

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One unique characteristic to the treatment of behavior maintained by escape from demands is that an inherent competing alternative behavior (compliance) might covary with problem behavior (Parrish, Cataldo, Kolko, Neef, & Egel, 1986). Results of previous studies show that contingent delivery of positive reinforcers for compliance (Carter, 2010; Lalli & Casey, 1996; Lalli et al., 1999; Mevers, Fisher, Kelley, & Frederick, 2014; Piazza et al., 1997) and noncontingent delivery of positive reinforcers (Lomas, Fisher, & Kelley, 2010) can effectively decrease problem behavior and simultaneously increase levels of compliance. Lalli and Casey (1996) found that problem behavior was likely influenced by multiple variables (e.g., the introduction of a task and the removal of appetitive activities) for a young boy with developmental delays. Treatment was most effective when experimenters delivered praise, toys, a break from demands, and social interaction contingent on compliance. These results suggest that positive reinforcement for compliance might produce shifts in response allocation despite the continued availability of escape for problem behavior. Results of this study occasioned a line of research that evaluated the conditions under which reinforcing compliance might treat negatively reinforced problem behavior while the contingency for problem behavior is maintained (i.e., negative reinforcement).

Piazza et al. (1997) compared the effects of positive and negative reinforcement with and without extinction on escape-maintained behavior. Three subjects' functional analysis results suggested that problem behavior was maintained by both negative and positive reinforcement. The introduction of a break contingent on compliance (without extinction for problem behavior) increased compliance and decreased problem behavior for one participant. The addition of positive reinforcement contingent on compliance resulted in a more immediate suppression of problem behavior for that subject as well as for a second subject. Finally, extinction for problem behavior was necessary to produce high levels of compliance and low levels of problem behavior for the third participant. Piazza et al. demonstrated that the addition of a tangible item during a period of escape was more effective than escape alone when EE was excluded as a treatment component. That being said, it is possible that positive reinforcers alone (i.e., without escape) would have been effective at reducing problem behavior.

To date, Lalli et al. (1999) and Carter (2010) have conducted the most direct comparisons of contingent positive and contingent negative reinforcement in the treatment of escape behavior without EE. In both studies, experimenters taught individuals with escape-maintained problem behavior to comply with instructions by providing either an edible item or a break contingent on compliance. Problem behavior resulted in escape throughout both evaluations. Across subjects, positive reinforcement was more effective at decreasing problem behavior and increasing compliance with task demands compared to negative reinforcement.

Nonetheless, some questions remain unanswered. First, in both the Piazza et al. (1997) and Lalli et al. (1999) studies, subjects experienced demands every 30 s rather than continuously. Lalli et al. also used 10-s interprompt intervals in the least-to-most prompting hierarchy. These prompting arrangements might compromise interpretation of the data because the prompting strategies themselves included brief breaks from instructions. Brief breaks within the broad instructional context might have contributed to decreased motivation to access breaks (abolishing operation) and abated escape-related responding. The extent to which brief breaks influenced responding in these arrangements is an empirical question. Control of the intertrial intervals (i.e., minimizing breaks from instructions that are not a part of the formal manipulation of the independent variable) is a reasonable step in the progression of comparing positive and negative reinforcement for treating escape-maintained problem behavior. Second, both Lalli et al. and Carter (2010) primarily used reversal designs.

Reliance on one type of design might compromise data interpretation (e.g., carryover effects might not occur as readily in alternative designs; Payne & Dozier, 2013). For example, for Jay (Lalli et al.), negative reinforcement contingencies were effective for treating problem behavior only when the positive reinforcement condition preceded the negative reinforcement condition.

The use of positive reinforcement to treat problem behavior maintained by escape offers potential benefits (Payne & Dozier, 2013). The delivery of positive reinforcers for appropriate behavior might be less disruptive to classroom or daily routines compared to providing escape for appropriate behavior. Teachers or practitioners might prefer to deliver a small edible item or token for compliance rather than a break. It is likely that the use of positive reinforcers also would influence the establishing operation for escape during aversive stimulation. If positive reinforcers attenuate the aversive qualities of the demand context, escape behavior might be less likely to occur.

Previous research that has demonstrated the efficacy of positive reinforcement to treat escape-maintained problem behavior without the use of EE holds great promise for application (e.g., Carter, 2010; Lalli & Casey, 1996; Lalli et al., 1999; Piazza et al., 1997). However, additional systematic research that directly compares positive and negative reinforcement for compliance while some of the previously discussed variables are controlled is warranted. In the current study, we sought to extend previous research by comparing positive reinforcement for compliance and negative reinforcement for compliance in the absence of EE while treating problem behavior maintained by escape from demands.

METHOD

Subjects and Setting

Subjects had been referred to the Behavior Analysis Research Clinic located on the University of Florida's campus or attended a local school for individuals with disabilities. The first five individuals (four boys and one girl, ranging in age from 4 to 8 years), whose functional analyses showed problem behavior maintained by escape, participated in this study. Braiden was a 4-year-old boy who, based on school records, had been diagnosed with an autism spectrum disorder (ASD). He communicated with gestures and a few modified words. He also followed some single-step instructions. Ali was a 7-year-old girl who had been diagnosed with ASD by a credentialed assessor using the Autism Diagnostic Observation Schedule (ADOS). She also had been diagnosed with ASD, attention deficit hyperactivity disorder, and oppositional defiant disorder by a personal physician. She spoke in multiword sentences and followed complex two-to three-step instructions. Nicholas was an 8-year-old boy who had been diagnosed with pervasive developmental disorder not otherwise specified by a personal physician and also through an ADOS assessment conducted by the aforementioned assessor. He spoke in short sentences and followed two-step instructions. Stephen was a 7-year-old boy who had been diagnosed with ASD by a personal physician. He could not speak vocally but used a few sign approximations to communicate his needs. He followed some single-step instructions. Milo was a 4-year-old boy who had been diagnosed with a developmental delay based on his school records. He did not have any functional communication and did not follow simple instructions at the start of this evaluation.

Experimenters conducted sessions either in a small pullout room (2 m by 2 m) at a local school or in a session room (3 m by 4 m) in a clinic. In both environments, session rooms were equipped with a one-way observation panel for research assistants to collect data unobtrusively. Experimenters conducted Milo's sessions in an area (3 m by 3 m) of a larger room that was blocked off to mitigate high levels of loud vocal stereotypy. The session room (or area) was empty except for items (e.g., edible items or instructional materials) needed to conduct the sessions as described below.

Response Definitions and Interobserver Agreement

The operational definitions for each subject's problem behavior are presented in Table 1. Braiden engaged in aggression (e.g., hitting, kicking, biting, and scratching) and spitting. Ali's target behavior consisted of vocal protests, a precursor behavior for more severe aggression. When the assessment was initiated, she produced loud whining vocal protests (e.g., "No, I don't want to!"). Her family and clinical staff agreed to focus on this precursor behavior to avoid dangerous aggression that typically occurred following the vocal protests. Nicholas displayed aggression in the form of hitting, pushing, kicking, scratching, grabbing, spitting, and hair pulling. Stephen's aggression included grabbing, hair pulling, and pinching. Milo's aggression took the form of pushing, climbing on others, and hitting. Due to the severity of the aggression across subjects, experimenters attempted to block instances that might have harmed the experimenter (e.g., a blow to the head). It is important to note that throughout the functional analysis, baseline, and treatment conditions, any blocked attempt was scored as an instance of problem behavior. Compliance was scored if the subject engaged in the topographically correct response following either a vocal or a model-plus-vocal prompt (see prompting sequence described below).

Interobserver agreement was scored using a proportional agreement method. Within each 10-s interval, the smaller number of observed instances was divided by the larger number of observed instances and converted to a percentage. If both observers recorded no behavior in a given 10-s interval, an agreement of 100% was scored for that interval. Finally, the percentages for each interval were added and divided by the number of intervals to produce an average in each session. Agreement data were collected across 58% (Braiden), 38% (Ali), 26% (Nicolas), 26% (Stephen), and 58% (Milo) of sessions and averaged 96% (range, 73% to 100%) for Braiden, 96% (range, 74% to 100%) for Ali, 94% (range, 61% to 100%) for Nicolas, 97% (range, 74% to 100%) for Stephen, and 96% (range, 74% to 100%) for Milo.

Table 1
Operational Definitions for the Topographies of Problem Behavior

Behavior	Subjects	Definition
Hitting	Braiden, Nicholas, Milo	Forceful contact of the subject's hand to another person from 6 in. or more.
Kicking	Braiden, Nicholas	Forceful contact of the subject's foot to another person from 6 in. or more.
Biting	Braiden, Nicholas	Closure of the subject's teeth around the skin or clothes of another person.
Scratching	Braiden, Nicholas, Stephen	Contact and subsequent movement of a minimum of 2 in. of the subject's fingernails along the experimenter's skin or clothes; each hand constitutes a separate instance of the behavior.
Spitting	Braiden, Nicholas	Expulsion of the subject's saliva in the direction of another person.
Hair pulling	Nicholas, Stephen	Closure of the subject's hand and subsequent pulling of the experimenter's hair.
Pinching	Nicholas, Stephen	Closure of the subject's thumb and pointer finger around the experimenter's skin or clothes.
Grabbing	Nicholas, Stephen	Closure of the subject's entire hand around the experimenter's skin or clothes excluding the experimenter's hand because some subjects use that as a communicative response (i.e., leading the experimenter).
Pushing	Nicholas, Milo	Placement of one or two hands on the experimenter followed by an attempt to forcefully displace the experimenter.
Vocal protest	Ali	Any vocal statement regarding not completing a task. These all began with the word "no." A separate instance was scored if the vocal protest stopped for 3 s before resuming again.
Climbing on others	Milo	Getting on the experimenter's back with all four limbs not making contact with the floor.

Procedure

Functional analysis. Before the treatment comparison, we conducted a functional analysis of problem behavior with each of the five subjects. Sessions lasted 5 min and were based on the procedures described by Iwata, Dorsey, Slifer, Bauman, and Richman (1982/1994). Not all subjects were exposed to all conditions. Anecdotal evidence of behavioral function influenced the selection of conditions. For example, if a caregiver suggested that problem behavior occurred often when preferred items were delayed or denied, the functional analysis included a tangible condition. Based on those reports, we selected some or all of the following conditions to include in a multi-element functional analysis. The sessions conducted for each individual are displayed in each subject's functional analysis graph (Figure 1).

In the no-interaction condition, the subject and experimenter were in the session room with no other materials. The experimenter did not engage with the subject or provide any programmed consequences for problem behavior. During the attention condition, the experimenter sat in the session room with materials (e.g., a book). The subject had continuous access to a moderately preferred tangible item (determined previously by a paired-stimulus preference assessment [PSPA]; Fisher et al., 1992). The session began with the experimenter saying, "I have some work to do; play with your toy." Contingent on any instance of problem behavior, the experimenter provided attention in the form of a brief reprimand (e.g., "Don't do that," "That hurts; ouch!" "I really don't like that.").

Before the start of tangible sessions, the subjects briefly interacted with leisure or edible items. The experimenter removed the item from the subject's possession to start the session. Contingent on problem behavior, the experimenter provided 20 to 30 s of access to the item for leisure items or a single piece of an edible item. We used edible items in the tangible condition for Braiden and Milo and a leisure

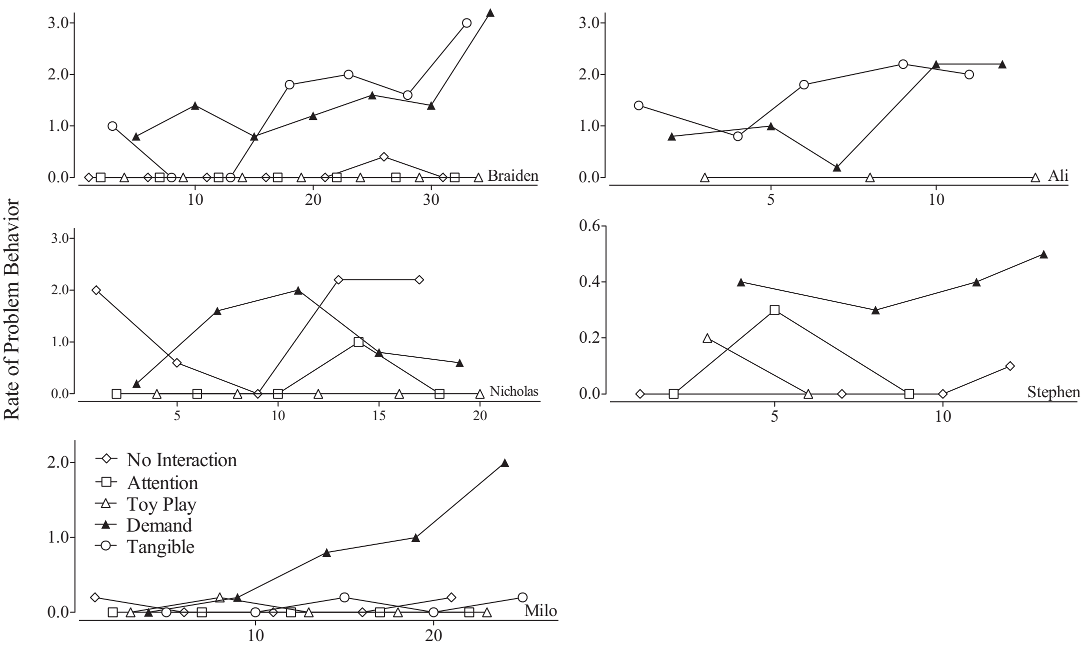

Figure 1. The rate of problem behavior during functional analysis conditions for each subject.

item for Ali. These items were selected based on parent and teacher reports as to what was typically delivered following problem behavior. For Braiden and Milo, teachers reported that they sometimes delivered edible items contingent on problem behavior because of those subjects' limited vocal repertoires (i.e., the teachers reported that those subjects did not have alternative appropriate communicative responses in their repertoires). For Ali, her father reported that he occasionally delivered leisure items to "calm her down." During play sessions (control), experimenters provided continuous access to a highly preferred tangible item (determined by a PSPA; Fisher et al., 1992) and continuous access to attention from the experimenter. No demands were placed, and no consequences were provided for problem behavior.

Finally, we identified appropriate instructions to be used during the demand condition of this analysis based on parent or teacher report or by direct observation of the subject during instructional situations. The experimenter delivered instructions continuously throughout these sessions. Regardless of the type of instruction, a three-step least-to-most prompting procedure was used in which instruction began with a vocal prompt. After an incorrect response or no response, the experimenter again provided a verbal prompt to complete an instruction and modeled the correct behavior. The experimenter issued brief praise contingent on correct responding after a vocal or model-plus-vocal prompt. Contingent on an incorrect response or no response, the experimenter repeated the vocal prompt and physically guided the subject to complete the instruction. Incorrect or no responses (within 3 s of an instruction) produced advancement through the prompting hierarchy. Experimenters issued instructions immediately after a physical prompt, thus limiting the amount of escape throughout these sessions. If problem behavior occurred at any point during instruction, the experimenter provided 30 s of escape. Problem behavior that occurred during the escape period did not produce programmed consequences.

We chose different demands for each subject. For subjects for whom sessions took place in the local school, the experimenter selected tasks that were in the subjects' current repertoires. For subjects for whom sessions were conducted in the clinic, the demands were selected based on new skill-acquisition programs. For example, experimenters issued an array of simple gross-motor instructions and imitation instructions (e.g., "touch your nose," "clap," "raise your hands") to Braiden, Stephen, and Nicholas. Nicholas's instructions also included selecting picture cards from an array of two cards (e.g., "touch the bird"). Ali's tasks included math worksheets with addition and subtraction problems. Milo's instructions consisted of four one-step instructions (i.e., "clap," "sit down," "stand up," and "give me a high five").

We interpreted the functional analysis and treatment-comparison data using standard visual-inspection procedures. A group of four or more behavior analysts examined the data to make a determination regarding behavioral function. Subjects whose functional analysis results suggested that problem behavior was maintained at least in part by negative reinforcement in the form of escape were eligible to participate in the treatment comparison.

Treatment comparison. We compared two treatments using a reversal design embedded within a multielement design. The 5-min sessions included distinct discriminative stimuli (i.e., colored T-shirts) to assist in discrimination between conditions (Conners et al., 2000). The demands included those used in the functional analysis demand condition for all subjects, with the exception of Ali. Ali's father reported that problem behavior related to instructions to pick up toys required intervention in the home.

Baseline. The baseline phase was identical to the demand condition of the functional analyses described above, with one exception. We incorporated a 3-s intertrial interval (ITI) between instructions to control for delivery time in the positive reinforcement condition described below (i.e., to equate the ITI in each condition).

Positive reinforcement. This condition differed from baseline in one way. Contingent on compliance, the experimenter delivered a small edible item that was selected based on verbal reports from the subject's teacher or parent. Experimenters delivered edible items, and not leisure items, because consumption of edible items did not compete with ongoing instructions or compliance. A new instruction was issued after 3 s regardless of whether the subject had completely consumed a previously delivered item, which produced the same ITI as in baseline. We used varied edible items for Braiden, Stephen, Ali, and Milo and only one edible item for Nicholas (per his request). These items included salty (e.g., pieces of potato chip), sweet (e.g., small pieces of chocolate), and liquid (e.g., juice) snacks. For subjects whose functional analysis data suggested sensitivity to positive reinforcement in the form of access to tangible items (i.e., edible items), one of the items delivered in the functional analysis was used in this phase (along with other items). Problem behavior continued to produce a 30-s break. Experimenters thinned the schedule of reinforcement from a fixed-ratio (FR) 1 to a variable-ratio (VR) 10 during Ali's second treatment comparison.

Negative reinforcement. This condition differed from baseline in one way. The experimenter delivered a 30-s break contingent on compliance (problem behavior continued to produce 30 s of escape).

RESULTS

Figure 1 displays problem behavior for each subject during the functional analyses. Across all subjects, problem behavior was maintained by negative reinforcement in the form of escape from instructions (Nicholas, Stephen, and Milo) or by both escape and access to tangible items (Braiden and Ali). Treatment data are depicted for each subject in Figure 2. For Braiden (top), levels of problem behavior were high and variable in baseline. Problem behavior remained at low or zero levels in the positive reinforcement condition. Problem behavior remained at lower levels in the first phase of the negative reinforcement condition compared to baseline; however, problem behavior remained at baseline levels in the second phase of the negative reinforcement condition. Braiden never engaged in high levels of compliance, although he engaged in more compliance in the positive reinforcement condition than in the negative reinforcement condition. For Ali (second panels from the top), levels of problem behavior were high and stable in both baseline phases. Problem behavior remained at low or zero levels in the positive reinforcement condition and at baseline levels in the negative reinforcement condition. Ali engaged in high and stable levels of compliance in the positive reinforcement condition and rarely engaged in compliance in the negative reinforcement condition.

Nicholas's (middle) and Stephen's (fourth panels from the top) levels of problem behavior were variable in both baseline phases. Problem behavior decreased in both the positive and negative reinforcement phases towards the end of the treatment-comparison phases. Both subjects showed larger reductions in problem behavior in the positive reinforcement condition relative to the negative reinforcement condition; however, both subjects engaged in similar levels of compliance in the two treatment conditions.

For Milo (bottom), levels of problem behavior were higher in the first baseline phase than in the second baseline phase. Problem behavior decreased in both the positive and negative reinforcement conditions in the first treatment-comparison phase compared to the first baseline phase. Problem behavior remained at low levels in the second phase of the positive

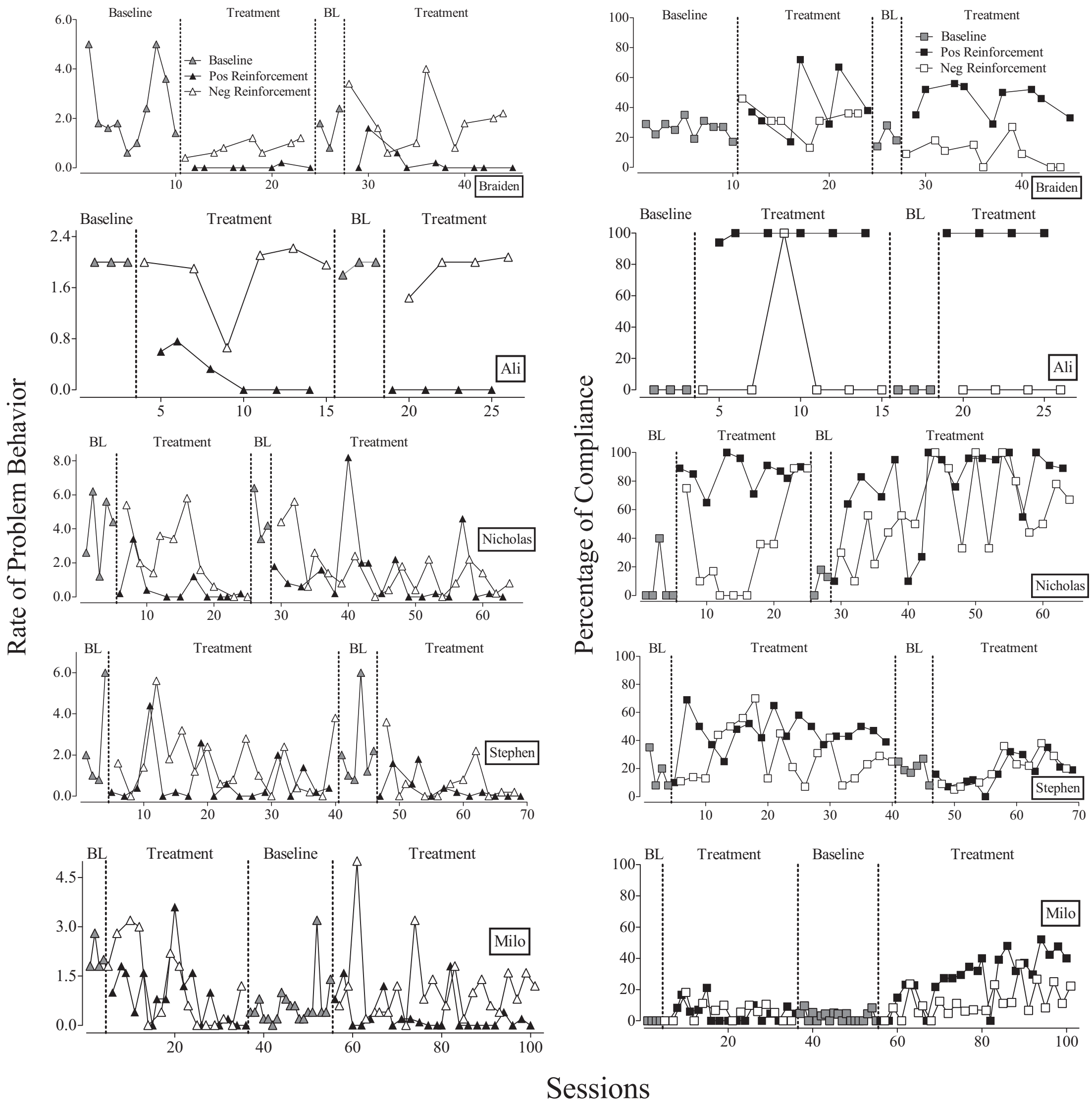

Figure 2. The rate of problem behavior during baseline and treatment conditions for each subject (left) and the percentage of compliance during baseline and treatment conditions for each subject (right) across sessions.

reinforcement condition and at baseline levels in the second phase of the negative reinforcement condition. Milo's compliance increased only in the second treatment-comparison phase and more so in the positive reinforcement condition than in the negative reinforcement condition.

Across the five subjects, the average rate of problem behavior was 2.4 in baseline, 0.5 in positive reinforcement, and 1.3 in negative reinforcement. Collectively, problem behavior was reduced by 79% from baseline in the positive reinforcement condition and 48% from baseline in the negative reinforcement condition. Similarly, levels of compliance were different in the positive reinforcement condition compared to the negative reinforcement condition. The average percentage of compliance was 11.0% in baseline, whereas compliance averaged 54.8% and 22.8% in the positive and negative reinforcement conditions, respectively.

DISCUSSION

Positive reinforcement in the form of contingent access to edible items produced decreases in problem behavior for all subjects. Only two subjects (Nicholas and Stephen) showed a decrease in problem behavior in the negative reinforcement condition relative to baseline. Compliance increased for all five subjects in the positive reinforcement condition. For two subjects (Braiden and Stephen), compliance increased moderately; for the other three subjects (Ali, Nicholas, and Milo), the positive reinforcement condition resulted in large gains in the levels of compliance compared to the baseline condition. Milo and Nicholas showed an increase in compliance in negative reinforcement compared to baseline. Yet, both subjects' levels of compliance were higher in positive reinforcement than in negative reinforcement conditions.

Further, positive reinforcement resulted in near-zero levels of problem behavior by the end of the treatment-comparison phases, but this was not the case for the negative reinforcement condition. For two subjects, (Ali and Braiden), those decreases in problem behavior were socially significant (i.e., 90% reduction in problem behavior). For two subjects (Nicholas and Milo), the positive reinforcement treatment required extended exposure to the contingencies before problem behavior was reduced and compliance increased, perhaps due to carryover effects or difficulty with discriminating between conditions due to use of the multielement design. Providing the functional reinforcer (escape) for compliance in the negative reinforcement condition was effective for only two subjects (Nicholas and Stephen).

Despite recent empirical attention to the role of positive reinforcement for treating behavior maintained by negative reinforcement, the mechanism by which positive reinforcers decrease problem behavior remains largely unknown (Payne & Dozier, 2013). It is possible that the delivery of edible items functions as an abolishing operation and reduces the aversive quality of the demand context and the evocative effect of the instructions. This hypothesis is supported in work conducted by Lomas et al. (2010) who showed that noncontingent delivery of edible items was effective in decreasing levels of problem behavior. On the other hand, positive reinforcers might simply be more preferred than other types of reinforcers (DeLeon, Iwata, & Roscoe, 1997; Lalli et al., 1999). Thus, when positive and negative reinforcers are placed in direct competition, positive reinforcers might support compliance over negative reinforcement.

The delivery of edible items might be particularly effective because these items are not often delivered throughout an individual's day, whereas it is likely that breaks are provided often (i.e., an open vs. closed economy). Finally, the delivery of negative reinforcers for compliance might have competed less effectively with escape-maintained problem behavior because both problem behavior and compliance became members of the same response class. In the negative reinforcement condition, the same reinforcer was provided for both problem behavior and compliance. It is possible that problem behavior remained within baseline levels because of the simultaneous strengthening of responses that are in the same response class (Catania, 1998).

It is important to note that although other studies have examined the utility of positive reinforcers to treat behavior maintained by negative reinforcement, the current study is the first to compare the two treatments with rapidly alternating conditions in the context of a multielement design. In addition, previous studies that have compared the use of positive and negative reinforcement for compliance without the use of EE primarily used reversal designs that might have resulted in sequence or carryover effects (Carter, 2010; Lalli et al., 1999). The use of a multielement design in our study allowed clear differentiation in responding across the two simultaneously conducted treatment conditions.

These data have several implications for clinicians. We suppressed problem behavior for every subject using edible reinforcers without extinction. Extinction can be difficult to implement due to the potential negative side effects (e.g., extinction bursts). Further, the use of EE is not possible in some cases (e.g., when individuals are larger or stronger than clinicians or caregivers). In contrast to the use of extinction, the procedures in the current study are relatively easy for a teacher or parent to implement. Further, the subjects received more instructions in the positive reinforcement condition, thus increasing the number of learning opportunities. For example, in Braiden's evaluation, the experimenter delivered an average of 25 and 12 instructions in the positive reinforcement and negative reinforcement conditions, respectively. This effect might have produced positive outcomes for Milo, who showed more rapid acquisition during positive reinforcement.

The current evaluation included several limitations. Functional analysis results for Braiden and Ali, the two subjects who showed the clearest results favoring the positive reinforcement condition, included evidence of problem behavior maintained by positive reinforcement in the form of access to tangible items. Therefore, the positive reinforcers we used might not have been entirely nonfunctional in relation to the function of problem behavior. The tangible condition was not included in Stephen's and Nicolas's functional analyses. It is possible that individuals whose functional analyses show both tangible and escape functions might be more responsive to the positive reinforcement condition when behavior maintained by negative reinforcement is treated. Conversely, individuals whose problem behavior is not sensitive to positive reinforcement in the form of access to tangible items might not be as responsive to treatment of negatively reinforced problem behavior with edible items. Future researchers should specifically examine the extent to which the identification of a positive reinforcement function increases the probability of positive reinforcers competing with negative reinforcement contingences.

One participant (Milo) had very low levels of compliance in the first treatment-comparison phase. Milo did appear to attempt to cooperate with instructions, but his limited receptive language skills interfered with his ability to meet the operational definitions established for this study. For example, when the experimenter asked him to touch his head and even modeled that behavior, he often pointed to the experimenter's hand. By the second treatment comparison, he appeared to be acquiring some responses, as represented by the increase in compliance for those sessions. Because his level of compliance was so low, we also calculated the trials in which no problem behavior occurred or trials in which he tolerated the instruction (i.e., the percentage of instructions that produced neither aggression nor compliance). Milo did not engage in problem behavior for 10.6% of trials in the first phase of baseline, 80.4% of trials in the first positive reinforcement condition, and 74.3% of trials in the first negative reinforcement condition. When we conducted the reversal, Milo displayed no problem behavior for 89.1% of trials in baseline, 93.1% of trials in positive reinforcement, and 76.2% in negative reinforcement. These results suggest that Milo's compliance might have become increasingly sensitive to the positive reinforcement contingency as his responding came under the discriminative control of the specific instructions.

Another potential limitation includes the limited duration of our sessions (5 min). Longer sessions (and thus more exposure to the edible items) might have produced satiation and compromised the extent to which these items were effective for treating problem behavior maintained by negative reinforcement. Thus, the extent to which these results are robust across time is unknown. Finally, we did not test for generalization to other settings, situations, or instructions. Overall, providing positive reinforcement for compliance yielded reductions in problem behavior and increased compliance displayed by individuals with escape-maintained problem behavior. In at least some cases, this procedure can be effective without the need for EE, a procedure that is at times dangerous or not feasible. From a clinical perspective, the positive reinforcement procedure seems to be feasible and reliable as a treatment for problem behavior maintained by escape. Future research should more closely evaluate the mechanisms responsible for the effectiveness of positive reinforcement to treat problem behavior and compliance.

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A COMPARISON OF VARIOUS FORMS OF REINFORCEMENT WITH AND WITHOUT EXTINCTION AS TREATMENT FOR ESCAPE-MAINTAINED PROBLEM BEHAVIOR

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The present investigation compared the effects of reinforcing compliance with either positive or negative reinforcement for a participant who displayed escape-maintained problem behavior. The results indicated that positive reinforcement in the form of a highly preferred edible or leisure item produced higher levels of compliance and lower levels of problem behavior when compared to negative reinforcement in the form of escape from demands. In addition, an extinction procedure was unnecessary to achieve high levels of compliance.

Key words: escape-maintained extinction, functional analysis, negative reinforcement, positive reinforcement, problem behavior

Positive reinforcement without extinction can be an effective treatment for problem behavior maintained by negative reinforcement or by a combination of positive and negative reinforcement (DeLeon, Neidert, Anders, & Rodriguez-Catter, 2001; Kodak, Lerman, Volkert, & Trosclair, 2007; Lalli et al., 1999; Piazza et al., 1997). Previous research has evaluated choice of positive or negative reinforcement with children with escape-maintained behavior (Gardner, Wacker, & Boelter, 2009). DeLeon et al. found that a child who engaged in escape-maintained problem behavior chose a food item over a break when work requirements were low (e.g., fixed-ratio 1), but chose a break when work requirements increased. Similarly, Kodak et al. evaluated choice between concurrently available forms of positive and negative reinforcement under increasing schedule requirements with individuals who engaged in problem behavior maintained by escape from demands. Results indicated that participants selected high-preference food items over breaks (even when the breaks contained access to high-preference toys).

Other studies have examined the necessary and sufficient treatment components for reducing escape-maintained problem behavior and increasing compliance with demands when extinction was not included as a component of treatment. Piazza et al. (1997) showed that destructive behavior maintained by positive and negative reinforcement was reduced for two of three participants when compliance produced access to tangible items, despite continued negative reinforcement for problem behavior. Lalli et al. (1999) extended this line of research by examining the effects of positive and negative reinforcement with and without extinction on the escape-maintained problem behavior of five participants. Results showed high levels of compliance and reductions in problem behaviors for all participants when compliance produced positive reinforcement (i.e., an edible item) rather than escape from demands. However, the authors did not evaluate whether alternative forms of positive reinforcement (e.g., social praise, leisure items) would have produced similar results. The current study replicated and extended Lalli et al. by comparing the effects of positive and negative reinforcement with and without extinction on levels of compliance and problem behavior with an individual who engaged in escape-maintained problem behavior. Specifically, the current study evaluated whether providing other forms of positive reinforcement (e.g., low-preference

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edible items and high-preference leisure items) contingent on compliance would result in reductions in problem behavior and increases in compliance similar to levels observed by Lalli et al.

METHOD

Participant and Setting

A 19-year-old man with profound mental retardation and a history of destructive behavior participated in the investigation. He was capable of following two-step instructions and communicated through gestures and limited vocalizations. He required supervision and direct assistance with self-care activities. All sessions were conducted in a therapy room or a changing room that included a sink for self-care activities (e.g., hand washing).

Response Definitions and Data Collection

Destructive behavior included aggression (slapping, pushing, hitting, or head butting) and disruption (throwing or destroying items). *Compliance* was defined as completing the demand within 5 s of a verbal prompt. Data were collected on destructive behavior and compliance using a 10-s partial-interval recording procedure during 5-min sessions. Interobserver agreement was scored using interval-by-interval comparisons, calculated by dividing the number of intervals the observers agreed that any behavior (regardless of the amount) occurred by the total number of intervals, and converting that ratio into a percentage. Mean interobserver agreement, obtained during 30% of conditions, was 92% (range, 80% to 100%).

Functional Analysis

The functional analysis consisted of procedures similar to those described by Iwata, Dorsey, Slifer, Bauman, and Richman (1982/1994). During the attention condition, leisure items were available, and the therapist diverted her attention except to provide reprimands contingent on problem behavior. The tangible condition involved the provision of the tangible item for 2 min prior to the session, removal of the item at the beginning of the session, and 30-s access following each occurrence of destructive behavior. The demand condition consisted of a least-to-most prompting hierarchy (verbal, model, and physical assistance) delivered every 30 s, descriptive praise for compliance, and a 30-s break for destructive behavior. The demand condition incorporated self-care tasks (e.g., putting on or removing jacket or shoes, washing hands, wiping face). During the toy play condition, preferred items were available, attention was provided on a 30-s schedule, and there were no programmed consequences for destructive behavior.

Preference Assessment

A paired-choice stimulus preference assessment was conducted for (a) food and (b) leisure items prior to treatment sessions (Fisher et al., 1992). High-preference items were those selected on at least 80% of all trials, and all other items were considered to be low preference. High-preference edible items included cookies and soda, and low-preference items were crackers, chips, dry cereal, pretzels, applesauce, and peanuts. High-preference leisure items included stickers and 30 s of music.

Experimental design. A series of reversals was used to evaluate the effects of treatment on compliance and destructive behavior.

Baseline. The baseline condition was identical to the demand condition of the functional analysis and included the same type of demands.

High-preference edible item for compliance plus escape for destructive behavior (Sr+HPE/Sr−). Prior to the delivery of an instruction, the therapist described the contingency for compliance (e.g., "When you —, then you get —") while presenting the item. The therapist randomly delivered the high-preference edible items when the participant completed the task following the verbal prompt. Instructions continued while the participant consumed the reinforcer. Following an occurrence of destructive behavior, the participant received a 30-s break.

Escape for compliance or destructive behavior (Sr− /Sr−). The therapist described the contingencies to the participant prior to the session. Both compliance with a verbal demand and destructive behavior resulted in a 30-s break.

High-preference leisure item for compliance plus escape for destructive behavior (Sr+HPL/Sr−). This condition was the same as Sr+HPE/Sr− except that the therapist delivered a high-preference leisure item following compliance. The therapist arbitrarily alternated between turning on a radio and placing a sticker on a notebook. Some instances of overlapping reinforcement occurred when the therapist placed a sticker on the notebook while the radio was playing or vice versa.

Low-preference edible item for compliance plus escape for destructive behavior (Sr+LPE/Sr−). This condition was the same as Sr+HPE/Sr− except that the therapist provided a low-preference edible item following compliance.

RESULTS AND DISCUSSION

The results of the functional analysis showed that destructive behavior was maintained by escape from self-care demands (Figure 1, top). During the initial treatment analysis (Figure 1, middle), presentation of a high-preference edible item contingent on compliance increased compliance and reduced destructive behavior even though destructive behavior produced a 30-s break from the task. Throughout the negative reinforcement for compliance and destructive behavior phase of the initial treatment analysis, the provision of a 30-s break from the tasks for both compliance and destructive behavior produced levels of responding similar to those observed during baseline.

During the follow-up treatment analysis (Figure 1, bottom), presentation of a high-preference item contingent on compliance increased compliance and reduced destructive behavior even though destructive behavior produced a 30-s break from the task, as occurred in the initial treatment analysis. In addition, presentation of a high-preference leisure item maintained high levels of compliance and low levels of destructive behavior in the second phase. However, delivery of a low-preference edible item contingent on compliance in the third phase resulted in a decrease in compliance and an increase in destructive

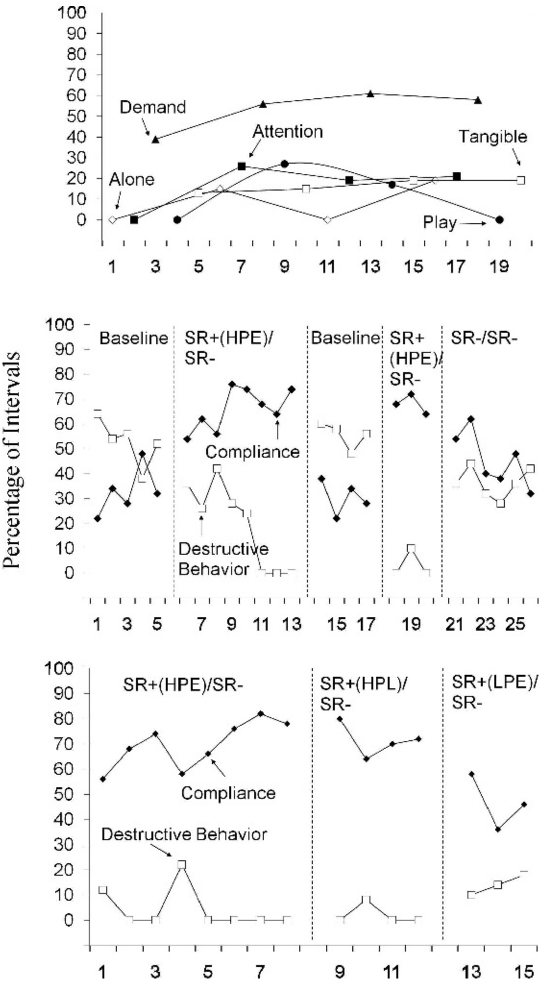

Figure 1. Results of the functional analysis, the initial treatment analysis, and the follow-up treatment analysis are shown in the top, middle, and bottom panels, respectively. Sr+HPE/Sr− = high-preference edible for compliance plus escape for destructive behavior; Sr−/Sr− = escape for compliance or destructive behavior; Sr+HPL/Sr− = high-preference leisure item for compliance plus escape for destructive behavior; Sr+LPE/Sr− = low-preference edible item for compliance plus escape for destructive behavior.

behavior. Despite these findings, the results of the follow-up treatment analysis should be interpreted cautiously and regarded as preliminary because the effects of the high-preference leisure item and the low-preference edible items were not replicated.

The results of this study are consistent with those of Lalli et al. (1999), further demonstrating the effectiveness of a treatment that provides high-preference items contingent on compliance in the absence of extinction. Escape extinction may be especially difficult to implement with individuals who display severe forms of aggression. Thus, treatments that do not require escape extinction should continue to be evaluated. Results also extended the findings of Lalli et al. by maintaining low levels of problem behavior and higher levels of compliance when high-preference leisure items were provided contingent on compliance. This is potentially important because dietary restrictions may require the need to identify reinforcers other than food items that may effectively compete with the reinforcement produced by problem behavior.

One limitation of this study was the possibility of order effects among the treatment conditions. In the initial treatment analysis, the final phase in which negative reinforcement of compliance was evaluated followed a phase in which positive reinforcement was delivered contingent on compliance. Thus, it is possible that discontinuation of positive reinforcement lessened the potential effectiveness of negative reinforcement of compliance. Conversely, in the follow-up treatment analysis, the introduction of the high-preference leisure item in the second phase followed a phase in which compliance was high and destructive behavior was low (due to the high-preference edible item). Thus, it is not clear whether the high-preference leisure item would have produced comparable reductions in destructive behavior and increases in compliance if it were introduced immediately after baseline. Future research should attempt to replicate the results of the current study with additional participants and with a more rigorous experimental design.

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THE EFFECTS OF FIXED-TIME ESCAPE ON INAPPROPRIATE AND APPROPRIATE CLASSROOM BEHAVIOR

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Few studies have explored the effects of fixed-time (FT) reinforcement on escape-maintained behavior of students in a classroom setting. We measured the effects of an FT schedule on the disruptive and appropriate academic behaviors of 2 junior high students in a public school setting. Results demonstrated that FT escape from tasks resulted in a substantial decrease in disruptive behavior and an increase in time engaged in tasks for both participants.

Key words: escape-maintained behavior, fixed-time reinforcement schedules, function-based interventions, noncontingent reinforcement

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The delivery of reinforcement on a fixed-time (FT) schedule (sometimes referred to as noncontingent reinforcement or NCR) has been shown to reduce rates of disruption, aggression, and self-injury, primarily with individuals with significant cognitive impairments (Carr et al., 2000). Kodak, Miltenberger, and Romaniuk (2003), for example, compared the effects of an FT schedule and differential negative reinforcement of other behavior (DNRO) on the escape-maintained behavior and compliance of 2 4-year-old boys during instructional sessions in a home setting. They found that an FT schedule of escape from tasks that was faded to 2 min decreased disruptive behavior and increased compliance to instructions. Recently, Austin and Soeda (2008) extended this line of research by demonstrating the effectiveness of FT reinforcement in a public school setting. After functional assessments identified social attention as the maintaining variable for participants' off-task behavior, they delivered FT attention on a 4-min schedule, which the teacher selected. The results indicated that the off-task behavior of both participants decreased and remained low in comparison to baseline.

Although the results of these studies are encouraging, additional research is necessary to determine the utility of FT procedures in classroom settings. We sought to build on and extend this work in several ways. First, we examined the effectiveness of FT reinforcement schedules on disruptive behavior maintained by negative reinforcement. Second, we collected data on the appropriate academic behavior of participants to determine whether appropriate behavior would increase as a result of the FT escape intervention. Finally, we evaluated the practical utility of thin FT procedures in a classroom setting.

METHOD

Participants and Setting

Teachers at the school identified 2 students who displayed highly disruptive behavior and referred them for participation in the study. Brent (13 years old) and David (14 years old) attended the eighth grade in a self-contained classroom in a public junior high school. Brent was classified with emotional disturbance. David was classified with a specific learning disability.

We conducted all sessions of the treatment evaluation during math class. The classroom was staffed by one special education teacher and a paraprofessional. Brent's and David's classes contained a total of 10 and 12 students,

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respectively. An additional special education paraprofessional employed by the school district conducted all sessions. The first author trained her to conduct the functional analysis and treatment sessions through modeling, practice, and feedback.

Response Measurement and Interobserver Agreement

We defined *disruption* as talking out without permission, inappropriate hand gestures, making noises (i.e., singing, humming, tapping), playing with or throwing objects, or getting out of the seat without permission. We defined *appropriate academic behavior* as writing on the worksheet, operating the calculator, and raising the hand and asking questions related to the assignment. We used 10-s partial-interval recording to measure both dependent variables.

A second observer independently scored disruptive behavior during 42% and 49% of sessions and appropriate academic behavior during 40% and 49% of sessions for Brent and David, respectively. We calculated interobserver agreement by dividing the number of intervals with agreements by the number of intervals with agreements plus disagreements and converting this ratio to a percentage. Mean agreement for both participants was above 95%.

Procedure

We conducted a functional analysis according to procedures described by Iwata, Dorsey, Slifer, Bauman, and Richman (1982/1994) with two procedural modifications. The paraprofessional instructed participants to complete math worksheets at the beginning of all sessions (except control) because teachers reported that problem behavior mainly occurred during independent seatwork time in math class. The second modification involved the inclusion of a peer attention condition in which two peer confederates provided social interaction via brief verbal statements (e.g., "You need to get back to work") each time disruption occurred. Sessions took place in a common area outside the classroom except for the peer attention condition, which occurred in the classroom. The escape condition was associated with the highest levels of problem behavior for both participants.

We evaluated the effects of the FT schedule on problem and appropriate behavior in the classroom using a reversal design. The regular classroom management system (i.e., intermittent reprimands and reminders to stay on task) was in place during all sessions. During baseline, the paraprofessional gave the participant independent math tasks and a verbal instruction to begin working. The classroom teacher behaved as usual, giving instructions, answering students' questions, and providing intermittent reprimands and reminders to keep working. We determined the initial FT schedule by measuring the mean latency to the first disruptive behavior during baseline sessions (Lalli, Casey, & Kates, 1997). The mean latency to the first target behavior was 23 s for Brent and 106 s for David. Initially, breaks were 1 min in duration and were later faded to 30 s.

At the beginning of each FT escape session, the paraprofessional placed two small (5 cm by 7 cm) sticky notes on the participant's desk, which were labeled "work" (yellow note) and "break" (orange note). At the beginning of each session, the paraprofessional walked by the participant's desk and pointed to the note labeled "work" as the prompt to begin working. At predetermined FT intervals, the paraprofessional walked by the participant's desk and pointed to the note labeled "break" to cue the participant to take an in-seat break from instruction. The paraprofessional used one silent vibrating timer to cue the delivery of escape on the appropriate reinforcement schedule and a second silent vibrating timer to measure the duration of the breaks. At the end of the break, the paraprofessional approached the participant's desk and pointed to the note labeled "work" as a prompt to return to working on the assigned task.

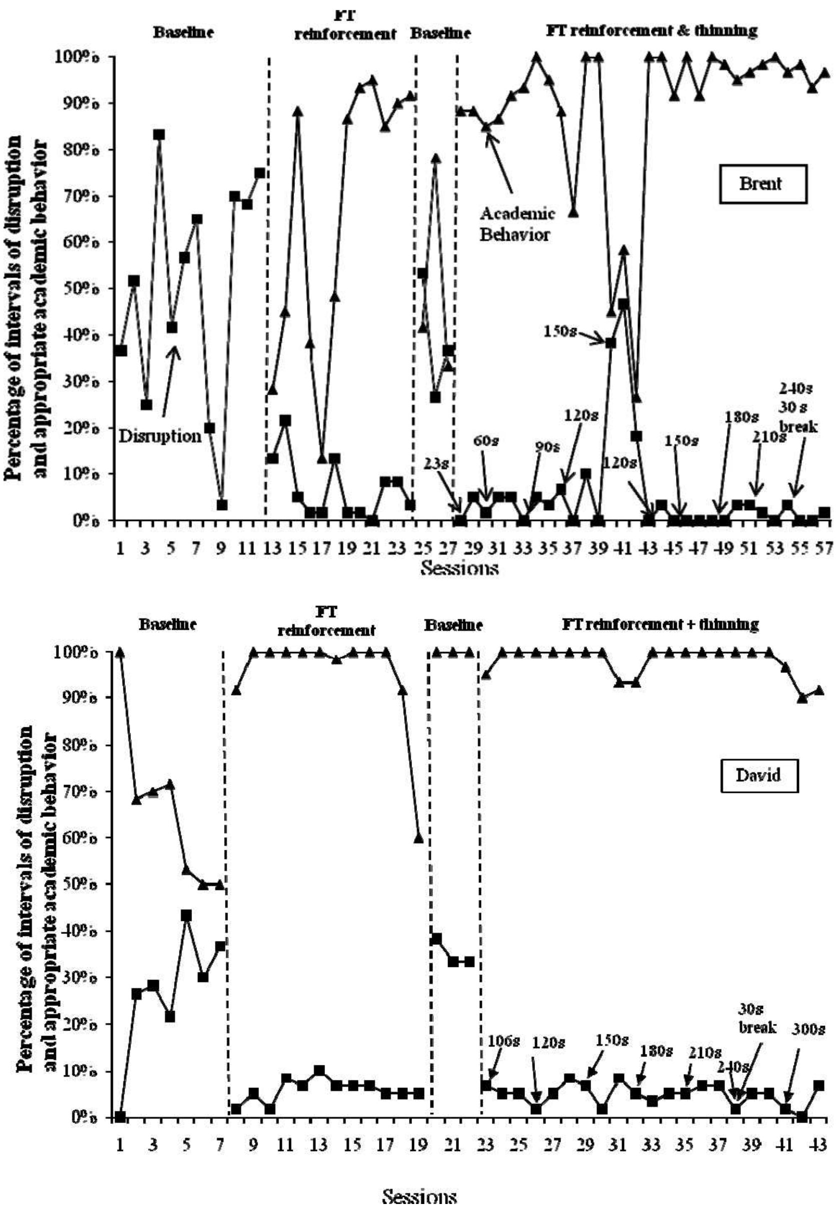

Figure 1. The percentage of intervals of disruption and appropriate academic behavior for Brent (top) and David (bottom) during the fixed-time (FT) reinforcement evaluation.

After a brief return to baseline, we reinstated conditions identical to those in the first FT phase. We increased the FT schedule when the rate of disruptive behavior remained under 10% for three consecutive sessions. The duration of the break decreased to 30 s when the FT schedule reached 240 s for both participants. If disruptive behavior occurred during more than 10% of the intervals for three consecutive sessions, we decreased the FT schedule by 30 s until the disruptive behavior remained below

10% of the intervals for three consecutive sessions.

RESULTS AND DISCUSSION

Figure 1 shows the effects of FT escape on the disruption and appropriate academic behavior of both participants. Brent's disruption rapidly decreased when treatment was introduced, and the mean percentage of appropriate academic behavior was 67%. This effect was replicated following the reversal to baseline. Disruption occurred during less than 10% of intervals as the schedule was thinned to 300 s.

David's disruption decreased to low levels, and appropriate academic behavior increased to nearly 100% of intervals during treatment. During the reversal to baseline, disruption increased and appropriate academic behavior remained high. In the second FT phase, disruption decreased and appropriate academic behavior remained high.

These findings provide further evidence for the effectiveness of relatively thin FT reinforcement schedules for treating problem behavior in classroom settings using school staff as behavior-change agents (Austin & Soeda, 2008). These results also extend those of Kodak et al. (2003) by showing that the provision of FT reinforcement for escape-maintained behavior can effectively reduce disruption while increasing appropriate behavior. One limitation of the study was the initial schedule of reinforcement (i.e., 23 s). This schedule may not be practical to implement in a classroom setting without additional staff assistance. Also, due to time restrictions, we were not able to thin the FT schedule beyond 300 s, which may still be impractical to implement in classrooms. Second, we measured appropriate academic behavior using partial-interval recording, which may have overestimated the level of appropriate behavior. Academic behavior may have been evaluated more accurately by measuring the quantity of assignments completed during sessions. Third, David's appropriate behavior did not decrease when treatment was withdrawn, perhaps because the behavior was controlled by contingencies other than the FT reinforcement schedule. Alternatively, the partial-interval data may not have been sensitive enough to detect small changes in behavior. Furthermore, we did not collect data on appropriate behavior during Brent's initial baseline, and levels of appropriate behavior were somewhat similar across the initial FT schedule treatment and the second baseline. As such, any conclusions regarding increases in appropriate behavior as a result of treatment implementation should be interpreted with caution. Finally, although the teachers were asked to select students with high levels of disruptive behavior for participation in the study, they were not asked to identify an acceptable level of disruption. Thus, the social validity of the outcomes remains in question. One novel aspect of this study was the visual cuing system using sticky notes. The notes served as a visual yet unobtrusive prompt to take a break or work. Discreet prompting procedures are necessary to minimize disruption to ongoing classroom activities and were more age appropriate for these 2 participants. In addition, discreet prompting procedures, such as the notes used in the current study, may minimize negative attention from peers (e.g., teasing), which can be important when working with adolescent populations.

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NONCONTINGENT REINFORCEMENT WITHOUT EXTINCTION PLUS DIFFERENTIAL REINFORCEMENT OF ALTERNATIVE BEHAVIOR DURING TREATMENT OF PROBLEM BEHAVIOR

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The effects of noncontingent reinforcement (NCR) without extinction during treatment of problem behavior maintained by social positive reinforcement were evaluated for five individuals diagnosed with autism spectrum disorder. A continuous NCR schedule was gradually thinned to a fixed-time 5-min schedule. If problem behavior increased during NCR schedule thinning, a continuous NCR schedule was reinstated and NCR schedule thinning was repeated with differential reinforcement of alternative behavior (DRA) included. Results showed an immediate decrease in all participants' problem behavior during continuous NCR, and problem behavior maintained at low levels during NCR schedule thinning for three participants. Problem behavior increased and maintained at higher rates during NCR schedule thinning for two other participants; however, the addition of DRA to the intervention resulted in decreased problem behavior and increased mands.

Key words: concurrent schedules, differential reinforcement, noncontingent reinforcement, problem behavior

Problem behavior in the form of aggression, self-injurious behavior (SIB), and disruption is common among individuals with intellectual disabilities and can prevent skill acquisition, hinder the development of social relationships, and affect family relationships (Matson, Wilkins, & Macken, 2009). Due to these and other reasons, assessment and treatment of problem behavior is important to produce improved outcomes for these individuals. Since the development of functional analysis methodology for identifying the reinforcers that maintain problem behavior (Iwata, Dorsey, Slifer, Bauman, & Richman, 1982/1994), researchers have been able to more precisely develop interventions that effectively decrease the behavior. These interventions often consist of various combinations of extinction, noncontingent reinforcement (NCR), or differential reinforcement (Iwata & Worsdell, 2005).

NCR has been used to treat problem behavior maintained by automatic and social reinforcement (Carr et al., 2000). When problem behavior is maintained by social reinforcement, NCR typically involves the delivery of the functional reinforcer (i.e., the reinforcer that maintains problem behavior) on a time-based schedule, independent of a response (Vollmer, Iwata, Zarcone, Smith, & Mazaleski, 1993). NCR schedules have been shown to be effective at reducing problem behavior maintained by social positive reinforcement (e.g., Hagopian, Fisher, & Legacy, 1994; Lalli, Casey, & Kates, 1997; Vollmer et al., 1993) and social negative reinforcement (e.g., Kodak, Miltenberger, & Romaniuk, 2003; O'Callaghan, Allen, Powell, & Salama, 2006; Vollmer, Marcus, & Ringdahl,

Lynsey Jackson is now at Endeavor Behavioral Institute, Nicole Stiefler is at Spectrum of Hope, Barbara Wimberly is at Trumpet Behavioral Health, and Amy Richardson is at Spectacular Kids. This study was conducted in partial fulfillment of the requirements for the second author's master's degree at the University of Houston-Clear Lake. We thank Kelsey Campbell, Rachel Hoffman, Dorothea Lerman, and Lorena Rodriguez for their assistance with this study.

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1995). There are several potential advantages to NCR. First, it may be easier to implement than procedures requiring response monitoring. Second, it may result in higher rates of reinforcement than differential reinforcement procedures (Vollmer et al., 1993). Finally, it may attenuate side effects of extinction, such as extinction bursts (Vollmer et al., 1998).

Extinction is typically included as a component of NCR and involves withholding reinforcement following problem behavior (i.e., reinforcement is delivered on the time-based schedule but is not delivered contingent on problem behavior; Wallace, Iwata, Hanley, Thompson, & Roscoe, 2012). A few studies have evaluated NCR without extinction; however, there is a paucity of research on this treatment strategy (Carr, Severtson, & Lepper, 2009). Furthermore, results of these studies have been somewhat mixed in that the intervention has been effective in some studies (e.g., Lalli et al., 1997) but not others (e.g., Hagopian, Crockett, Van Stone, DeLeon, & Bowman, 2000; Wallace et al., 2012) as the NCR schedule is thinned. For example, Lalli et al. (1997) evaluated NCR without extinction for one participant. The rate of problem behavior gradually decreased to zero as they thinned the NCR schedule and maintained at low levels at the terminal schedule. Conversely, Hagopian et al. (2000) and Wallace et al. (2012) both observed increases in problem behavior when the NCR schedule was thinned without extinction, and the inclusion of extinction was effective in decreasing problem behavior when it was used. Although NCR with extinction effectively decreased problem behavior in both studies, extinction cannot be implemented in all situations. For example, it might be impossible to prevent physically large individuals from accessing preferred items following problem behavior, such as when they hit or shove a caregiver who is blocking access to preferred items, or caregivers might not be able to refrain from providing attention following aggression directed toward them. Therefore, research on additional strategies to improve the effectiveness of NCR without extinction is needed.

One potential solution might be to combine NCR with differential reinforcement of alternative behavior (DRA) without extinction. Studies have shown that this combined intervention strategy can be highly effective in decreasing problem behavior and increasing appropriate behavior when extinction is included (Goh, Iwata, & DeLeon, 2000; Marcus & Vollmer, 1996). For example, Goh et al. (2000) used NCR combined with DRA to decrease problem behavior maintained by social positive reinforcement, but an increase in the alternative response did not occur until the NCR schedule was thinned. It is unknown if the treatment would be similarly effective if extinction was not included.

Although combining DRA with NCR may increase the effort of implementing treatment (compared to NCR alone), it might be a viable alternative when extinction is not possible. In those cases, caregivers interact with the individual when problem behavior occurs, but also on a time-based schedule and following appropriate, alternative behavior (mands). This strategy would be desirable if mands increase and low rates of problem behavior maintain as the NCR schedule is thinned. Furthermore, if the intervention results in significant decreases in problem behavior, the effort of the intervention should decrease as NCR is thinned. Even if mands are emitted at a similar rate as problem behavior during baseline, the intervention should be at least no more difficult to implement than baseline procedures.

The purpose of this study was to evaluate the effects of thinning NCR schedules without extinction for problem behavior maintained by social positive reinforcement. This study extends previous research by evaluating a combined intervention of NCR schedule thinning plus DRA without extinction when NCR schedule thinning alone is not effective in maintaining low rates of problem behavior.

METHOD

Participants and Setting

Five individuals who engaged in problem behavior maintained by social positive reinforcement were included in this study. All participants attended day treatment centers for at least 15 hr per week where they had been referred for assessment and treatment of problem behavior. Charley was a 9-year-old male diagnosed with autism whose problem behavior consisted of property destruction. (Charley also infrequently engaged in aggression, which was not included in this study.) Gilbert was a 7-year-old male diagnosed with autism who engaged in screaming. Dyson was a 6-year-old male diagnosed with autism who kicked people and other surfaces. Alan was a 3-year-old male diagnosed with autism who engaged in screaming. Harry was a 7-year-old male diagnosed with autism and obsessive-compulsive disorder who engaged in SIB.

All sessions took place at a day treatment center in rooms (approximately 3 m by 3 m) containing a table, chairs, and the materials necessary to conduct the sessions.

Response Measurement and Reliability

The dependent variables (problem behavior and mands) were measured using frequency or 10-s partial interval recording (Gilbert only). The frequency data were converted to responses per min (RPM) and the partial interval data were converted to percentage of intervals. A secondary analysis of latency (in seconds) from the time leisure items were removed to the first instance of problem behavior also was conducted during the first 5 min of Dyson's baseline (sessions 1, 2, and 4; problem behavior did not occur in session 3) or during the tangible condition sessions of the functional analysis for Alan. Problem behavior included screaming (Gilbert and Alan), property destruction (Charley), kicking self and objects (Dyson), and SIB (Harry). Screaming was defined as a nonfunctional, vocal response that was paired with an open mouth and negative facial affect (e.g., frowning, crying). Property destruction was defined as audible contact between the participant's hands or feet with objects in the environment, throwing objects, and audible contact between two or more objects in the participant's hands. Kicking was defined as extension of the leg with contact between the participant's foot and surfaces or a person (did not include contact while rolling on the floor). SIB was defined as any audible contact between the hand and head or body of the participant. The mand taught during DRA was defined as placing a card in the therapist's hand. Alan exchanged a card that contained a picture of his preferred items, and Harry exchanged a card that had the word "toys" printed on it.

A second independent observer collected data for 18% to 100% of sessions during each condition to assess reliability. Proportional agreement scores for frequency data were determined by comparing the observers' recorded frequencies for each response in each 10-s interval. The smaller number of responses was divided by the larger number of responses in each interval, the fractions were averaged across intervals, and the result was multiplied by 100. Interval agreement scores for partial interval data were determined by comparing the observers' recording of occurrence or nonoccurrence of the response in each interval. If the records matched within the interval, the interval was scored as an agreement. The number of agreement intervals was divided by the total number of intervals in the session and multiplied by 100. For latency measures, two observers recorded the number of seconds from leisure item removal until problem behavior occurred, and agreement was scored if the observers' records differed by 5 s or less.

Mean interobserver agreement scores for problem behavior were 92% (range, 76%-

100%) in baseline, 99% (range, 90%-100%) in NCR, and 98% (range, 80%-100%) in NCR plus DRA (Alan and Harry only). Mean interobserver agreement scores for mands were 99% (range, 90%-100%) in NCR plus DRA (Alan and Harry only). Mean interobserver agreement scores for latency to problem behavior were 90% (range, 67%-100%).

Procedure

A functional analysis (FA) was conducted with all participants prior to treatment using procedures similar to those described by Iwata et al. (1982/1994). A tangible condition also was included for all participants because their caregivers reported that problem behavior occurred when preferred items were removed, and all participants engaged in problem behavior at the highest rates (or almost exclusively) in the tangible condition. Results are available from the corresponding author.

During the treatment evaluation, the same highly preferred items were delivered on the NCR schedule (all conditions), contingent on problem behavior (all conditions), and contingent on mands (NCR plus DRA only). Sessions were 5 min (Alan only) or 10 min in duration. Experimental control was demonstrated using a nonconcurrent multiple baseline across participants design.

Baseline. Participants were given at least 30-s, presession access to a variety of highly preferred leisure items. The items were removed at the start of the session and remained visible but out of the participant's reach. Participants were given 20-s access to the preferred items contingent on problem behavior. All other behavior was ignored, and the therapist did not interact with the participant during session. Baseline sessions were conducted until stable or increasing rates of problem behavior were observed.

NCR. During this condition, preferred items were delivered for 20 s on a time-based schedule and for 20 s contingent on problem behavior. The therapist wore a vibrating pager to discretely signal when the preferred items should be delivered on the NCR schedule. The initial NCR schedule for all participants was three reinforcer deliveries per min (i.e., continuous reinforcement in which the participant had uninterrupted access to the preferred items). Problem behavior that occurred during the reinforcement interval was scored but did not result in additional reinforcement time (i.e., the items were removed after 20-s access, regardless of whether problem behavior occurred during the reinforcement interval). The NCR schedule thinning procedure was identical to the procedures used by Marcus and Vollmer (1996), in which the NCR schedule was thinned to two deliveries per min, 1 per min, 0.5 per min, 0.33 per min, 0.25 per min, and 0.2 per min, if problem behavior maintained at or below 20% of baseline rates for at least three consecutive sessions. If at any time during the schedule thinning rates of problem behavior were greater than 20% of baseline levels and were without a decreasing trend for at least five consecutive sessions, mand training was initiated.

Mand training. Prior to the NCR plus DRA condition, mands for access to the preferred items were taught to the participants using a backward chaining procedure (Hagopian, Fisher, Sullivan, Acquisto, & LeBlanc, 1998). The three steps were: (a) moving the participant's hand toward the card, (b) picking up the card, and (c) handing the card to the therapist. Initially, the minimal amount of physical guidance necessary was used to prompt the participant to engage in each step of the alternative communication procedure. Next, minimal physical guidance was used to prompt the participant through all steps except the final step in the chain (step c). If the participant failed to independently complete the final step within 5 s, physical guidance was used. The final stage involved guiding the participant to complete the first step in the chain (step a), and then allowing 5 s to pass for the participant to independently emit the correct response before prompting was provided. Each session consisted of 10 trials. The criterion for moving through each stage in the mand training process was independent completion of the targeted steps for at least 80% of trials for two consecutive sessions. During mand training, all participants were given 5 s to independently engage in the response before any prompting was provided to promote independent responding. Preferred items were delivered following each prompted and unprompted response. The mand was considered mastered when independent (unprompted) responding occurred for at least 80% of trials for two consecutive sessions. The therapist blocked problem behavior that occurred during mand training sessions, did not provide access to the preferred items, and did not provide eye contact or any other attention.

NCR plus DRA. During this condition, preferred items were delivered (a) contingent on problem behavior, (b) on the fixed-time (FT) schedule of reinforcement, and (c) contingent on a mand. The participants had continuous access to the reinforcers at the beginning of this phase, and the subsequent NCR schedule thinning procedure was identical to the NCR-only condition. The card was available throughout sessions once NCR schedule thinning began for Alan (i.e., the card was not available during continuous NCR due to experimenter error) and during all sessions for Harry (i.e., the card was available during continuous NCR and all subsequent sessions). Problem behavior and mands that occurred during the reinforcement interval were scored but did not result in additional reinforcement time (i.e., the items were removed after 20-s access).

RESULTS

Results of baseline and treatment are depicted in Figure 1 for Charley, Gilbert, and Dyson. NCR schedule thinning without extinction was effective in reducing the problem behavior of these three participants. Charley's property destruction averaged 1.4 RPM during baseline, and continuous NCR produced near-zero levels of problem behavior. As the NCR schedule was thinned, Charley intermittently engaged in moderate to high levels of problem

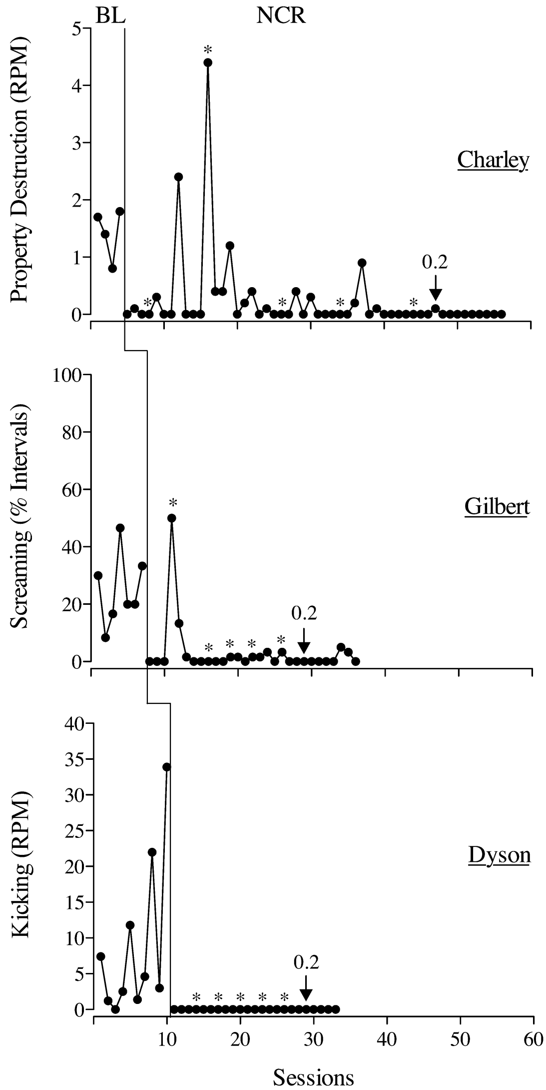

Figure 1. Results of treatment during NCR. Asterisks indicate sessions in which the NCR schedule was thinned. Arrows indicate sessions in which the terminal NCR schedule was initiated.

behavior; however, problem behavior returned to below 20% of baseline rates. The NCR schedule was successfully thinned to the terminal schedule of 0.2 reinforcers per min in 42 sessions. Gilbert's screaming averaged 25% of intervals during baseline and immediately decreased to zero when continuous NCR was introduced. Screaming increased to baseline levels during the first NCR thinning session; however, problem behavior decreased in the subsequent session and remained at near-zero levels for the remainder of the treatment. The NCR schedule was thinned to the terminal criterion in 21 sessions for Gilbert. Dyson's kicking occurred at increasing rates during baseline and averaged 8.8 RPM. His problem behavior decreased to zero immediately when continuous NCR was introduced and remained at zero as the schedule was thinned. The terminal NCR schedule was reached in 18 sessions for Dyson.

Results of baseline and treatment are depicted in Figure 2 for Alan and Harry. Although NCR was initially effective when they had continuous access to the reinforcers, problem behavior increased once the NCR schedule was thinned. Alan's screaming averaged 1.4 RPM during baseline and immediately decreased to zero during continuous NCR. During the first NCR schedule thinning session, Alan's screaming increased to baseline levels and maintained at steady rates for eight sessions. After mand training, continuous NCR again was implemented, which produced near-zero rates of screaming, and the picture card was introduced during the first step of NCR schedule thinning (i.e., the card was not available during continuous NCR). Alan engaged in zero rates of screaming and increasing rates of mands during the NCR schedule thinning plus DRA condition.

Harry's SIB averaged 4.3 RPM during baseline and immediately decreased to zero during continuous NCR. Although SIB initially remained low during the first step of NCR schedule thinning, it subsequently increased

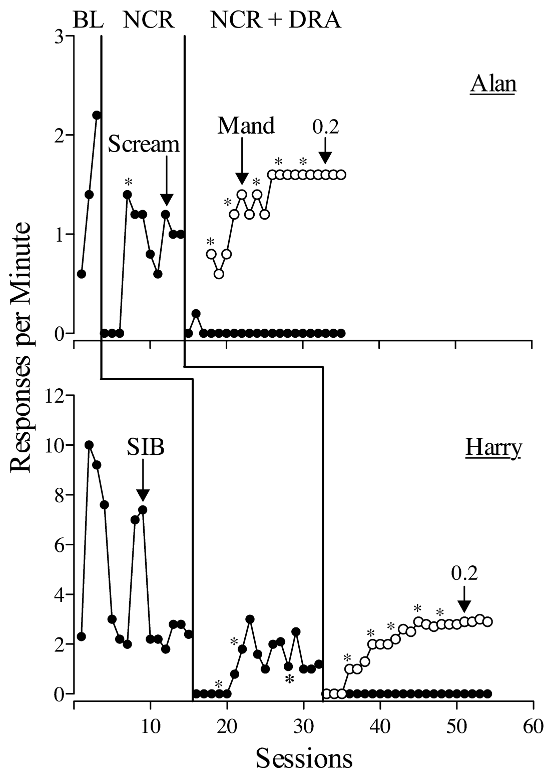

Figure 2. Results of treatment during NCR and NCR + DRA. Asterisks indicate sessions in which the NCR schedule was thinned, and a bold asterisk (session 28 for Harry) indicates a return to the previous NCR schedule.

and maintained during sessions when NCR was thinned further. We returned to the first step of NCR schedule thinning in session 28; however, SIB persisted at near baseline levels for five sessions under these conditions. Therefore, the card was available and continuous NCR was again implemented after mand training. Harry did not engage in SIB during the remainder of treatment. He also did not engage in mands during continuous NCR; however, mands gradually increased as the NCR schedule was thinned. The terminal criterion for the NCR schedule was reached in 18 sessions for both Alan and Harry.

It was interesting that NCR schedule thinning without extinction was effective for three of the five participants, especially in eliminating Dyson's problem behavior. It seemed possible that the latency to problem behavior from the removal of the preferred items might predict if NCR thinning without extinction might be an effective intervention. Therefore, we calculated the latency from toy removal until the first instance of problem behavior occurred during the sessions for the best and worst responders during NCR schedule thinning without extinction (i.e., Dyson, whose problem behavior never occurred, and Alan, whose problem behavior increased to baseline rates as soon as NCR thinning started). We analyzed the first three sessions of baseline in which problem behavior occurred for Dyson (i.e., sessions 1, 2, and 4 of baseline, because problem behavior never occurred in session 3; shown in Figure 1) and the three sessions of the tangible condition from the FA for Alan in which he received 30-s access to preferred items contingent on problem behavior (overall rate of problem behavior was 1.2, 1.8, and 1.2 RPM in these sessions, respectively). These sessions were selected because greater differences in responding might be expected during early exposure to the reinforcement contingency for problem behavior (i.e., before problem behavior became more efficient due to a recent history of reinforcement), and this is when a clinician would likely make a determination regarding potential treatment strategies (i.e., lengthy baselines are not common in clinical practice). Results are shown in Figure 3. The average latency to problem behavior following the removal of preferred items was 246 s for Dyson and 14 s for Alan. Furthermore, the shortest latency to Dyson's kicking was 173 s, and Alan consistently engaged in screaming within a few seconds of toy removal (median latency was 5 s).

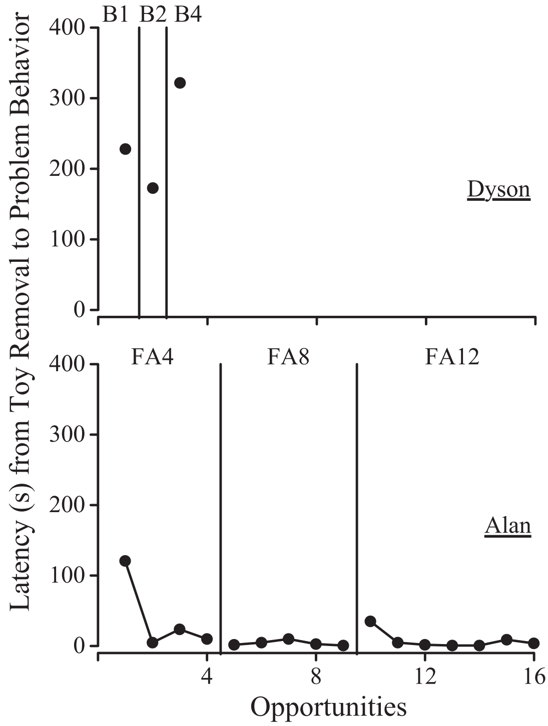

Figure 3. Latency in seconds from toy removal to problem behavior during the first 5 min of baseline sessions 1, 2, and 4 for Dyson and functional analysis sessions 4, 8, and 12 (tangible condition) for Alan.

DISCUSSION

NCR without extinction was effective in reducing problem behavior maintained by social positive reinforcement for three of five participants—replicating the results of some previous studies (Hagopian, LeBlanc, & Maglieri, 2000; Lalli et al., 1997). Systematically thinning the NCR schedule resulted in continued low levels of problem behavior for three participants, even though problem behavior occurred at moderate to high levels and contacted the reinforcement contingency during some sessions of the schedule thinning process for two of three participants. The terminal NCR schedule of FT 5 min was achieved in an average of 30 sessions for these three participants and accounted for only 3–7 hr of treatment. These results are promising for situations in which NCR is a desirable intervention but extinction is not feasible or caregivers do not implement extinction with integrity.

For the two participants for whom NCR schedule thinning without extinction was not effective in maintaining low rates of problem behavior, the addition of a DRA component was effective in decreasing problem behavior to zero rates and maintaining mands. This provides a promising approach to treatment without extinction that requires a relatively short time commitment, as the terminal NCR schedule of FT 5 min was achieved in only 1.5-3 hr (18 sessions) for both participants.

These results extend the findings of previous studies that showed a combined strategy of NCR thinning and DRA with extinction can be effective in decreasing problem behavior (Goh et al., 2000; Marcus & Vollmer, 1996) by showing this treatment can be effective without extinction. Furthermore, these results extend the work of Wallace et al. (2012) by demonstrating that lean schedules of NCR can be effective in reducing problem behavior without extinction when the NCR schedule is gradually thinned and combined with DRA. Given the elimination of problem behavior during this treatment, it is possible that the systematic thinning of the NCR schedule might have been a critical treatment component, as other studies that have used DRA without extinction have not produced such favorable outcomes (e.g., Hagopian et al., 1998; Shirley, Iwata, Kahng, Mazaleski, & Lerman, 1997; Worsdell, Iwata, Hanley, Thompson, & Kahng, 2000).

If practical implementation was a primary concern, additional treatment strategies would be necessary for these individuals to reduce the reinforcement rate provided. For example, Alan engaged in nearly identical rates of problem behavior (1.4 RPM) in baseline as rates of mands during the last three sessions of NCR plus DRA (1.6 RPM). Similar results were observed with Harry (4.3 RPM of problem behavior in baseline and 2.3 RPM of mands in the last four treatment sessions). Therefore, this treatment strategy did not reduce the overall reinforcement rate for either participant from baseline to the final treatment phase. Additional strategies, such as establishing stimulus control of the mand through the use of multiple schedules (e.g., Hanley, Iwata, & Thompson, 2001; Saini, Miller, & Fisher, 2016) or strengthening other contextually appropriate behavior through contingency-based delays (Ghaemmaghami, Hanley, & Jessel, 2016) might be effective in reducing rates of mands while maintaining treatment effects. Future research might evaluate this possibility in the absence of reinforcement for problem behavior.

Results of the secondary analyses suggest that patterns of responding during early exposure to contingent reinforcement for problem behavior (i.e., FA or baseline sessions) might be useful in predicting if NCR schedule thinning without extinction will be an effective intervention. Specifically, results of the secondary analysis suggested that longer latencies from removal of preferred items until problem behavior occurred might be predictive of the relative effectiveness of NCR schedule thinning without extinction. The latency to Dyson's problem behavior (average of 246 s) was significantly longer than the latency to Alan's problem behavior (average of 14 s) following the removal of preferred items, and NCR schedule thinning without extinction eliminated Dyson's problem behavior. Future research should examine this possibility more systematically with additional individuals in order to draw more definitive conclusions.

It also is unknown whether NCR schedule thinning without extinction would have been as effective at leaner schedules. We selected FT 5 min as the terminal NCR schedule based on the termination criteria of previous research; however, longer NCR schedules might be more desirable for caregivers, especially when the reinforcer is access to highly preferred activities. The FT 5-min schedule might be more appropriate for problem behavior maintained by attention, and future research might examine social validity related to this issue.

The reason NCR plus DRA without extinction was effective for the remaining two participants remains unknown. As noted previously, it is possible that it was simply the combination of gradually thinning the NCR schedule while simultaneously providing contingent reinforcement for a relatively low-effort response (card exchange). However, there are no data to show that the mand was less effortful than problem behavior for the current participants, and it seems a tenuous hypothesis that card exchange was less effortful than screaming for Alan.

Another possibility is that the mand training procedures influenced responding during this condition. Although backward chaining and prompting strategies were used to teach the card exchange response, extinction was in place for problem behavior during training (i.e., reinforcement was not delivered following problem behavior for both participants, and Harry's SIB was blocked). This preceding history might have caused a sequence effect in which problem behavior was lower than it otherwise might have been at the start of the NCR thinning plus DRA intervention, potentially as a result of stimulus control (i.e., the card might have functioned as an S-delta). It is possible that the mand could have been taught without extinction or blocking, using procedures similar to Richman, Wacker, and Winborn (2001). In that study, one participant engaged in aggression to access preferred items, and the researchers taught the participant to hand a card to the caregiver without the use of extinction. Under conditions of continuous reinforcement for mands and aggression, the participant generally engaged in the mand and little problem behavior occurred. Therefore, the prior exposure to extinction for our participants might have accounted for why problem behavior never occurred during the NCR thinning plus DRA phase rather than occurring at low rates, as in the Richman et al. study.

Despite these limitations, results of this study suggest that adding DRA to NCR is a promising approach to the treatment of problem behavior without extinction, especially during the schedule thinning process. NCR is often viewed as a straightforward and reinforcement-based behavioral intervention, and this study provides a means of programming the intervention when caregivers cannot or will not implement extinction to produce clinically significant reductions in problem behavior.

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AN INVESTIGATION OF DIFFERENTIAL REINFORCEMENT OF ALTERNATIVE BEHAVIOR WITHOUT EXTINCTION

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We manipulated relative reinforcement for problem behavior and appropriate behavior using differential reinforcement of alternative behavior (DRA) without an extinction component. Seven children with developmental disabilities participated. We manipulated duration (Experiment 1), quality (Experiment 2), delay (Experiment 3), or a combination of each (Experiment 4), such that reinforcement favored appropriate behavior rather than problem behavior even though problem behavior still produced reinforcement. Results of Experiments 1 to 3 showed that behavior was often sensitive to manipulations of duration, quality, and delay in isolation, but the largest and most consistent behavior change was observed when several dimensions of reinforcement were combined to favor appropriate behavior (Experiment 4). Results suggest strategies for reducing problem behavior and increasing appropriate behavior without extinction.

Key words: attention deficit hyperactivity disorder, autism, concurrent schedules, differential reinforcement, extinction, problem behavior

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Differential reinforcement is a fundamental principle of behavior analysis that has led to the development of a set of procedures used as treatment for problem behavior (Cooper, Heron, & Heward, 2007). One of the most frequently used of these procedures is the differential reinforcement of alternative behavior (DRA). DRA typically involves withholding reinforcers following problem behavior (extinction) and providing reinforcers following appropriate behavior (Deitz & Repp, 1983). Pretreatment identification of the reinforcers that maintain problem behavior (i.e., functional analysis) permits the development of extinction procedures, which, by definition, must match the function of problem behavior (Iwata, Pace, Cowdery, & Miltenberger, 1994). In addition, the reinforcer maintaining problem behavior can be delivered contingent on the occurrence of an alternative, more appropriate response. Under these conditions, DRA has been successful at reducing problem behavior (Dwyer-Moore & Dixon, 2007; Vollmer & Iwata, 1992).

Although extinction is an important and powerful component of DRA, it is, unfortunately, not always possible to implement it (Fisher et al., 1993; Hagopian, Fisher, Sullivan, Acquisto, & LeBlanc, 1998). For example, a caregiver may be physically unable to prevent escape with a large or combative individual, leading to compromises in integrity of escape extinction. It would also be difficult to withhold reinforcement for behavior maintained by attention in the form of physical contact if physical blocking is required to protect the individual or others. For example, if an individual's attention-maintained eye gouging

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is a threat to his or her eyesight, intervention is necessary to protect vision.

Several studies have found that DRA is less effective at decreasing problem behavior when implemented without extinction (Volkert, Lerman, Call, & Trosclair-Lasserre, 2009). For example, Fisher et al. (1993) evaluated functional communication training (FCT; a specific type of DRA procedure) without extinction, with extinction, and with punishment contingent on problem behavior. Results showed that when FCT was introduced without an extinction or punishment component for problem behavior, the predetermined goal of 70% reduction in problem behavior was met with only one of three participants. FCT was more effective at reducing problem behavior when extinction was included, and the largest and most consistent reduction was observed when punishment was included.

Hagopian et al. (1998) conducted a replication of the Fisher et al. (1993) study and found that a predetermined goal of 90% reduction in problem behavior was not achieved with any of 11 participants exposed to FCT without extinction. When FCT was implemented with extinction, there was a 90% reduction in problem behavior for 11 of 25 applications, with a mean percentage reduction in problem behavior of 69% across all applications.

McCord, Thomson, and Iwata (2001) found that DRA without extinction had limited effects on the self-injurious behavior of two individuals, one whose behavior was reinforced by avoidance of transition and another whose behavior was reinforced by avoidance of transition and avoidance of task initiation. In both cases, DRA with extinction and response blocking produced sustained decreases in self-injury. These examinations of research on DRA without extinction have shown a bias in responding toward problem behavior when the rate and immediacy of reinforcement of problem and appropriate behavior are equivalent.

When considering variables that contribute to the effectiveness (or ineffectiveness) of DRA without extinction as a treatment for problem behavior, it is helpful to conceptualize differential reinforcement procedures in terms of a concurrent-operants arrangement (e.g., Fisher et al., 1993; Mace & Roberts, 1993). Concurrent schedules are two or more schedules in effect simultaneously. Each schedule independently arranges reinforcement for a different response (Ferster & Skinner, 1957). The matching law provides a quantitative description of responding on concurrent schedules of reinforcement (Baum, 1974; Herrnstein, 1961). In general, the matching law states that the relative rate of responding on one alternative will approximate the relative rate of reinforcement provided on that alternative. Consistent with the predictions of the matching law, some studies have reported reductions in problem behavior without extinction when differential reinforcement favors appropriate behavior rather than problem behavior (Piazza et al., 1997; Worsdell, Iwata, Hanley, Thompson, & Kahng, 2000).

For example, Worsdell et al. (2000) examined the effect of reinforcement rate on response allocation. Five individuals whose problem behavior was reinforced by social positive reinforcement were first exposed to an FCT condition in which both problem and appropriate behavior were reinforced on fixed-ratio (FR) 1 schedules. During subsequent FCT conditions, reinforcement for problem behavior was made more intermittent (e.g., FR 2, FR 3, FR 5), while appropriate behavior continued to be reinforced on an FR 1 schedule. Four of the participants showed shifts in response allocation to appropriate behavior as the schedule of reinforcement for problem behavior became more intermittent. There were several limitations to this research. For example, reinforcement rate was thinned in the same order for each participant such that reductions in problem behavior may have been due in part to sequence effects. In addition, the reinforcement schedule was thinned to FR 20 for two individuals. For these two participants, problem behavior rarely contacted reinforcement. The schedule in these cases may have been functionally equivalent to extinction rather than intermittent reinforcement. Nevertheless, these results suggest that extinction may not be a necessary treatment component when the rate of reinforcement favors appropriate behavior rather than problem behavior.

In another example of DRA without extinction, Piazza et al. (1997) examined the effects of increasing the quality of reinforcement for compliance relative to reinforcement associated with problem behavior. Three individuals whose problem behavior was sensitive to negative reinforcement (break from tasks) and positive reinforcement (access to tangible items, attention, or both) participated. Piazza et al. systematically evaluated the effects of reinforcing appropriate behavior with one, two, or three of the reinforcing consequences (a break, tangible items, attention), both when problem behavior produced a break and when it did not (escape extinction). For two of the three participants, appropriate behavior increased and problem behavior decreased when appropriate behavior produced a 30-s break with access to tangible items and problem behavior produced a 30-s break. The authors suggested that one potential explanation for these findings is that the relative rates of appropriate behavior and problem behavior were a function of the relative value of the reinforcement produced by escape. It is unclear, however, whether the intervention would be effective with individuals whose problem behavior was sensitive to only one type of reinforcement.

Together these and other studies have shown that behavior will covary based on rate, quality, magnitude, and delay of reinforcement. Responding will favor the alternative associated with a higher reinforcement rate (Conger & Killeen, 1974; Lalli & Casey, 1996; Mace, McCurdy, & Quigley, 1990; Neef, Mace, Shea, & Shade, 1992; Vollmer, Roane, Ringdahl, & Marcus, 1999; Worsdell et al., 2000), greater quality of reinforcement (Hoch, McComas, Johnson, Faranda, & Guenther, 2002; Lalli et al., 1999; Neef et al.; Piazza et al., 1997), greater magnitude of reinforcement (Catania, 1963; Hoch et al., 2002; Lerman, Kelley, Vorndran, Kuhn, & LaRue, 2002), or more immediate delivery of reinforcement (Mace, Neef, Shade, & Mauro, 1994; Neef, Mace, & Shade, 1993; Neef, Shade, & Miller, 1994).

Although previous research suggests that extinction may not always be a necessary component of differential reinforcement treatment packages, as described above there were certain limitations inherent in previous investigations. In addition, there has not been a comprehensive analysis of several different reinforcement dimensions both singly and in combination. The current study sought to extend this existing research by examining the influence of multiple dimensions of reinforcement and by incorporating variable-interval (VI) reinforcement schedules.

Interval schedules are less likely than ratio schedules to push response allocation exclusively toward one response over another. Under ratio schedules, reinforcer delivery is maximized when responding favors one alternative (Herrnstein & Loveland, 1975). Under interval schedules, reinforcer delivery is maximized by varying response allocation across alternatives (MacDonall, 2005). If responding favors one response alternative over another under an interval schedule, this would indicate a bias in responding that is independent of the schedule of reinforcement. This bias would not be as easily observable during ratio schedules of reinforcement. In the current application, an interval schedule allowed us to identify potential biases in responding that were independent of the reinforcement schedule. In addition, the application of a VI schedule mimics, to a degree, the integrity failures that could occur in the natural environment.

In the natural environment, caregivers may not always implement extinction procedures accurately. They also may fail to implement reinforcement procedures accurately (Shores et al., 1993). Therefore, it may be important to identify a therapeutic differential reinforcement procedure that is effective despite intermittent reinforcement of both appropriate and problem behavior. The use of concurrent VI schedules in the current experiments allowed the examination of the effects of failure to withhold reinforcement following every problem behavior and failure to reinforce every appropriate behavior in a highly controlled analogue setting.

We evaluated several manipulations that could be considered in the event that extinction either cannot or will not be implemented. In Experiments 1 to 3, we manipulated a single dimension of reinforcement such that reinforcement favored appropriate behavior along the lines of duration (Experiment 1), quality (Experiment 2), or delay (Experiment 3). In Experiment 4, we combined each of these dimensions of reinforcement such that reinforcement favored appropriate behavior.

GENERAL METHOD

Participants and Setting

Seven individuals with developmental disorders who engaged in severe problem behavior participated. These were the first seven individuals who engaged in problem behavior sensitive to socially mediated reinforcement (as identified via functional analysis) and were admitted to an outpatient clinic (Justin, Henry, Corey, Kenneth, Lana) or referred for behavioral consultation services at local elementary schools (George, Clark). (See Table 1 for each participant's age, diagnosis, problem behavior, and appropriate behavior.) We selected the targeted appropriate behavior for each participant based on the function of problem behavior. For example, if an individual engaged in problem behavior to access attention, we selected a mand for attention as the appropriate behavior. Targeted response forms were in the participants' repertoires, although the behavior typically occurred at low rates.

Session rooms in the outpatient clinic (3 m by 3 m) were equipped with a one-way observation window and sound monitoring. We conducted sessions for George and Clark in a classroom at their elementary schools. The rooms for all participants contained materials necessary for a session (e.g., toys, task materials), and the elementary school classrooms contained materials such as posters and tables (George and Clark only). With the exception of the final experimental condition assessing generality, no other children were in the room during the analyses with George and Clark.

Trained clinicians served as therapists and conducted sessions 4 to 16 times per day, 5 days per week. Sessions were 10 min in duration, and there was a minimum 5-min break between each session. We used a multielement design during the functional analysis and a reversal design during all subsequent analyses.

Response Measurement and Interobserver Agreement

Observers were clinicians who had received training in behavioral observation and had previously demonstrated high interobserver agreement scores (>90%) with trained observers. Observers in the outpatient clinic sat behind a one-way observation window. Observers in the school sat out of the direct line of sight of the child. All observers collected data on desktop or laptop computers that provided real-time data and scored events as either frequency (e.g., aggression, disruption, self-injury, and screaming) or duration (e.g., delivery of attention, escape from instructions; see Table 1 for operational definitions of behavior). Observations were divided into 10-s bins, and observers scored the number (or duration) of observed responses for each bin. The smaller number (or duration) of observed responses within each bin was divided by the larger number and converted to agreement

Table 1
Participants' Characteristics

Name	Age (years)	Diagnosis	Problem behavior	Appropriate behavior
Justin	7	Attention deficit hyperactivity disorder instructional (ADHD)	Aggression: forcefully hitting, kicking, biting others' body parts, pinching skin between fingers, scratching others with nails, forceful pushing, and head head butting others. Behavior drew blood or caused bruises on his victims. Disruption: forcefully throwing objects and hitting walls. Inappropriate sexual behavior: touching himself or the therapist in a sexual way by contact of the hand to the torso, bottom, or genitals.	Compliance with demands such as "fold the clothing" or "pick up the trash."
Henry	8	Autism	Aggression: forcefully hitting and kicking others resulting in bruising his victims. Disruption: forcefully throwing objects.	Exchange of a picture card
Corey	9	Autism and ADHD	Aggression: forcefully hitting, biting, spitting, and kicking resulting in bruising or bleeding of victims. Disruption: forcefully throwing objects around room and at people, tearing paper materials.	Vocal request ("May I have my toy please?")
Kenneth	6	Autism	Aggression: forcefully hitting, scratching, and pinching resulting in bleeding or bruising of victims. Disruption: throwing objects around room and at people.	Exchange of a picture card
Lana	4	Autism	Aggression: forcefully hitting, kicking, and scratching resulting in bruising or bleeding in victims.	Sign language (sign for "play")
George	10	Autism	Aggression: forcefully hitting, kicking, and biting resulting in bruising or bleeding victims. Disruption: throwing objects around the room and at people.	Exchange of a picture card
Clark	12	Autism	Aggression: hitting, kicking, and scratching resulting in bruising or bleeding of victims.	Vocal request ("toy please")

percentages for frequency measures (Bostow & Bailey, 1969). Agreement on the nonoccurrence of behavior within any given bin was scored as 100% agreement. The agreement scores for bins were then averaged across the session.

Two independent observers scored the target responses simultaneously but independently during a mean of 37% of functional analysis sessions (range, 27% to 49%) and 29% of experimental analysis sessions (range, 25% to 32%). We assessed interobserver agreement for problem behavior (aggression, disruption, inappropriate sexual behavior) and appropriate behavior (compliance and mands) of all participants and for the therapist's behavior, which included therapist attention, delivery of tangible items, and escape from demands.

For Justin, mean agreement was 98% for aggression (range, 87% to 100%), 96% for disruption (range, 85% to 100%), 100% for inappropriate sexual behavior, and 98% for compliance (range, 86% to 100%). For Henry, mean agreement was 100% for aggression, 99.9% for disruption (range, 99.7% to 100%), and 97% for mands (range, 95% to 99%). For Corey, mean agreement was 100% for aggression and disruption and 97% for mands (range, 95% to 100%). For Kenneth, mean agreement was 98% for aggression (range, 94% to 100%), 99% for disruption (range, 97% to 100%), and 99% for mands (range, 95% to 100%). For Lana, mean agreement was 99% for aggression (range, 99% to 100%) and 100% for mands. For George, mean agreement was 99% (range, 98% to 100%) for aggression, 99% for disruption (range, 98% to 100%), and 93% for mands (range, 88% to 99%). Mean interobserver agreement scores for 39% of all sessions was 100% for therapist attention, 99.9% for access to tangible items (range, 99% to 100%), and 100% for escape from instructions.

Stimulus Preference Assessment

We conducted a paired-stimulus preference assessment for each participant to identify a hierarchy of preferred items for use in the functional analysis (Fisher et al., 1992). In addition, for those participants whose problem behavior was reinforced by tangible items (Corey, Lana, and Clark), a multiple-stimulus-without-replacement (MSWO) preference assessment (DeLeon & Iwata, 1996) was conducted immediately prior to each session of the treatment analyses. We used informal caregiver interviews to select items used in the preference assessments, and a minimum of six items were included in the assessments.

Functional Analysis

We conducted functional analyses prior to the treatment evaluation. Procedures were similar to those described by Iwata, Dorsey, Slifer, Bauman, and Richman (1982/1994) with one exception to the procedures for George. His aggression was severe and primarily directed toward therapists' heads; therefore, a blocking procedure was in place throughout the functional analysis for the safety of the therapist. Blocking consisted of a therapist holding up his arm to prevent a hit from directly contacting his head. During the functional analysis, four test conditions (attention, tangible, escape, and ignore) were compared to a control condition (play) using a multielement design.

Figure 1 shows response rates of problem behavior during the functional analyses for Justin, Corey, Kenneth, and Henry. We collected data for aggression and disruption separately and obtained similar results for each topography for all participants; therefore, both topographies were combined in these data presentations. We obtained similar results for inappropriate sexual behavior for Justin, which we combined with aggression and disruption.

Justin engaged in the highest rates of problem behavior in the escape condition. Although the overall trend in the escape condition is downward, inspection of the data showed that he was becoming more efficient in escape behavior by responding only when the therapist presented demands. Corey engaged in the highest rates of problem behavior during the tangible condition. Kenneth engaged in the highest rates of aggression and disruption during the attention and escape conditions. Henry displayed the highest rates of aggression and disruption in the escape condition.

Figure 2 shows the results of the functional analyses for Lana, Clark, and George. Lana and Clark displayed the highest rates of aggression during the tangible condition. George engaged in the highest rates of aggression and disruption during the attention condition.

Baseline

During baseline and all subsequent conditions of Experiments 1 to 4, equal concurrent VI schedules of reinforcement (VI 20 s VI 20 s) were in place for both problem and appropriate behavior. A random number generator selected intervals between 1 s and 39 s, with a mean interval length of 20 s, and the programmed intervals for each session were available on a computer printout. A trained observer timed intervals using two timers set according to the programmed intervals. The first instance of behavior following availability of a reinforcer resulted in delivery of the reinforcer for 30 s (for an exception, see Experiment 1 involving manipulations of reinforcer duration). When reinforcement was available for a response (i.e., the interval elapsed) and the behavior occurred, the observer discreetly tapped on the one-way window from the observation room (clinic) or

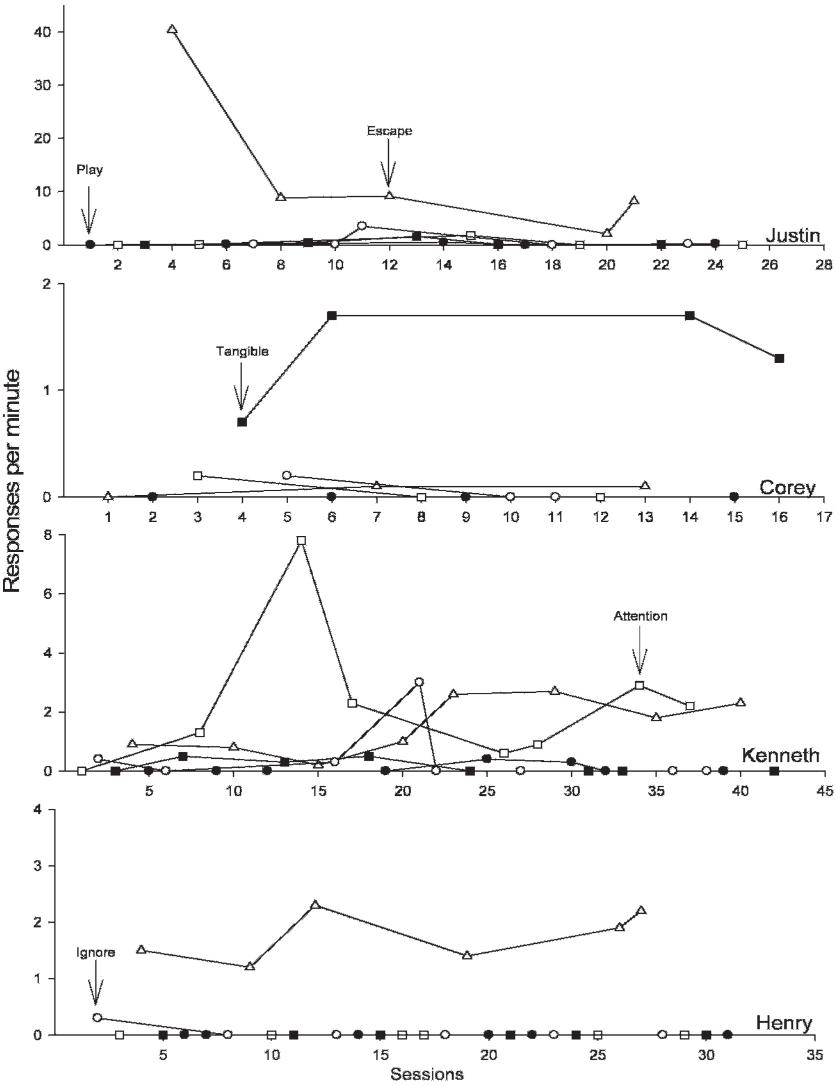

Figure 1. Response rates during the functional analysis for Justin, Corey, Kenneth, and Henry.

briefly nodded his head (classroom) to prompt the therapist to reinforce a response. After 30 s of reinforcer access (or the pertinent duration value in Experiment 1), the therapist removed the reinforcer and reset the timer for that response. The VI clock for one response (e.g., appropriate behavior) stopped while the participant consumed the reinforcer for the other response (e.g., problem behavior). The therapist reinforced responses regardless of the interval of time since the last changeover from the other response alternative. The reinforcer identified for problem behavior in the functional analysis served as the reinforcer for both responses during baseline. In Experiments 2 and 4, which involved manipulations of quality, participants received the same high-quality toy contingent on appropriate or problem behavior during baseline.

We conducted each baseline in the experiment as described but labeled them differently in order to highlight the dimensions of

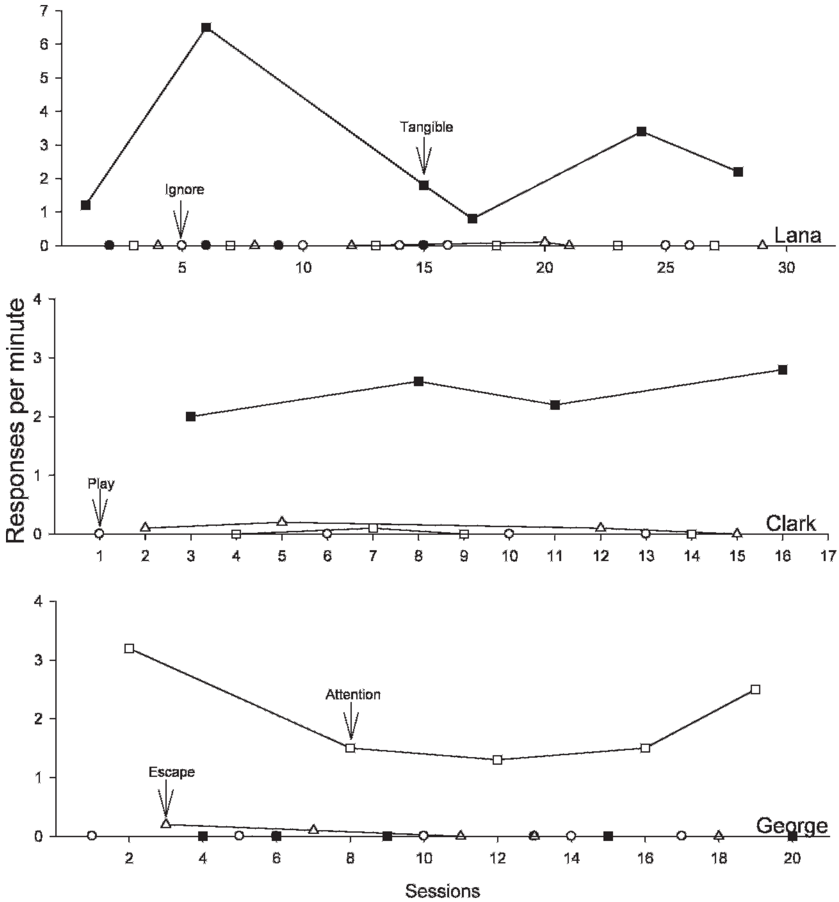

Figure 2. Response rates during the functional analysis for Lana, Clark, and George.

reinforcement that varied across experiments. For example, in Experiment 1 we manipulated duration of reinforcement, and baseline is labeled 30-s/30-s dur to indicate that reinforcement was provided for 30 s (duration) following problem and appropriate behavior. In Experiment 2, we manipulated quality of reinforcement, and baseline is labeled 1 HQ/1 HQ to indicate that a high-quality reinforcer was delivered following appropriate and problem behavior. In Experiment 3, we manipulated delay to reinforcement, and baseline is labeled 0-s/0-s delay. In Experiment 4 we manipulated duration, quality, and delay in combination, and baseline is labeled 30-s dur 1 HQ 0-s delay/ 30-s dur 1 HQ 0-s delay.

EXPERIMENT 1: DURATION

Method

The purpose of Experiment 1 was to examine whether we could obtain clinically acceptable changes in behavior by providing a longer duration of access to the reinforcer following appropriate behavior and shorter duration of access to the reinforcer following problem behavior.

30-s/10-s dur. Justin and Lana participated in the 30-s/10-s dur condition. For Justin, appropriate behavior produced a 30-s break from instructions. Problem behavior produced a 10-s break from instructions. For Lana, appropriate behavior produced access to the most preferred toy for 30 s, and problem behavior produced access to the same toy for 10 s.

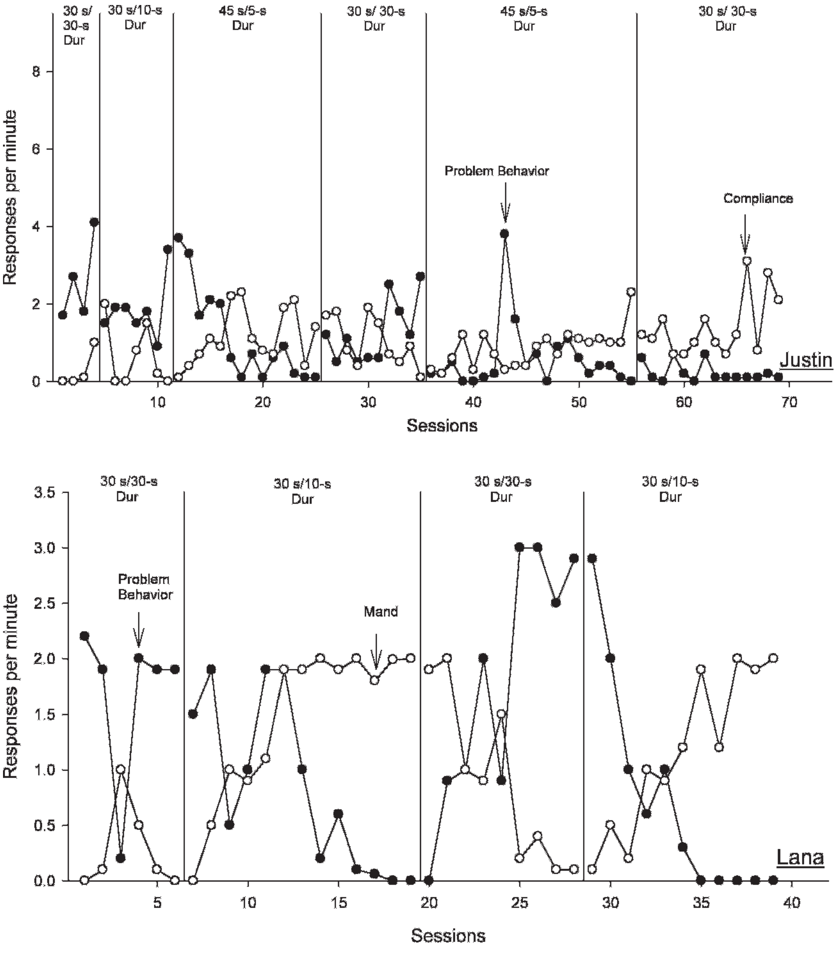

Figure 3. Justin's and Lana's response rates during the duration analysis for problem behavior and appropriate behavior.

45-s/5-s dur. Justin participated in the 45-s/5-s dur condition during which the duration of reinforcement was more discrepant across response alternatives. Appropriate behavior produced a 45-s break from instructions, and problem behavior produced a 5-s break from instructions.

Results and Discussion

Figure 3 shows the results for Justin and Lana. For Justin, during the 30-s/30-s dur baseline condition, problem behavior occurred at higher rates than appropriate behavior. In the 30-s/10-s dur condition, there was a slight decrease in the rate of problem behavior, and some appropriate behavior occurred. Because problem behavior still occurred at a higher rate than appropriate behavior, we conducted the 45-s/5-s dur condition. In the last five sessions of this condition, problem behavior decreased to low rates, and appropriate behavior increased. In a reversal to the 30-s/30-s dur baseline, problem behavior returned to levels higher than appropriate behavior. In the subsequent return to the 45-s/5-s dur condition, the favorable effects were replicated. Responding stabilized in the last five sessions of this condition, with problem behavior remaining low and appropriate behavior remaining high. In a reversal to the 30-s/30-s dur baseline, however, there was a failure to replicate previous baseline levels of responding. Instead, low rates of problem behavior and high rates of appropriate behavior occurred.

During the 30-s/30-s dur baseline, Lana's problem behavior occurred at higher rates than appropriate behavior. During the 30-s/10-s dur condition, appropriate behavior occurred at higher rates, and problem behavior decreased to zero. The effects of the 30-s/30-s dur baseline and the 30-s/10-s dur condition were replicated in the final two conditions.

In summary, the duration analysis indicated that for both participants, the relative rates of problem behavior and appropriate behavior were sensitive to the reinforcement duration available for each alternative in four of the five applications in which duration of reinforcement was unequal. This finding replicates the findings of previous investigations on the effects of reinforcement duration on choice responding (Catania, 1963; Lerman et al., 2002; Ten Eyck, 1970).

There were several limitations to this experiment. For example, the participants did not show sensitivity to the concurrent VI schedules when both the rate and duration of reinforcement were equal. Under this arrangement, the participants would have collected all of the available reinforcers had they distributed their responding roughly equally between the two response options. The failure to distribute responding across responses indicates a bias toward problem behavior. Additional research into this failure to show sensitivity to the concurrent VI schedules is warranted but was outside the scope of this experiment.

With Justin, we were unable to recapture baseline rates of problem and appropriate behavior in our final reversal to the 30-s/30-s dur baseline. This failure to replicate previous rates of responding may be a result of his recent history with a condition in which reinforcement favored appropriate behavior (i.e., the 5 s/45-s dur condition). Nevertheless, this lack of replication weakens the demonstration of experimental control with this participant. With both participants, there was a gradual change in responding in the condition that ultimately produced a change favoring the alternative behavior, which is not surprising given that extinction was not in place. Responding under intermittent schedules of reinforcement can be more resistant to change (Ferster & Skinner, 1957).

EXPERIMENT 2: QUALITY

The purpose of Experiment 2 was to examine whether we could obtain clinically acceptable changes in behavior by providing a higher quality reinforcer following appropriate behavior and lower quality reinforcer following problem behavior.

Method

Reinforcer assessment. We conducted a reinforcer assessment using procedures described by Piazza et al. (1999) before conducting the quality analysis with Kenneth. The assessment identified the relative efficacy of two reinforcers (i.e., praise and reprimands) in a concurrent-operants arrangement. During baseline, the therapist stood in the middle of a room that was divided by painter's tape and provided no social interaction; toy contact (e.g., playing with green or orange blocks on either side of the divided room) and problem behavior resulted in no arranged consequences. Presession prompting occurred prior to the beginning of the initial contingent attention phase and the reversal (described below). During presession prompting, the experimenter prompted Kenneth to make contact with the green and orange toys. Prompted contact with green toys resulted in praise (e.g., "Good job, Kenneth," delivered in a high-pitched, loud voice with an excited tone). Prompted contact with the orange toys resulted in reprimands (e.g., "Don't play with that," delivered in a deeper pitched, loud voice with a harsh tone). Following presession prompting, we implemented the contingent attention phase. The therapist stood in the middle of a room divided by painter's tape and delivered the consequences to which Kenneth had been exposed in presession prompting. The therapist delivered continuous reprimands or praise for the duration of toy contact and blocked attempts to play with two different-colored toys simultaneously.

During the second contingent attention phase, we reversed the consequences associated with each color of toys such that green toys were associated with reprimands and orange toys with praise. The different-colored toys were always associated with a specific side of the room, and the therapist ensured that they remained on that side. Kenneth selected the colored toy associated with praise on a mean of 98% of all contingent attention sessions.

1 HQ/1 LQ. For Justin, problem behavior produced 30 s of escape with access to one low-quality tangible item identified in a presession MSWO. Appropriate behavior produced 30 s of escape with access to one high-quality tangible item identified in a presession MSWO. Although the variable that maintained his problem behavior was escape, we used disparate quality toys as a way of creating a qualitative difference between the escape contingencies for appropriate and problem behavior.

For Kenneth, problem behavior produced reprimands (e.g., "Don't do that, I really do not like it, and you could end up hurting someone"), which the reinforcer assessment identified as a less effective form of reinforcement than social praise. Appropriate behavior produced praise (e.g., "Good job handing me the card; I really like it when you hand it to me so nicely."), which was identified as a more effective form of reinforcement in the reinforcer assessment.

3 HQ/1 LQ. For Justin and Kenneth, problem behavior did not decrease to therapeutic levels in the 1 HQ/1 LQ condition. For Justin, within-session analysis showed that as sessions progressed during the 1 LQ/1 HQ condition, he stopped playing with the toy and showed decreases in compliance, possibly due to reinforcer satiation. Unfortunately, we did not have access to potentially higher quality toys that Justin had requested (e.g., video game systems). Given this limited access, we increased the number of preferred toys provided contingent on appropriate behavior as a way of addressing potential satiation with the toys. We provided three toys selected most frequently in presession MSWO assessments. Therefore, for Justin, in the 3 HQ/1 LQ condition, appropriate behavior produced 30 s of escape with access to three high-quality toys. Problem behavior produced 30 s of escape with access to one low-quality tangible item.

For Kenneth, anecdotal observations between sessions showed that he frequently requested physical attention in the forms of hugs and tickles by guiding the therapist's hands around him or to his stomach. Based on this observation, we added physical attention to the social praise available following appropriate behavior. Therefore, during the 3 HQ/1 LQ condition, appropriate behavior produced praise and the addition of physical attention (e.g., "Good job handing me the card," hugs and tickles). Problem behavior produced reprimands.

Results and Discussion

During the 1 HQ/1 HQ baseline condition, Justin (Figure 4, top) engaged in higher rates of problem behavior than appropriate behavior. In the 1 HQ/1 LQ condition, rates of problem behavior decreased, and appropriate behavior increased. However, toward the end of the phase, problem behavior increased, and appropriate behavior decreased. Lower rates of problem behavior than appropriate behavior were obtained in the 3 HQ/1 LQ condition. During the subsequent 1 HQ/1 HQ baseline reversal, there was a failure to recapture previous rates of problem and appropriate behavior. Instead, problem behavior occurred at a lower rate than appropriate behavior. Despite this, problem behavior increased relative to what was

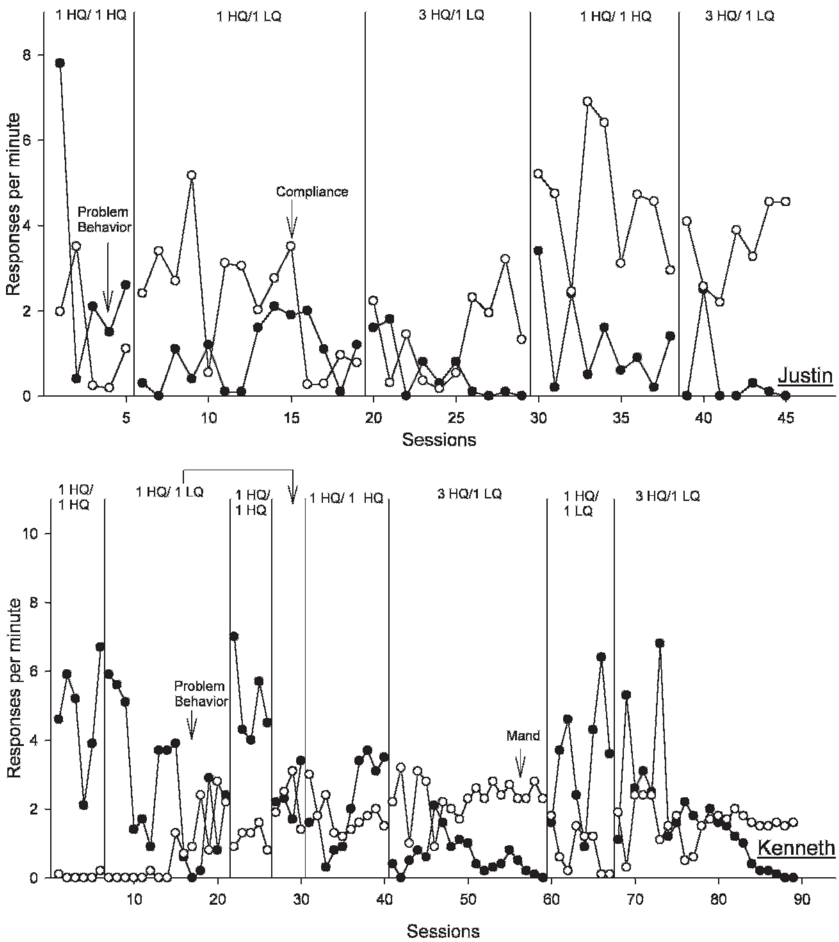

Figure 4. Response rates for Justin and Kenneth during the quality analysis for problem behavior and appropriate behavior.

observed in the immediately preceding 3 HQ/1 LQ condition. Problem behavior decreased, and appropriate behavior increased to high levels during the return to the 3 HQ/1 LQ condition.

Kenneth (Figure 4, bottom) engaged in higher rates of problem behavior than appropriate behavior in the 1 HQ/1 HQ baseline. In the 1 HQ/1 LQ condition, rates of problem behavior decreased, and appropriate behavior increased. During the last five sessions, responding shifted across response alternatives across sessions. During a replication of 1 HQ/1 HQ baseline, we observed high rates of problem behavior and relatively lower rates of appropriate behavior. During a subsequent replication of the 1 HQ/1 LQ condition, slightly higher rates of problem behavior than appropriate behavior were obtained, with responding again shifting across response alternatives across sessions. In a replication of 1 HQ/1 HQ baseline, high rates of problem behavior and lower rates of appropriate behavior were obtained. Following this replication, we conducted the 3 HQ/1 LQ condition, and problem behavior decreased to rates lower than observed in previous conditions and appropriate behavior increased to high rates. The effects of the 1 HQ/1 HQ baseline and the 3 HQ/1 LQ condition were replicated in the final two conditions.

In summary, results of the quality analyses indicated that for both participants, the relative rates of both problem behavior and appropriate behavior were sensitive to the quality of reinforcement available for each alternative. These results replicate the findings of previous investigations on the relative effects of quality of reinforcement on choice responding (Conger & Killeen, 1974; Hoch et al., 2002; Martens & Houk, 1989; Neef et al., 1992; Piazza et al., 1997).

One drawback to this study was the manipulation of both magnitude and quality of reinforcement with Justin. Given the circumstances described above, a greater number of higher quality toys were provided contingent on appropriate behavior relative to problem behavior prior to obtaining a consistent shift in response allocation.

As in Experiment 1, the failure to replicate prior rates of appropriate behavior in our final reversal to the 1 HQ/1 HQ baseline weakened experimental control with Justin. Again, baseline levels of behavior were not recaptured after an intervening history in which the reinforcement quality and magnitude favored appropriate behavior.

EXPERIMENT 3: DELAY

Method

The purpose of Experiment 3 was to examine whether we could produce clinically acceptable changes in behavior by providing immediate reinforcement following appropriate behavior and delayed reinforcement following problem behavior.

0-s/30-s delay. Corey and Henry participated in the 0-s/30-s delay condition. For Corey, appropriate behavior produced 30-s immediate access to a high-quality toy (selected from a presession MSWO). Problem behavior produced 30-s access to the same high-quality toy after a 30-s unsignaled delay. For Henry, appropriate behavior produced an immediate 30-s break from instructions. Problem behavior produced a 30-s break from instructions after a 30-s unsignaled delay. With both participants, once a delay interval started, additional instances of problem behavior did not reset the interval. When problem behavior occurred, the data collector started a timer and signaled the therapist to provide reinforcement when the timer elapsed by a discreet tap on the one-way window. If a participant engaged in appropriate behavior during the delay interval for problem behavior, the therapist immediately delivered the reinforcer for appropriate behavior (as programmed), and the delay clock for problem behavior temporarily stopped and then resumed after the reinforcement interval for appropriate behavior ended.

0-s/60-s delay. When the initial delay interval did not result in therapeutic decreases in problem behavior for Corey, we altered the delay interval such that problem behavior produced 30-s access to a high-quality toy (selected from a presession MSWO) after a 60-s unsignaled delay. Appropriate behavior continued to produce 30-s immediate access to the same high-quality toy. For Henry, problem behavior produced a 30-s break from instructions after a 60-s unsignaled delay, and appropriate behavior continued to produce an immediate 30-s break.

Results and Discussion

During the 0-s/0-s delay baseline, Corey (Figure 5, top) engaged in higher rates of problem behavior than appropriate behavior. In the 0-s/30-s delay condition, problem behavior continued to occur at a higher rate than appropriate behavior. Given this, the 0-s/60-s delay condition was implemented, and a gradual decrease in problem behavior and increase in appropriate behavior was obtained. During a reversal to the 0-s/0-s delay baseline, there was an increase in problem behavior and a decrease in appropriate behavior. In the final reversal to the 0-s/60-s delay condition, Corey became ill with strep throat. His caregiver continued to bring him to the clinic and did not

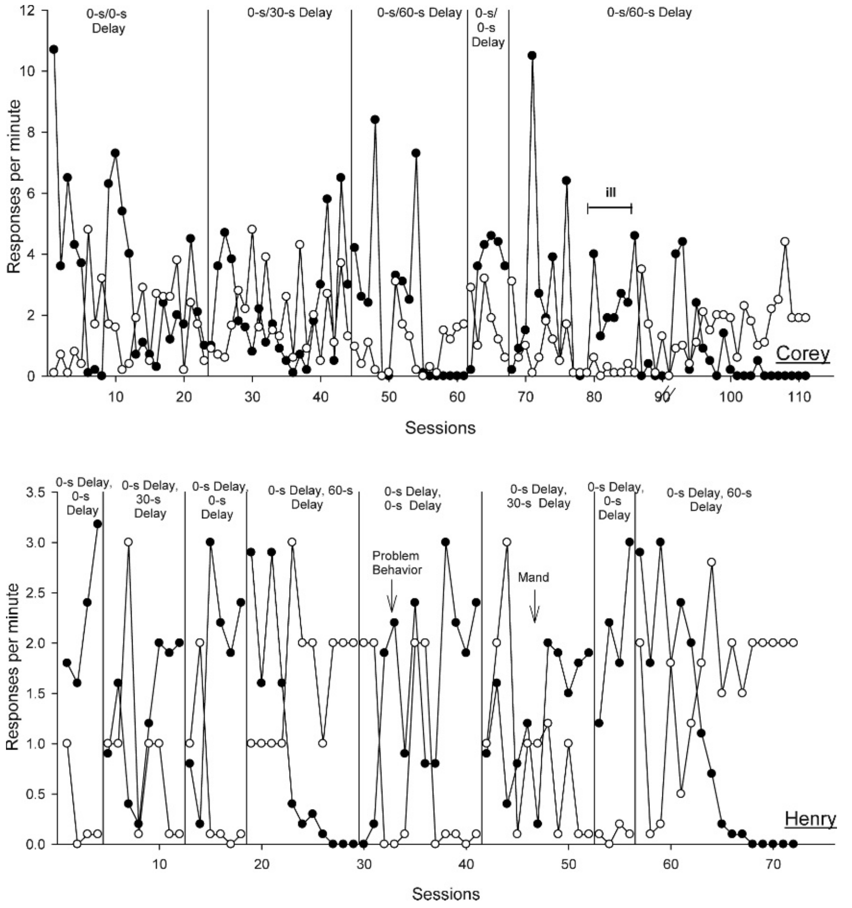

Figure 5. Corey's and Henry's response rates during the delay analysis for problem behavior and appropriate behavior.

inform us until after he began treatment. (We have indicated this period on the graph.) Following his illness, problem behavior ceased, and appropriate behavior increased to high, steady rates.

During the 0-s/0-s delay baseline, Henry (Figure 5, bottom) engaged in higher rates of problem behavior than appropriate behavior. In the 0-s/30-s delay condition, Henry continued to engage in a higher rate of problem behavior than appropriate behavior. In a reversal to 0-s/0-s delay baseline, there was a slight increase in problem behavior from the previous condition and a decrease in appropriate behavior. During the 0-s/60-s delay condition, there was a decrease in problem behavior to zero rates and an increase in appropriate behavior to steady rates of two per minute (perfectly efficient responding given 30-s access). These results were replicated in the reversals to 0-s/0-s delay baseline and 0-s/60-s delay condition.

In summary, results of the delay analysis indicate that the relative rates of problem behavior and appropriate behavior were sensitive to the delay to reinforcement following each alternative. These results replicate the findings of previous investigations on the effects of unsignaled delay to reinforcement (Sizemore & Lattal, 1978; Vollmer, Borrero, Lalli, & Daniel, 1999; Williams, 1976). For example, Vollmer et al. showed that aggression occurred when it produced immediate but small reinforcers even though mands produced larger reinforcers after an unsignaled delay. In their study, participants displayed self-control when therapists signaled the delay to reinforcement.

It is important to note that the programmed delays were not necessarily those experienced by the participant. The occurrence of problem behavior started a timer that, when elapsed, resulted in delivery of reinforcement. Additional problem behavior during the delay did not add to the delay in order to prevent extinction-like conditions. It was therefore possible that problem behavior occurred within the delay interval and resulted in shorter delays to reinforcement. This rarely occurred with Henry. By contrast, Corey's problem behavior sometimes occurred in bursts or at high rates. In these cases, problem behavior was reinforced after delays shorter than the programmed 30 s or 60 s. Nevertheless, the differential delays to reinforcement following inappropriate and appropriate behavior eventually shifted allocation toward appropriate responding. One way to address this potential limitation would be to add a differential reinforcement of other behavior (DRO) component with a resetting reinforcement interval. The resetting feature would result in the occurrence of problem behavior during the interval resetting the interval and therefore delaying reinforcement. With high-rate problem behavior, this DRO contingency would initially result in very low rates of reinforcement, making the condition similar to extinction. We did not add a DRO component in the current experiment because our aim was to evaluate treatments without extinction.

Another potential limitation to the current experiment was the possibility of adventitious reinforcement of chains of problem and appropriate behavior. For example, when appropriate behavior occurred during the delay interval for problem behavior and the VI schedule indicated reinforcement was available for that response, there was immediate reinforcement of appropriate behavior. This reinforcement could have strengthened a chain of problem and appropriate behavior. Although this did not seem to be a concern in the current experiment, one way to control for this limitation would be to add a changeover delay (COD). A COD allows a response to be reinforced only if a certain interval has passed since the last changeover from the other response alternative. The COD could prevent adventitious reinforcement of problem and appropriate behavior and result in longer periods of responding on a given alternative and thus greater control by the relative reinforcement available for those alternatives (Catania, 1966).

EXPERIMENT 4: DURATION, QUALITY, AND DELAY

The purpose of Experiment 4 was to evaluate the effects of delivering immediate, longer duration access to high-quality reinforcement following appropriate behavior and delayed, shorter duration access to low-quality reinforcement following problem behavior. We observed gradual treatment effects in the previous experiments. This was to be expected, because both types of responding were reinforced, but is not an ideal clinical outcome. In addition, experimental control was not clear in several of the cases, and none of the experiments clearly demonstrated how reinforcement that favored appropriate behavior could be used in a practical manner as a treatment for problem behavior. The focus of Experiment 4, therefore, was to combine all the variables and examine whether clinically acceptable changes in behavior could be produced by making reinforcement for appropriate behavior greater along several dimensions. We also assessed the maintenance and generality of treatment effects. George and Clark participated in Experiment 4.

Method

Reinforcer assessment. Before conducting the experimental analyses with George, we conducted a reinforcer assessment using procedures similar to those described in Experiment 2. We compared the reinforcing efficacy of praise (e.g., "Good job, George") and physical contact (e.g., high fives, pats on the back) with reprimands (e.g., "Don't do that") and physical contact (e.g., therapist using his hands to block aggression from George for safety reasons). George allocated a mean of 96% of his responses to the colored toys that resulted in praise and physical contact.

30-s dur HQ 0-s delay/5-s dur LQ 10-s delay. As in previous experiments, equal concurrent VI schedules of reinforcement (VI 20 s VI 20 s) were in place for both problem and appropriate behavior throughout the experiment. For George, appropriate behavior immediately produced 30 s of high-quality attention in the form of social praise and physical attention (e.g., high fives, pats on the back). Problem behavior produced 5 s of low-quality attention in the form of social disapproval and brief blocking of aggression after a 10-s unsignaled delay. For Clark, appropriate behavior produced 30 s of immediate access to a high-preference toy. Problem behavior produced 5 s of access to a low-preference toy after a 10-s unsignaled delay. The therapist timed delays to reinforcement in the same manner as described in Experiment 3. We assessed maintenance of treatment effects and extended treatment across therapists with both participants. George's participation concluded with a 1-month follow-up to evaluate the maintenance of treatment effects. His teacher conducted the final three sessions of this condition. Clark's participation concluded with a 2-month follow-up during which his teacher conducted sessions. Teachers received written descriptions of the protocol, one-on-one training with modeling of the procedures, and feedback after each session regarding the accuracy of their implementation of the procedures.

Results and Discussion

During the 30-s dur 1 HQ 0-s delay/30-s dur 1 HQ 0-s delay baseline, George (Figure 6, top) engaged in higher rates of problem behavior than appropriate behavior. In the 30-s dur HQ 0-s delay/5-s dur LQ 10-s delay condition, there was a decrease in problem behavior and an increase in appropriate behavior. In a reversal to baseline, there was an increase in problem behavior and a decrease in appropriate behavior. In the final reversal to the 30-s dur HQ 0-s delay/5-s dur LQ 10-s delay condition, there was a further decrease in problem behavior and an increase in appropriate behavior. At the 1-month follow-up, no problem behavior occurred, and appropriate behavior remained high.

During the 30-s dur 1 HQ 0-s delay/30-s dur 1 HQ 0-s delay baseline, Clark (Figure 6, bottom) engaged in higher rates of problem behavior than appropriate behavior. In the initial 30-s dur HQ 0-s delay/5-s dur LQ 10-s delay condition, there was a decrease in problem behavior and an increase in appropriate behavior. In a reversal to baseline, there was an increase in problem behavior and a decrease in appropriate behavior. In a reversal to the 30-s dur HQ 0-s delay/5-s dur LQ 10-s delay condition, there was a further decrease in problem behavior and an increase in appropriate behavior. At the 2-month follow-up, no problem behavior occurred, and appropriate behavior remained high.

In summary, results of the combined analyses indicate that for these participants the relative rates of problem behavior and appropriate behavior were sensitive to a combination of the quality, delay, and duration of reinforcement following each alternative. Compared to the first three experiments, Experiment 4 resulted in clear experimental control; there were rapid changes in response allocation across conditions and consistent replications of responding under previous conditions, despite the fact that we did not include an extinction component.

There were several limitations to this experiment. We did not conduct within-subject

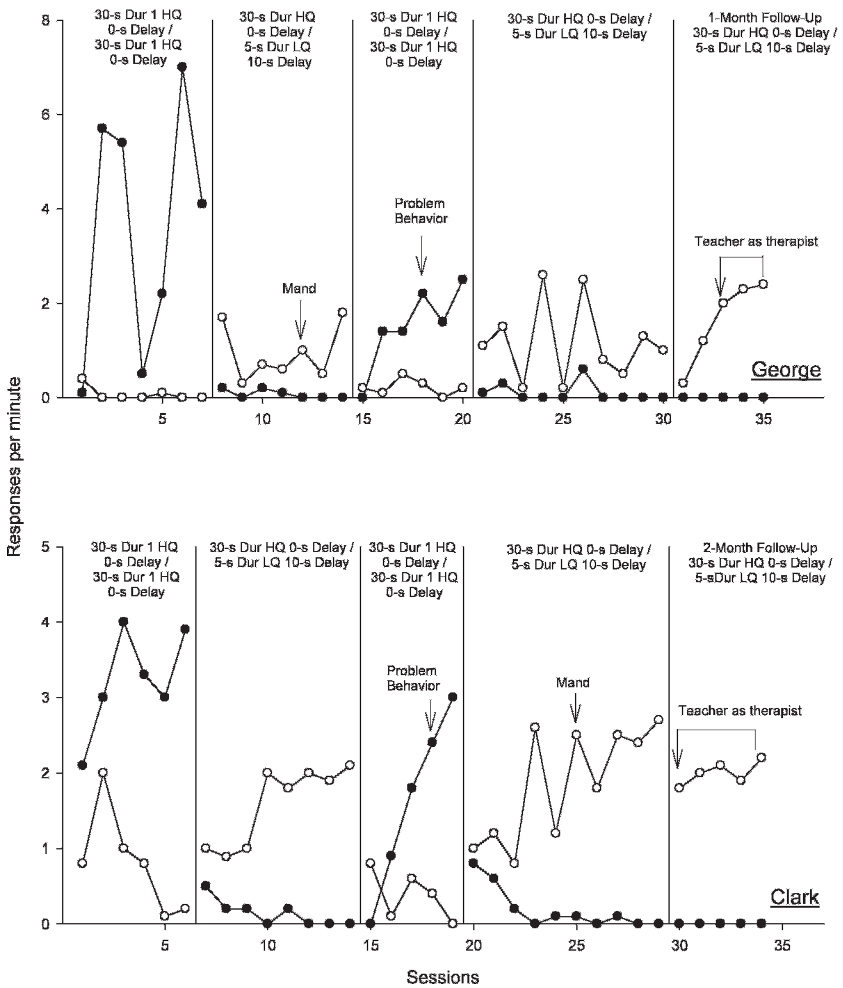

Figure 6. George's and Clark's response rates for problem behavior and appropriate behavior.

comparisons of manipulating single versus multiple dimensions of reinforcement. In addition, the response blocking included in George's case limits conclusions regarding efficacy of treatments that do not include extinction because response blocking may function as either extinction or punishment (Lerman & Iwata, 1996). Unfortunately, George's aggression tended to cause substantial harm to others and warranted the use of the briefest sufficient block to prevent harm. The blocking used during treatment was the same as that used in the functional analysis. The blocking response did not serve to suppress aggression in the functional analysis, and it is doubtful that it exerted any such suppressive effects during the intervention. We did attempt to control for the addition of physical contact required following problem behavior by adding physical contact contingent on appropriate behavior.

A potential strength of this investigation was that we assessed both maintenance and generality of the procedures in a 1-month follow-up, with George's and Clark's teachers serving as therapists in several of the sessions. George's teacher reported that he had a history of attacking peers, making his behavior too severe to ignore. His teacher also indicated that the presence of four other children in the room limited the amount of attention she could deliver following appropriate behavior. Clark's behavior was so severe that prior to this investigation, he had been moved to a classroom in which he was the only student; he returned to a small-size (four peers) classroom following this investigation. The current procedure identified an effective treatment in which teachers delivered a relatively long duration of high-quality reinforcement immediately following some appropriate behavior and brief, low-quality reinforcement after a short delay following some problem behavior. Our specific recommendation to both teachers was to follow the procedures in Experiment 4 to the best of their abilities, with the caveat that each should immediately intervene for aggression that was directed toward peers or was likely to cause severe harm.

GENERAL DISCUSSION

The current experiments attempted to identify differential reinforcement procedures that were effective without extinction by manipulating several dimensions of reinforcement. We sought to extend prior research that focused solely on multiply maintained problem behavior (Piazza et al., 1997) and examined only single manipulations of reinforcement (Lalli & Casey, 1996; Piazza et al.). The present studies showed the effectiveness of DRA that provided some combination of more immediate, longer duration, or higher quality of reinforcement for appropriate behavior relative to reinforcement for problem behavior. In cases in which extinction is not feasible, the current studies offer a method of decreasing problem behavior and increasing appropriate behavior without the use of extinction. For example, if problem behavior is so severe (e.g., severe aggression, head banging on hard surfaces) that it is not possible to withhold or even delay reinforcement, it may be possible to manipulate other parameters of reinforcement such as duration and quality to favor appropriate behavior. If attention maintains problem behavior in the form of severe self-injury, for example, problem behavior could result in brief social attention and appropriate behavior could result in a longer duration of attention in the form of praise, smiles, conversation, laughter, and physical attention such as hugs and tickling.

One potential contribution of the current experiments was procedural. The use of intermittent schedules of reinforcement in the treatment of problem behavior had several benefits. For example, these schedules likely mimic to a degree the schedules of reinforcement in the natural environment. It is unlikely that at home or school, for example, each instance of behavior produces reinforcement. It is likely, however, that variable amounts of appropriate and problem behavior are reinforced or that varying amounts of time pass between reinforced episodes. Further, concurrent VI arrangements allow comparisons to and translations from experimental work on the matching law.

One limitation of these experiments is the brevity and varying length of the conditions. In a laboratory, it may be possible to conduct conditions until meeting a stability criterion (e.g., a difference of less than 5% between data points); however, in a clinical setting, it is not always possible to bring each condition to stability before exposing behavior to another condition (i.e., Corey and Kenneth).

A second potential limitation to the current experiment is the difference in obtained versus programmed schedules of reinforcement. VI schedules of reinforcement involve delivery of a reinforcer for the first response after an average length of time has passed since the last reinforcer. Participants did not always respond immediately after the required length of time elapsed, resulting at times in a less dense reinforcement schedule than programmed. The differences in obtained versus programmed reinforcement schedules were neither large nor consistent, however.

Our study suggests several areas for future research. These experiments included concurrent schedules of VI 20-s reinforcement for problem and appropriate behavior. Future research may involve similar analyses using concurrent-schedules arrangements based on naturalistic observations. The extent to which relative response allocation is similar under descriptive and experimental arrangements may suggest values of reinforcement parameters that may increase both the acceptability and integrity of treatment implementation by caregivers. For example, researchers could conduct descriptive analyses (Bijou, Peterson, & Ault, 1968) with caregivers and analyze the results using reinforcers identified in a functional analysis with procedures similar to those described by Borrero, Vollmer, Borrero, and Bourret (2005). If descriptive analysis data show that problem behavior is reinforced on average every 15 s and appropriate behavior is reinforced on average every 30 s, treatment might involve reinforcing appropriate behavior every 15 s and problem behavior every 30 s.

Investigations similar to the current experiments could further explore the dimensions of quality, duration, and delay with more participants and with additional values of these dimensions. In addition, future researchers could investigate the effect of concurrent manipulations of the dimensions of reinforcement as treatment for problem behavior. For example, when it is not possible to withhold reinforcement for problem behavior, it may be that the rate of reinforcement can continue to favor problem behavior if several dimensions of reinforcement, such as magnitude, quality, and duration, favor appropriate behavior. This area of research may result in the development of more practical and widely adopted interventions for problem behavior.

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MANIPULATING PARAMETERS OF REINFORCEMENT TO REDUCE PROBLEM BEHAVIOR WITHOUT EXTINCTION

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Differential reinforcement of alternative behavior (DRA) most often includes extinction as a treatment component. However, extinction is not always feasible and it can be counter-therapeutic if implemented without optimal treatment integrity. Researchers have successfully implemented DRA without extinction by manipulating various parameters of reinforcement such that alternative behavior is favored. We extended previous research by assessing three participants' sensitivities to quality, magnitude, and immediacy using arbitrary responses and reinforcers that maintain problem behavior. The results were used to implement an intervention for problem behavior using DRA without extinction. Our findings indicate that arbitrary responses can be used to identify individual and relative sensitivity to parameters of reinforcement for reinforcers that maintain problem behavior. Treatment was effective for all participants when we manipulated parameters of reinforcement to which they were most sensitive, and, for two participants, the treatment was less effective when we manipulated parameters to which they were least sensitive.

Key words: DRA, function-based interventions, parametric analysis, problem behavior

Extensive research has established differential reinforcement of an alternative response (DRA) as an effective intervention for problem behavior, particularly when problem behavior is placed on extinction (e.g., Kelley, Lerman, & Van Camp, 2002; Shirley, Iwata, Kahng, Mazaleski, & Lerman, 1997). Perfect treatment integrity for DRA with extinction requires therapists to deliver reinforcers every time an individual engages in an alternative response and refrain from delivering reinforcers following any instance of problem behavior. However, data from at least two studies suggest that errors of omission (failing to deliver reinforcers consistently following alternative behavior) have

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relatively small effects on treatment outcome (St. Peter Pipkin, Vollmer, & Sloman, 2010; Vollmer, Borrero, Lalli, & Daniel, 1999). In comparison, errors of commission (delivering reinforcers following problem behavior) more greatly reduce the effectiveness of DRA, particularly when the rate of reinforcement no longer favors the alternative behavior.

Resources may not always be available to provide the necessary support to ensure DRA with extinction is implemented with optimal treatment integrity, and there are some cases in which extinction is not feasible. For example, when problem behavior is dangerous and reinforced by attention, it may be unreasonable (and unsafe) to prescribe an extinction procedure. Additionally, if extinction is not possible, and problem behavior occurs at a high rate, it may be difficult to manipulate the rate of reinforcement so that it favors alternative behavior. Thus, alternative approaches to DRA without extinction should be considered to improve the feasibility of behavior analytic treatments.

One potential approach is to conceptualize DRA as a concurrent-operants arrangement (e.g., Athens & Vollmer, 2010), in which two independent schedules of reinforcement are in effect simultaneously for two different responses (Ferster & Skinner, 1957). In traditional DRA procedures, the alternative response is initially reinforced on a continuous schedule and problem behavior is on extinction. However, this is only one of many different concurrent schedule arrangements. Other concurrent schedules of reinforcement can be arranged in which problem behavior does result in reinforcement but at a lower rate than that of alternative behavior, so that alternative behavior is differentially favored over problem behavior. Parameters of reinforcement other than rate, such as magnitude, immediacy, and quality, can also produce shifts in response allocation. For example, Borrero, Vollmer, Borrero, and Bourret (2005) found that one participant's behavior appeared sensitive to manipulations of magnitude of reinforcement. Horner and Day (1991) evaluated the effects of immediacy of reinforcement on response allocation between problem behavior and alternative behavior when all other parameters were held constant. One participant, a woman diagnosed with autism and severe mental retardation, engaged in severe self-injury and aggression maintained by negative reinforcement in the form of escape. When immediacy favored problem behavior over alternative behavior, the participant continued to engage in a higher rate of problem behavior; however, her response allocation shifted to the alternative behavior when immediacy was manipulated to favor that behavior. Neef, Mace, Shea, and Shade (1992) reported different patterns of responding for three participants when both reinforcement rate and quality were manipulated. Although evaluated with academic tasks and not problem behavior, quality overrode rate of reinforcement for two individuals; that is, they emitted more of the response that produced higher quality reinforcement at a lower rate than the response resulting in lower quality reinforcement at a higher rate.

Numerous studies have found that sensitivity to parameters of reinforcement varies across individuals (Neef & Lutz, 2001a, 2001b; Neef, Mace, & Shade, 1993; Neef, Shade, & Miller, 1994; Perrin & Neef, 2012), and therefore similar manipulations are unlikely to be similarly effective for different individuals. Collectively, these results suggest that it might be useful for parameter sensitivity to be assessed at an individual level. If sensitivity to various parameters of reinforcement could be assessed in advance, interventions could be prescribed that capitalize on individual differences in parameter sensitivity rather than relying on extinction being carried out with perfect treatment integrity.

Neef et al. (1994) evaluated parameter sensitivity for six individuals using arbitrary responses (i.e., math problems) rather than problem behavior. The authors used an automated computer-based assessment that presented pairs of math problems from which participants could choose. Each option was associated with a reinforcement contingency that could be manipulated across different parameters; that is, if students answered the problem on the left correctly, they contacted one contingency, and if students answered the problem on the right correctly, they contacted a different contingency. The goal of the assessment was to identify relative sensitivity across rate, quality, immediacy, and response effort by pitting each parameter against every other parameter. For example, to compare sensitivity to quality, response allocation was recorded when high- and low-quality reinforcers were combined with other parameters: high and low rate of reinforcement, high and low response effort, and short and long delays to reinforcement. Responding differed across individuals when dimensions were combined and pitted against one another. Although this procedure identified relative sensitivities to a range of parameters, there are limitations to applying it to assess problem behavior. It might not only be difficult to capture the motivating operations to assess the efficacy of reinforcers that maintain problem behavior, but also it might be difficult to deliver reinforcement via an automated program when problem behavior is maintained by positive reinforcement, especially in the form of attention. Thus, an alternative procedure appears necessary to assess parameter sensitivity in the context of problem behavior.

Athens and Vollmer (2010) evaluated individual sensitivities of problem behavior to magnitude, quality, and immediacy of reinforcement. After identifying the function of problem behavior (aggression) for seven children, independent assessments were conducted to determine whether individuals' behavior was sensitive to quality, magnitude, and immediacy manipulations. The assessments consisted of a concurrent-schedule arrangement in which both problem behavior and alternative behavior were reinforced; however, parameters of reinforcement either favored problem behavior or alternative behavior. When the contingencies were reversed, a shift in responding was observed such that more responding was allocated to the response that produced the highest quality, largest magnitude, or most immediate consequence.

Athens and Vollmer (2010) proposed an assessment procedure that might reasonably be applied to problem behavior. However, the procedures employed by Athens and Vollmer require the participants to engage in problem behavior, which could be problematic depending on the severity of the behavior. A blended approach that combines the advantages of Athens and Vollmer's use of reinforcers maintaining problem behavior with Neef et al.'s (1994) use of arbitrary responses might be useful. One benefit of using arbitrary responses to identify sensitivities to parameters of reinforcement, as in Neef et al. (1994), is that it does not require an individual to engage in problem behavior. Although not evaluated in the context of problem behavior, basic researchers have previously demonstrated that participant responses to hypothetical tests to determine sensitivity to immediacy of reinforcement is indicative of how the individuals will allocate responding in real choice situations (Odum, 2011). Thus, other parameter sensitivities identified in analog assessments may also predict sensitivities in other contingency arrangements; that is, it may be possible to assess sensitivity to different parameters in the context of arbitrary responses rather than problem behavior, but then to apply the results to a DRA-without-extinction procedure.

Thus, the purpose of this study was to determine whether arbitrary responses (not problem behavior) could be used to identify individual and relative sensitivities to quality, magnitude, and immediacy for individuals who engage in problem behavior maintained by social-positive reinforcement. Additionally, we evaluated whether a DRA procedure in which problem behavior was not placed on extinction was effective when the alternative behavior was differentially favored using the parameter of reinforcement to which the participant was most and least sensitive.

GENERAL METHODS

Participants and Setting

Three individuals participated in this study: Rufus, Sabrina, and Max. Rufus was a 31-year-old male diagnosed with cerebral palsy and a visual impairment; however, he could differentiate between colors, shapes, and large pictures and objects. He was referred for aggression, property destruction, and inappropriate vocalizations. Sabrina was a 24-year-old female diagnosed with mood disorder, autism spectrum disorder, post-traumatic stress disorder, psychotic disorder (not otherwise specified; NOS), personality disorder (NOS), and paranoid and antisocial traits. She was referred for inappropriate vocalizations. Max was a 10-year-old male diagnosed with autism spectrum disorder. He was referred for inappropriate vocalizations, disruption, and aggression. All three participants' problem behavior was determined through functional analysis (Iwata, Dorsey, Slifer, Bauman, & Richman, 1982/1994) to be multiply maintained by access to tangibles and escape from demands (Figure 1). The tangible items used in the functional analysis were based on the results of a paired stimulus preference assessment (Fisher et al., 1992) for Rufus and a multiple stimulus without replacement preference assessment (DeLeon & Iwata, 1996) for Sabrina and Max. Items included in the preference assessments included familiar items commonly used by the participants per caregiver report.

We conducted sessions with Rufus in an empty room at a university-based day program that he attended during the week. We conducted sessions with Sabrina and Max in a university-based clinic equipped with a one-way mirror. Both settings included a table and chairs for the participants and therapists and relevant materials for the condition being conducted (e.g., highly preferred items, less preferred items, etc.). We used colored cards and colored touch-lights as response manipulanda in the individual parameter sensitivity assessments and relative parameter sensitivity assessments (additional descriptions provided below).

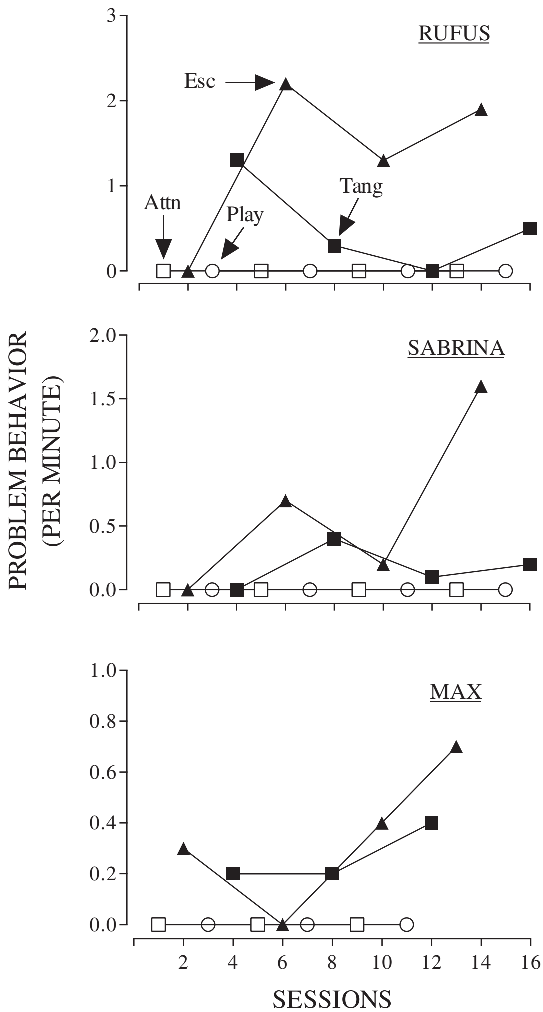

Figure 1. Functional analysis data for Rufus, Sabrina, and Max.

Response Measurement

Topographies of problem behavior included inappropriate vocalizations for all three participants, aggression for Rufus and Max, property destruction for Rufus, and disruption for Max. *Inappropriate vocalizations* were defined as yelling and/or directing profanity toward another person. For Sabrina, inappropriate vocalizations also included name calling and making false accusations about staff or therapists (e.g., "You're torturing me," "You're abusing me"). For Max, inappropriate vocalizations also included grunting vocal protest (e.g., "No you're not," "I don't have to," "I'm not going to"), and threatening to leave the area or call the police or another authority. *Aggression* was defined as hitting, kicking, or grabbing. For Rufus, aggression also included pushing, pinching, biting, and spitting at others. *Property destruction* was defined for Rufus as throwing items (not in the direction of a person), hitting/swiping items off a surface, or hitting any surface with his hand or foot. Finally, *disruption* was defined for Max as stomping one or both of his feet. We collected data on the occurrence of problem behavior throughout the study.

Additionally, in Experiment 1 and 2, we collected data on response allocation between various contingencies. A response was counted when the participant pressed one of the touch-lights such that it illuminated or touched one of the colored cards (Rufus only). Data collectors scored the response as the parameter value selected (e.g., if the card associated with low magnitude reinforcement was touched, "low magnitude" was scored).

Materials

Each participant was presented with a set of buttons that served as the response manipulanda during the parameter sensitivity assessments. For Sabrina and Max, the buttons were 6.4-cm diameter colored touch-lights, which we placed on top of 8.9-cm cards that corresponded in color. We used the same colored cards as the buttons for Rufus; however, the touch-light was omitted to make his selections easier. Different colored buttons and/or cards were used for each assessment. A highly preferred item (iPad for all participants) was used as the high-quality item during the parameter sensitivity assessments. Rufus watched a variety of children's television shows on the iPad, Sabrina played various games and watched movies, and Max played two specific games. Less preferred items (Sesame Street cards for Rufus, a magazine for Sabrina, and an *I Spy* book for Max) were used as low-quality items during the parameter sensitivity assessments.

Token Economy

During the individual and relative parameter sensitivity assessments, we observed both Rufus and Sabrina engage in problem behavior between sessions and during exposure trials. Because both participants had multiply controlled problem behavior (i.e., tangible and escape functions), it is plausible that attending sessions (Sabrina) and being instructed to "pick one" during sessions (Rufus) was evoking problem behavior maintained by escape. We therefore introduced a token economy in which Sabrina received tokens for entering and remaining in the room where sessions were held and Rufus received a token for each instance of compliance with the instruction to make a selection (regardless of the selection made). We selected this intervention because we thought it could easily be implemented and would not interfere with response allocation during the parameter sensitivity assessments. It also allowed us to delay when back-up reinforcement was delivered for compliance (Carr, Frazier, & Roland, 2005), such that we did not adventitiously reinforce participants' response allocation during the parameter sensitivity assessments. A token economy was not necessary for Max.

We introduced the token economy with Rufus during the immediacy sensitivity assessment (Experiment 1). Rufus did not have previous experience with token economies; thus, brief training was provided. Rufus earned stars contingent on making a selection when instructed to do so. The therapist increased the exchange requirement across sessions until he earned five stars before receiving the backup reinforcer (i.e., an edible reinforcer—ranch flavored chip—that was identified as highly preferred during a paired-stimulus preference assessment). It took six training sessions to establish the token economy. Problem behavior only occurred during the initial training session and was placed on extinction. The therapist implemented the token economy for the remainder of the immediacy sensitivity assessment and the tracking test.

We introduced the token economy with Sabrina during the relative parameter sensitivity assessment (Experiment 2) when immediacy was tested against quality. Sabrina had prior experience with token economies; thus, rather than providing training, the therapist described the contingency at the beginning of each appointment. Sabrina earned a happy face for each hour she remained in the therapy room, regardless of the selections she made during the assessments. When she had five happy faces (earned across multiple days), the primary therapist took her to the campus food court where Sabrina could choose to purchase one item that cost less than three dollars. Sabrina consistently selected fruit smoothies as her reinforcer. Problem behavior was not observed presession after the token economy was implemented. The therapist implemented the token economy for the remainder of the relative parameter sensitivity assessment (immediacy vs. quality and magnitude vs. quality).

EXPERIMENT 1: INDIVIDUAL PARAMETER SENSITIVITY ASSESSMENT

The purpose of the individual parameter sensitivity assessment was to assess participants' sensitivity to quality, magnitude, and immediacy using arbitrary responses and reinforcers that maintain problem behavior. We used arbitrary responses to decrease the likelihood of the participants engaging in problem behavior during the assessment. Although all three participants engaged in problem behavior maintained by both social positive reinforcement in the form of access to tangibles and social negative reinforcement in the form of escape, the individual parameter sensitivity assessment exclusively focused on the social positive function. Table 1 contains a summary of the values used for each of the individual parameter sensitivity assessments.

Table 1
Summary of Individual Parameter Sensitivity Assessment Values

Manipulated Parameter	Definition	Consequence 1	Consequence 2	Constant Parameters
Quality	Preference for stimulus	High Quality iPad	Low Quality Rufus: cards Sabrina: magazine Max: book	Magnitude 30-s access Immediacy 0-s delay
Magnitude	Duration of access	High Magnitude 90-s access	Low Magnitude 15-s access	Quality High Immediacy 0-s delay
Immediacy	Delay between behavior and reinforcer delivery	Immediate 0-s delay	Delayed Rufus: 10-s Sabrina: 280-s Max: 136-s	Quality High Magnitude 30-s access

Method

Design. The individual parameter sensitivity assessments consisted of giving the participants an opportunity to choose between two concurrently available buttons that were associated with different parameters of a particular consequence. Each selection resulted in the participant experiencing the relevant consequence associated with that switch. We used an ABAB design in which the contingency associated with each button was reversed across phases to test whether the participant tracked the preferred contingency. For example, if the purple button was associated with a high-quality reinforcer and the green button was associated with a low-quality reinforcer in the first phase, during the subsequent phase, the green button was associated with the high-quality reinforcer and the purple button was associated with the low-quality reinforcer.

Each session consisted of 10 trials in which a therapist presented the participant with the two buttons and instructed them to "pick one." During the trials, all other materials were kept off the table (i.e., reinforcers were not present) until the participant made a selection and the therapists positioned their timers facing away from the participants so that there were no visible cues associated with the different contingencies. Contingent on a selection, the therapist delivered the corresponding consequence. Throughout all individual parameter sensitivity assessments all instances of problem behavior were ignored and the therapist honored all bids for attention.

A second trained observer collected data for 59% of the individual parameter sensitivity assessment sessions. An agreement was defined as both data collectors scoring the same selected parameter value (e.g., low magnitude) during a given choice opportunity. Reliability was calculated for each session by taking the number of agreements and dividing by the total number of agreements plus disagreements and multiplying by 100 to yield a percentage. Mean reliability across sessions was 99% (range, 95%-100%).

Procedure

Throughout the experiment, we collected data on the occurrence of problem behavior (rate) and response allocation.

Exposure trials. Prior to each phase of the individual parameter sensitivity assessments, we conducted six exposure trials (three per switch). Each exposure trial consisted of presenting the relevant antecedent for problem behavior by restricting highly preferred items and prompting the participant to touch one of the buttons. The therapist then delivered the relevant consequence associated with that button (e.g., 15-s vs. 90-s access to tangibles). Sessions within a phase sometimes took place across multiple days; therefore, therapists conducted two exposure trials (one for each switch) prior to the first session of the day to increase the likelihood of behavior in session coming under the control of the arranged contingencies.

Quality sensitivity assessment. The purpose of the quality sensitivity assessment was to evaluate sensitivity to quality of reinforcement. Thus, we made a high-quality reinforcer (i.e., highly preferred item) and a low-quality reinforcer (i.e., less preferred item) available. The high-quality stimulus was defined as a stimulus selected in more than 80% of trials in the tangible preference assessment (Koehler, Iwata, Roscoe, Rolider, & O'Steen, 2005). The low-quality stimulus was defined as a stimulus that was selected in 10% to 30% of trials during the tangible preference assessment (Koehler et al., 2005). We hypothesized that stimuli that fell within this range would still function as reinforcers despite being identified as less preferred (Roscoe, Iwata, & Kahng, 1999).

During the quality sensitivity assessment, either the high-quality item or the low-quality item was delivered contingent on the button selected. We kept magnitude and immediacy constant; that is, therapists delivered the selected item immediately and for 30 s, regardless of the item was selected.

Magnitude sensitivity assessment. The purpose of the magnitude sensitivity assessment was to evaluate sensitivity to reinforcer magnitude (i.e., duration of access to reinforcer). We set the magnitude values based on values used in Athens and Vollmer (2010). Athens and Vollmer used a 1:6 ratio in setting magnitude values; thus, low magnitude was 15-s access and high magnitude was 90-s access. For Rufus and Max, we doubled the high magnitude to 180 s (a 1:12 ratio) after not observing sensitivity to the high magnitude at 90 s.

During the magnitude sensitivity assessment, therapists delivered either the high-magnitude or low-magnitude consequence contingent on the button selected. Subsequent trials were conducted immediately following the termination of the low or high magnitude reinforcement interval. We kept quality and immediacy constant; that is, both selections resulted in the therapists delivering the high-quality item immediately.

Immediacy sensitivity assessment. The purpose of the immediacy sensitivity assessment was to test for sensitivity to immediacy of reinforcement. The immediate value was a 0-s delay. For the delay condition, we wanted to set a delay that would both affect response allocation and be anchored to an aspect of behavior maintained by that individual's reinforcer. We felt this approach might be more favorable than selecting an arbitrary but equal delay for each participant. Hence, we selected a delay that was twice as long as the median interresponse time (calculated with reinforcement intervals omitted) in the tangible condition of the functional analysis. Previous research suggests interresponse time is sensitive to individual motivation for reinforcement and is commonly used as a basis for determining schedules of reinforcement (e.g., Kahng, Iwata, DeLeon, & Wallace, 2000). Median values were selected over means because the former are less sensitive to outliers. This resulted in a delay value of 10 s for Rufus, 280 s for Sabrina, and 136 s for Max. We doubled the delay for Rufus to 20 s (four times the median IRT) after we did not observe sensitivity to immediacy.

During the immediacy sensitivity assessment, therapists either delivered reinforcement immediately or after a delay, contingent on the button selected. We kept quality and magnitude constant; that is, both selections produced the highly preferred item for 30 s.

Tracking test. Due to Rufus' insensitivity to magnitude and immediacy, we conducted a tracking test to assess side and color bias that might have masked the effects of manipulating these parameters. Using the same colors used in the immediacy sensitivity assessment, we tested immediacy against quality (a parameter to which Rufus showed sensitivity). One button was associated with the low-quality item delivered immediately and the other button was associated with the high-quality item delivered after a 20-s delay. We used an ABA design to demonstrate that he tracked contingencies when a parameter to which he was sensitive was manipulated.

Results

Rufus. Rufus' parameter sensitivity data are depicted in Figure 2. In the quality sensitivity assessment, Rufus consistently allocated more responding to the card associated with the high-quality item, even when the contingencies were switched across phases. These data suggest he was sensitive to quality of reinforcement.

When we assessed sensitivity to magnitude, data were less consistent. Initially, Rufus alternated between the high- and low-magnitude options. We increased the high-magnitude value to 180 s (session 7), but he continued to allocate more responding to the button associated with low magnitude. When we switched the contingencies across phases, Rufus continued to allocate his responding to the pink button (positioned on the right) regardless of the contingency associated with it, indicating either

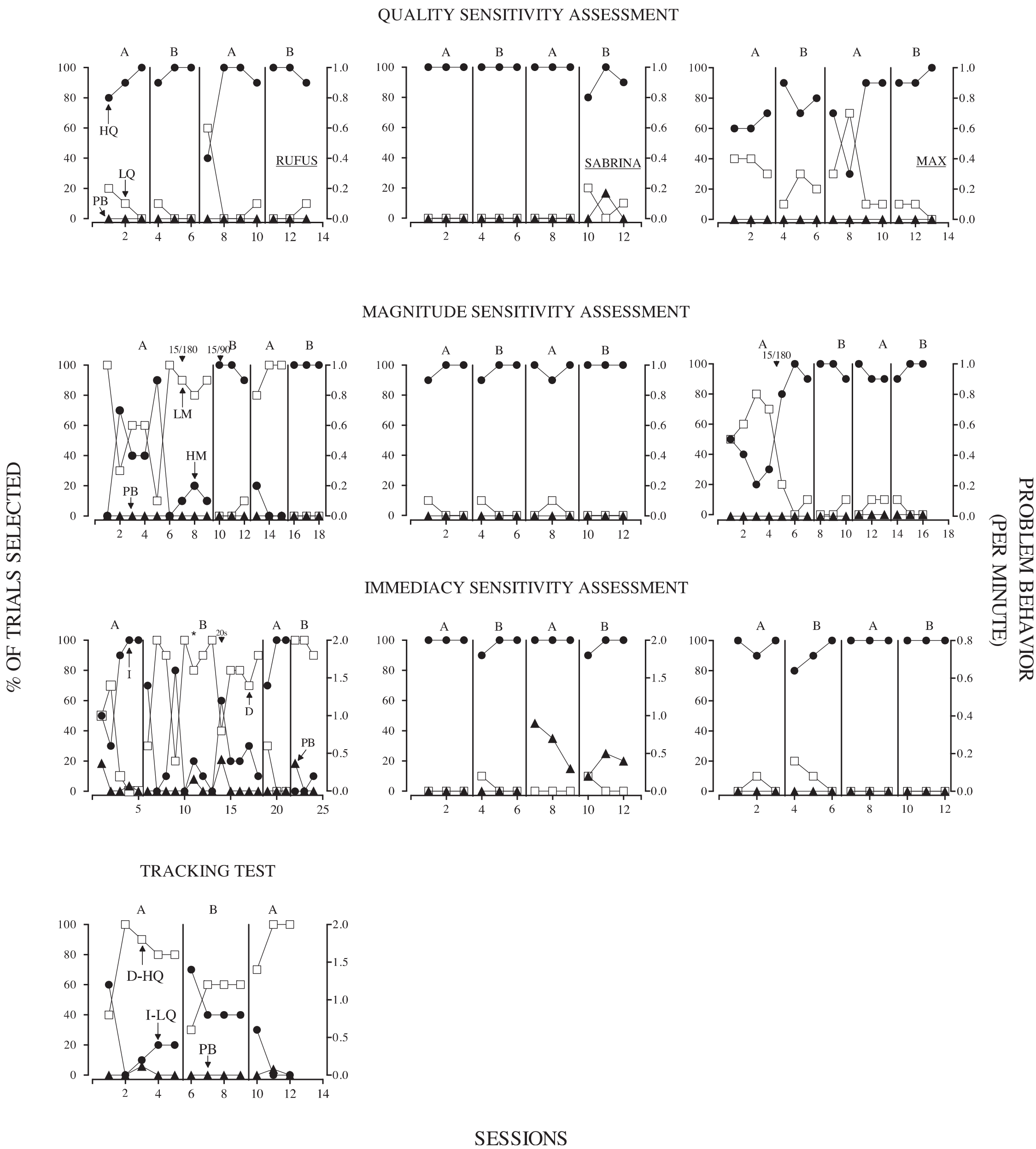

Figure 2. Individual parameter sensitivity assessments for Rufus (left column), Sabrina (center column), and Max (right column). PB = Problem behavior; HQ = high quality; LQ = low quality; HM = high magnitude; LM = low magnitude; I = immediate; D = delay. The asterisk on Rufus' immediacy sensitivity assessment graph denotes when the token economy was introduced. The bottom row depicts Rufus' tracking test.

a lack of sensitivity to magnitude at these values or a potential position or color bias.

When we assessed sensitivity to immediacy, he initially allocated more responding to the button associated with immediate reinforcement. However, when we switched the contingencies, he continued to select the red button (positioned on the right). The therapist introduced the token economy with Rufus at session 11 when we observed an increase in problem behavior between sessions and during exposure trials. The token economy did not appear to affect his response allocation, as he continued to select the button associated with the delayed consequence more frequently. We increased the delay to 20 s (session 14) to see if he would be sensitive to a longer delay; however, he continued to select the red button (positioned on the right) regardless of the consequence associated with it. These results suggest that he was not sensitive to immediacy of reinforcement at the delays we tested or that there was a position or color bias.

A tracking test was conducted after we failed to observe sensitivity to two parameters to examine whether extraexperimental features (e.g., side bias, color bias) were overriding the effects of the parameter manipulations. Rufus consistently allocated more responding to the button associated with the high-quality delayed consequence, regardless of the button color or side on which it was presented. This indicates that Rufus tracked consequences when parameters to which he was sensitive were manipulated. Thus, we concluded he was sensitive to only quality of reinforcement at the parameter values we manipulated.

Sabrina. The results of Sabrina's quality sensitivity assessment are depicted in Figure 2. Sabrina consistently selected the button associated with the high-quality item more than the button associated with the low-quality item. Additionally, she tracked the contingencies across phases, suggesting that Sabrina was sensitive to quality as a parameter of reinforcement. Similar patterns of responding were observed during the magnitude sensitivity assessment, suggesting she was also sensitive to magnitude of reinforcement. During the immediacy sensitivity assessment, Sabrina allocated more responding to the option that produced immediate reinforcement. She tracked the contingencies across phases; however, we observed a higher rate of problem behavior (range, 0.2-0.9) during the last two phases of the assessment. Nonetheless, her response allocation suggests she was also sensitive to immediacy as a parameter of reinforcement.

Max. Max's data are depicted in Figure 2. When we assessed sensitivity to quality, he consistently allocated more responding to the button that produced the high-quality reinforcer. This was consistent across phases, showing that he tracked contingencies, and suggesting he is sensitive to quality of reinforcement. For magnitude of reinforcement manipulations, Max initially allocated more responding to the button that was associated with low-magnitude reinforcement. Similar to Rufus, we increased the value of the high-magnitude option from 90 s to 180 s (session 4). At these values, we saw sensitivity to magnitude of reinforcement, as he consistently allocated his responding to the button that produced high-magnitude reinforcement. Finally, when we evaluated sensitivity to immediacy of reinforcement, Max consistently allocated more responding to the button that produced immediate reinforcement. Thus, he was found to be sensitive to all three parameters.

Discussion

The results of Experiment 1 indicate that one participant, Sabrina, was sensitive to all three parameter manipulations at their initial values. Max was also found to be sensitive to all three parameters; however, his sensitivity to magnitude was detected only when we increased the values such that the high-magnitude value was 12 times that of the low-magnitude value. Rufus was found to be sensitive to only quality. When we assessed immediacy and magnitude, he continued to allocate responding to whichever contingency was associated with the button on his right. One potential explanation for this response pattern is that there was a position bias that was potentially a function of differential response effort; Rufus is right-hand dominant

Table 2
Summary of Relative Parameter Sensitivity Assessment Values

Manipulated Parameters	Consequence 1	Consequence 2	Constant Parameter
Magnitude vs. Immediacy	Low Magnitude-Immediate 15-s access 0-s delay	High Magnitude-Delayed Sabrina 90-s access, 280-s delay Max 180-s access, 136-s delay	Quality High
Immediacy vs. Quality	Low Quality-Immediate Low quality 0-s delay	High Quality-Delayed Sabrina High quality, 280-s delay Max High quality, 136-s delay	Magnitude 30-s access
Magnitude vs. Quality	Low Magnitude-High Quality 15-s access High quality	High Mag-Low Quality Sabrina 90-s access, low quality Max 180-s access, low quality	Immediacy 0-s delay

and therefore it is possible that when we manipulated parameters to which he was not sensitive, selecting the button on his right may have been slightly less effortful.

EXPERIMENT 2: RELATIVE PARAMETER SENSITIVITY ASSESSMENT

The purpose of the relative parameter sensitivity assessment was to obtain a hierarchy of parameters to which participants were sensitive, for participants who demonstrated sensitivity to more than one parameter during Experiment 1. Sabrina and Max participated in Experiment 2 because the results of their individual parameter sensitivity assessments indicated they were sensitive to multiple parameters. We used the same materials as those used in the individual parameter sensitivity assessments and presented them in the same concurrent arrangement.

Method

Design and procedures. We conducted sessions using an ABAB design as in the individual parameter sensitivity assessments, reversing the consequences associated with the buttons across phases. We conducted sessions identical to the individual parameter sensitivity assessments, with the exception that buttons were associated with a combination of parameter manipulations (e.g., high-quality, delayed reinforcement vs. low-quality, immediate reinforcement). Materials and values were identical to those used in Experiment 1. Table 2 contains a summary of the values used for the relative parameter sensitivity assessment.

A second trained observer collected data for 26% of the relative parameter sensitivity assessment sessions, and interobserver agreement was calculated using the same procedures as in the parameter sensitivity assessment. Mean reliability across sessions was 99.7% (range, 99%-100%).

Magnitude versus immediacy. The purpose of this assessment was to determine whether Sabrina and Max were more sensitive to magnitude or immediacy of reinforcement when specific values were tested. The two consequences we evaluated in this assessment were low-magnitude reinforcement delivered immediately and high-magnitude reinforcement delivered after a delay. We kept quality consistent across both options; that is, both choices resulted in Sabrina and Max receiving the iPad.

Immediacy versus quality. The purpose of this assessment was to determine whether Sabrina

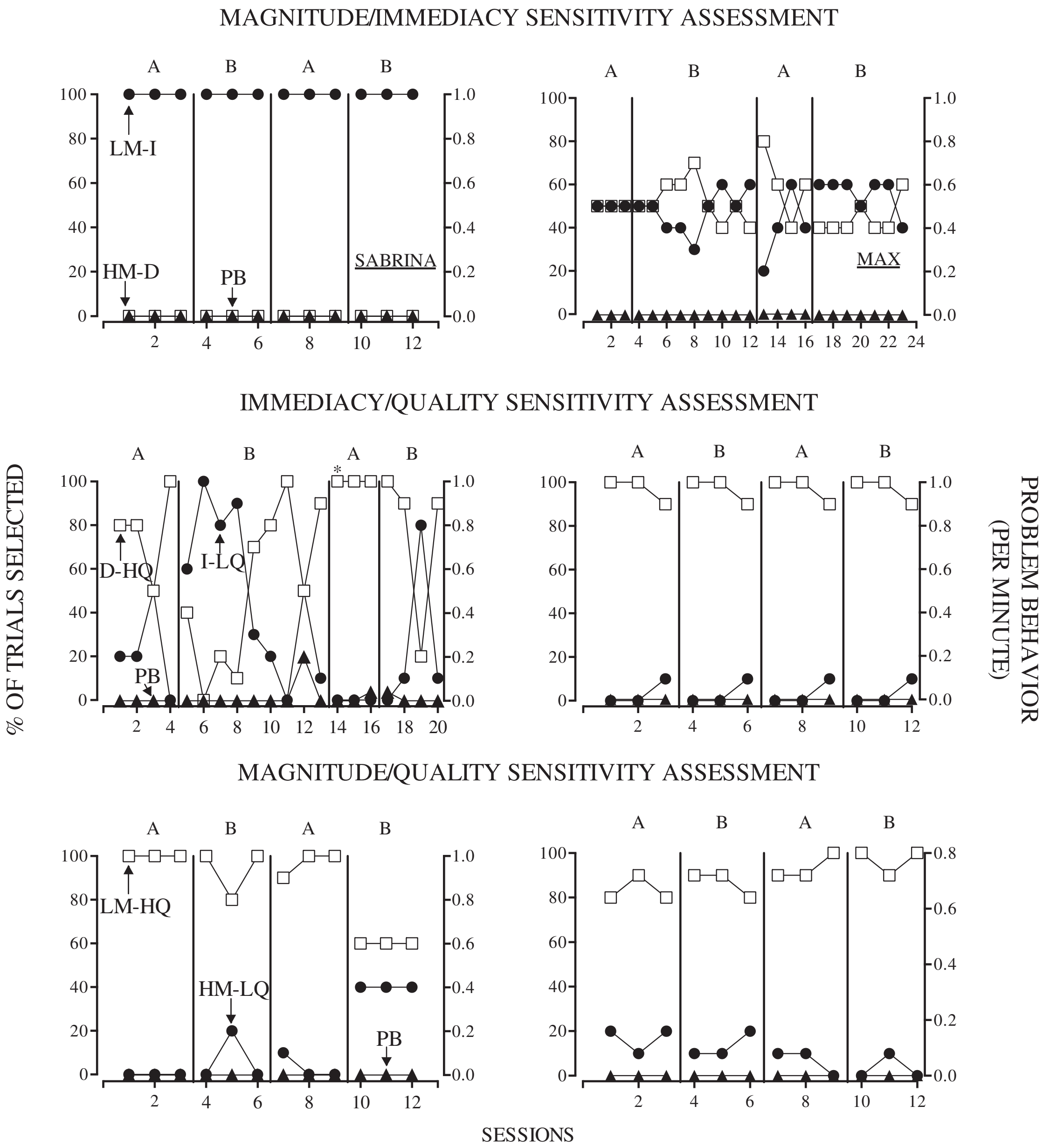

Figure 3. Relative parameter sensitivity assessments for Sabrina (left column) and Max (right column). PB = Problem behavior; HM = high magnitude; LM = low magnitude; I = immediate; D = delay; HQ = high quality; LQ = low quality. The asterisk on Sabrina's immediacy versus quality sensitivity assessment graph denotes when the token economy was introduced.

and Max were more sensitive to immediacy or quality of reinforcement. The two consequences we evaluated in this assessment were low-quality reinforcement delivered immediately and high-quality reinforcement delivered after a delay. We kept magnitude consistent across both options; that is, both choices resulted in Sabrina and Max having access to the reinforcer for 30 s.

Magnitude versus quality. The purpose of this assessment was to determine whether Sabrina and Max were more sensitive to magnitude or quality. In this assessment, we compared high magnitude of a low-quality reinforcer to low magnitude of a high-quality reinforcer. We kept immediacy consistent across both options; that is, the therapist delivered both consequences immediately after Sabrina or Max made a selection.

Results

Sabrina. The results of Sabrina's relative parameter sensitivity assessment are in Figure 3. When we compared magnitude and immediacy, Sabrina responded more frequently on the button associated with low-magnitude, immediate reinforcement, suggesting her behavior was more sensitive to immediacy than magnitude. Problem behavior was not observed during this parameter sensitivity assessment.

When we compared immediacy and quality, Sabrina initially allocated more responding to the button associated with high-quality reinforcement delivered after a delay. However, when we changed phases, she started selecting the immediate low-quality option more frequently. After additional sessions, she returned to allocating more responding to the delayed, high-quality option. The therapist introduced the token economy at the beginning of session 14, because Sabrina began engaging in more problem behavior between sessions and during exposure trials, and she made statements about choosing the immediate option so that she could go home sooner. After we incorporated the token economy, Sabrina tracked the option that produced the delayed, high-quality reinforcement (in the third phase). In the final phase, she again allocated more responding to the option that produced delayed, high-quality reinforcement, with the exception of session 19. These data indicate that she was more sensitive to quality than immediacy.

Finally, we compared magnitude and quality. Sabrina consistently allocated more responding to the button associated with the low-magnitude, high-quality consequence, suggesting she was more sensitive to quality than magnitude. Together, these results suggest Sabrina was most sensitive to quality and least sensitive to magnitude.

Low rates of problem behavior were observed during three sessions (range, 0.04 to 0.2) when sensitivity to immediacy and quality of reinforcement was assessed.

Max. The results for Max are depicted in Figure 3. When we compared magnitude and immediacy, Max did not consistently allocate his responding to either switch. Across conditions, his response allocation sometimes favored magnitude and sometimes favored immediacy. These results suggest that neither parameter manipulation was strong enough to alter response allocation.

To rule out color bias, we used the same colors when assessing quality and immediacy. We observed clear differentiation in his response allocation—he consistently selected the button associated with the high-quality delayed reinforcer, regardless of position of the button. These results suggest Max was more sensitive to quality than immediacy.

Finally, we compared magnitude and quality. Max consistently allocated more responding to the button associated with the low-magnitude, high-quality consequence, suggesting he was more sensitive to quality than magnitude. Together, the results indicate Max was most sensitive to quality and less sensitive to immediacy and magnitude. Relative sensitivity to immediacy and magnitude could not be determined.

Problem behavior was not observed during any of the relative parameter sensitivity assessment sessions.

Discussion

Both participants were most sensitive to quality of reinforcement. Although there was clearly differentiated sensitivity for Sabrina, Max allocated his responding such that relative sensitivity could not be determined between magnitude and immediacy. Thus, relative sensitivity was not the same across participants, and the participants were not equally sensitive to all parameters of reinforcement. These results provide additional support for identifying individual relative sensitivities to parameters of reinforcement.

EXPERIMENT 3: DRA WITHOUT EXTINCTION

In Experiments 1 and 2, we assessed sensitivity to parameters of reinforcement using arbitrary responses. Experiment 3 was designed to determine whether the results of the sensitivity assessments could be used to inform an effective intervention for problem behavior. The purpose of Experiment 3 was to determine whether a DRA-without-extinction procedure that uses the parameter to which the participant is most sensitive is more effective than a DRA without extinction procedure that uses a parameter to which the participant is less sensitive.

Methods

Materials and response definitions. We used the high-quality and low-quality tangible items during Experiment 3. Prior to starting this phase of the study, we hypothesized that Rufus was habituating to the iPad because he would often try to engage in conversation with therapists while he had access to the iPad rather than engage with the iPad. As such, we included additional preferred items (i.e., nesting blocks and a Sight-and-See puzzle) for Rufus.

We selected simple alternative responses for the participants. Prior to baseline, mand training was conducted, and all participants acquired the alternative responses and independently emitted the responses within four training sessions (data available upon request). During the training, Sabrina and Max did not engage in any instances of problem behavior; Rufus engaged in one occurrence, which was ignored. Rufus' alternative response consisted of handing the primary therapist a communication card (8.9-cm and lined in bright yellow) that said, "Share with me." Sabrina and Max's alternative response was to say, "Can I have a turn, please?" Approximations of this response (e.g., leaving off the word "please") were not reinforced.

Design and procedures. In Experiment 1 for Rufus and Experiment 2 for Sabrina and Max, all three participants were most sensitive to quality of reinforcement. Sabrina was least sensitive to magnitude of reinforcement. Rufus was insensitive to both magnitude and immediacy of reinforcement; however, there was less variability in his selections during the magnitude parameter sensitivity assessment, suggesting he may have been slightly less sensitive to magnitude. Therefore, we manipulated magnitude as the parameter to which Rufus was least sensitive. Max was equally sensitive to magnitude and immediacy; however, during the initial magnitude sensitivity assessment, when we tested 90-s access as the high-magnitude value, we did not see sensitivity. Thus, we also manipulated magnitude for Max as the parameter to which he was least sensitive.

We used a multiple baseline design across the three participants to determine the effectiveness of magnitude and quality manipulations for treating problem behavior. In all phases, we programmed reinforcement for both problem behavior and alternative behavior; however, the parameters of reinforcement varied across phases. Sessions were 10 min.

A second trained observer collected data for 69% of the treatment evaluation sessions. An agreement was defined as both data collectors scoring the occurrence of the alternative response or problem behavior in a 10-s interval.

Reliability was calculated for each session by taking the number of agreements and dividing by the total number of agreements plus disagreements and multiplying by 100 to yield a percentage. Mean reliability across sessions was 99% (range, 95%-100%).

Baseline. We used baseline procedures similar to those used in Athens and Vollmer (2010) and the establishing operation for problem behavior was presented by restricting access to high preferred items. Problem behavior and alternative behavior both resulted in high-quality, high-magnitude reinforcement; that is, the programmed consequence for problem behavior and alternative behavior was 90-s access to the iPad.

Magnitude manipulation. During the magnitude manipulation, reinforcement favored the alternative behavior; that is, therapists delivered high-magnitude reinforcement (i.e., 90 s) contingent on alternative behavior and low-magnitude reinforcement (i.e., 15 s) contingent on problem behavior. We kept immediacy of reinforcement constant, such that therapists always delivered reinforcement immediately. We also kept quality of reinforcement consistent for both problem behavior and alternative behavior; however, we used low-quality items to assess the effectiveness of the magnitude manipulation to ensure that high-quality reinforcers (a parameter to which both participants were sensitive) would not overshadow the effect of magnitude. No prompts were provided to engage in the alternative response.

Quality manipulation. The quality manipulation consisted of favoring alternative behavior using differential reinforcer quality. The programmed consequence for alternative behavior was access to a high-quality reinforcer, and the programmed consequence for problem behavior was access to a low-quality reinforcer. We kept magnitude and immediacy consistent; that is, therapists delivered reinforcers immediately, and participants had access for 30 s. No prompts were provided to engage in the alternative response.

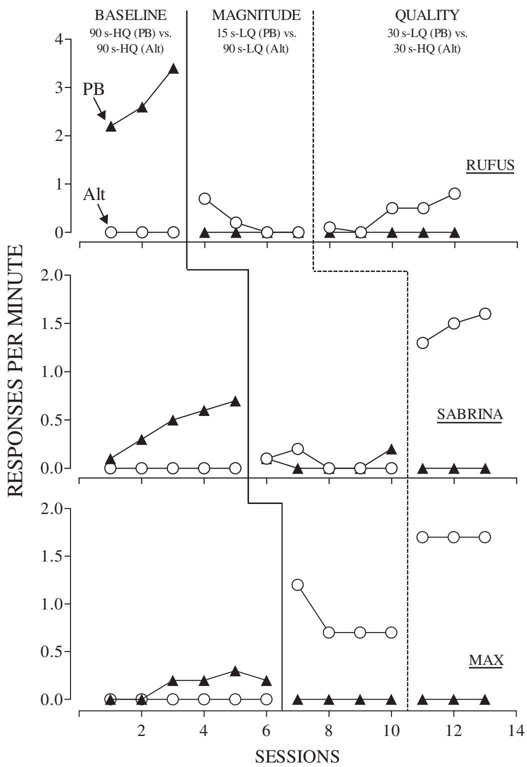

Figure 4. Treatment evaluation. PB = problem behavior; Alt = alternative behavior; HQ = high quality; LQ = low quality.

Results

The results of the treatment evaluation are depicted in Figure 4. During baseline, when problem behavior and alternative behavior both resulted in the same consequences, we observed increasing trends in problem behavior for all participants and no alternative behavior. When we manipulated magnitude to favor alternative behavior, we initially observed instances of alternative behavior for all three participants, but it decreased to zero for Rufus and Sabrina. The alternative behavior maintained for Max. We did not observe problem behavior with Rufus or Max, but we did observe a few instances with Sabrina. In the last phase, when we manipulated quality, we did not observe any problem behavior for any of the participants but saw an increase in alternative behavior for all three.

Discussion

For Sabrina, the magnitude manipulations resulted in a decrease in problem behavior, but alternative behavior was not maintained. However, the magnitude manipulation provided sufficient reinforcement to suppress problem behavior for Rufus and Max and maintain alternative behavior for Max, despite both showing insensitivity to these parameter values during Experiment 1. In comparison, the quality manipulation suppressed problem behavior and increased alternative behavior for all three participants. Although both the magnitude and quality manipulations were effective for Max, we observed a higher rate of alternative behavior during the quality manipulation, suggesting that it was more effective to manipulate the parameter to which he was most sensitive.

The results of Experiment 3 provide further support for identifying individual sensitivities to parameters of reinforcement as not all parameter manipulations were equally successful in shifting responding away from problem behavior, despite the individual being sensitive to the parameter. For example, Sabrina was sensitive to magnitude during the individual parameter sensitivity assessment; however, when we manipulated magnitude during DRA without extinction, it did not alter her response allocation, suggesting that magnitude only matters when the reinforcer is of sufficient quality. Although both magnitude and quality manipulations were effective for Max, manipulating the parameter to which he was most sensitive produced a higher rate of alternative behavior, which may indicate more robust treatment effects. Thus, individual sensitivity assessments alone may not be sufficient in identifying which parameter to manipulate. Relative parameter sensitivity assessments, however, identified the parameter to which each participant was most sensitive and led to the most effective treatment.

GENERAL DISCUSSION

The results of this study indicate that it may be possible to use arbitrary responses to assess individual sensitivity to different parameters of reinforcement that maintain problem behavior. In addition, when an individual is sensitive to multiple parameters of reinforcement, relative parameter sensitivity can also be determined using arbitrary responses rather than problem behavior. The results of the intervention for all three participants validate the results of the individual parameter sensitivity assessment (Rufus) and the relative parameter sensitivity assessment (Sabrina and Max). Moreover, a parameter sensitivity assessment using arbitrary responses may be used to develop effective treatments for problem behavior in situations in which extinction is not feasible. It is important to note, however, that problem behavior was not reinforced during the individual or relative parameter sensitivity assessments, and therefore, it is still unclear whether this assessment is appropriate if extinction is also not feasible during the assessment itself. These results must be interpreted cautiously; future research should include the implementation of these procedures with additional participants, including those with problem behavior maintained by attention and/or escape. Although our participants' problem behavior was also maintained by escape, these parameter sensitivity assessments were not directly applied to that function.

This study extends previous research in several ways. First, this study extends the work of Athens and Vollmer (2010) and Neef et al. (1994) by using arbitrary responses and reinforcers that maintain problem behavior to assess sensitivity to parameters of reinforcement for the purpose of developing a treatment for problem behavior. We were able to identify parameter sensitivity during an assessment using arbitrary responses, and the results allowed us to predict which parameter manipulations would be more and less effective when applied to a treatment designed to reduce problem behavior and increase functionally alternative responses.

Second, our use of arbitrary responses also made it possible to expose participants to contingencies prior to conducting the sensitivity assessments. In using problem behavior to assess sensitivity to parameters of reinforcement, it is unclear whether the participants in Athens and Vollmer (2010) were exposed to the contingencies as intended because preexposure sessions were not conducted. This is particularly important for the immediacy parameter sensitivity assessment. Participants may have experienced the delay in reinforcement delivery as extinction rather than as a delayed consequence, potentially resulting in extinction-induced side effects (e.g., high rate of responding). Thus, ensuring that participants are exposed to the relevant contingencies prior to assessment could more accurately identify sensitivity to immediacy.

Third, we sought to identify one parameter to which each participant was most sensitive so that an intervention could be developed using only one parameter manipulation rather than multiple parameter manipulations, as other researchers have done. The results of Rufus' individual parameter sensitivity assessment indicate that some individuals will be insensitive to certain parameters of reinforcement in some contexts. Thus, it should not be assumed that all individuals would be equally sensitive to all parameters of reinforcement. We successfully identified the most influential parameter for all three participants and subsequently implemented effective treatments. By reducing the number of treatment components to the most important parameter for each participant, it may be possible to increase overall treatment integrity and long-term effectiveness of the intervention. There may be cases in which the parameter to which an individual is most sensitive cannot easily be manipulated (e.g., delaying reinforcement for problem behavior). Future researchers may want to investigate the extent to which various parameters can be manipulated to produce positive treatment effects; that is, can more than one parameter to which the individual is less sensitive be combined to outweigh a single parameter to which an individual is more sensitive?

It is possible that had we tested additional magnitude and immediacy values, we may have been able to detect sensitivity for Rufus. For example, basic researchers have assessed sensitivity to immediacy of reinforcement (i.e., impulsivity) by testing a variety of values and determining an indifference point (e.g., Madden & Johnson, 2010). Procedures such as these could be useful in determining exact values necessary to completely shift response allocation from one option to another; however, doing so would likely be time consuming and therefore less feasible for clinicians and practitioners. Although we tested only two or three values per parameter, it is likely that we can make certain extrapolations beyond the tested values. For example, if a participant is sensitive to magnitude when 15-s access and 90-s access are compared, it is likely that they would also be sensitive to larger magnitudes (e.g., 120-s access) when compared to 15-s access. We extended previous research by selecting values for magnitude and immediacy that were potentially relevant for the participants instead of using arbitrary values. For immediacy values, we extended previous research by selecting values based on individual participant behavior (i.e., IRT). Therefore, we would expect that the delays tested would have been sufficient and any sensitivity to immediacy should have been detected. Similarly, we attempted to choose values for the magnitude assessment that would be detectable and meaningful to the participants but also feasible for implementation. An alternative could be to determine what is feasible for the behavior change agents to implement. Additional research should investigate various methods for efficiently selecting values to be evaluated in the parameter sensitivity assessments.

One potential limitation of this study is that, although problem behavior was relatively infrequent for all participants during the parameter sensitivity assessments, all occurrences were ignored while the button touches were reinforced. During the intervention phase of the study, we reestablished baseline rates of problem behavior; however, it is possible that the arrangement used during the parameter sensitivity assessments inadvertently contributed to the rapid reduction of problem behavior during the intervention phase of the study. One potential explanation is that problem behavior contacted extinction during the parameter assessments, thus weakening the behavior. Alternatively, it is possible that we established a strong reinforcement history for alternative behavior in general. Additional participants are needed to determine whether such rapid reductions are common after exposure to the parameter sensitivity assessments. If such reductions are common, it may be useful to conduct future research on whether similar effects are observed when parameter assessments are conducted in a brief format.

A second limitation is the low rate of problem behavior observed during the intervention parameter manipulations. The purpose of the intervention phase was to evaluate a DRA-without- extinction procedure using the parameters to which each participant was most and least sensitive. However, Rufus and Max did not engage in problem behavior during the magnitude manipulation phase or the quality manipulation phase; Sabrina also did not engage in problem behavior during the quality manipulation phase. Thus, they did not contact the programmed contingencies for problem behavior in those conditions. Therefore, although procedurally we implemented DRA without extinction, we cannot be certain that reinforcing both problem behavior and alternative behavior but favoring the alternative behavior would be effective. However, it is important to note that manipulating the parameter to which the participants were most sensitive produced the highest rate of alternative behavior for all three participants. Thus, we can conclude that manipulating parameters for which participants are most sensitive may increase alternative behavior, but we cannot make strong conclusions about the parameter manipulation effects on problem behavior.

All three participants had behavior maintained by social positive reinforcement in the form of access to tangibles as well as social negative reinforcement in the form of escape. It was necessary to address the escape function during the parameter sensitivity assessments for Rufus and Sabrina because participants' attempts to escape from the sessions could have otherwise interfered with the results. The inclusion of token economies sufficiently addressed the escape function for both participants, allowing us to obtain results on parameter sensitivity for tangible items. The token economy was in place for all conditions once it was introduced; therefore, it cannot directly account for differential results across conditions. However, the extent to which the token economy interacted with the experimental contingencies is unclear. Although we identified the parameters to which both participants were most sensitive and implemented an effective intervention, it is possible that, without treating both functions, the parameter manipulations would not be as effective. That is, practitioners are cautioned against treating only one function of problem behavior through parameter manipulations. Additional research is needed on how multiple functions for problem behavior might influence sensitivity to parameters of reinforcement and subsequently influence the effectiveness of an intervention.

Finally, social negative reinforcement was excluded from this investigation because research thus far has not directly manipulated quality in parameter manipulations for negatively reinforced behavior. For example, Peterson, Frieder, Smith, Quigley, and Van Norman (2009) manipulated quality of demand by providing a break from the demand with high quality (or high-preference) items. This manipulation enriches the break with a combined positive and negative reinforcement contingency rather than altering the quality of the break. Rather, quality of negative reinforcement varies based on the aversiveness of the demand (e.g., Knighton, Bloom, & Clark, 2014). Additional research is needed on quality manipulations for behavior maintained by social negative reinforcement so that procedures, such as those investigated here, can be applied to and evaluated with problem behavior with various functions.

The participants who took part in this study were referred for problem behavior with relatively low severity and therefore it may be feasible to place their problem behavior on extinction if those implementing the intervention are able to do so consistently. It is possible that individuals with more severe topographies of problem behavior would engage in more problem behavior during the parameter sensitivity assessments. This could be problematic if the behavior interferes with the assessment. To combat this risk, the assessments were designed to provide a reinforcing outcome for either response, decreasing the motivation to engage in problem behavior once the selection response was acquired. Nonetheless, additional research should be conducted to evaluate this assessment procedure with other populations.

The use of parameter manipulations to implement DRA-without-extinction procedures is still relatively new. Additional research is needed to determine the most efficient and effective procedures to determine how best to manipulate parameters and whether the time allocated to such activities increases the odds of a meaningful treatment effect when implemented by teachers and parents in classrooms and homes.

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FURTHER EVALUATION OF DIFFERENTIAL EXPOSURE TO ESTABLISHING OPERATIONS DURING FUNCTIONAL COMMUNICATION TRAINING

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Recent research findings (DeRosa, Fisher, & Steege, 2015) suggest that minimizing exposure to the establishing operation (EO) for destructive behavior when differential reinforcement interventions like functional communication training (FCT) are introduced may produce more immediate reductions in destructive behavior and prevent or mitigate extinction bursts. We directly tested this hypothesis by introducing FCT with extinction in two conditions, one with limited exposure to the EO (limited EO) and one with more extended exposure to the EO (extended EO) using a combined reversal and multielement design. Results showed that the limited-EO condition rapidly reduced destructive behavior to low levels during every application, whereas the extended-EO condition produced an extinction burst in five of six applications. We discuss these findings in relation to the effects of EO exposure on the beneficial and untoward effects of differential reinforcement interventions.

Key words: differential reinforcement, establishing operation, extinction, extinction burst, functional analysis, functional communication training

Functional communication training (FCT; Carr & Durand, 1985) is a differential reinforcement of alternative behavior (DRA) intervention that is an effective and well-established treatment for a variety of problem behaviors, including severe destructive behavior (e.g., aggression, self-injurious behavior; Greer, Fisher, Saini, Owen, & Jones, 2016; Hagopian, Fisher, Thibault-Sullivan, Acquisto, & LeBlanc, 1998; Jessel, Ingvarsson, Metras, Kirk, & Whipple, 2018; Kurtz, Boelter, Jarmolowicz, Chin, & Hagopian, 2011; Kurtz et al., 2003; Rooker, Jessel, Kurtz, & Hagopian, 2013). Functional communication training has three primary components: (a) identifying the reinforcer(s) for problem behavior via a functional analysis, (b) training the individual to emit an alternative mand that is functionally equivalent to problem behavior, and (c) establishing generalization and maintenance of the alternative response (Fisher, Greer, & Bouxsein, in press; Tiger, Hanley, & Bruzek, 2008). Functional communication training is most appropriate and effective for problem behavior reinforced by social consequences (e.g., attention, escape, tangible items; Greer & Fisher, 2017).

Prior research on FCT has shown that it is more effective when combined with extinction than when it is implemented alone (e.g., Hagopian et al., 1998; Shirley, Iwata, Kahng, Mazaleski, & Lerman, 1997). For example, Hagopian et al. (1998) implemented FCT alone with 11 participants who displayed severe destructive behavior reinforced by escape ($n = 4$), attention ($n = 6$), and access to tangible reinforcement ($n = 1$). Functional communication training alone resulted in no change or an increase in destructive behavior during five of these applications, and in no application did FCT alone reduce destructive behavior by 90%

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or more. By contrast, Hagopian et al. found that FCT with extinction reduced problem behavior much more consistently and to a greater degree than FCT alone, but they also found FCT to be most effective when combined with punishment. However, more recent large-scale studies have shown that FCT combined with extinction reduces destructive behavior as well or nearly as well as FCT combined with punishment, especially when researchers use alternative reinforcement and/or multiple schedules during reinforcement schedule thinning (Greer et al., 2016; Rooker et al., 2013) and when they arrange contingency-based progressive delays (Ghaemmaghami, Hanley, & Jessel, 2016; Jessel et al., 2018).

Extinction, when implemented alone, can result in untoward side effects like temporary response bursting, extinction-induced aggression, and negative emotional behavior (Goh & Iwata, 1994; Lerman & Iwata, 1995; Lovaas, Freitag, Gold, & Kassorla, 1965; Piazza, Patel, Gulotta, Sevin, & Layer, 2003). These extinction effects are sometimes seen when FCT with extinction is first introduced (cf. Lerman & Iwata, 1995) and when the extinction component of a multiple schedule is introduced as a means of thinning the reinforcement schedule (Briggs, Fisher, Greer, & Kimball, in press; Kuhn, Chirighin, & Zelenka, 2010; Saini, Miller, & Fisher, 2016; Shamlian et al., 2016). The limitations of extinction can be mitigated or prevented in many cases through the delivery of the reinforcer contingent on an alternative response or on a response-independent (time-based) schedule (e.g., Betz, Fisher, Roane, Mintz, & Owen, 2013; Fisher, Greer, Fuhrman, & Querim, 2015; Fritz, Jackson, Stiefler, Wimberly, & Richardson, 2017).

When alternative reinforcement (e.g., FCT) is combined with extinction, each treatment component generally adds to the effectiveness of the other, but these complementary or additive effects have not been consistent across studies. For example, Shirley et al. (1997) found that adding extinction to FCT facilitated acquisition of the functional communication response (FCR) and a reduction in self-injurious behavior (SIB). However, Shirley et al.'s introduction of FCT with extinction resulted in an extinction burst during all three applications, based on the criteria specified by Lerman and Iwata (1995). In contrast, the addition of differential reinforcement components (e.g., FCT) to extinction generally mitigates the untoward side effects of extinction (Azrin, Hutchinson, & Hake, 1966; Lerman & Iwata, 1995; Lerman, Iwata, & Wallace, 1999; Piazza et al., 2003; Terrace, 1966). For example, Lerman et al. (1999) found that untoward side effects involving bursts of SIB or extinction-induced aggression occurred in 20% of applications in which the investigators combined extinction with the delivery of alternative reinforcement (i.e., DRA or noncontingent reinforcement) or antecedent interventions (e.g., demand fading). By contrast, when they implemented extinction alone, untoward side effects occurred in 60% of applications. These results show that DRA can mitigate the untoward side effects of extinction, but the fact that untoward side effects can still occur in a percentage of applications of DRA with extinction suggests that additional research is needed to elucidate the conditions under which DRA procedures (e.g., FCT) do and do not prevent extinction bursts.

The results of several basic investigations (Azrin, 1961; Azrin et al., 1966; Mowrer & Jones, 1943; Skinner, 1938) suggest that differential reinforcement interventions (e.g., FCT) may mitigate the untoward side effects of extinction by preventing or greatly limiting exposure to periods with no reinforcement. It seems reasonable to assume that differential reinforcement interventions that completely prevent exposure to periods of no reinforcement should produce rapid reductions in destructive behavior without extinction bursts, whereas those that lessen but do not eliminate periods of no reinforcement may reduce destructive behavior more slowly and be somewhat more prone to extinction-induced bursting, aggression, and/or emotional responses. A recent study by DeRosa, Fisher et al. (2015) provided data consistent with this notion.

DeRosa, Fisher et al. (2015) implemented FCT with extinction in two conditions with two participants in Study 1. A card touch served as the FCR in one condition and a vocal response served as the FCR in the other condition. In the card-touch condition, the investigators greatly limited exposure to the establishing operation (EO) by introducing the EO, prompting the card touch, and delivering the reinforcer in rapid succession (e.g., issuing a demand, prompting the card touch, and allowing escape from the demands all within a few seconds). By contrast, in the vocal-response condition, the EO for problem behavior often remained in effect for longer periods because the investigators could prompt the FCR (using a model prompt) but could not guarantee its quick emission by the participants. The card-touch condition produced less response bursting, larger and more rapid reductions in problem behavior, and faster acquisition of the alternative mand relative to the vocal-response condition. Despite the differences in FCR topography across FCT conditions, these results suggested that controlling and limiting exposure to the EO for problem behavior promoted rapid treatment effects and prevented the untoward side effects associated with extinction. DeRosa, Fisher et al. provided additional support for this hypothesis in Study 2 by delivering alternative reinforcement on time-based schedules yoked to the card-touch and vocal-response conditions from Study 1, with one of the participants. The time-based schedule yoked to the card-touch condition (i.e., the condition associated with a limited exposure to the EO) produced lower rates of problem behavior than the time-based schedule yoked to the vocal-response condition (i.e., the condition associated with greater exposure to the EO).

In the current study, we aimed to replicate and extend the findings of DeRosa, Fisher et al. (2015) by directly testing whether limiting exposure to the EO for problem behavior during initiation of FCT with extinction would promote rapid treatment effects and prevent the untoward side effects of extinction. We eliminated the major limitation of Study 1 in the DeRosa, Fisher et al. study (i.e., that the observed differences resulted from response variables rather than EO exposure) by directly manipulating the duration of exposure to the EO while holding response variables constant (i.e., we implemented an equivalent card-touch or card-exchange FCR in both conditions). Unlike Study 2 in the DeRosa, Fisher et al. study, we evaluated differential exposure to the EO across two otherwise identical FCT conditions and not across two time-based schedules.

METHOD

Subjects and Settings

Carson, a 4-year-old boy diagnosed with autism spectrum disorder (ASD) and alpha-thalassemia X-linked intellectual disability (ATRX) syndrome, engaged in SIB (head hitting with hand or shoulder), which resulted in tissue damage to his face and chin. For Carson's safety, we conducted a rapid-restraint evaluation similar to the procedures described by Wallace, Iwata, Zhou, and Goff (1999) and with the modifications suggested by DeRosa, Roane, Wilson, Novak, and Silkowski (2015) to quickly identify a level of restraint rigidity that would minimize the occurrence of hand-to-head SIB (i.e., the more injurious of his two topographies of SIB), without interfering with activities of daily living. We specifically placed Carson in arm splints with varying levels of rigidity and assessed levels of SIB, item interaction, and compliance across multiple contexts (i.e., while self-feeding, during toy play, and with gross-and fine-motor demands). We determined that Carson's SIB remained lowest without impeding his ability to engage in adaptive responses while he wore protective sleeves (splints) without stays. Carson remained in these protective sleeves without stays throughout all sessions, with periodic breaks from the sleeves between sessions. The arm sleeves controlled Carson's hand-to-head SIB but not his shoulder-to-head SIB. Thus, we conducted the current analyses using his shoulder-to-head SIB as the target response. Carson communicated using gestures.

Alan, a 3-year-old boy diagnosed with ASD, engaged in SIB (i.e., head hitting, body slamming) and aggression (i.e., hitting, pushing, kicking, biting). Alan also participated in a previous study (Fisher, Greer, Romani, Zangrillo, & Owen, 2016) that compared two approaches to functional analysis and that did not involve FCT. Unlike Carson, the topography and frequency of Alan's SIB did not require the use of restraints. Alan communicated primarily using gestures and picture exchanges. Both children walked without assistance.

In addition to the protective sleeves worn by Carson, we minimized the risk of each child's SIB using the safety precautions described by Betz and Fisher (2011). We conducted all sessions in clinic therapy rooms (approximately 3 m by 3 m) that contained padding on the floors and walls. Additional safety precautions included the use of session-termination criteria. No session was terminated prematurely due to SIB resulting in reddening of the skin or bleeding. A Board Certified Behavior Analyst supervised all sessions. We equipped each room with a one-way observation mirror, two-way intercom system, and any necessary session materials (e.g., preferred toys, instructional materials).

Measurement and Interobserver Agreement

Trained data collectors observed sessions from behind the mirror in an adjacent observation booth and used laptop computers to measure the frequency of destructive behavior (SIB for Carson; SIB and aggression for Alan) and FCRs, as well as the duration of reinforcer deliveries. *Destructive behavior* consisted of SIB (i.e., head banging, self-hitting, body slamming) for Carson and Alan and aggression (i.e., hitting, kicking, pushing, biting others) for Alan. The *FCR* consisted of touching an index card (Carson) that measured 7.6 cm by 12.7 cm and contained a picture of the child consuming the identified reinforcer or handing the card to the therapist (Alan). *Reinforcer delivery* consisted of the therapist providing the child access to the putative reinforcer (i.e., providing the tangible item or escape).

A second, independent observer collected data simultaneously with the primary data collector during 22% and 63% of functional analysis sessions for Carson and Alan, respectively and during 27%, 65%, and 33% of FCT-evaluation sessions for Carson, Alan (tangible), and Alan (escape), respectively. We calculated exact interobserver agreement within 10-s intervals for destructive behavior and proportional interobserver agreement within 10-s intervals for reinforcement deliveries. We computed grand means across assessments and participants for destructive behavior (*GM* = 96%; range, 70% to 100%), FCRs (*GM* = 95%; range, 70% to 100%), and reinforcer deliveries (*GM* = 94%; range 75% to 100%).

Because it was critically important for the therapist to control exposure to the EO across FCT conditions, we also calculated procedural fidelity for all FCT sessions. We considered the reinforcer to be delivered correctly if the therapist provided it within 5 s of its scheduled delivery (i.e., following a prompted or independent FCR for Carson or following an independent FCR for Alan). If destructive behavior preceded (within 3 s) or co-occurred with the FCR, the therapist waited 3 s, and then prompted (Carson) or continued waiting (Alan) for an additional FCR without preceding or co-occurring destructive behavior. In these situations, we considered the reinforcer to be delivered correctly if the therapist withheld the reinforcer following the destructive response and then delivered it within 5 s of a subsequent FCR that occurred without preceding or simultaneous destructive behavior. All reinforcers were delivered with 100% fidelity across all FCT sessions for both participants.

Functional Analysis

We conducted functional analysis sessions using procedures similar to those described by Iwata, Dorsey, Slifer, Bauman, and Richman (1982/1994) with the following modifications. Functional analysis sessions lasted 5 min. Prior to beginning the multielement functional analysis, we screened for the presence of automatically reinforced destructive behavior by conducting a series of consecutive ignore sessions (Querim et al., 2013). Rates of destructive behavior remained low (Alan) or decreased across sessions (Carson), suggesting that neither child displayed destructive behavior maintained by automatic reinforcement (data not shown in the figure). Within the multielement functional analysis, we equated the reinforcer durations across test conditions (Fisher, Piazza, & Chiang, 1996). We used paired-stimulus preference assessments informed by caregiver nomination (Fisher, Piazza, Bowman, & Amari, 1996; Fisher et al., 1992) to identify preferred stimuli for Carson and Alan.

Ignore. We conducted additional ignore sessions with Carson. The therapist remained alone with Carson in a barren therapy room and ignored all instances of destructive behavior.

Attention. The therapist provided 1- to 2-min of vocal (e.g., talking with or singing to the child) and physical (e.g., tickles, rubs on the back) attention prior to starting the session. The attention session began with the therapist terminating the delivery of attention and moving away from the child who retained access to a less-preferred toy. Destructive behavior resulted in attention delivery in the form of verbal reprimands for 20 s.

Toy play. During toy play, the therapist provided the child with the same forms of attention that preceded the attention condition, but did so noncontingently and continuously throughout the session, and the child retained access to his most highly preferred materials (i.e., a musical toy for Carson and a backpack and truck for Alan). The therapist delivered no programmed consequences for destructive behavior.

Escape. The therapist presented demands (e.g., stack blocks, pick up toys, get dressed) to each child using a least-to-most (i.e., vocal, model, physical) prompting hierarchy. We selected demands for both boys based on caregiver nomination. Destructive behavior resulted in a 20-s break (escape) from instructions. Compliance following the vocal or model prompt resulted in brief praise (e.g., "Nice job stacking the blocks") and presentation of the next demand. For the purposes of another study, half of Alan's escape sessions included preferred demands, and the other half included less-preferred demands. Only data from the sessions with less-preferred demands are presented in this study.

Tangible. Prior to the tangible condition, the therapist provided 1- to 2-min access to the child's most highly preferred materials. The tangible condition began with the therapist removing the preferred materials, and destructive behavior resulted in the delivery of those materials for 20 s.

FCT Evaluation

Following each child's functional analysis, we evaluated the effects of FCT when initiated as treatment for destructive behavior using two variations of FCT that differed only according to the level of exposure to the EO for destructive behavior. In one version of FCT (limited EO), the therapist limited the EO by guiding the child to emit the FCR (Carson) or providing the response card (Alan) immediately after introduction of the EO, whereas in the other version of FCT (extended EO), the therapist imposed a fixed duration of EO exposure by either waiting to physically guide the FCR upon presenting the EO (Carson) or by presenting the EO while withholding the availability of the FCR materials (Alan). The FCR always resulted in the immediate delivery of the identified reinforcer, regardless of whether the FCR was prompted. Additionally, both variations of FCT targeted the same FCR modality (i.e., card touch for Carson, card exchange for Alan) to allow for a more direct comparison between the effects of EO exposure and rates of destructive behavior associated with each version of FCT than the comparison in DeRosa, Fisher et al. (2015).

We used an ABAB reversal design in which baseline sessions comprised the "A" phases, and both "B" phases consisted of a multielement, pairwise comparison between the two variations of FCT. This design allowed us to determine (a) whether either variant of FCT reduced rates of destructive behavior below those in baseline and (b) whether one variant of FCT proved more effective than the other. Because Alan's functional analysis results suggested two functions of his destructive behavior, we conducted this ABAB design for both functions of Alan's destructive behavior, but we staggered the implementation of phases across functions, creating a concurrent multiple-baseline-across-functions design.

Baseline. The tangible condition of the functional analysis served as the baseline for Carson and Alan's (tangible) FCT evaluations, and the escape condition of the functional analysis served as the baseline for Alan's (escape) FCT evaluation. We conducted baseline sessions separate from the functional analysis using the procedures described above. All baseline sessions lasted 5 min.

Selecting the EO-exposure durations. We initially attempted to teach the FCR to both Carson and Alan using clinic-standard teaching procedures that consisted of presenting the EO for destructive behavior, immediately guiding the FCR, and then immediately delivering the functional reinforcer, across 10-trial sessions. Following every two consecutive sessions with low levels of destructive behavior, the therapist increased the delay to physically guiding the FCR using the following progression: 0 s, 2 s, 5 s, and 10 s or until the child began emitting the FCR independently on 90% or greater of trials with low levels of destructive behavior.

Carson rarely emitted the FCR without physical guidance and often displayed destructive behavior within 2 s to 5 s after the EO was introduced. Therefore, we set his extended-EO duration at 5 s and his limited-EO duration at 0 s. Alan learned to emit the FCR independently, but he rarely did so without also displaying destructive behavior. Therefore, we conducted two progressive interval (PI) assessments with Alan, one in the escape context and one in the tangible context. At the start of the first trial of each PI assessment, we presented the EO by removing the tangible item or initiating a demand and then terminated the EO by presenting the tangible item or by providing escape after a preset period of time (e.g., 2 s). We then progressively increased the duration of the EO exposure after two trials at a given EO duration according to the following schedule until Alan emitted a destructive response (two trials at each of the following durations: 2 s, 5 s, 10 s, 20 s, 40 s). The PI assessment ended once Alan emitted a destructive response, at which point we provided the tangible item and then used the current interval as the EO duration for the extended-EO duration in the following treatment analysis. We set the extended EO at 10 s in the tangible condition and 40 s in the escape condition. As with Carson, we set the limited-EO duration at 0 s for both of Alan's FCT evaluations. Destructive behavior for Carson and Alan resulted in extinction in all subsequent FCT sessions.

Limited EO. Prior to the start of each limited-EO session conducted with Carson, the therapist provided him with brief (i.e., 1- to 2-min) access to the tangible reinforcer. We divided each session into ten 30-s trials. At the start of each trial, the therapist introduced the EO by withdrawing the tangible reinforcer. The therapist then immediately physically guided Carson to emit the FCR and returned the tangible reinforcer, so that exposure to the EO was as short as physically possible. Carson retained access to the tangible reinforcer for the remainder of the trial following the FCR. Carson's FCR card remained available throughout all FCT sessions.

We conducted Alan's limited-EO sessions in a similar manner, except that we did not divide the sessions into 30-s trials, and we provided 20-s access to the reinforcer following the FCR, regardless of how much time expired between the EO presentation and the FCR. At the start of each session for the tangible condition, the therapist introduced the EO by withdrawing the tangible reinforcer and placing the FCR card in or immediately next to Alan's hand. If Alan emitted the FCR, the therapist immediately returned the tangible reinforcer for 20 s. The EO remained in place until Alan emitted the FCR or until 10 min elapsed from the start of the session, at which point the session terminated. In addition, if destructive behavior occurred as the therapist was providing the FCR card, the therapist implemented a changeover delay by withholding the FCR card for 3 s. All sessions ended after 10 reinforcer deliveries.

At the start of each session for the escape condition, the therapist introduced the EO by presenting a demand and placing the FCR card in or immediately next to Alan's hand. Compliance following the vocal or model prompt resulted in brief praise and presentation of the next demand. If Alan emitted the FCR, the therapist immediately terminated the demand for 20 s. The EO remained in place until Alan emitted the FCR or until 10 min elapsed from the start of the session. All sessions ended after 10 reinforcer deliveries.

Extended EO. For Carson, we conducted this condition identically to his limited-EO tangible condition, except that during each trial, the therapist withdrew the tangible reinforcer, waited 5 s, and then physically guided Carson to emit the FCR and returned the tangible reinforcer (so that exposure to the EO lasted about 5 s longer than in the limited-EO condition for Carson). If destructive behavior occurred when the 5 s elapsed, the therapist implemented a 3-s changeover delay prior to prompting the FCR.

For Alan, we conducted his extended-EO tangible condition identically to his limited-EO tangible condition, except that when the therapist withdrew the tangible reinforcer, Alan was unable to emit an FCR until the therapist placed the FCR card in or immediately next to Alan's hand after 10 s. If destructive behavior occurred when the 10 s elapsed, the therapist implemented a 3-s changeover delay before making the FCR card available. If Alan emitted the FCR, the therapist immediately provided the tangible reinforcer for 20 s. All sessions ended after 10 reinforcer deliveries, except for Session 17, which ended at 10 min, with nine reinforcer deliveries.

We conducted Alan's extended-EO escape condition identically to his limited-EO condition, except that when the therapist presented a demand, Alan was unable to emit an FCR until the therapist placed the FCR card in or immediately next to Alan's hand after 40 s. If destructive behavior occurred when the 40 s elapsed, the therapist implemented a 3-s changeover delay before making the FCR card available. If Alan emitted the FCR, the therapist immediately terminated the demand for 20 s. All sessions ended after 10 reinforcer deliveries.

Data Analysis

To more clearly quantify the effects that the limited- and extended-EO exposures had on each child's destructive behavior, we calculated the rate of destructive behavior and the percentage of session duration in which the EO was in place for each session of the FCT evaluation. We obtained the percentage of session duration with EO exposure by summing the durations of all reinforcer deliveries within each session and subtracting these durations from each session's total duration, yielding the duration that the EO was in place for destructive behavior for each session. We then divided this number by the session duration and converted the resulting quotient to a percentage, which produced the percentage of session duration with EO exposure. This calculation enabled us to easily compare the relative difference in EO exposures across sessions and conditions of the FCT evaluation, which when combined with the rate of destructive behavior per session, allowed for a more direct examination of how changes in EO exposure affected rates of destructive behavior.

We also evaluated the extent to which the introduction of each treatment resulted in an extinction burst, using the criteria reported by Lerman and Iwata (1995). These investigators defined an extinction burst as an increase in the response rate during any of the first three treatment sessions above that observed in all of the previous five baseline sessions (or all baseline sessions when there were fewer than five).

RESULTS

Figure 1 depicts the relevant portions of the functional analysis results for Carson and Alan. Carson engaged in consistently high levels of SIB during the tangible condition, suggesting that his SIB was reinforced by access to preferred stimuli. Carson also engaged in variable rates of SIB during the attention and escape conditions. We addressed the tangible function

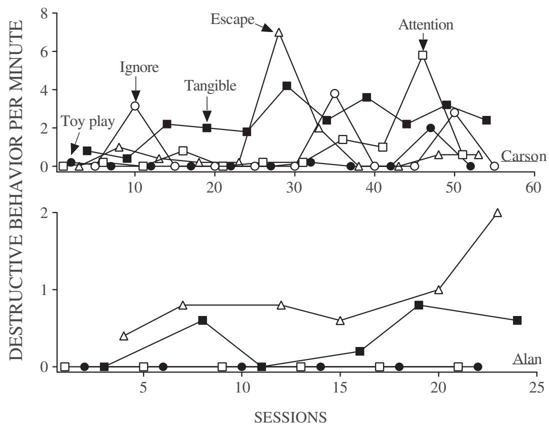

Figure 1. Functional analysis results for Carson (top panel) and Alan (bottom panel).

of Carson's SIB in the current study. We replotted Alan's first functional analysis from Fisher et al. (2016) for the purposes of this study. Alan engaged in elevated rates of destructive behavior in both the escape and tangible conditions. We addressed both functions of Alan's destructive behavior in the current study.

Figure 2 depicts the rates of destructive behavior, as well as the corresponding percentages of session duration with EO exposure during the baseline and FCT conditions of the FCT evaluation, for Carson. During the initial baseline, Carson displayed relatively efficient rates of SIB (M = 2.7 responses per min [RPM]) and was exposed to the EO for SIB for an average of 18% of baseline-session durations. Rates of SIB decreased (M = 0.3 RPM) when the EO for SIB was minimized (M = 7.8% of session duration) by the therapist immediately guiding the FCR in the limited-EO condition, whereas response rates increased beyond baseline levels (M = 7.7 RPM) when the therapist inserted a 5-s delay before physically guiding the FCR in the extended-EO condition, which produced additional exposure to the EO for SIB (M = 20.7% of session duration). We obtained similar results across the final two phases. Due to the prompting

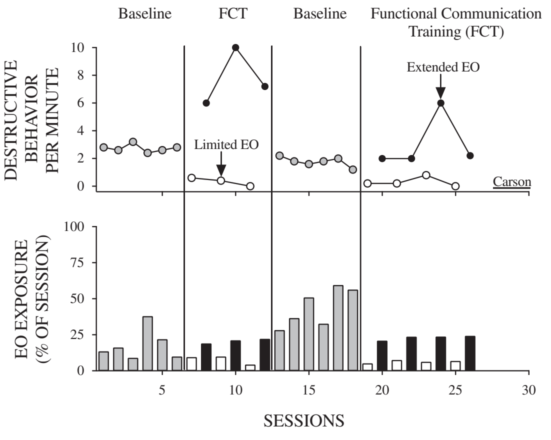

Figure 2. FCT-evaluation results for Carson with destructive behavior per minute (top panel) and corresponding percentages of session duration with EO exposure (bottom panel).

procedure we used with Carson, we observed high rates of prompted FCRs across all FCT sessions (not displayed). On five occasions, Carson emitted an independent FCR before the therapist physically guided this response after the 5-s prompt delay in the extended-EO condition. All of these instances occurred in the final phase of FCT.

Alan's FCT evaluation showed similar results to those described above for Carson across both functions of his destructive behavior. Alan displayed moderate yet efficient rates of destructive behavior (*M* = 2.5 RPM) during the initial tangible baseline, which correlated with moderate exposures to the EO for destructive behavior (*M* = 20.7% of session duration). When we implemented FCT in the tangible context, Alan displayed low and decreasing rates of destructive behavior in the limited-EO condition (*M* = 0.4 RPM), which was associated with slightly less exposure to the EO for destructive behavior (*M* = 16.9% of session duration) and high and increasing rates of destructive behavior during the extended-EO condition (*M* = 5.9 RPM), which corresponded with greater exposure to the EO for destructive behavior (*M* = 58.1% of session duration). We replicated these findings across the final two phases of the tangible context.

Alan engaged in moderate rates of destructive behavior during the initial escape baseline (*M* = 1.5 RPM) in which the EO for destructive behavior was controlled only by the occurrence of Alan's destructive behavior (*M* = 58.4% of session duration). During FCT, Alan's destructive behavior decreased to near-zero rates in the limited-EO condition (*M* = 0.2 RPM) in which the EO for destructive behavior was minimized (*M* = 34.5% of session duration) by the therapist providing immediate access to the FCR card. Rates of Alan's destructive behavior increased in the extended-EO condition (*M* = 2.3 RPM) in which the therapist temporarily withheld the FCR card, which produced relatively greater exposure to the EO for destructive behavior (*M* = 74% of session duration). We obtained similar results across the final two phases of the escape context. Alan's FCR data (not displayed) indicated high levels of independent FCRs across all FCT conditions for both functions of destructive behavior, with 10 FCRs occurring in all but one FCT session.

We observed the lowest rates of destructive behavior across sessions in the three limited-EO conditions (*M*s = 0.3, 0.2, and 0.4 RPM for Carson, Alan [tangible], Alan [escape], respectively), which coincided with the lowest levels of exposure to the EO (*M*s = 7%, 17%, and 33% of session duration) for Carson, Alan (tangible), and Alan (escape), respectively. By contrast, we observed the highest rates of destructive behavior across sessions in the extended-EO condition (*M*s = 5.1, 5.7, and 1.7 RPM for Carson, Alan [tangible], and Alan [escape], respectively), and this coincided with the highest levels of exposure to the EO for Alan's tangible and escape functions (*M*s = 58% and 73% for tangible and escape, respectively), but not for Carson (*M* = 22%). Nevertheless, levels of exposure to the EO correlated highly with rates of destructive behavior during the treatment phases for all three applications (r = .70, .95, and .85, for Carson, Alan [tangible], and Alan [escape], respectively).

Based on the criteria reported by Lerman and Iwata (1995), we observed an extinction burst in five of the six treatment phases in the extended-EO condition (83.3%). By contrast, we observed an extinction burst in zero of the six treatment phases in the limited-EO condition. In addition, Lerman and Iwata observed the prevalence of extinction bursts to be 12.2% (i.e., 7 of 59 applications) when extinction was combined with alternative procedures, which is much lower than the 83.3% of applications in which we observed an extinction burst in the extended-EO condition.

DISCUSSION

In this investigation, we directly tested the hypothesis that limiting exposure to the EO for destructive behavior produces more rapid reductions in destructive behavior and prevents extinction bursts during initiation of DRA interventions (e.g., FCT). Results showed that the limited-EO condition produced more rapid and consistent reductions in destructive behavior relative to the extended-EO condition, and the extended-EO condition produced an extinction burst in five of six applications, whereas the limited-EO condition did so in zero applications.

These findings replicate and extend the findings of DeRosa, Fisher et al. (2015). First, the current findings closely align with those of DeRosa, Fisher et al. in that both investigations found that limited exposure to the EO produced less response bursting and larger and more rapid reductions in destructive behavior. However, DeRosa, Fisher et al. used a card-touch response as the FCR in their limited-EO condition and a vocal response as the FCR in their extended-EO condition. This arrangement left open the possibility that the type of FCR (card touch or vocal) contributed to the observed differences in responding, to some degree. The current investigation controlled for this limitation by using the same FCR in both the limited- and extended-EO conditions (i.e., touching a picture card in both conditions for Carson, exchanging a picture card in both for Alan). Further support for the interpretation that duration of exposure to the EO produced the differential outcomes for the limited- and extended-EO conditions in the current investigation comes from the fact that duration of exposure to the EO correlated highly with rates of destructive behavior across the two treatment conditions for all three applications.

One interesting finding from our results was that mean rates of destructive behavior in baseline fell between those in the extended- and limited-EO conditions for two of the three applications (the tangible and escape evaluations conducted with Alan). This may have been due in part to the fact that the participants' destructive responses controlled the duration of EO exposure in baseline, whereas the extended-EO condition imposed a fixed duration of EO exposure each time the therapist presented the EO, which for Alan's applications extended EO exposure beyond that in baseline. By contrast, the therapist lessened the overall duration of EO exposure in the limited-EO condition to levels generally lower than in baseline by physically guiding the FCR (Carson) or by making the FCR cards continuously available (Alan).

We divided Carson's FCT sessions into ten 30-s trials in which the FCR (independent or prompted) resulted in the therapist delivering Carson's preferred tangible item for the remainder of the 30-s trial. We did this to yoke the total number of reinforcer deliveries across the limited- and extended-EO conditions, while ensuring that session duration did not vary systematically across conditions. However, in doing so, Carson accessed a slightly longer duration of reinforcement (i.e., a larger magnitude) per trial in the limited-EO condition, as the therapist immediately guided Carson to emit the FCR at the start of each trial in that condition. By contrast, the therapist waited 5 s before prompting the FCR at the start of each trial in the extended-EO condition. Though reinforcer durations were shorter in the extended-EO condition, most FCRs in Carson's limited- and extended-EO conditions produced over 20-s access to the reinforcer (*M*s = 28 s and 23 s for limited- and extended-EO conditions, respectively). Nevertheless, this difference in reinforcer magnitude across trial types likely influenced the rate of Carson's SIB across FCT conditions.

Because the therapist physically guided the FCR with Carson but did not do so with Alan, this procedural difference ostensibly caused fluctuations in how precisely the therapist controlled the EO for destructive behavior across participants in the limited- and extended-EO conditions. Carson experienced a minimal duration of EO exposure in the limited-EO condition (*M* = 7% of session duration) when the therapist physically guided the FCR, whereas Alan experienced a greater duration of EO exposure (*M*s = 17% and 33% of session duration for Alan's tangible and escape functions, respectively). Unlike Carson, we required Alan to emit an independent FCR upon the presentation of the FCR card in order to terminate the EO for his destructive behavior (i.e., to access the reinforcer). As can be inferred from his data for the limited-EO conditions displayed in Figure 3, Alan did not consistently emit this independent FCR quickly, which then extended the duration of time in which the EO remained present. Nevertheless, this arrangement rapidly reduced his destructive behavior to low levels in the first treatment session in three of four applications and in the second treatment session in the fourth application.

When behavior analysts teach FCRs initially, there are two common prompting strategies from which to choose. In least-to-most

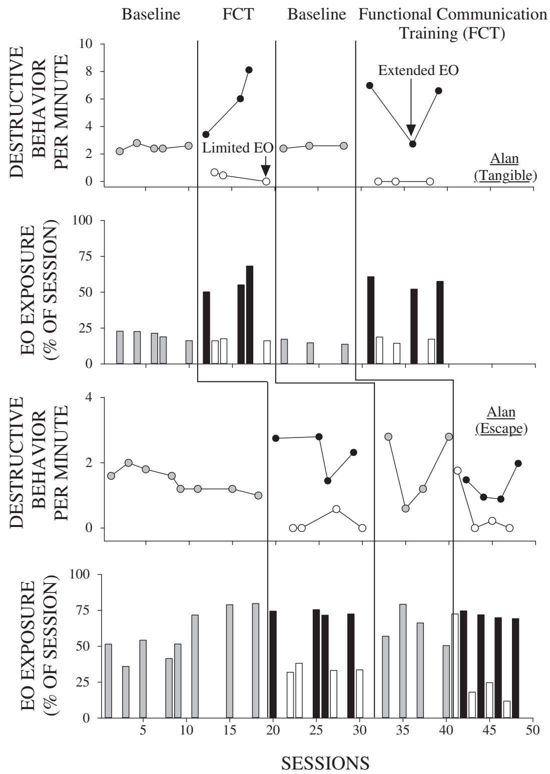

Figure 3. FCT-evaluation results for Alan's tangible function (top two panels) and escape function (bottom two panels) of destructive behavior. The top panel within each panel set displays responses per minute of destructive behavior, while the bottom panel within each panel set displays the corresponding percentages of session duration with EO exposure.

prompting (Shirley et al., 1997), the behavior analyst provides the opportunity for independent FCRs to occur by programming a period of exposure to the relevant EO prior to the behavior analyst verbally or physically prompting the FCR. In most-to-least prompting (e.g., the progressive-prompt-delay procedures used to teach FCRs in Greer et al., 2016, and Jessel et al., 2018), the behavior analyst begins teaching the FCR by physically guiding the response immediately after the EO is presented and then programs progressively longer exposures (e.g., 2 s, 5 s) to the EO following low levels of destructive behavior at the previously programmed prompt delay until FCRs occur independently. In this way, least-to-most and most-to-least prompting approximate the extended-EO and limited-EO conditions in the present study, respectively. As Tiger et al. (2008) noted, a possible advantage of least-to-most prompting is that it allows for destructive behavior to contact extinction quickly, which may help decrease the probability of future destructive behavior, whereas, by preventing destructive behavior from contacting extinction, most-to-least prompting may result in destructive behavior as treatment progresses. In the present study, however, destructive behavior often increased in the extended-EO condition and persisted despite contacting continued extinction. The limited-EO condition approximated the initial stages of most-to-least prompting and resulted in few instances of destructive behavior contacting extinction. Though a direct comparison of prompt-delay procedures and their effects on later treatment success (e.g., during reinforcement schedule thinning) is needed, our findings suggest that most-to-least prompting may be an optimal strategy for minimizing untoward side effects of extinction seen in the extended-EO condition and may be beneficial early on when initiating FCT.

It is worth noting that the duration of EO exposure that was associated with low levels of destructive behavior varied across participants and applications within a participant. That is, Carson typically displayed destructive behavior within a few seconds after presentation of the EO. By contrast, Alan's latency to destructive behavior following introduction of the EO was somewhat longer for his tangible function and much longer for his escape function. The PI assessment used with Alan might be a useful tool in determining an optimal EO exposure when teaching an FCR. For example, Alan's PI assessment indicated that he tolerated exposure to the EO for 5 s, but not for 10 s, in the tangible condition. Therefore, it probably would have been better to physically guide the FCR after 5 s of exposure to the EO without an independent FCR. Such results may inform most-to-least prompting to both mitigate destructive behavior when teaching the FCR, but also may allow the behavior analyst to progress more quickly than had she selected arbitrary prompt delays (e.g., 0 s, 2 s). The PI assessment might also be useful for identifying the initial schedule density for the commencement of reinforcement schedule thinning (e.g., the duration of the initial extinction component of a multiple schedule used for schedule thinning). This may be important because destructive behavior often recurs during reinforcement schedule thinning as FCRs contact extinction (Briggs et al., in press; Kuhn et al., 2010; Shamlian et al., 2016).

In conclusion, prior investigations have identified a variety of variables that impact the efficacy of FCT, such as response effort, reinforcer density, reinforcer delay, combining reinforcement of the FCR with extinction, and bringing the FCR under the discriminative control of a multiple schedule (e.g., Fisher et al., 2015; Greer et al., 2016; Hagopian et al., 1998; Horner & Day, 1991; Shirley et al., 1997; Wacker et al., 1990). Adding to this list, the preliminary findings of DeRosa, Fisher et al. (2015) suggest, and the current results confirm, that controlling the level of exposure to the EO can be an important variable that affects the efficacy of FCT by rapidly reducing problem behavior to low levels and preventing extinction bursts when initiating treatment with FCT.

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ENHANCING THE EFFECTS OF EXTINCTION ON ATTENTION-MAINTAINED BEHAVIOR THROUGH NONCONTINGENT DELIVERY OF ATTENTION OR STIMULI IDENTIFIED VIA A COMPETING STIMULUS ASSESSMENT

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Recent research has shown that the noncontingent delivery of competing stimuli can effectively reduce rates of destructive behavior maintained by social-positive reinforcement, even when the contingency for destructive behavior remains intact. It may be useful, therefore, to have a systematic means for predicting which reinforcers do and do not compete successfully with the reinforcer that is maintaining destructive behavior. In the present study, we conducted a brief competing stimulus assessment in which noncontingent access to a variety of tangible stimuli (one toy per trial) was superimposed on a fixed-ratio 1 schedule of attention for destructive behavior for individuals whose behavior was found to be reinforced by attention during a functional analysis. Tangible stimuli that resulted in the lowest rates of destructive behavior and highest percentages of engagement during the competing stimulus assessment were subsequently used in a noncontingent tangible items plus extinction treatment package and were compared to noncontingent attention plus extinction and extinction alone. Results indicated that both treatments resulted in greater reductions in the target behavior than did extinction alone and suggested that the competing stimulus assessment may be helpful in predicting stimuli that can enhance the effects of extinction when noncontingent attention is unavailable.

DESCRIPTORS: attention-maintained problem behavior, competing stimuli, extinction, functional analysis, noncontingent reinforcement

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Since the emergence of functional analytic methods, treatment of severe behavior disorders using extinction has become considerably more precise (Iwata, Pace, Cowdery, & Miltenberger, 1994). That is, by identifying the specific reinforcers for problem behavior, functional analysis also specifies the contingency that must be discontinued for extinction to occur. Nevertheless, extinction implemented in isolation has a variety of potential limitations.

One limitation of extinction is that it is sometimes associated with a rather gradual decline in rates of the target behavior (e.g., Goh & Iwata, 1994). Another important limitation of implementing extinction in isolation is that it sometimes removes the individual's primary means of obtaining reinforcement without providing an alternative; this may result in a substantial decrease in the amount of reinforcement received. A related limitation is that when extinction produces reinforcement deprivation, negative side effects like bursts of the target response, extinction-induced aggression, and emotional behavior are more likely (Goh & Iwata; Lerman & Iwata, 1996; Lovaas, Freitag,

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Gold, & Kassorla, 1965; Piazza, Patel, Gulotta, Sevin, & Layer, 2003).

One approach that has been used to offset these limitations has been to combine extinction with delivery of the consequent stimulus that historically reinforced problem behavior on a response-independent or time-based schedule, a treatment sometimes referred to as *noncontingent reinforcement* (NCR; Vollmer, Iwata, Zarcone, Smith, & Mazaleski, 1993). Although this term has been criticized for being inaccurate and imprecise (for discussions of the terminology issues, see Poling & Normand, 1999; Vollmer, 1999), we use it here to maintain contact with the literature most relevant to the current investigation.

In contrast to extinction (implemented alone), NCR often results in rapid and large reductions in problem behavior, and the individual is not deprived of access to the stimulus that historically reinforced problem behavior (e.g., Hagopian, Fisher, & Legacy, 1994; Lalli, Casey, & Kates, 1997). In addition, Vollmer et al. (1998) compared the effects of extinction with and without NCR and found that extinction, when implemented alone, was associated with bursts of behavior for 2 of the 3 participants, whereas extinction with NCR was not.

One potential difficulty of using NCR to enhance the reductive effects of extinction is that it may not always be possible or feasible to deliver the reinforcer that maintains the problem behavior. For example, problem behavior reinforced by attention is most likely to occur when a parent's (or caregiver's) attention is diverted away from the child (Vollmer, Borrero, Wright, Van Camp, & Lalli, 2001). Thus, this sometimes creates a conflict in which we ask parents to deliver dense, time-based schedules of attention to a child at times when they are busy with other activities (e.g., taking an important phone call; balancing the checkbook; closing windows at the start of a storm).

One approach that has been proposed to address this potential conflict has been to deliver alternative (Hanley, Piazza, & Fisher, 1997), arbitrary (Fischer, Iwata, & Mazaleski, 1997), or competing reinforcers or stimuli (Fisher, O'Connor, Kurtz, DeLeon, & Gotjen, 2000) at times when it is impossible or impractical to deliver the reinforcer that maintains the problem behavior. The terms *alternative, arbitrary,* and *competing* reinforcers have been used in the studies cited above to label preferred stimuli that may compete with the reinforcer for problem behavior but that do not reinforce that behavior (either because a contingency between the response and the stimulus has not previously existed or because a contingency existed but failed to maintain the response). The terms, however, are not interchangeable, because arbitrary reinforcers do not necessarily compete with the behavior of interest. Therefore, for the remainder of this article, we will use the term *competing* to describe stimuli that compete with the reinforcer for problem behavior, because this term seems to clearly describe its relation to the target response and the reinforcer that maintains that response.

A variety of methods have been used to identify competing stimuli, but in most studies, the accuracy of those methods has not been evaluated. Both Hanley et al. (1997) and Fischer et al. (1997) used the paired-choice preference assessment described by Fisher et al. (1992) in selecting the competing reinforcers. Fisher et al. (2000) replicated and extended these findings by showing that a competing stimulus assessment, based on methods used to treat automatic reinforcement (e.g., Piazza et al., 1998; Shore, Iwata, DeLeon, Kahng, & Smith, 1997), could be used to predict which stimuli would and would not effectively compete with attention-maintained destructive behavior.

Although competing stimuli have sometimes reduced problem behavior to low levels without extinction (Fischer et al., 1997; Fisher et al., 2000), from a clinical perspective it may make intuitive sense to combine the two procedures (competing stimuli plus extinction) whenever it is feasible. For example, Hanley et al. (1997) compared the effects of competing stimuli (noncontingent tangible [NCT]) combined with extinction to noncontingent attention (NCA) combined with extinction with 2 participants who displayed destructive behavior reinforced by attention. Both treatments were effective with each participant. However, for 1 participant, destructive behavior decreased gradually (similar to what might be expected if extinction were implemented alone). For the other participant, destructive behavior decreased to zero in the first NCT plus extinction session (before the participant contacted nonreinforced responding or extinction). Thus, in the Hanley et al. study, it appeared that extinction was the primary operative mechanism for 1 participant (the one who showed the gradual decline in responding), whereas the competing stimulus appeared to be the essential operative mechanism for the other participant (the one who showed an immediate reduction in responding). That is, competing stimuli appeared to enhance the effects of extinction with 1 participant but not the other.

Our interpretation of Hanley et al.'s (1997) results (that competing stimuli contributed substantially to the treatment effects in one case but not the other) remains somewhat speculative because the enhancing effects of the competing stimuli were not isolated in that investigation. To isolate the enhancing effects of competing stimuli, it would be necessary to evaluate the effects of competing stimuli with extinction relative to a condition in which extinction was implemented alone, just as Vollmer et al. (1998) evaluated the enhancing effects of NCR by comparing NCR plus extinction with extinction alone. In the current investigation, we extended the results of Hanley et al. and replicated the results of Vollmer et al. by comparing the effects of (a) extinction implemented alone, (b) extinction implemented with noncontingent delivery of the reinforcer that maintained destructive behavior (attention), and (c) extinction implemented with noncontingent delivery of competing stimuli (those identified through the competing stimulus assessment). A secondary purpose of the current investigation was to further evaluate the usefulness of a competing stimulus assessment for destructive behavior reinforced by social contingencies, because the Fisher et al. (2000) study addressed this issue with only 1 participant.

METHOD

Participants and Setting

Four individuals participated in the study. Jill was a 9-year-old girl who had been diagnosed with mild mental retardation. Sally was a 33-year-old woman who had been diagnosed with severe mental retardation and intermittent explosive disorder. Katy was a 5-year-old girl who had been diagnosed with moderate to severe mental retardation. Jill, Sally, and Katy displayed destructive behavior consisting of aggression, self-injury, and disruptive behavior. Carl was a 7-year-old boy who had been diagnosed with severe mental retardation. His destructive behavior included aggression and self-injury. All sessions were conducted in a hospital specializing in the treatment of behavior disorders.

Data Collection and Interobserver Agreement

During all assessment and treatment sessions, trained observers used laptop computers to record the frequency of destructive behavior and the duration of item interaction. A second observer independently collected data on 62% of functional analysis sessions, 38.3% of the competing stimulus assessment trials, and 69.1% of treatment analysis sessions. For duration measures, the smaller number of seconds per 10-s interval (30-s intervals for Jill's competing stimulus assessment) was divided by the larger number of seconds and multiplied by 100%. For frequency measures, exact agreement coefficients were calculated by comparing observer agreement on the exact number of occurrences of a response during each 10-s interval of a session (30-s interval for Jill's competing stimulus assessment). An agreement was scored if both observers recorded exactly the same number of responses in an interval. Agreement coefficients were computed by dividing the number of intervals with agreements by the total number of intervals in a session and multiplying the quotient by 100%. Average agreement coefficients for Jill were, for aggression, 93.1%; self-injury, 98.2%; disruptive behavior, 93.3%; and item interaction, 88.8%. Average agreement coefficients for Sally were, for aggression, 99.4%; self-injury, 99.9%; disruptive behavior, 99.9%; and item interaction, 97.9%. Average agreement coefficients for Katy were, for aggression, 99.0%; self-injury, 97.8%; disruptive behavior, 77.5%; and item interaction, 96.5%. Average agreement coefficients for Carl were, for aggression, 92.8%; self-injury, 99.9%; and item interaction, 97.9%.

Procedure and Experimental Design

Phase 1: Functional analysis. A functional analysis of destructive behavior was conducted with each participant using procedures similar to those described by Iwata, Dorsey, Slifer, Bauman, and Richman (1982/1994). The conditions included for each participant varied slightly as a function of caregiver information or initial informal observations. For example, tangible conditions were included if parents reported that toy removal sometimes set the occasion for problem behavior. For Jill, the functional analysis included social attention, demand, tangible, and toy play conditions. In the social attention condition, the therapist read a magazine while Jill was instructed to play quietly with low to moderately preferred toys. Contingent on destructive behavior, the therapist provided a brief verbal reprimand on a fixed-ratio (FR) 1 schedule of reinforcement. In the demand condition, the therapist used three-step guided compliance to instruct Jill to complete educational tasks. Contingent on destructive behavior, Jill was allowed to escape the task for 30 s. The tangible condition was conducted to determine if Jill's destructive behavior was maintained by access to preferred stimuli. In this condition, Jill was given 2-min access to a highly preferred item prior to the session. At the start of the session, the therapist removed the item. Contingent on destructive behavior, Jill was given access to the item for 30 s. The toy play condition was included as a control condition in which no demands were placed on Jill, she received noncontingent access to attention and highly preferred stimuli, and destructive behavior was ignored. All sessions were 10 min in length and were conducted using a multielement design.

Carl's functional analysis was run similarly with the addition of an alone condition. In the alone condition, Carl was placed in an empty session room while one or two data collectors observed through a one-way mirror. Sally's functional analysis was run similarly in that she also was exposed to an alone condition; however, the tangible condition was not included in her functional analysis. For Carl and Sally, all sessions were 10 min in length.

Katy was exposed to social attention, demand, tangible, toy play, ignore, and mands conditions in her functional analysis. The mands condition was based on the test condition of the mand analysis described by Bowman, Fisher, Thompson, and Piazza (1997). In this condition, prior to the beginning of the session the therapist asked Katy, "What do you want to do?" Then the therapist complied with any mands the child emitted (unless the requested activity was dangerous). After 2 min, the session began. The therapist then told Katy, "Now we are going to play my way," and chose a different activity. Contingent on target maladaptive behavior, Katy was given access to 30 s of playing her way. The purpose of this condition was to determine the extent to which Katy's destructive behavior was maintained by compliance with her requests and was conducted as part of a different investigation. In addition, each condition was conducted with one of three different therapists across sessions. This was arranged to confirm anecdotal observations that the majority of her destructive responses occurred in the presence of a specific therapist. For Katy, all sessions were 20 min in length. Finally, the analysis was conducted using a pairwise comparison design (Iwata, Duncan, Zarcone, Lerman, & Shore, 1994) to help Katy discriminate among the different conditions.

Phase 2: Competing stimulus assessments. Phase 2 was then conducted for each participant. A variety of stimuli and activities were selected for the assessment based on caregiver interviews and the results of a prior paired-choice preference assessment (Fisher et al., 1992). Fifteen stimuli were identified for Jill (three of which included interactive play with the therapist), and 11 stimuli were identified for Sally (three with interactive play), Katy, and Carl. In addition, for Sally and Carl, a control condition (in which no stimuli were available) and an NCA condition (in which the therapist verbally interacted with the participant) were evaluated. Finally, Carl's competing stimulus assessment also included an NCA condition in which physical attention (i.e., tickling, rubbing his back) was provided.

In the competing stimulus assessments, each item or condition was presented three times for Carl, Sally, and Katy and four times for Jill. During each trial, an item was presented by itself (no other toys or stimuli were present) and destructive behavior continued to produce attention on an FR 1 schedule. Trials lasted 30 s for Jill, 3 min for Carl, and 4 min for Sally and Katy. Trial length varied across participants partly as a pilot effort to identify the trial duration that best predicted long-term competition effects, again as a prelude to a different investigation. During each trial, observers recorded the frequency of destructive responses and the percentage of the trial time that the participant interacted with the available item. The frequency of destructive behavior was summed across trials for each item and was then converted to rate (responses per minute). The interaction percentages were averaged across trials for each item. Stimuli that competed effectively with destructive behavior (ones with low rates of destructive behavior and high percentages of item interaction) were then evaluated in treatment sessions.

Phase 3: Treatment analysis. All sessions during the treatment analyses lasted 10 min. The baseline conditions were identical to the attention conditions of the functional analysis. That is, at the start of the session, the participant was instructed to play quietly with low to moderately preferred toys (the ones that were present during the attention condition of the functional analysis). These toys were present during all baseline and treatment sessions. Thereafter, the therapist read a magazine in the treatment room and delivered a brief verbal reprimand each time the participant displayed a target response. Rates of behavior during the baseline phases were compared to rates during a treatment phase using an ABAB design.

During the treatment phases, three conditions were alternated in a multielement design, with one exception. Because NCT plus extinction was the primary treatment of interest, we implemented this condition first with each of the 4 participants. We did this so that we could better evaluate the rapidity with which this treatment produced effects on destructive behavior. This eliminated the possibility that reductions observed in the first NCT plus extinction were due, in part, to prior exposure to extinction or NCA plus extinction (i.e., carryover effects).

During extinction, the therapist did not interact with the participant and simply ignored all instances of destructive behavior. During NCA plus extinction, the therapist provided continuous interaction throughout the session, but did not respond differentially to destructive behavior. During NCT plus extinction, the therapist again did not interact with the participant and ignored destructive responses, but stimuli selected on the basis of the competing stimulus assessments (listed below for each participant in the results for Phase 2) were continuously available along with the low to moderately preferred toys that were available across all sessions in Phase 3.

RESULTS

Phase 1. Results of the functional analyses conducted in Phase 1 are presented in Figure 1. Jill's functional analysis suggested that her destructive behavior was maintained by positive reinforcement in the form of access to adult attention (social attention, $M = 7.1$ responses per minute; toy play, $M = 0.05$; demand, $M = 0.8$; tangible, $M = 0.9$). The functional analysis suggested that Sally's destructive behavior was maintained by access to adult attention and escape from instructional tasks (social attention, $M = 1.0$ responses per minute; alone, $M = 0.06$; toy play, $M = 0.2$; demand, $M = 1.2$).

Carl displayed high and variable rates of destructive behavior across the attention, demand, and tangible conditions (social attention, $M = 3.2$ responses per minute; alone, $M = 1.6$; toy play, $M = 0.1$; demand, $M = 1.7$; tangible, $M = 1.3$). Extended evaluation of the social attention and toy play conditions revealed clear differential responding in the attention condition (social attention, $M = 4.3$; toy play, $M = 0.2$). The data from Katy's functional analysis suggested that her destructive behavior was maintained by positive reinforcement in the form of access to adult attention (attention, $M = 16.7$ responses per minute; ignore, $M = 3.4$; tangible, $M = 0.7$; toy play, $M = 0.02$; demand, $M = 2.4$; mands, $M = 1.1$). However, close examination of these data suggested that Katy's destructive behavior was maintained by positive reinforcement with only one of the three therapists. Due to the therapist-specific nature of Katy's destructive behavior, all subsequent treatment evaluation sessions were conducted with this therapist.

Phase 2. Results of the competing stimulus assessment are presented in Figure 2. Jill displayed the lowest rates of destructive behavior when either the make-believe item or the crayons (both interactive play items) were available noncontingently and displayed higher levels of interaction with the former stimulus ($M = 96\%$) than with the latter stimulus ($M = 45\%$). However, these stimuli involved the delivery of both the tangible item and attention. The stimuli that did not involve interactive play that competed best with contingent attention (i.e., produced the lowest rates of destructive behavior) were a Walkman® with a tape (item interaction, $M = 86\%$; destructive behavior, $M \cong 3$ reponses per minute) and a keyboard (item interaction, $M = 76\%$; destructive behavior, $M \cong 2$ responses per minute). These two stimuli were included in the noncontingent tangible condition in Phase 3.

During Sally's competing stimulus assessment, the headphones (with music) were associated with high levels of item interaction ($M = 95\%$) and zero rates of destructive

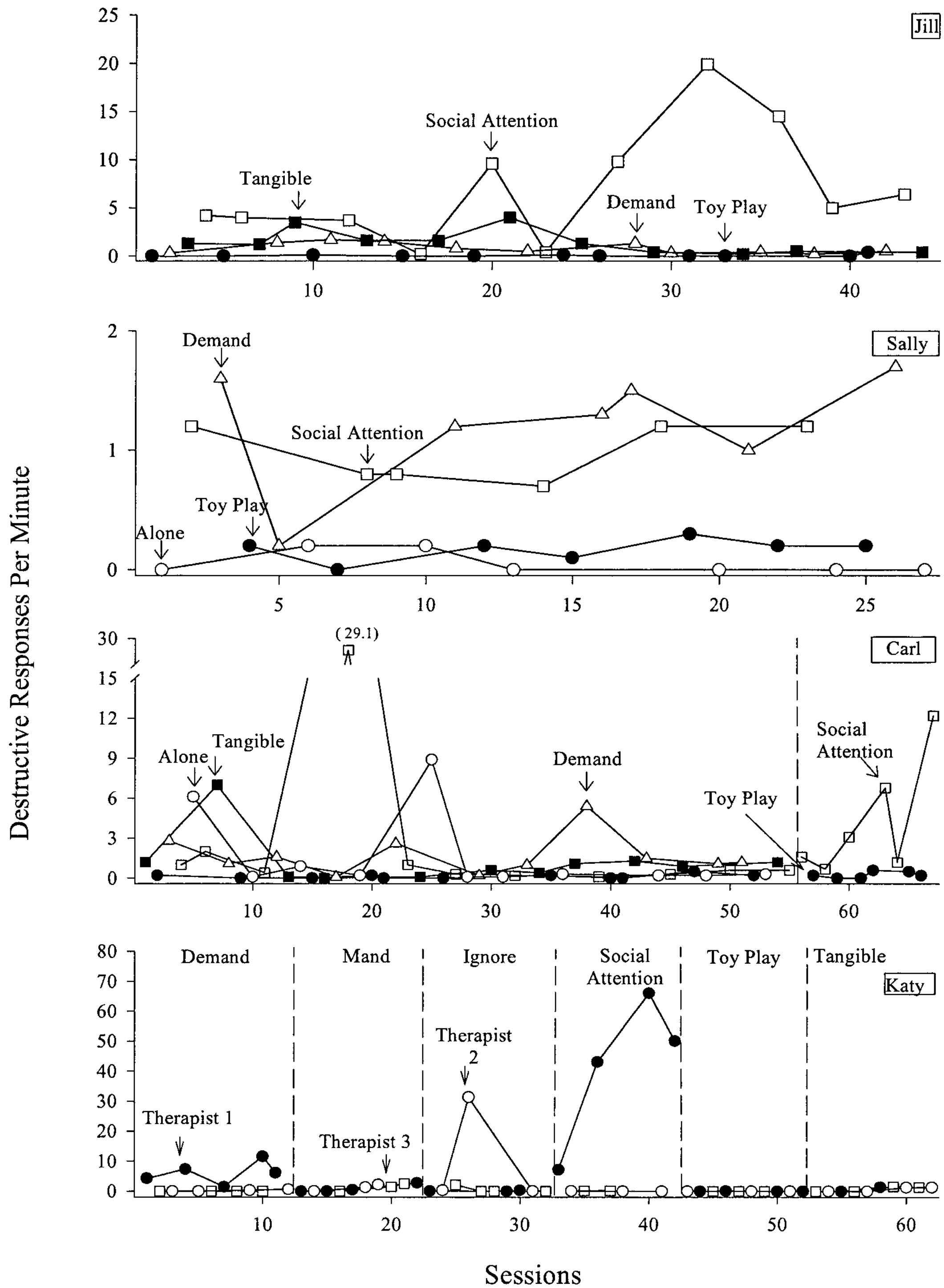

Figure 1. Rates of destructive behavior during functional analysis conditions for Jill, Sally, Carl, and Katy.

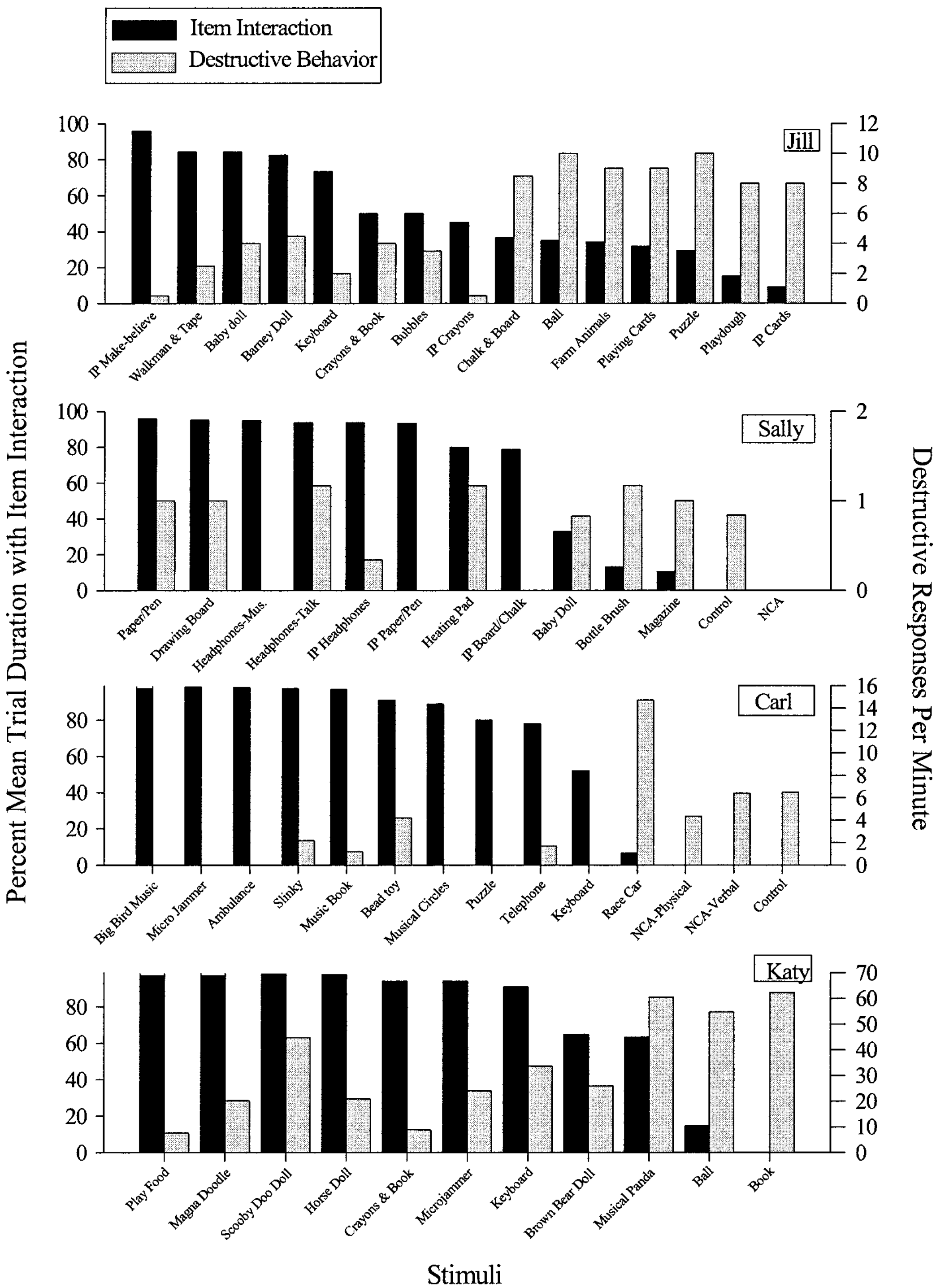

Figure 2. Rates of destructive behavior and mean duration of item interaction during the competing stimulus assessments for Jill, Sally, Carl, and Katy. IP = interactive play.

behavior, and this item was included in the treatment evaluation in Phase 3. During Carl's competing stimulus assessment, a Big Bird® musical toy (item interaction, M = 99.0%; destructive behavior, M = 0) and musical circles (item interaction, M = 89.5%; destructive behavior, M = 0) were identified as stimuli that could compete with attention-maintained behavior. These two stimuli were used in the treatment evaluation in Phase 3.

During Katy's competing stimulus assessment, play food (item interaction, M = 99%; destructive behavior, $M \cong 7.7$ responses per minute), a coloring book with crayons (item interaction, M = 94.2%; destructive behavior, $M \cong 8.8$ responses per minute), and a horse doll (item interaction, M = 97.8%; destructive behavior, $M \cong 20.9$ responses per minute) were stimuli that competed at least to some extent with contingent attention, although rates of destructive behavior were unacceptably high in these sessions. These three stimuli were used in the treatment evaluation in Phase 3.

Phase 3. Results from Phase 3 are depicted in Figure 3. Rates of destructive behavior for Jill averaged about 11 across the two baseline phases. During the treatment analysis, rates of destructive behavior were considerably lower than baseline in all three treatment conditions, with NCA plus extinction producing the lowest rates (M = 0) followed closely by NCT plus extinction (M = 0.5) and extinction (M = 2.1). In addition, NCT plus extinction reduced destructive behavior to zero in 6 of 10 sessions.

Baseline rates of destructive behavior averaged 1.0 for Sally. All three treatment conditions reduced destructive behavior to zero (NCA plus extinction and NCT plus extinction) or almost zero (extinction, M = 0.04). It should be noted that Sally's destructive behavior decreased to zero in the first three treatment sessions, which were NCT plus extinction, extinction, and NCA plus extinction, respectively. This suggests that the noncontingent delivery of the competing stimuli and attention may have decreased destructive behavior in the extinction condition (carryover effects), because Sally did not come in contact with nonreinforced responding in the first extinction session.

Baseline rates for Carl averaged about 4.2 across phases. As with the other participants, all three treatments reduced destructive behavior substantially; however, the lowest rates were observed during NCT plus extinction (M = 0.3), followed by NCA plus extinction (M = 1.1) and extinction (M = 1.9). In addition, extinction was associated with a large burst of destructive behavior in the fourth session.

For Katy, rates of destructive behavior averaged 46.6 across the two baseline phases. Extinction produced a relatively slow and gradual reduction in destructive behavior (M = 9.5). By contrast, both NCA plus extinction (M = 0.1) and NCT plus extinction (M = 0.3 RPM) immediately reduced destructive behavior to almost zero.

Across the 4 participants, NCT plus extinction was always the first treatment implemented so that we could evaluate the rapidity with which it produced effects on destructive behavior. NCT plus extinction reduced destructive behavior to near zero in the first session for Sally, Katy, and Carl and in the second session for Jill. In the one case in which a burst of destructive behavior occurred (Carl), it occurred in extinction but not in NCA plus extinction or NCT plus extinction.

DISCUSSION

In the current investigation, 4 individuals with mental retardation displayed destructive behavior that was shown to be sensitive to attention as reinforcement during the functional analyses conducted in Phase 1. In Phase 2, a competing stimulus assessment

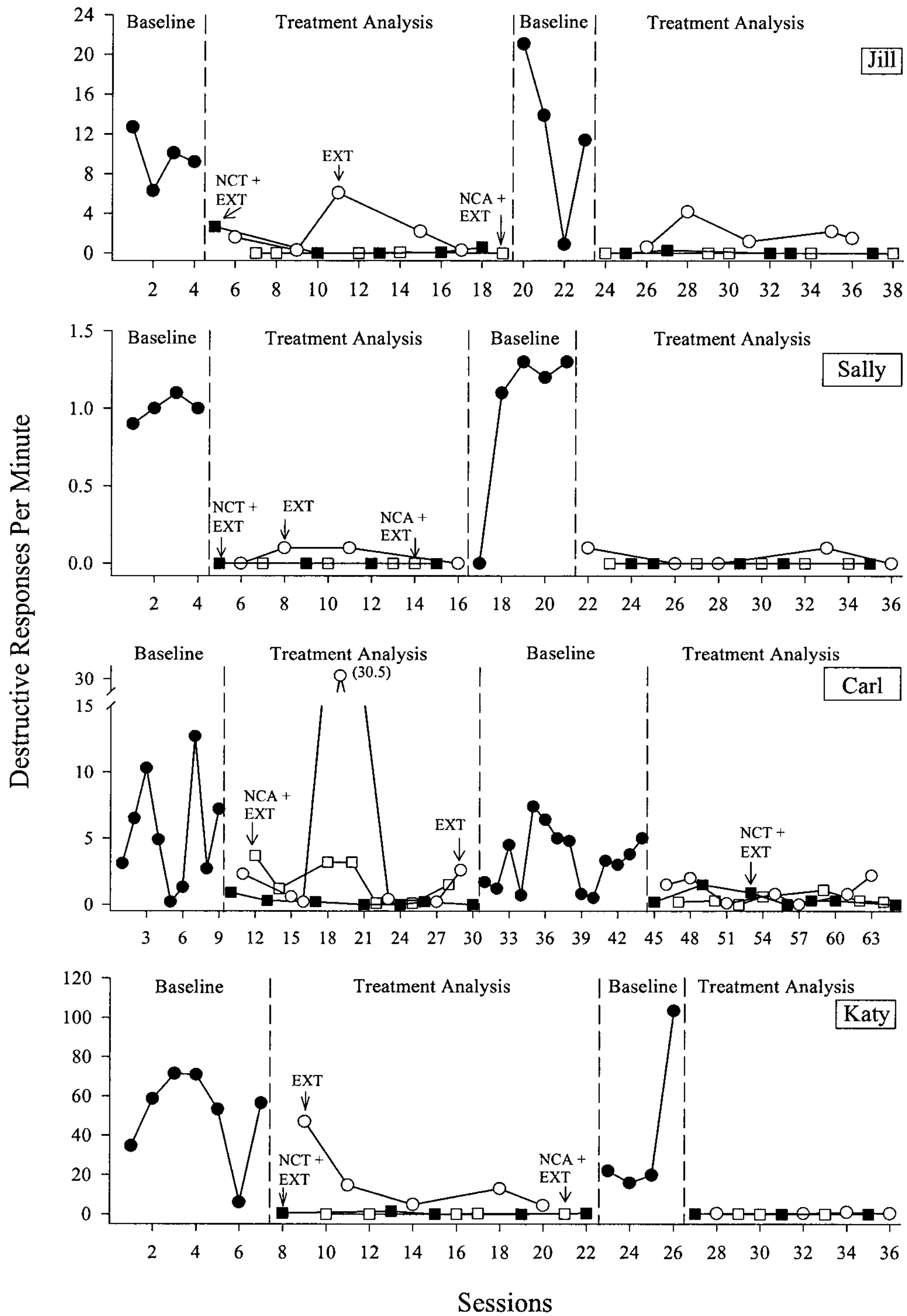

Figure 3. Rates of destructive behavior during baseline and during the extinction (EXT), noncontingent attention plus extinction (NCA + EXT), and noncontingent tangible items plus extinction (NCT + EXT) conditions of the treatment analyses.

(Piazza et al., 1998) was used to identify stimuli (e.g., toys, music) that, when presented noncontingently during brief assessment trials, reduced rates of destructive behavior, even though this response continued to produce its reinforcer (attention) on an FR 1 schedule. In Phase 3, we evaluated whether the stimuli that competed effectively with attention in Phase 2 would enhance the effectiveness of extinction by comparing extinction implemented (a) alone, (b) in combination with NCA, and (c) in combination with the stimuli identified in Phase 2 (NCT plus extinction). In general, results indicated that NCT plus extinction and NCA plus extinction produced rapid and dramatic reductions in destructive behavior (i.e., they were approximately equally effective), and both were more effective than when extinction was implemented alone.

The current investigation adds to the literature on treatment of destructive behavior using competing stimuli in several ways. First, previous investigations have shown that noncontingent presentation of the reinforcer that maintained problem behavior (Vollmer et al., 1998) or competing stimuli (Hanley et al., 1997) in combination with extinction can produce rapid reductions in destructive behavior; however, the current investigation is the first one to directly compare these two approaches relative to the effects of extinction alone. The fact that the competing stimuli were effective substitutes for attention is encouraging.

From a clinical perspective, being able to substitute competing stimuli for the maintaining reinforcer permits greater flexibility in how and when each procedure (NCA or NCT) might be implemented with extinction. NCA plus extinction might be most relevant to situations involving naturally occurring exchanges of social interaction (e.g., meals, games, discussions). During these types of situations, NCA would not require much additional effort on the part of caregivers. For example, a parent might be taught to deliver frequent verbal attention to the child as a routine component of such activities (e.g., including the child in the conversation, periodically talking about topics the child prefers), as well as delivering intermittent physical attention (e.g., pats on the back). In these types of social situations, the amount of additional effort required from the caregiver to implement NCA would be minimal. By contrast, NCT plus extinction might be more relevant to situations in which parents or caregivers are too busy to deliver frequent attention to the child (e.g., preparing for an important meeting at work, intimacy time for the parents). Alternately implementing NCA plus extinction (during naturally occurring social activities) and NCT plus extinction (when it is difficult or inconvenient for caregivers to deliver attention) allows parents and other caregivers more flexibility in planning their daily schedules. For example, if a child displays problem behavior reinforced by attention, the parent could schedule a period of NCA when the child first returns home from school followed by a period of NCT when the parent needs to prepare dinner.

A second contribution of the current investigation is that it showed that the competing stimuli enhanced the effects of extinction about as well as NCA did. That is, in the two cases in which extinction produced a relatively slow and gradual reduction in destructive behavior (Jill and Katy), NCT plus extinction produced an immediate and sustained reduction in the target behavior to near zero (as did NCA plus extinction). Similarly, in the one case in which an extinction burst occurred (Carl), no bursting occurred in NCT plus extinction (or in NCA plus extinction), and rates of destructive behavior were lower in NCT plus extinction than in NCA plus extinction.

A third contribution is that the current results provide further evidence supporting the utility of the competing stimulus assessment. The purpose of the competing stimulus assessment is to identify stimuli that are effective substitutes for the reinforcer that maintains the target behavior. Reinforcers are said to be substitutable when consumption of one reinforcer is associated with a decrease in consumption of a concurrently available reinforcer (Green & Freed, 1993; Shore et al., 1997). Most previous studies that have used competing stimuli have done so to treat problem behavior purportedly maintained by automatic reinforcement, because it is often difficult or impossible to implement extinction for behavior thus maintained (e.g., Piazza et al., 1998; Piazza, Roane, Keeney, Boney, & Abt, 2002; Shore et al., 1997). The current results show that using a competing stimulus assessment can be useful even with responses reinforced by social consequences, for which extinction can be implemented.

Although the competing stimulus assessment identified stimuli that enhanced the effects of extinction, one limitation of this study is that it remains unclear whether the same result could have been produced with a less time-consuming preference assessment (e.g., DeLeon & Iwata, 1996). However, results of the competing stimulus assessment in this investigation and in the Piazza et al. (1998) study suggest that this approach to identifying competing stimuli provides information not available with other preference assessments. Perhaps the best example of this is the results obtained for Sally in Phase 2. During Sally's competing stimulus assessment, there were multiple stimuli with high levels of item interaction (suggesting that they were highly preferred) and high rates of destructive behavior (suggesting that they were not effective substitutes for attention). In fact, for all of the participants, there were stimuli that appeared to be similar in terms of item interaction (i.e., how much they were preferred) but were different in terms of how well they competed with the reinforcer for destructive behavior (i.e., how well they substituted for attention). Participants in the study by Piazza et al. (1998) showed similar patterns when a competing stimulus assessment was used to identify stimuli that competed with pica. Moreover, in a previous investigation we showed that a competing stimulus assessment accurately identified which stimuli would and would not compete with destructive behavior reinforced by attention (Fisher et al., 2000).

Despite these findings, a better test of the usefulness of the competing stimulus assessment would be to compare it directly with a more efficient preference assessment that does not evaluate substitutability (e.g., DeLeon & Iwata, 1996; Fisher et al., 1992). That is, one could identify items chosen through a different preference assessment that are associated with high levels of problem behavior in the competing stimulus assessment to show that the knowledge obtained in the competing stimulus assessment provides utility beyond that provided by the other format.

Another potential limitation of the current investigation is that the reinforcers used in the NCT conditions were not tested to determine whether they maintained the target response. This approach has been used in other studies as a means of ensuring the arbitrary nature of the stimuli employed (e.g., Fischer et al., 1997). Thus, it remains possible that NCT plus extinction suppressed behavior because it attenuated the motivation to gain access to tangible reinforcers.

Finally, the rates of destructive behavior were not dramatically lower during NCA plus extinction or NCT plus extinction relative to extinction alone. Furthermore, only 1 participant displayed an extinction burst, and in just one session. Although this was not surprising given the prevalence of extinction bursts (24%; Lerman & Iwata, 1996), NCT plus extinction would need to be implemented with many more participants before one could determine the extent to which the presence of competing stimuli help to prevent extinction bursts. However, it is possible that the effects of NCA and NCT would have been more pronounced had the three treatments been compared using a reversal design rather than a multielement design. For example, Sally's destructive behavior decreased to zero in the first treatment session, which was an NCT plus extinction session, and remained at zero during the second treatment session, which was extinction. Thus, Sally's destructive behavior decreased to zero in the first extinction session without contacting extinction (or nonreinforced responding). This raises the possibility that rates of destructive behavior during extinction were lower than they would have been if this intervention had not been alternately implemented in close temporal proximity to NCA plus extinction and NCT plus extinction. Future studies should evaluate the potential benefits of implementing NCA or NCT in combination with extinction (e.g., prevention of bursting, more rapid reductions in problem behavior) with a larger cohort of participants using alternative experimental designs.

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STUDY QUESTIONS

1. What undesirable effects are sometimes associated with the use of extinction?

2. What potential difficulty did the authors describe in attempting to supplement extinction with noncontingent reinforcement, and what alternative approach did they illustrate in the present study?

3. How did Katy's functional analysis differ from those for the other participants?

4. Describe the competing stimulus assessment and how its results were used to identify stimuli used in the current study.

5. Describe the three treatment conditions and how they were compared.

6. Why were the interactive play toys not used in Jill's NCT plus extinction condition even though they produced the lowest rates of problem behavior and highest percentages of item manipulation during her assessment?

7. Summarize the results of the treatment comparison.

8. What is the main practical implication of the present results?

Questions prepared by Leah Koehler and Stephen North, University of Florida

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EVALUATING COMPETING ACTIVITIES TO ENHANCE FUNCTIONAL COMMUNICATION TRAINING DURING REINFORCEMENT SCHEDULE THINNING

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Arranging periods in which requests for reinforcement are denied in a multiple schedule may result in increased destructive behavior during these periods for individuals who receive functional communication training (FCT) as treatment for severe destructive behavior. Providing access to competing activities during periods of reinforcer unavailability has been shown to minimize destructive behavior. We evaluated methods to identify effective competing activities for use when thinning reinforcement availability in a multiple schedule and compared competing activities embedded within the multiple schedule using an alternating-treatments design. Results suggested at least one competing activity facilitated favorable treatment outcomes for each participant. We discuss building on this empirical approach to identify effective competing activities for use during reinforcement schedule thinning.

Key words: competing activities, destructive behavior, functional communication training, multiple schedule

A functional analysis (Iwata, Dorsey, Slifer, Bauman, & Richman, 1982/1994) enables a behavior analyst to evaluate the effects of certain variables on destructive behavior and provides the analyst a direction for intervention. Literature reviews have shown that interventions that manipulate reinforcers demonstrated to maintain destructive behavior during a functional analysis are more likely to be efficacious than interventions not informed by the results of a functional analysis (Didden, Duker, & Korzilius, 1997; Didden, Korzilius, van Oorsouw, & Sturmey, 2006). One such function-based intervention is functional communication training (FCT) in which a behavior analyst teaches an alternative and more socially appropriate functional communication response (FCR) as a means of accessing the maintaining reinforcer and places destructive behavior on extinction (Carr & Durand, 1985; Fisher et al., 1993). FCT is typically initiated with reinforcement for the FCR delivered on an impractically dense schedule to ensure acquisition of the novel response. However, after acquisition of the FCR, behavior analysts often make reinforcement available less frequently to improve the practicality of the intervention.

One of the most researched schedule-thinning procedures involves arranging a multiple schedule (Betz, Fisher, Roane, Mintz, & Owen, 2013; Fisher, Greer, Fuhrman, & Querim, 2015; Greer, Fisher, Saini, Owen, & Jones, 2016; Hanley, Iwata, & Thompson, 2001; Rooker, Jessel, Kurtz, & Hagopian, 2013; Saini, Miller, & Fisher, 2016; Sidener, Shabani, Carr, & Roland, 2006). In multiple schedules, periods in which the FCR produces continuous reinforcement alternate with periods in which the FCR does not result in reinforcement (i.e., extinction; typically, this period is brief initially). Each of these periods is associated with a distinct stimulus. The individual learns to respond only in the presence of

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the stimulus associated with reinforcement availability (termed the S^D) and to not respond in the presence of the stimulus associated with reinforcement unavailability (termed the S^Δ). After the individual learns to respond almost exclusively during S^D presentations, the time in which the S^D is present decreases, and the time in which the S^Δ is present increases until practical durations of both are achieved. For children with escape-maintained destructive behavior, behavior analysts may program a chained schedule in which the presence of the S^D is contingent on the completion of a specified number of demands during the S^Δ period. The response requirement is typically set initially low and gradually increased until a practical duration of work time is achieved (Lalli, Casey, & Kates, 1995).

One challenge experienced during schedule thinning is that extending S^Δ periods (i.e., those in which a functional reinforcer is withheld) further establishes the value of the functional reinforcer, increasing the likelihood of responses that have historically produced that reinforcer (Michael, 1982). As a result, extended S^Δ periods can involve the reemergence of destructive behavior (Briggs, Fisher, Greer, & Kimball, in press), increased rates of the FCR (essentially nagging), or both. Thus, reinforcement schedule thinning may deteriorate treatment effects.

Research has shown that providing competing activities noncontingently during S^Δ periods may facilitate reinforcement schedule thinning during FCT (Greer et al., 2016; Hagopian, Contrucci Kuhn, Long, & Rush, 2005; Rooker et al., 2013). Researchers have used various methods for identifying competing activities to deliver during FCT. For example, Fisher, Kuhn, and Thompson (1998) conducted stimulus preference assessments to identify highly preferred tangibles to deliver during periods when functional reinforcers were unavailable. Hagopian et al. (2005) conducted competing-stimulus assessments in which items were identified based upon selections during a preference assessment and the absence of destructive behavior during stimulus delivery. Fisher, Thompson, Hagopian, Bowman, and Krug (2000) prompted one child to complete demands when tangibles were unavailable to facilitate reinforcement schedule thinning; however, the authors did not describe how they arrived at demands as a competing activity. Despite these contributions, no study has directly compared the efficacy of different competing activities within individuals. We compared the efficacy of providing various competing activities to two individuals whose destructive behavior was resistant to initial attempts to thin a multiple schedule of reinforcement during FCT.

METHOD

Subjects and Setting

Two children referred for the assessment and treatment of destructive behavior participated in the current study. Jacob was a 6-year-old boy diagnosed with unspecified disruptive, impulse-control, and conduct disorder who displayed aggression and property destruction and spoke in complete sentences. Alan was a 3-year-old boy diagnosed with autism spectrum disorder, stereotypic movement disorder with self-injurious behavior, and other specified disruptive, impulse-control, and conduct disorder who displayed aggression and self-injurious behavior (SIB) and communicated primarily using gestures or by exchanging pictures.

We conducted all sessions in 3-m by 3-m padded (Alan) or nonpadded (Jacob) rooms. Session rooms contained a table and chairs (Jacob only), any necessary session materials (e.g., instructional materials, preferred stimuli), a one-way observation window, and a two-way intercom system.

Prior to and following participation in the current study, Jacob participated in Fisher et al. (2015). A functional analysis revealed that both access to tangibles (i.e., an iPad) and escape from demands reinforced his destructive behavior. In addition, an initial evaluation of FCT reduced his destructive behavior and maintained the FCR at efficient levels. Please refer to Fisher et al. (2015) for the functional-analysis and FCT-evaluation results for Jacob.

Prior to participating in the current study, Alan participated in Fisher, Greer, Romani, Zangrillo, and Owen (2016) and in Fisher et al. (2018). A functional analysis revealed that access to preferred tangibles (i.e., an iPad) and escape from demands reinforced his destructive behavior. In addition, the results of an initial FCT evaluation provided evidence that FCT was an efficacious treatment for Alan's destructive behavior. Please refer to Fisher et al. (2016) or Fisher et al. (2018) for the functional-analysis results and Fisher et al. (2018) for the FCT-evaluation results.

Response Measurement and Interobserver Agreement

We collected data on each child's destructive behavior and FCRs using laptop computers located behind the observation window. *Self-injurious behavior* (Alan only) included head banging, self-hitting, body-slamming, flopping, and self-biting. *Aggression* included hitting or kicking the therapist, biting, or throwing objects at the therapist. *Property destruction* included hitting or kicking objects, overturning furniture, and throwing or ripping materials. Session-termination criteria remained in place throughout the study for safety purposes (see Betz & Fisher, 2011); however, termination criteria were not met in any session. *Functional communication responses* included stating, "My turn please" (Jacob) or exchanging a card with a picture of the child consuming the functional reinforcer (Alan). During multiple schedules, data collectors scored FCRs as correct when they occurred independently during the S^D component, as prompted when the therapist had to prompt the response during the S^D component (Alan only), and as incorrect when they occurred during the S^Δ component.

An independent, second observer collected data simultaneously with the primary observer on at least 28% of sessions for Jacob and Alan. We calculated interobserver agreement by dividing each session into successive 10-s intervals and scoring an agreement for each interval in which both observers recorded the same number of responses (i.e., exact agreement). We then divided the number of agreement intervals by the total number of intervals in the session and converted each quotient to a percentage. Mean interobserver-agreement coefficients for Jacob were 97% (range, 85%-100%) for aggression, 99% (range, 85%-100%) for property destruction, and 98% (range, 87%-100%) for FCRs. Mean interobserver-agreement coefficients for Alan were 99% (range, 87%-100%) for aggression, 100% for property destruction, 99% (range, 87%-100%) for SIB, and 99% (range, 93%-100%) for FCRs.

Reinforcement Schedule Thinning

Mult FCT (Jacob). A yellow wristband served as the S^D. Prior to each session, the therapist told Jacob, "When I have the yellow bracelet on, if you say 'my turn please,' you can have the iPad." Each session began with a 60-s S^D component. FCRs during the S^D component produced praise (e.g., "Good job saying 'my turn please'") and 20-s access to the iPad. The first S^D period was followed immediately by a 60-s S^Δ component in which the yellow wristband was removed, and FCRs produced no programmed consequence (i.e., extinction). Subsequent S^D and S^Δ components alternated quasirandomly throughout the remainder of the session with no more than two identical components occurring consecutively. Destructive behavior resulted in no consequence across components. Jacob's sessions ended following five intervals of each component type (i.e., sessions lasted approximately 10 min). We incorporated a 3-s changeover delay (COD; Herrnstein, 1961) to prevent adventitious reinforcement of destructive behavior. That is, the therapist withheld reinforcement if destructive behavior occurred within 3 s of the FCR, and the therapist required Jacob to emit another FCR without co-occurring destructive behavior in order to access the reinforcer. In addition, we included a 3-s COD to prevent adventitious (secondary) reinforcement of destructive behavior by transitioning from the S^{Δ} to the S^{D} following destructive behavior (Ferster & Perrott, 1968; Spradlin & Simon, 2011; Williams & Heyneman, 1981). Therefore, if Jacob displayed destructive behavior just before a scheduled transition from the S^{Δ} to the S^{D}, we delayed that transition until 3 s elapsed without destructive behavior. Although the incorporation of a COD added a response-based contingency, the procedure was in place across all treatment conditions and was only implemented if destructive behavior occurred within 3 s of the scheduled transition from the S^{Δ} to the S^{D}.

Mult FCT (Alan). Alan's sessions were identical to Jacob's except (a) sessions lasted 5 min; (b) stimuli consisted of green (S^{D}) and red (S^{Δ}) index cards (7.6 cm by 12.7 cm) to signal schedule components (whereas with Jacob, the signals consisted of the presence of and removal of a yellow wristband); (c) prior to each session, the therapist presented the discriminative stimuli and FCR card singly in Alan's line of sight and stated, "Look, the card you use to ask for the iPad [*displaying the FCR card*], a green card [*displaying the S^{D}*], and a red card [*displaying the S^{Δ}*];" (d) throughout the session, the therapist blocked all incorrect FCRs and physically guided Alan to emit the FCR if he had not already done so within 10 s of the presentation of the S^{D} component; and (e) Alan's S^{D} component lasted 30 s. We also used variable S^{Δ} durations with Alan to make the schedule-thinning steps less discriminable. The duration of Alan's S^{Δ} component increased according to the following progression: 5 s, 8 s, variable (v) 8 s, v15 s, v30 s, v60 s, v90 s, v120 s, and v240 s following a minimum of two consecutive sessions with at least 90% of FCRs occurring during the S^{D} component and low levels of destructive behavior. Variable S^{Δ} durations (beginning with Session 16) ranged from 50% above and below the mean S^{Δ} duration and were randomized for each session (e.g., v8 s resulted in nine intervals, ranging from 4 s to 12 s). Beginning with Session 30, we decreased this range of values to 20% above and below the mean duration to minimize the occurrence of relatively long S^{Δ} durations. At this point, we began randomizing the possible interval durations and selected the first nine of those randomized values for the upcoming session (e.g., with v60 s, every integer between 48 s and 72 s was randomized, and the first nine of those randomized values were selected). If the lowest value and highest values were randomized to occur consecutively, we randomized the values again to avoid large (and potentially discriminable) differences between successive S^{Δ} durations.

Comparison of Competing Activities During Periods of Reinforcer Unavailability

The purpose of comparing competing activities was to evaluate their effectiveness when reinforcement schedule thinning produced elevated rates of destructive behavior during times in which the functional reinforcer was unavailable (within-session data available upon request).

We selected the competing activities by conducting informal observations, evaluating the functional-analysis results, and speaking with the caregivers of each of the participants. For Jacob, we used attention and demands as the two competing activities, and for Alan, we used attention and an alternative tangible. We selected attention for both participants because caregivers reported often using attention to redirect destructive behavior. We used demands as one of the competing activities for Jacob because we identified an escape function of destructive behavior and would have addressed this function within treatment, regardless. Thus, we wanted to evaluate whether the completion of demands during the S^{Δ} component (with a contingency in place for compliance; chained FCT) effectively competed with the establishing operation (EO) for destructive behavior maintained by tangible reinforcement. Alan frequently had access to an alternative toy and/or adult attention when his iPad was unavailable. Therefore, we chose to evaluate an alternative tangible, rather than demands, as Alan's second competing activity. We addressed Alan's escape function following his participation in the current study.

Baseline. Prior to the session, the therapist provided 1-min access to the iPad. At the start of session, the therapist removed the iPad and delivered it again for 20 s following each instance of destructive behavior. Sessions lasted 10 min for Jacob and 5 min for Alan.

Mult FCT. Mult-FCT sessions were conducted similarly to those described above and did not include competing activities during S^{Δ} periods. Each component lasted 60 s (Jacob) or 30 s (Alan), and the therapist signaled each component using colored wristbands (Jacob) or colored index cards (Alan). Green discriminative stimuli served as the S^{D}, whereas red discriminative stimuli served as the S^{Δ}. These stimuli remained unchanged from reinforcement schedule thinning for Alan, but we modified Jacob's discriminative stimuli from those described above. That is, to be more consistent with the procedures used with Alan and to more clearly signal when extinction was in place for the FCR, we signaled the components with green and red wristbands instead of with the presence and absence of a yellow wristband. Prior to each session, the child or the therapist labeled the therapist's shirt color and the therapist said, "When I have the green wristband/card on [*displaying the* S^{D}], if you [describe topography of FCR], you can have the iPad. When I have the red wristband/card on [*displaying the* S^{Δ}], you have to wait for the iPad, and if you [describe target behavior], it will take longer for me to put on the green wristband/card." We included the last clause to indicate the continued presence of the 3-s COD. Otherwise, we used the same procedures as those used during reinforcement schedule thinning. Sessions lasted 10 min for Jacob and 5 min for Alan.

Mult FCT plus attention. This condition was identical to the mult-FCT condition, except the therapist provided attention throughout the S^{Δ} component of the multiple schedule. Prior to each session, the child or therapist labeled the therapist's shirt color, and the therapist said, "When I have the green wristband/card on [*displaying the* S^{D}], if you [describe topography of FCR], you can have the iPad. When I have the red wristband/card on [*displaying the* S^{Δ}], you have to wait for the iPad, but we can talk and play. If you [describe target behavior], it will take longer for me to put on the green wristband/card." During each S^{Δ} component, the therapist provided high-quality attention in the form of physical play [Alan and Jacob] and conversation [Jacob]. The therapist's attention was unavailable during the S^{D} component.

Mult FCT plus alternative tangible. Only Alan experienced this condition, which was identical to the mult-FCT condition, except the therapist provided Alan with a preferred tangible (other than the iPad) throughout the S^{Δ} component of the multiple schedule. That is, at the start of the S^{Δ} component, the therapist removed the iPad and handed Alan the alternative tangible item. At the start of the S^{D} component, the therapist removed the alternative tangible item and restricted access to it until the next S^{Δ} component. Prior to each session, the therapist conducted a one-trial multiple-stimulus-without-replacement (MSWO) preference assessment (DeLeon & Iwata, 1996) and delivered the stimulus selected on the first trial of the MSWO throughout the S^{Δ} component of the upcoming session. Following the first two sessions, we removed highly preferred tangibles (i.e., items selected during the one-trial MSWO) from the MSWO array, leaving relatively less-preferred stimuli in the array, and thus preventing access to highly preferred stimuli in future sessions. We did this to minimize the likelihood that stimuli delivered during the S^{Δ} component of the multiple schedule were as preferred (and reinforcing) as the iPad.

Prior to these sessions, Alan or the therapist labeled the therapist's shirt color, and the therapist said, "When I have the green wristband/card on [*displaying the* S^D], if you [describe topography of FCR], you can have the iPad. When I have the red wristband/card on [*displaying the* S^{Δ}], you can have [alternative tangible]. If you [describe target behavior], it will take longer for me to put on the green wristband/card."

Chained FCT. Only Jacob experienced the chained-FCT condition, which was identical to the mult-FCT condition, except the therapist required Jacob to comply with a requisite number of demands prior to switching from the S^{Δ} component to the S^D component. We chose math problems as demands to remain consistent with what was nominated by the child's caregiver and what we used during the escape condition of the functional analysis. We set the initial response requirement at a fixed-ratio (FR) 7 to equate the duration of S^{Δ} components in other conditions (i.e., he typically required 60 s to complete seven math problems. We later decreased (FR 3) and thereafter increased (FR 7) the response requirement to account for fluctuations in the obtained duration of his S^{Δ} component to keep it at approximately 60 s. The therapist used three-step prompting (i.e., vocal, model, physical) to guide Jacob to complete each math problem of the FR requirement. Jacob was required to complete each math problem following either the vocal or model prompt in order for the completion to count towards the FR requirement.

Prior to each session, Jacob or the therapist labeled the therapist's shirt color, and the therapist said, "When I have the green wristband/card on [*displaying the* S^D], if you [describe topography of FCR], you can have the iPad. When I have the red wristband/card on [*displaying the* S^{Δ}], you have to finish some work before I put on the green wristband/card. If you [describe target behavior], it will take longer for me to put on the green wristband/card."

Experimental design. We alternated experimental conditions in a reversal design with an embedded alternating-treatments (i.e., multielement) design for the purpose of demonstrating experimental control. To promote discrimination between experimental conditions, we arranged unique discriminative stimuli for each condition using colored shirts.

RESULTS

Figure 1 displays the results of the competing-activities comparison for Jacob. Reinforcement schedule thinning using mult FCT resulted in rapid recurrence of destructive behavior. The percentage of correct FCRs increased across mult-FCT sessions. We terminated Jacob's original mult FCT 60/60 condition after six sessions in which rates of destructive behavior decreased initially, but later increased to baseline levels. Within-session data analysis from the mult-FCT condition indicated that destructive behavior occurred exclusively during periods of time in which Jacob did not have access to the functional reinforcer (i.e., only EO-present destructive behavior). This pattern of responding suggested that providing access to competing activities during these periods of time (e.g., during the

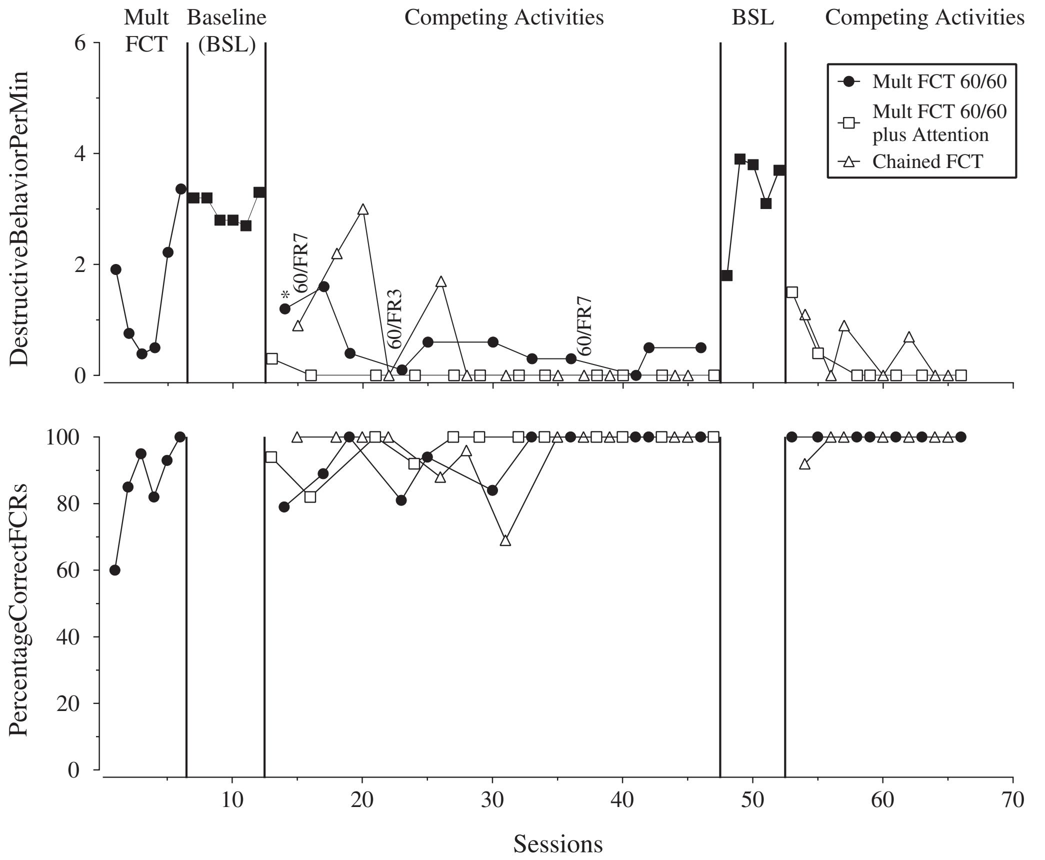

Figure 1. Results of the competing-activities comparison for Jacob. The asterisk denotes the first session of mult FCT 60/60 in which we used the green and red wristbands as discriminative stimuli to signal the S^D and S^Δ components.

S^Δ component) of mult FCT might facilitate reinforcement schedule thinning.

Both baseline phases of the comparison for Jacob resulted in elevated levels of destructive behavior. The initial competing-activities comparison showed lower overall rates of destructive behavior when the therapist provided attention throughout the S^Δ component (i.e., mult FCT 60/60 plus attention). Although the initial chained-FCT sessions resulted in variable and often high rates of destructive behavior, reducing the response requirement from FR 7 to FR 3 corresponded with decreased rates of destructive behavior, which maintained when the requirement returned to FR 7. The mult FCT 60/60 condition (which arranged green and red wristbands to signal the S^D and S^Δ components, respectively) for Jacob resulted in an overall decrease in rates of destructive behavior when compared to those in baseline; however, Jacob's destructive behavior persisted at low rates across these sessions, unlike either of the other two variations of mult FCT. Jacob's percentage of correct FCRs remained high across all variations of mult FCT. Following a return to baseline, we later replicated the results of mult FCT 60/60 plus attention and chained FCT, with relatively greater suppression of responding with the use of attention. Percentage of correct FCRs remained at or near one hundred percent across mult FCT 60/60 plus attention and chained FCT. These results suggest that all three variations of FCT were effective in reducing Jacob's baseline rates of destructive behavior but that the addition of a competing activity in the form of attention provided when Jacob did not have access to the functional reinforcer best suppressed his destructive behavior. Immediately following the comparison of competing activities, Jacob participated in Fisher et al. (2015), during which the reinforcement schedule of mult FCT plus attention was rapidly thinned from a mult FCT 60/60 to a mult FCT 60/300.

Figure 2 displays the results of the competing-activities comparison for Alan. Reinforcement schedule thinning using mult FCT resulted in a gradual recurrence of destructive behavior as the reinforcement schedule became progressively lean. Although the percentage of correct FCRs remained generally high and rates of destructive behavior remained near zero throughout the first few steps of reinforcement schedule thinning, relatively leaner schedules produced elevated response rates, and our attempts to reestablish low rates of destructive behavior by returning to previously effective reinforcement schedules proved ineffective. Similar to Jacob, within-session data analysis from the mult-FCT condition indicated that destructive behavior occurred exclusively during EO-present periods, suggesting that providing access to competing activities during the S^{Δ} component of mult FCT might facilitate reinforcement schedule thinning.

Alan engaged in increasing and elevated rates of destructive behavior in both baseline phases of the comparison. The initial comparison showed lower and decreasing rates of destructive behavior in both mult FCT 30/30 and mult FCT 30/30 plus attention. However, when the therapist provided Alan with a moderately preferred tangible during the S^{Δ} component (i.e., mult FCT 30/30 plus alternative tangible), he displayed variable and sometimes high rates of destructive behavior across both components of the multiple schedule. Percentage of correct FCRs were variable across conditions with the highest and most stable responding in mult FCT 30/30 plus alternative tangible. Following a return to baseline, we replicated the treatment effects of mult FCT 30/30 and mult FCT 30/30 plus attention, showing slightly better suppression of destructive behavior with the use of attention and high, stable levels of correct FCRs across both conditions. Immediately following the comparison of competing activities, we transitioned Alan's mult FCT plus attention condition to a chained schedule of reinforcement (data not displayed) in which gaining access to the S^{D} component was dependent on his compliance with a gradually increasing number of demands (i.e., FR 1 to a variable ratio 12). Alan's terminal treatment consisted of him working for approximately 240 s for 30-s access to his iPad.

DISCUSSION

We attempted to thin the schedule of reinforcement using a multiple schedule and observed the recurrence of destructive behavior with two participants. We replicated previous research demonstrating that providing competing activities during periods without the functional reinforcer effectively reduced destructive behavior (e.g., Fisher et al., 1998; Fisher et al., 2000; Hagopian et al., 2005). Furthermore, we extended previous research by comparing multiple competing activities within-subject.

With Jacob, providing attention resulted in lower levels of destructive behavior than providing demands. The efficacy of attention as a competing activity was similar to one demonstration in Austin and Tiger (2015), but the finding that providing competing demands did not result in the immediate suppression of

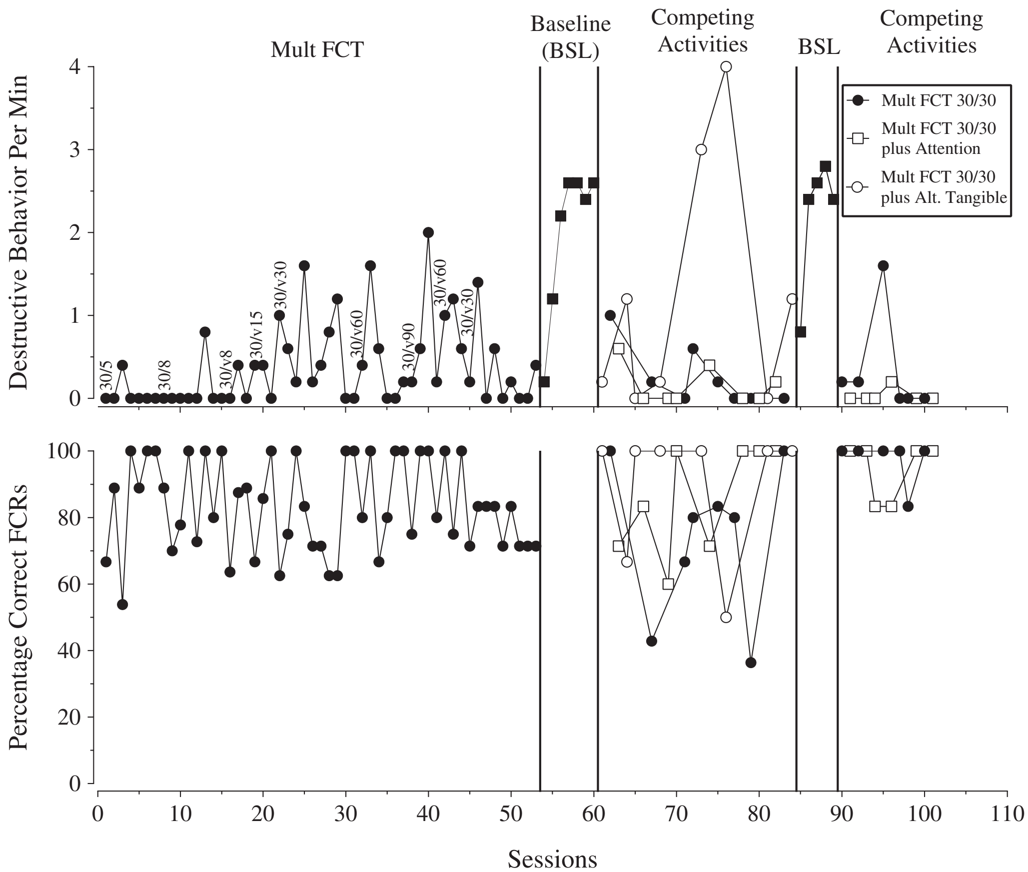

Figure 2. Results of the competing-activities comparison for Alan.

destructive behavior can be contrasted with Fisher et al. (2000), who demonstrated sustained low levels of destructive behavior when demands were provided during schedule thinning. For Alan, providing attention resulted in lower levels of destructive behavior than providing an alternative tangible. This result can be contrasted with the results of Hagopian et al. (2005) and Austin and Tiger, who each demonstrated that providing alternative tangibles facilitated schedule thinning. Collectively, these results demonstrate that there are individual differences in terms of what activities will successfully reduce destructive behavior and that the selection of competing activities should be subjected to empirical validation before incorporation into schedule thinning.

What we have referred to as "competing activities" included a variety of procedures, including: (a) providing access to competing activities that did not function as reinforcers for destructive behavior (i.e., attention for both Jacob and Alan); (b) possible functional reinforcers (i.e., less-preferred tangibles for Alan); and (c) demands (i.e., instructions embedded within a chained schedule for Jacob). We chose these specific activities for inclusion in the alternating-treatment comparison based on caregiver report, informal therapist observation, and prior evidence in the literature demonstrating success with these approaches. However, future researchers may consider evaluating whether and to what extent different types of competing activities affect the efficacy of reinforcement schedule thinning during FCT.

With Alan, providing an alternative tangible during extinction periods produced highly variable rates of destructive behavior. Destructive behavior in this condition occurred most often when the therapist replaced the S^{Δ} with the S^{D} (signaling that the iPad was available) and removed the alternative tangible. We removed the alternative tangible when the iPad became available to ensure that Alan would continue to emit the FCR during the S^{D}. However, doing so still involved disrupting his engagement and removing a tangible item. Thus, destructive behavior maintained by access to tangibles extended beyond the iPad to other items such that the removal of any valued tangible evoked destructive behavior. Thus, it may be the case that providing alternative tangibles as a competing activity only during periods of reinforcer unavailability is not ideal for individuals with destructive behavior maintained by access to tangibles. Future research should evaluate the relative preference for functional and alternative tangibles and consider limiting additional exposure to the EO by providing continuous access to the alternative tangible across both components of the multiple schedule.

For Jacob, providing demands during periods when his iPad was unavailable was insufficient in producing an immediate suppression in rates of destructive behavior. This result is not surprising given that Jacob also displayed escape-maintained destructive behavior during his functional analysis. One interpretation of these data could be that if presenting demands during periods of reinforcer unavailability, practitioners should initially program a low response requirement when using demands as a competing activity for individuals with escape-maintained destructive behavior. We interpret these results to indicate that we successfully treated two behavioral functions simultaneously in ways that were likely to occur in the natural environment. That is, parents are likely to simultaneously establish tangibles and escape from demands as reinforcers, for example by instructing their children to put away their iPad and work on their homework. In that regard, we suggest evaluating each competing activity as a potential context that would need to be mastered for successful transition of intervention into the natural environment. That is, sometimes children will have to put away their iPad to do work, sometimes they will have to put away their iPad and play with something else, and sometimes they will have to put their iPad away and talk with their family. It is also important to consider the feasibility of each of these contexts for caregivers. For example, when children have to put away their iPad to do work, sometimes they may have to complete demands that require repeated prompting from caregivers (similar to those in the current study), and sometimes they may complete demands that entail extended, independent engagement (e.g., reading or working through a full worksheet). Comprehensive intervention will assess treatment success in each of these contexts and ensure families can address the challenges they are likely to experience.

With Jacob and Alan, arranging periods of reinforcement and nonreinforcement using a multiple schedule initially resulted in increased levels of destructive behavior. We made reinforcement-based modifications to the S^{Δ} component of the multiple schedule that proved sufficient for producing clinically significant reductions in rates of destructive behavior without the use of punishment, which commonly has been implemented in the literature (Fisher et al., 1993; Greer et al., 2016; Hagopian, Fisher, Thibault-Sullivan, Acquisto, & LeBlanc, 1998; Rooker et al., 2013). One of the challenges of arranging periods of extinction is that a predominant response (i.e., the FCR) is no longer effective, and such periods of extinction are likely to occasion response topographies that have reliably resulted in reinforcement in the past (e.g., destructive behavior). Presumably, competing activities are likely effective in decreasing rates of destructive behavior by strengthening other forms of behavior (e.g., engagement) that are incompatible with destructive behavior. In situations in which those competing activities do not promote engagement, punishment may be necessary but should be reserved as a final option.

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CONTINGENCIES PROMOTE DELAY TOLERANCE

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The effectiveness of functional communication training as treatment for problem behavior depends on the extent to which treatment can be extended to typical environments that include unavoidable and unpredictable reinforcement delays. Time-based progressive delay (TBPD) often results in the loss of acquired communication responses and the resurgence of problem behavior, whereas contingency-based progressive delay (CBPD) appears to be effective for increasing tolerance for delayed reinforcement. No direct comparison of TBPD and CBPD has, however, been conducted. We used single-subject designs to compare the relative efficacy of TBPD and CBPD. Four individuals who engaged in problem behavior (e.g., aggression, vocal and motor disruptions, self-injury) participated. Results were consistent across all participants, and showed lower rates of problem behavior and collateral responses during CBPD than during TBPD. The generality of CBPD treatment effects, including optimal rates of communication and compliance with demands, was demonstrated across a small but heterogeneous group of participants, reinforcement contingencies, and contexts.

Key words: contingency-based delay, delayed reinforcement, functional communication training, generality, schedule thinning, severe problem behavior

Functional communication training (FCT; e.g., Carr & Durand, 1985), a form of function-based differential reinforcement, has been shown to reduce problem behavior by teaching the individual an appropriate alternative behavior that serves the same function as problem behavior. In fact, FCT combined with extinction has been shown to be an efficacious treatment for a variety of problem behaviors that differ both functionally and topographically (Kurtz, Boelter, Jarmolowicz, Chin, & Hagopian, 2011; Tiger, Hanley, & Bruzek, 2008). Problems arise, however, because caregivers cannot always reinforce requests immediately, and these periods of nonreinforcement for appropriate communication can lead to the resurgence of problem behavior (Hanley, Iwata, & Thompson, 2001).

To increase the generality of effects, thinning the schedule of reinforcement for the functional communication response (FCR) is often listed as an essential component of FCT when treatment is extended to the typical environment (e.g., Durand & Moskowitz, 2015; Kurtz et al., 2011). Various procedures for increasing tolerance for delays to reinforcement (here defined as near-zero levels of problem behavior and manding during extensive nonreinforcement periods and the resumption of manding when appropriate) have been evaluated (see Hagopian, Boelter, & Jarmolowicz, 2011, for a review). One common procedure involves programing gradually increasing delays between the FCR and the delivery of the reinforcer, often indicated with a brief signal such as "wait" (Vollmer, Borrero, Lalli, & Daniel, 1999). This procedure has been referred to as a delay schedule (Hagopian et al., 2011). Delay schedules have an intuitive appeal because the arrangement best emulates the typical situations experienced in the natural environment (i.e., when parents cannot provide requested

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items or interactions, they tell the child to wait and then provide that which was requested when it is possible to do so). This procedure, however, frequently results in the loss of the newly acquired FCR and a resurgence of problem behavior, usually within the first 16 s of delay (Fisher, Thompson, Hagopian, Bowman, & Krug, 2000; Hagopian et al., 2011; Hanley et al., 2001). Delayed reinforcement could also elicit negative emotional responses as well as evoke an excessive amount of manding (Fisher et al., 2000) before the resurgence of problem behavior, and these collateral responses may be as disruptive as the original problem behavior.

The apparent obstacle to achieving general effects of FCT may be partly due to the extinction-like periods created by the long delays that could result in the resurgence of the previously reinforced problem behavior (Lieving & Lattal, 2003) and agitated or emotional responding (Lerman & Iwata, 1996). Lieving and Lattal (2003) showed that as schedules of intermittent reinforcement are thinned, longer periods of nonreinforcement are created that are functionally equivalent to conventional extinction and can lead to the resurgence of the previously reinforced response. Volkert, Lerman, Call, and Trosclair-Lasserre (2009) demonstrated that problem behavior may resurge when the newly acquired FCR is placed on an intermittent schedule of reinforcement during generalization attempts with FCT. In fact, deterioration of FCT treatment effects during implementation in more typical environments has often been reported (Fisher et al., 2000; Hagopian, Fisher, Sullivan, Acquisto, & LeBlanc, 1998; Hagopian et al., 2011; Hanley et al., 2001; Rooker, Jessel, Kurtz, & Hagopian, 2013). For instance, Hagopian et al. (1998) found that when delays to reinforcement and demand fading were introduced, the efficacy of FCT with extinction was maintained in less than one half of the applications (i.e., clinically acceptable outcomes were not achieved). In most of their cases, the addition of punishment was necessary to attain a 90% reduction in problem behavior. Wacker et al. (2011) also showed that long periods of FCT treatment (an average of 14 months) were required before treatment effects would persist during 5-min periods of extinction, and even longer periods of treatment were required when a 15-min extinction period was used. In addition, although problem behavior was reduced during repeated extinction exposures, after nearly 2 years of treatment, problem behavior was not eliminated for half the children.

The negative side effects observed with delayed schedules may also be attributed to a contingency-weakening effect that occurs under this arrangement (Hanley et al., 2001). Positive contingency strength may be defined as the probability of obtaining reinforcement given a response being greater than the probability given no response (Hammond, 1980). Luczynski and Hanley (2014) found that delivering reinforcement after a delay resulted in a contingency strength of −1 (the weakest possible contingency) because no reinforcers were ever delivered in close temporal proximity to the communication response. Thus, the delay schedule created a context that was probably aversive to the participating children, in that they preferred a context with no reinforcement at all to one in which delayed reinforcement was programmed.

To mitigate the contingency-weakening effects associated with delay, multiple schedules (e.g., Fisher, Kuhn, & Thompson, 1998; Hanley et al., 2001), chained schedules (e.g., Fisher et al., 1993; Lalli, Casey, & Kates, 1995), or a combination of the two (e.g., Falcomata, Muething, Gainey, Hoffman, & Fragale, 2013) have been adopted and have successfully maintained zero or near-zero rates of problem behavior during long periods of nonreinforcement. Multiple schedules involve a time-based alternation between reinforcement and extinction components, both of which are correlated with distinct stimuli (e.g., colored cards). Chained schedules incorporate a response requirement, either a specific number of demands or a specific duration of time engaged in work activity, to be completed, after which the first instance of FCR results in reinforcement. Neither multiple nor chained schedules, however, precisely emulate the unplanned and therefore unpredictable delays that are often experienced in homes and schools.

Chained and multiple schedules require parents and teachers to plan periods of nonreinforcement or demand time, during which an individual's FCRs are ignored. After these periods are over (either when a time criterion has been met or through completion of required demands), an interval of reinforcement then sets in, and parents are advised to reinforce requests immediately. Delays in the typical environment, however, do not emulate this arrangement, and are often sudden, unexpected, and unplanned. Individuals can request a variety of items at a given time, and in these cases, caregivers may not know whether the reinforcer is available until the specific request has been made, making it difficult to plan for immediate reinforcement. One must also be able to tolerate periods in which their reinforcing activities are suddenly interrupted and their requests are not granted in the absence of clear stimuli that signal the unavailability of reinforcement and even under stimulus conditions that would normally signal immediate reinforcement (e.g., a toy is available but the battery runs out). In such cases, the only naturally occurring stimuli may be brief verbal responses of "wait," "not right now," or "in a minute" to the request. The individual is, then, expected to wait for the request to be granted without engaging in repeated manding, problem behavior, and negative emotional responses. In addition, the individual will often be required to comply with an adult's requests or acquiesce to someone else's preferences during the delay. At other times, the individual might need to scan the environment and find alternative activities while he or she waits for the preferred items and others' attention. Delay schedules are structurally ideal for teaching behavioral expectations in these situations; however, strategies for mitigating the extensive negative side effects associated with their application have not yet been articulated.

One change to typical delay procedures that may reduce the commonly reported negative side effects is the addition of probabilistic immediate reinforcement of the communication response. The addition of immediate reinforcement of some FCRs would increase the FCR-reinforcer positive contingency strength. This change may also increase the ecological validity of this procedure because requests in the typical environment are also immediately granted sometimes. Another change that may improve the effectiveness of delay schedules involves the addition of a response requirement during the delay. In other words, the negative side effects may be mitigated by changing from a time-based delay to a contingency-based delay in which a chain of responses after the FCR will result in the delivery of reinforcement. A contingency-based delay increases the FCR reinforcer positive contingency strength by building a chain of responses that ultimately contacts reinforcement, thereby minimizing the creation of long delays that emulate conventional extinction.

These procedural changes to the delay schedule were described in a study by Hanley, Jin, Vanselow, and Hanratty (2014) in which probabilistic immediate reinforcement and contingency-based delay were used to treat problem behaviors maintained by positive reinforcement for one child and a synthesis of positive and negative reinforcement for other children. During contingency-based delay, following the cue to wait, the children were initially required to engage in a tolerance response (e.g., saying "okay"); progressively more difficult response chains were then prompted before reinforcers would be delivered. In this way, the experimenters were able to extend the delay to practical levels that included completion of age-appropriate demands and engagement with appropriate leisure items during the delay without the resurgence of problem behavior.

Given that Hanley et al. (2014) implemented multiple changes to the way in which delays are traditionally scheduled, the extent to which each of the changes is necessary for the success of this treatment remains unclear. For example, the addition of probabilistic reinforcement to increase the contingency strength of FCRs may be sufficient to produce the same results with time-based delay. Also, the mere presence of and redirection to an alternative activity may be sufficient to maintain zero levels of problem behavior during the delay. For instance, Fisher et al. (2000) showed that in one case the addition of an alternative work activity, without a contingency, was enough to reduce positively reinforced problem behavior and collateral responses during nonreinforcement intervals. These authors, however, did not report on the rate of excessive manding or compliance with demands during these intervals. The extent to which the mere presence of an alternative activity during delays to reinforcement, without a response contingency, will be sufficient to eliminate severe problem behavior without the emergence of other collateral responses remains to be investigated.

The main purpose of this study was to evaluate the direct effects of a response contingency during delayed reinforcement. Although contingency-based delay has been used as the main treatment (Hanley et al., 2014) or a component of treatment (e.g., Carr & Carlson, 1993), the effects of a response contingency alone have not been evaluated. We therefore conducted a comparative analysis of time-based (TBCD) versus contingency-based (CBPD) delay tolerance training. To isolate the effects of a response contingency alone, we included both probabilistic reinforcement and alternative activities in both time-based and contingency-based delay conditions. The second purpose of this study was to evaluate the direct effects of contingency-based delay on collateral responses (e.g., excessive manding, negative emotional responding) and compliance with adult instructions, so multiple measures were collected across all participants. The third purpose of this study was to assess the generality of delay tolerance training. In addition to the systematic replication of the comparison across a wide range of participant characteristics and different reinforcement contingencies, we also evaluated the extent to which behavior changes that occurred as a function of experience with either delay procedure would generalize to a second context in which problem behavior during the delay would be reinforced (i.e., a context that emulates typical environments with no extinction during delays).

GENERAL METHOD

Participants and Settings

Four individuals, ranging in age from 21 months to 30 years, who had been referred to our university-based outpatient services, participated in this study. Nico was a 23-month-old typically developing boy who reportedly had difficulty waiting for preferred items and activities. Nico's parents reported that he would often repeat his requests multiple times, say "no" when told to wait, and would sometimes have a tantrum that included crying and flopping if his requests were not granted. Nico could follow multistep vocal instructions, had a typically developing imitation repertoire and fine and gross motor skills, and communicated using gestures, single words, and partially framed sentences. He had an age-appropriate play repertoire including imaginative play. Nico attended a center-based day-care.

Will was a 30-year-old man with a diagnosis of pervasive developmental disorder, comorbid intellectual disability, attention deficit hyperactivity disorder, and episodic mood disorder. He had a long history of severe self-injurious behavior (SIB), which consisted primarily of hand-to-head hitting that often led to open wounds on his forehead, as well as finger biting. Will reportedly engaged in SIB throughout the day at his rehabilitation center, his group home, and during transport to and from the center. Staff reported that they often gave him food and drinks to calm him down. He was nonvocal and had no formal communication system. He could follow some simple gestural prompts, had no echoic or motor imitation repertoire, and had limited gross motor and fine motor skills. He could walk independently and feed himself but was not toilet trained and had no independent play or leisure skills. He attended the day habilitation center 5 days per week and spent the majority of his time eating, taking walks, or sleeping.

Jack was a 21-month-old boy with a diagnosis of an autism spectrum disorder (ASD) who engaged in severe problem behavior multiple times each day. His problem behavior included motor disruptions and aggression toward peers and adults (usually toward his mother) when preferred activities were interrupted and when an item he requested was not available. These episodes usually led to the family leaving social settings or providing Jack with the requested item or other preferred items as well as physical and verbal attention (e.g., hugs, squeezes, reprimands). He could follow simple vocal instructions, had good fine motor skills, could imitate simple motor responses and partially echo two-word phrases, and communicated using gestures and word approximations. He had no independent play or leisure skills. He received early intervention services at home that included early intensive behavioral intervention, speech language services, and occupational therapy. He also attended a home-based day-care.

Alex was a 6-year old boy with a diagnosis of ASD who engaged in daily episodes of severe problem behavior that included vocal and physical disruptions and aggression toward adults and peers. Alex reportedly became highly emotional and aggressive at home, school, and other community outings when his preferred activities were interrupted or not available and when asked to comply with demands. These episodes usually led to adults complying with Alex's requests and providing access to preferred items to calm him down as well as physical and verbal attention (e.g., hugs, squeezes, reprimands). He could follow multistep vocal instructions, had a typically developing imitation repertoire, fine and gross motor skills, and spoke in full sentences. He had a developmentally appropriate play repertoire including imaginative play. He had some difficulty pronouncing certain sounds and was receiving speech services. He attended a public school in which he spent the majority of his time in a resource room that included the support of paraprofessionals and had an individualized educational plan.

All sessions for Nico, Jack, and Alex were conducted in small treatment rooms (4 m by 3 m) at a university setting equipped with a one-way observation panel, audio-video equipment, child-sized tables, two chairs, and academic and play materials as needed. All sessions for Will were conducted in an open area in the day rehabilitation center that contained cafeteria-style tables and adult-sized chairs. Sessions were conducted 2 to 4 days per week, two to eight times each day. Sessions lasted 3 to 5 min throughout the functional analyses and mand analysis. Sessions lasted 3 to 5 min (Nico and Jack) or five evocative trials (Will and Alex) during FCT. An evocative trial involved the presentation of the evocative situation and was as long as necessary to allow the target FCR to occur and for any scheduled delays and reinforcement periods to be presented. Sessions lasted for five evocative trials throughout the comparative analyses unless the time-based session termination criteria were met (20-min session for Nico and 10 min of crying for Jack). A minimum of three evocative trials was required for a session to be included in the analyses.

Data Collection and Interobserver Agreement

Trained observers recorded data using pencil and paper during the functional and preference analyses for Will. Otherwise, trained observers collected data via computers that provided a second-by-second account of participants' responses and relevant contextual features. Specific response definitions and data collection and conversion details are provided in the relevant sections.

Interobserver agreement was assessed by having a second observer collect data on all target behaviors simultaneously but independently during at least 20% (range, 20% to 60%) of the sessions in each condition for each participant. Each session's data were divided into 10-s intervals and compared on an interval-by-interval basis. Agreement percentages were calculated by dividing the smaller number of responses or duration (in seconds) in each interval by the larger number, averaging the fractions, and converting the result to a percentage. Interobserver agreement averaged 95% (range, 76% to 100%) for Nico, 96% (range, 80% to 100%) for Will, 93% (range, 76% to 100%) for Jack, and 92% (range, 74% to 100%) for Alex.

Preference Assessment

We conducted a preference assessment that involved presenting an array of items simultaneously, similar to a multiple-stimulus-without-replacement preference assessment (e.g., DeLeon & Iwata, 1996). For Jack, Alex, and Nico, highly preferred and neutral items and activities nominated by caregivers during an open-ended interview along with other age-appropriate toys and academic activities (10 to 20 items) were arbitrarily arranged on two semicircle-shaped tables before sessions. The items included varied for each child but remained the same throughout all assessment and treatment analyses for each child. During the assessment, the analyst directed the child to the tables and reviewed the items that were available by touching and naming each activity. She then allowed the child to walk around the table and manipulate the items briefly before prompting the child to choose three to five preferred items to bring into the session room. The analyst then selected one to three items that the child had not chosen during the previous two selection opportunities and used those as the neutral items for the alternative activity or demands. Access to the tables was typically provided after two to four sessions.

PART 1: FUNCTIONAL ASSESSMENT

Data Collection and Response Definitions

Target problem behavior for Jack and Alex included *aggression* (defined as hitting, biting, kicking, hair pulling, head butting, and pushing) and *disruptions* (defined as both physical disruptions such as throwing, ripping, swiping, and pushing items, banging items together, and vocal disruptions such as a high-pitched scream). Will's problem behavior was *self-injurious behavior* in the form of hand-to-head hits and knuckle biting. Target behavior for Nico included problem behavior (i.e., aggression), minor problem behavior (defined as crying, whining, throwing, ripping, and swiping), gestures (defined as reaching and pointing), single words, or framed mands. Counts of participants' problem behavior were collected and converted to a rate for all analyses.

Procedure

Open-ended functional assessment interview and interactive observation. An open-ended interview, as described by Hanley (2012), was conducted with the participants' caregivers primarily to discover potential reinforcers that might influence the individual's problem behavior and contexts in which problem behavior was most likely. The interview lasted 45 to 60 min and was followed by a 20-min informal observation of the participant interacting with parents (Nico, Jack, and Alex) or staff (Will) in which play preferences, language skills, topographies of problem behavior, fine and motor skills, and other unique characteristics described by caregivers during the interview were directly observed to individualize and prepare for analyses.

Mand analysis. The open-ended interview with Nico's parents revealed that concerns centered exclusively on situations when an item or activity or their attention was not immediately available and Nico was asked to wait, during which time he would mostly engage in excessive manding and minor problem behavior such as whining, crying, and throwing items. Given that these behaviors often followed one-word or framed mands for preferred items and the parent reported that Nico seldom engaged in any severe problem behavior, a mand analysis (Hernandez, Hanley, Ingvarsson, & Tiger, 2007) was determined to be more suitable for identifying the predominant response form that functioned as a mand for tangible items. The analysis involved rapidly alternating between two conditions. The test consisted of differential reinforcement of target responses (DRA), whereas the control consisted of continuous noncontingent reinforcement (NCR). During NCR, the preferred toys, DVDs, and activities were made available freely and continuously. During DRA, the preferred items were placed on a table but access was blocked by the analyst. Access to items was provided for 30 s contingent on any target response.

Functional analyses. Following open-ended interviews, functional analyses were designed for Will's, Jack's, and Alex's problem behavior. The analyses involved rapidly alternating between test and control sessions by (a) presenting the reported evocative situation (e.g., presenting writing tasks, taking away toys or tablet, removing attention) in test sessions and allowing 30-s access to the reported consequences immediately after problem behavior, and (b) withholding the same evocative situations in control sessions by presenting the putative reinforcers continuously. Events that were not suspected of maintaining problem behavior (e.g., escape from demands for Jack, analyst's attention and escape from demands for Will) were freely available in both the test and control conditions, ensuring that the only difference between test and control conditions was the programmed reinforcement contingency.

Will. Staff reported that whenever Will appeared agitated or started to engage in self-injury, they gave him snack items. Based on the results of this interview and the brief observation, an analysis of a social-positive reinforcement contingency was conducted using the typically available food items (e.g., raisins, crackers, peanuts, cheese, cookies). Two to three of these snack items were visible but slightly out of reach in both test and control conditions. During the control condition, very small bites of each snack were placed on a plate, and the plate was presented to Will approximately every 10 s independent of his behavior. Following his selection, the plate was removed. By contrast, the plate with the snack items was presented during the test sessions only after instances of head hitting or finger biting; each instance resulted in the plate being presented and a snack bite obtained.

Jack. Based on the interview results and observation with Jack's mother, a synthesized contingency of attention and tangible items was analyzed in one context conducted by his mother (Context 1) and in another by the analyst (Context 2). Two analyses were conducted to create two baselines from which the direct and general effects of the delay procedures could be evaluated. Preferred items (e.g., a hair brush, broom and dust pan, DVDs) identified by Jack's mother during the interview and some additional age-appropriate toys and activities were placed in the preference assessment. Given the mother's report that to calm Jack down she would often attend to him and provide access to the preferred items, a synthesized attention and tangible reinforcement contingency was tested in the analysis. During the control condition, Jack had continuous and noncontingent access to his mother's (or the analyst's) attention (e.g., sitting in her lap, pretend cooking with her) and access to preferred items. During the test condition, the adult pretended to be busy with one of the items and also blocked access to all other preferred items. Contingent on any instance of problem behavior, the adult immediately attended to Jack (e.g., comforted and played with him) and gave him access to the preferred items for 30 s.

Alex. During the interview, Alex's mother reported that dinosaurs were his favorite topic. He often engaged in imaginative play and constructed elaborate dinosaur theme sets that "had to remain untouched" in the family home. He would demand that his parents and younger brother play along with the very specific roles he would assign to them. Any movement of these items by others, interruption of play, or failure to assume the assigned role resulted in severe tantrums that included aggression and could last up to 30 min. Alex's specific requests extended to other activities in the home and school. For example, he often demanded that his peers play by his rules in the gym, and he insisted on doing academic tasks in a specific manner regardless of the teacher's instructions. Most interruptions or redirections of preferred activities resulted in severe tantrums. Alex's mother reported that when these tantrums occurred, she helped Alex calm down by removing her demands and encouraging him to take a breath and tell her what he wants, which then resulted in the resumption of his preferred activity and compliance with his requests. The results of the open-ended interview suggested that problem behavior was evoked when adults stopped complying with his requests (see Bowman, Fisher, Thompson, & Piazza, 1997, for a similar functional relation) and interrupted his preferred activities to place demands to engage in other tasks. Given that problem behavior often resulted in the simultaneous delivery of attention, removal of demands, and adult compliance with mands, a synthesized contingency of positive and negative reinforcement was arranged in two analyses conducted by the same analyst but in two different contexts. Context 1 contained materials selected from the preference assessment that did not include any dinosaur-related items. Instead, items in the preference assessment included other activities reported as highly preferred by Alex's mother (e.g., drawing activity, Legos, tablet), other age-appropriate toys and activities, and demand materials. Context 2 included only Alex's most preferred activity, which was dinosaur figure sets along with dinosaur-themed books and stickers. During the control condition, Alex was given uninterrupted access to his preferred activity and the analyst complied with all of his reasonable requests (i.e., those that could be granted in the session room safely) and presented no demands. During the test condition, the analyst interrupted play, denied his requests, and presented a demand (e.g., the therapist deviated from the play as instructed by Alex and told him to do something else). Three-step prompting was used to ensure compliance with demands. Contingent on any instance of problem behavior, the analyst removed demands, allowed Alex to resume his activity in his preferred manner, and honored his requests for 30 s.

Results

Nico. Although all of Nico's target responses, including aggression, would have produced reinforcement during the DRA condition of the mand analysis, only minor problem behavior (e.g., whining and throwing), gestures, and single-word and partially framed mands were emitted. Single-word mands, however, emerged as Nico's predominant response (Figure 1). The rate of single-word responses was consistently higher in the DRA sessions, and Nico engaged exclusively in single-word mands during the last test–control dyad. The results suggested that his predominant response for preferred tangible items and adult attention was a single-word mand.

Will. Problem behavior was observed exclusively in test sessions in which Will's problem behavior resulted in snack items (Figure 1). The result of the functional assessment process showed that problem behavior was maintained by access to food.

Jack. Problem behavior was observed exclusively in test sessions in which Jack's problem behavior yielded access to preferred items and adult attention, irrespective of whether his mother or the analyst implemented the contingency (Figure 1). The result of the functional assessment process suggested that problem behavior was maintained by a combination of social-positive reinforcers. Although the exact role of each reinforcer included in the synthesized contingency was not isolated and the extent to which main effects, interactions, or both were maintaining problem behavior were not determined, the analysis did emulate the typical conditions Jack experienced and identified a context that demonstrated control over his problem behavior. The inclusion of all possible contingencies of reinforcement resulted in a reliable baseline from which to evaluate the effects of FCT and a highly challenging context

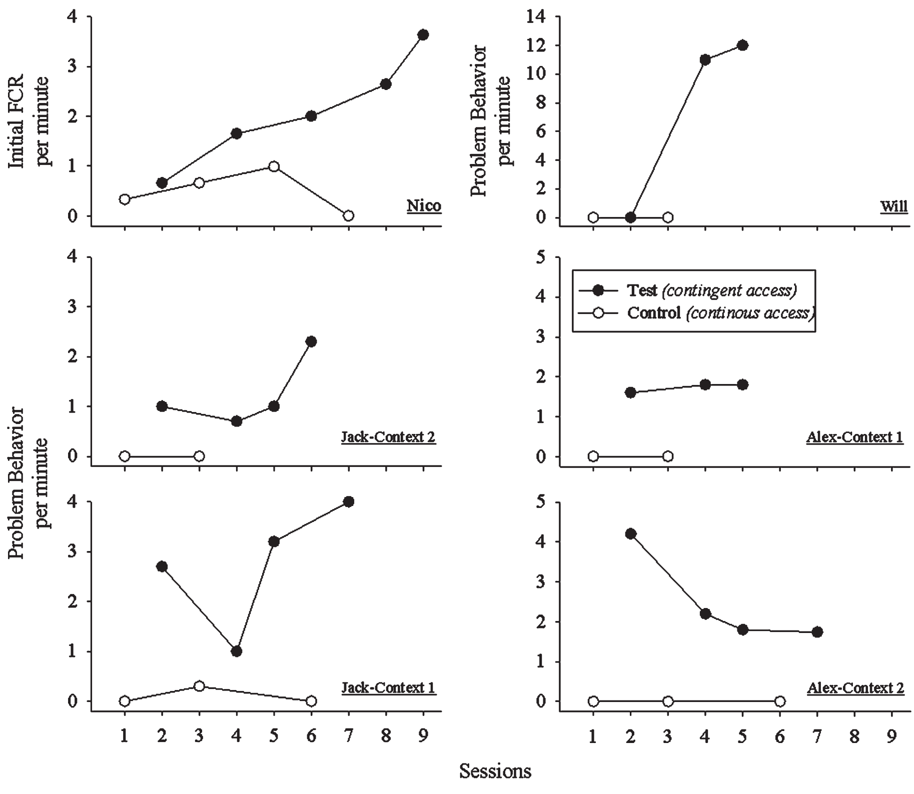

Figure 1. Results of the mand form analysis for Nico and the interview-informed synthesized contingency analyses for Will, Jack, and Alex.

to evaluate reinforcement delay (see Ghaemmaghami, Hanley, Jin, & Vanselow, 2016; Hanley et al., 2014; and Jessel, Hanley, & Ghaemmaghami, 2016, for more detailed discussions of the interview-informed synthesized contingency analysis).

Alex. Problem behavior was observed exclusively in the test conditions when Alex's problem behavior terminated adult instruction and allowed him access to preferred activities, adult attention, and having his requests granted (Figure 1). The result of the functional assessment process suggested that problem behavior was sensitive to a combination of social-positive and negative reinforcers. Isolating the suspected contingencies of reinforcement was also not desirable or possible in Alex's case, because most events that evoked problem behavior involved a simultaneous provision of both negative and positive reinforcement. For example, removing interruptions of activity meant that he simultaneously escaped the adult instruction and resumed uninterrupted access to his preferred activity. That is, both positive and negative reinforcement operated in tandem. Similar to Jack, however, the inclusion of all possible reinforcers in the contingency also provided us with a challenging and reliable baseline from which to evaluate communication and tolerance skills.

PART 2: FUNCTIONAL COMMUNICATION TRAINING

Data Collection and Response Definitions

In addition to problem behavior and responses defined above, the following responses were also measured during this phase. Nico's initial FCR was a single-word mand (e.g., "music," "dance") identified via the mand analysis. His target FCR was a fully framed mand (e.g., "I want [item] please," "More [activity] please"). Will's target FCR consisted of handing a food icon to the analyst. Jack's target FCR consisted of a hand gesture to his chest or a vocal response of "my way." Given Jack's limited vocal imitation repertoire, a novel hand gesture was added to supplement the vocal response and allow immediate prompting. Alex's initial FCR was "my way, please." His target FCR consisted of saying "excuse me" and then waiting for acknowledgment before saying "May I have my way please?" FCRs were considered prompted if the analyst prompted any part of the FCR within 10 s of the participant emitting the response. Only independent FCRs are reported. Counts of participants' communication responses and problem behavior were collected and converted to a rate for all analyses.

Procedure

When reinforcers were identified for problem behavior or predominant mand forms, we attempted to replace problem behavior and simple mand forms with more socially acceptable and developmentally appropriate mand forms via FCT plus extinction. The effects of FCT plus extinction were demonstrated in a concurrent operants AB design for Nico and Will and a concurrent operants within a multiple baseline design across contexts for Jack and Alex. The test sessions of the mand or functional analysis served as the baselines for all FCT evaluations.

During FCT, access to reinforcers was provided for approximately 1 min before each session; the session started by the removal of all reinforcers and the presentation of an evocative situation for each participant (e.g., the analyst paused the DVD player and turned away from Jack, or the analyst placed a bite of food on a plate visible to Will but out of his reach). A target FCR was selected and reinforced on a fixed-ratio (FR) 1 schedule in which each instance of the FCR resulted in 30 s of reinforcement. All problem behavior was placed on extinction. A small number of presession training trials (up to five) were conducted before introduction of FCT. These trials included a brief instructional statement, modeling of the FCR, role-play of emitting the FCR, and accessing reinforcement and praise or correction of the FCR. During sessions, a most-to-least prompting hierarchy was used to teach the target FCR until 80% of FCRs were independent, after which prompts were faded to a vocal prompt every 60 to 90 s as needed. For Alex, when problem behavior was eliminated in both contexts and initial FCRs were emitted independently for two consecutive sessions, the analyst increased the complexity of the response required via prompting and differential reinforcement.

Results

Figure 2 depicts the results of FCT. There was a reduction in initial FCRs and variable rates of the target FCR observed with Nico, but after a period of variability, the target FCR was emitted exclusively and at an optimal rate. FCT resulted in an immediate elimination of problem behavior for Will and the acquisition of the target FCR. Despite some variability in problem behavior, FCT resulted in an eventual elimination of problem behavior and acquisition of the FCR with Jack in both contexts. FCT resulted in an immediate reduction of problem behavior for Alex and the acquisition of the initial FCR in both contexts.

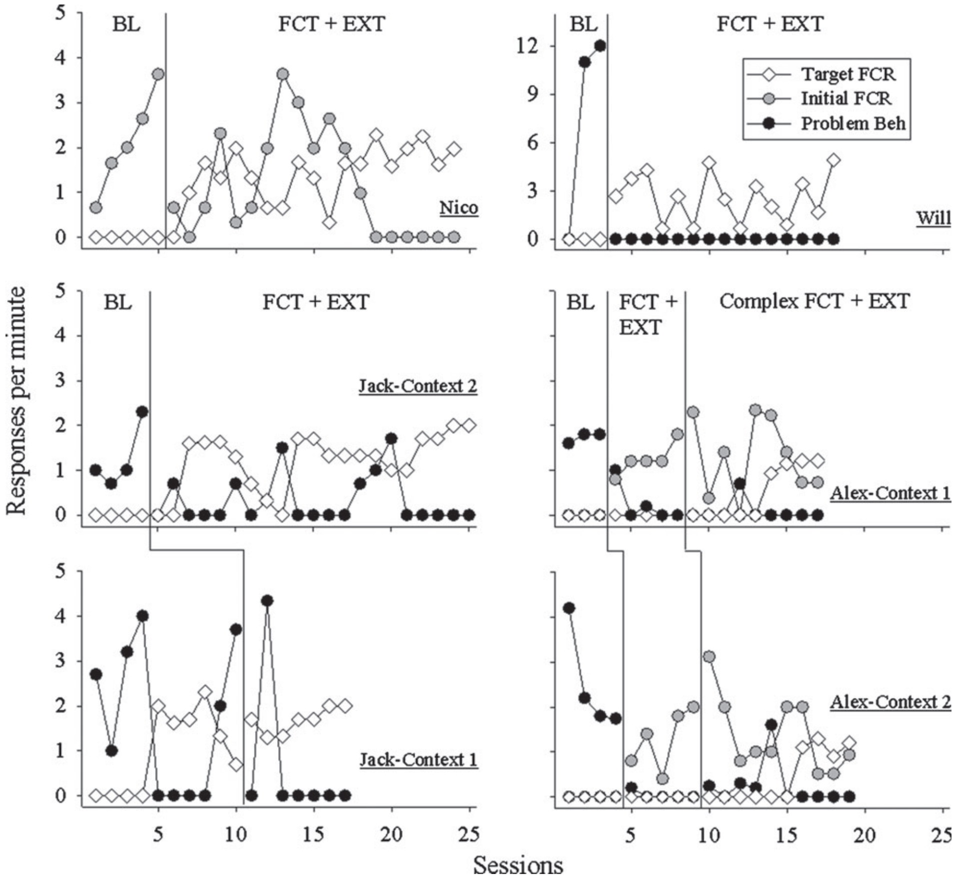

Figure 2. Results of the functional communication training plus extinction (FCT + EXT) for Nico, Will, Jack, and Alex.

Independent and target FCRs eventually occurred at a higher rate than simple FCRs and to the exclusion of problem behavior in both contexts. By the end of FCT, all participants emitted the target FCR at an efficient rate, maximizing reinforcement to near-continuous access, in the absence of problem behavior (Will, Jack, and Alex) or initial FCRs (Nico).

PART 3: COMPARATIVE ANALYSIS OF TOLERANCE TRAINING

Data Collection and Response Definitions

In addition to response rates defined above (e.g., target problem behavior and FCRs), the following responses and rates were also measured during the comparative analysis. The tolerance response (TR) for Nico, Jack, and Alex consisted of saying "okay" in an appropriate tone and volume within 5 s in response to the delay cue. TRs were considered prompted if the analyst prompted any aspect of the response within 10 s of the participant emitting the response. Only independent TRs are reported. For all participants, an optimal rate of FCR was calculated by dividing the number of evocative trials presented by the total duration of that session. For Nico, an optimal rate of TR was also calculated for each session by dividing the total number of opportunities (i.e., the total number of delay trials) by the total duration of that session. The optimal rates are depicted in each figure as a dotted data path.

Nico's collateral responses were in the form of *excessive mands* (defined as any additional requests during the delay that were different than the target FCR that initiated the delay interval). Will's collateral responses included *motor disruptions* (defined as throwing, swiping, and pushing items) and *grabbing others*. Jack's collateral responses were in the form of *negative emotional responding* (defined as crying, pouting, and saying "no"). Alex's collateral responses included *attempts to control* during the delay (defined as negotiating to change the qualitative features of the task or the amount, vocally refusing or completing the task in a manner different than what the analyst indicated, and making additional requests).

Alternative activity engagement was defined as actively manipulating, responding to (e.g., dancing to music), or orienting towards materials (e.g., neutral toys, beads) as instructed by the analyst without problem behavior or collateral responses for Nico, Will, and Jack. Engagement was recorded using a 3-s onset–offset delay. For Alex, counts were collected on each verbal and gestural instruction issued by the adult and his compliance with each instruction. *Compliance* was defined as orienting towards the materials within 5 s of the instruction and completing the task correctly without any collateral responses or problem behavior and without any need for a physical prompt from the adult.

Counts of participants' communication and tolerance responses, problem behavior, and discrete collateral responses (i.e., excessive manding, grabbing and motor disruptions, and attempts to control) were collected and converted to a rate for all analyses. Duration data were collected on other collateral responses (e.g., crying), scheduled and experienced delays (the interval of time between the delivery of the delay cue, e.g., "wait," and the delivery of reinforcement), and engagement in the alternative activity during delays. The percentage of session engaged in negative emotional responding was calculated by dividing the duration of negative emotional responding by the session duration. The percentage of delay interval engaged in alternative activity was calculated by dividing the duration of alternative activity engagement by the delay duration.

General Procedure

After 1-min access to all reinforcers, every session started with the removal of all reinforcers and the presentation of the participant-specific evocative situation (e.g., taking away toys or tablet, removing attention, presenting writing tasks). Sessions were as long as necessary to allow five presentations of the evocative situations and all the scheduled delays and reinforcement periods, henceforth referred to as trials. This resulted in session durations that ranged from 2.5 to 40 min depending on the delay. During all delay conditions, FCRs were reinforced immediately on two of five randomly selected trials. On the remaining three trials, the FCR resulted in one of several brief verbal delay signals (e.g., "wait," "not yet," "in a minute"), that were rotated within participants, and reinforcement was provided after either the scheduled amount of time (TBPD) or the scheduled response requirement (CBPD). The specific response contingencies for each participant during CBPD are summarized in Table 1 and explained in detail under specific procedures. The contingency and prompting procedures chosen in CBPD were dictated by the parental goals and expectations during the delay.

A geometric progression starting at 1 s (i.e., 1, 2, 4, 8, …) was used to reach the terminal delay in an efficient manner and perhaps to allow differences in the procedures to be revealed more readily than with a less rapid progression. This geometric progression was used as a guide for increasing the scheduled delay. The geometric progression was used until the target terminal delay was reached, at which point the scheduled delay was capped at that level. The target terminal delay for each participant was guided by caregiver and setting requirements. The participant-specific criteria to increase delays are described in the specific procedures below. The experienced duration of each delay in a CBPD session was determined based on the speed with which the participant completed the response requirement and refrained from engaging in problem behavior or collateral responses. The experienced duration of each delay in a TBPD session, however, did not always precisely match this programmed delay due to (a) being yoked to the experienced duration of the delay in the CBPD session (Nico only), (b) slight variations in the time required to reset the reinforcing materials (Will and Context 1 of Jack and Alex), or (c) termination of the delay due to problem behavior (Context 2 of Jack and

Table 1
Participant-Specific Prompts, Response Contingency, and Consequences During the Delays in the Comparative Analysis

	Time-based delay	Contingency-based delay		
Participant	Prompts	Prompts	Contingency	Consequences for PB and CR
Nico	None	Gestural and physical every 30 to 45 s	DRA-DRO: TR and continuous engagement in alternative activity without PB or CR (say "okay" then play in area with low-preference toys)	Restart delay interval
Will	Single vocal	Three-step every 15 s	DRA: Cumulative number of compliance responses (place all the provided beads on a string)	Block PB
		Single vocal	DRO: Cumulative amount of time without PB or CR (engage in any or no activity)	Block PB, pause, and hold up timer
Jack	Single vocal	Single vocal	DRA-DRO: TR and cumulative amount of time without PB or CR (say "okay" and engage in any or no activity)	Pause timer
Alex	Three-step as needed	Three-step as needed	DRA-DRO: TR and cumulative number of compliances without PB or CR (say "okay" and independently comply with a mixture of adult-directed academic and toy-based demands)	Continue demands

Note. PB = problem behavior, CR = collateral responses, DRA = DRA-based contingency delay, DRO = DRO-based contingency delay, TR = tolerance response, Three-step = vocal, model, physical prompting.

Alex). Reinforcement intervals were increased from 30 s to 120 s (30 s for delays of 0 to 32 s, 60 s for delays of 64 to 128 s, and 120 s for delays of 256 to 600 s).

No-delay baseline. These sessions were identical to the final sessions of FCT. Reinforcement was withheld until the target communication response was emitted. In all trials, the FCR was immediately reinforced and neither problem behavior nor collateral responses resulted in programmed consequences.

Time-based progressive delay (TBPD). On the three delay trials, the FCR resulted in a delay signal and either no additional prompts (Nico), a single prompt (Will and Jack), or multiple prompts (Alex) to engage in the alternative activity or comply with demands. Although the alternative activity or instructional materials were present and freely available during these sessions, there was no requirement for the participant to engage these materials or independently comply with demands (i.e., the delay ended based on time alone). At the end of the scheduled delay, the reinforcers were delivered with a verbal statement (e.g., "Now you can have —," "Here you go"). Problem and collateral behavior resulted in no programmed consequences throughout the session.

Tolerance response (TR) training. TR training was conducted before the start of CBPD for Nico, Jack, and Alex. Training sessions of 10 trials, 60% of which were delay trials, were used to teach a specific TR ("okay") to the adult's delay cues. A minimum of two sessions with 80% independent FCRs and TRs were conducted before the start of CBPD. The training sessions started with a brief instructional statement, modeling of the FCR followed by the delay cue and the TR, role-play of emitting both the FCR and the TR to access reinforcement, and ended with praise or any necessary corrections. A most-to-least prompting procedure was used during each trial.

Contingency-based progressive delay (CBPD). On the three delay trials, the FCR resulted in a delay signal and either a single prompt (Jack, Will in DRO) or multiple prompts (Nico, Will in DRA, and Alex) to engage in the alternative activity or comply with demands. The participant was required to emit the TR or either engage in additional specific responses or refrain from engaging in problem behavior or collateral responses to terminate the delay. In other words, reinforcement was withheld until the participant completed the response requirements.

Specific Procedures

Nico. The relative efficacy of CBPD and TBPD was evaluated with Nico in a multielement design. TR training was conducted before the start of the comparative analysis. Throughout the comparative analysis, the two conditions were presented as a dyad in which the first condition to be presented in each dyad was randomly selected. During both delay conditions, the highly preferred toys were placed on a table where Nico and the analyst sat, and the neutral toys used as the alternative activity were placed on foam mats. Green (TBPD) and red (CBPD) plastic sheets on the wall and the table of the session room were correlated with each condition. In addition, the positions of the table and foam mats were flipped during TBPD and CBPD.

During TBPD, FCRs were reinforced immediately on two of five randomly selected trials by providing access to requested toys and attention. On the remaining three trials, the FCR resulted in a brief verbal delay signal (e.g., "wait"), and access to the highly preferred toys and attention was withheld until the scheduled amount of time had elapsed. Problem behavior resulted in no programmed consequences throughout the session. CBPD was similar to TBPD except that DRA-DRO was used to terminate the delay. After the delay signal, Nico was required to say "okay" and then play with the less preferred or neutral toys on the foam mats for a target amount of time. Access to the highly preferred toys and attention was provided only after continuous engagement with the alternative activity (neutral toys) for the target amount of time. The delay was restarted if Nico stopped engaging in the alternative activity or if he engaged in problem behavior or collateral responses. Gestural and physical prompts to engage in the alternative activity were provided every 30 to 45 s if he was not doing so.

Both conditions progressed through the delay levels according to the following schedule: one session at each of the first three delays (approximately 1, 2, and 4 s), two sessions at each of the next three delays (approximately 8, 16, and 32 s), and one session at a delay of 64 s, irrespective of problem behavior or collateral responses. The exact duration of each delay within a session in TBPD was yoked to the experienced duration of the delay in the CBPD session. The comparative analysis was concluded at the delay of 64 s, but CBPD was used to increase the delay to 128 s, after which the treatment was extended to Nico's father and then his mother at the terminal delay of 256 s.

Will. We systematically replicated the comparison between CBPD and TBPD using a slightly modified contingency in an ABAC design to allow a more independent evaluation of the presence of a response contingency during delay. For Will, the delay response contingency during CBPD was modified to require completion of a cumulative, rather than a consecutive, number of beading tasks (i.e., the contingency was not reset if Will stopped engaging in the activity). The terminal delay duration was set at 180 s or the placement of roughly 10 beads on the string.

During both delay conditions, the edible items were placed on a table where Will and the analyst sat, and various toys and beading materials were also placed on the table in front of Will. The toys and beading materials were freely available throughout all sessions. TBPD was introduced first. During TBPD, FCRs were reinforced immediately on two of five randomly selected trials by providing access to a bite of food. On the remaining three trials, the FCR resulted in a brief verbal delay signal (e.g., "in a minute") and a single vocal prompt ("you can play or bead if you want") to highlight the option of engaging with the neutral activities (i.e., there was no requirement to engage with these items). Access to food was withheld until the scheduled amount of time had elapsed. Problem behavior was blocked but resulted in no other programmed consequences throughout the session.

After a return to the no-delay baseline, CBPD was introduced. During CBPD, two of five randomly selected trials included immediate reinforcement of FCRs, and the remaining three trials included a delay. In this condition, however, after the delay signal, Will was prompted to engage in a beading task ("first put the beads on"), and access to food was provided after completion of a predetermined number of beads that corresponded to the target delay. Vocal and model prompts to engage in the beading task were provided every 15 s if he was not doing so. Attempts at self-injury were blocked but resulted in no other programmed consequences. In both conditions, delays were increased after one session with no problem behavior and collateral responses or after two sessions if there were any instances of these behaviors. The first comparative analysis was concluded at a delay of 180 s.

Among other factors, the pace of the progression may have contributed to the persistence of Will's problem behavior and collateral responses during the first comparative analysis. A second analysis that used a multielement design was conducted to evaluate the effects of two versions of CBPD, DRA only and DRO only, simultaneously against TBPD with a slower programmed progression of the delay. The three conditions were presented in a random and counterbalanced order. The conditions were signaled using color-correlated stimuli (tablecloths, plates, and beads). The time-based condition was signaled with yellow stimuli and was identical to the previous TBPD condition. The DRA condition was signaled with red stimuli and was identical to the previous CBPD condition. The DRO condition was signaled with blue stimuli and was similar to the CBPD condition described above, except that the response contingency was further modified to consist of the absence of problem behavior and collateral responses for a cumulative amount of time. A single vocal prompt ("you can play or bead if you want") to highlight the option of engaging with the neutral activities (i.e., there was no requirement to engage with these items) was provided after the delay cue. No additional vocal prompts were used to direct Will to play or bead, but in addition to blocking self-injury, the analyst held up the timer and paused if Will engaged in any problem behavior or collateral responding. This comparison was started at a 64-s delay, which was the point at which problem behavior and collateral responses emerged during the previous analysis. When stable and desirable trends were observed in one condition, the delay was increased to 90 s, 120 s, and finally 180 s.

Jack and Alex. Although the multielement designs provided a clear demonstration of the relative efficacy of each condition, there was some apparent carryover across conditions (e.g., the TR generalized to the TBPD context with Nico). Therefore, to isolate the effects of each condition better, a multiple baseline design across participants was used with Jack and Alex to evaluate the direct effects of a response contingency during the delay, while the general effects were demonstrated in the secondary context with each participant.

During both CBPD and TBPD, highly preferred toys were placed on a table where the children and the adult sat, and the neutral toys used as the alternative activity were placed in the corner of the room for Jack or the instructional materials were placed on the table for Alex. The direct effects of TBPD and CBPD were evaluated in Context 1, and general effects were evaluated in Context 2 using terminal delay probes (described below). TBPD was introduced first followed by the no-delay baseline, TR training, and finally CBPD. During both TBPD and CBPD conditions in Context 1, terminal delay baseline probes were conducted on every fifth session in Context 2. Finally, CBPD was implemented in Context 2.

Terminal delay probes (generality test). This condition was arranged with Jack and Alex to evaluate the extent to which treatment effects would generalize to a context in which problem behavior during the delay was reinforced (i.e., no extinction during the delay). Context 2 (the analyst context for Jack and the dinosaur context for Alex) was designated as the generalization context. The terminal delays of approximately 5 min for Jack and 10 min for Alex were used during these probes. All problem behavior before the emission of FCR was placed on extinction. However, any instances of problem behavior after the delivery of the denial cue terminated the delay and resulted in the immediate delivery of the reinforcers. The alternative activity or demands were available throughout this condition; there was, however, no engagement or compliance requirement. If no problem behavior was emitted during the delay, the reinforcers were delivered at the end of the scheduled terminal delay. This condition served as a rigorous test of the generality of delay treatments, given that direct reinforcement of problem behavior was programmed.

Jack. The general TBPD and CBPD procedures described above were implemented with Jack. The terminal delay was set at 256 s. The delay response contingency used during CBPD included emitting the tolerance response and engagement in any activity without engaging in problem behavior or collateral responses (i.e., both a DRA and a DRO contingency) for a cumulative amount of time.

During both conditions, after the delay cue, a single vocal prompt to engage with the alternative activity (i.e., "play with [activity] if you want") was issued. No additional prompts were used throughout the delay. During CBPD, Jack was required to say "okay" in response to the delay signal and access to the high-preference toys and attention was withheld until he met the target cumulative amount of time not engaging in any problem behavior or collateral responses. During both TBPD and CBPD, delay levels were increased after one session if no problem behavior or collateral responses occurred, and after two to four sessions if any of these responses occurred. The comparative analysis was concluded at the delay of 256 s, after which CBPD was also implemented in Context 2 and also with a new adult (Jack's father).

Alex. The general TBPD and CBPD procedures described above were implemented with Alex. The terminal delay was set at 600 s or roughly 50 age-appropriate demands. Given that problem behavior was at least partly maintained by escape from demands, the delay response contingency used during CBPD included emitting the tolerance response and compliance with a fixed number of adult instructions without engaging in problem behavior or attempts to control (i.e., both a DRA and a DRO contingency).

During both conditions, following the delay cue ("not right now" or "wait"), demands (e.g., "write J," "Color the bird blue") were presented and three-step prompting (vocal, model, full physical) was used to ensure compliance with demands. During CBPD, after the delay signal, Alex was required to say "okay" and comply with a cumulative number of adult instructions without engaging in any problem behavior or collateral responses. At the beginning, he was required to say "okay" and sit facing the therapist or the demand materials. Starting at the 4-s delay, a demand was added to this response chain. The number of demands was then increased using a geometric progression (1, 2, 4, …). During the delay, demands continued until Alex complied with the target number of demands. In both conditions, delay levels were increased after one session with no problem behavior or collateral responses, or after two sessions if there were any instances of these behaviors. The comparative analysis was concluded at the delay of 64 s or 16 demands.

We then merged both contexts into one and further extended the delay and demand requirements to 32 demands. The response contingency during the delay was then changed from compliance with a cumulative number of demands to a consecutive number. To signal this change in the contingency, tokens (checkmarks) were introduced. Alex initially earned a checkmark for each demand he completed and lost all checkmarks earned in each section if he engaged in any problem behavior or collateral responses. Finally, the demand requirement was changed to a variable ratio of 50 demands. Checkmarks were earned for an average of three demands completed, and a total of 16 checkmarks were required to earn 120 s of reinforcement (i.e., an average of 24 demands needed to be completed in a row without any problem behavior or collateral responses to earn reinforcement time).

Results

Nico. The no-delay baseline showed that target FCRs occurred at an optimal rate, problem behavior was at zero, and no TRs occurred (Figure 3). After TR training and with the introduction of progressive delay, target FCRs slowly decreased but remained near the optimal rate in both conditions. The TR was observed in both conditions; however, they occurred at an optimal rate in CBPD whereas excessive amounts were emitted during TBPD. After a

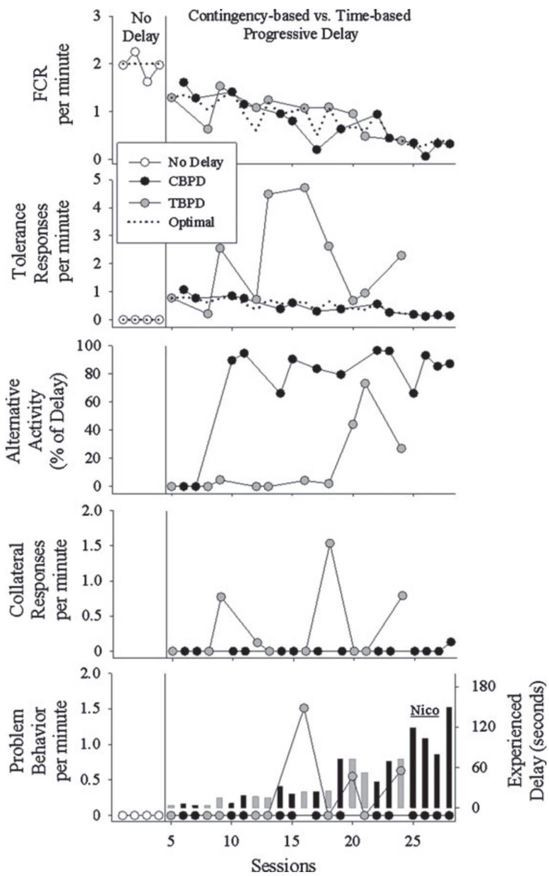

Figure 3. Results of the time-based versus contingency-based comparative analysis for Nico.

few sessions of CBPD, Nico spent approximately 80% of the delay engaging in the alternative activity (third panel). Engagement in the alternative activity did not occur for several sessions in TBPD and then never exceeded 75%. Collateral responses and problem behavior were highly variable but occurred almost exclusively in TBPD, despite the fact that the experienced delays were similar across CBPD and TBPD. Overall, it appeared that CBPD was more effective than TBPD at increasing Nico's tolerance for delayed reinforcement. CBPD treatment effects maintained as the delay was extended to an average of 5 min and treatment was implemented by Nico's parents (data available from the second author).

Will. During the no-delay baseline in Will's initial analysis (Figure 4), target FCRs occurred at an optimal rate, and problem behavior (i.e., SIB) and collateral responses were at zero or near-zero levels. FCRs decreased but maintained at an optimal rate, and no engagement in the alternative activity was observed during TBPD. Problem behavior remained low initially; however, as the delays increased, collateral responses such as grabbing others and swiping materials emerged and maintained and SIB resurged. The return to the no-delay baseline resulted in an immediate reduction of SIB and collateral responses, and FCRs persisted. The introduction of CBPD resulted in a gradual reduction of FCRs toward an optimal rate, high and variable engagement in the alternative activity, and zero levels of SIB and collateral responses, but these latter behaviors resurged as the demand requirements were increased. Due primarily to the resurgence of SIB and collateral responses as the delays were increased, neither CBPD nor TBPD was effective in developing tolerance for delayed reinforcement with Will.

Will's limited fine-motor repertoire and independent play skills may have contributed to the moderate level of engagement in the alternative activity, which in turn may have contributed to the resurgence of problem behavior. He also may have required a slower progression of the response requirement during the delay to allow him to acquire the beading skills relevant to the alternative activity. These considerations informed the second analysis, the results of which are depicted in Figure 5. The optimal number of FCRs per reinforcer in each condition was one; this was obtained during most DRA sessions. By contrast, Will emitted twice that many FCRs during TBPD and DRO. Alternative activity engagement was exclusively observed during DRA. Both SIB and collateral responses occurred at higher rates during TBPD and DRO than during DRA. These patterns persisted as the delay increased to 180 s. Overall, CBPD using a DRA

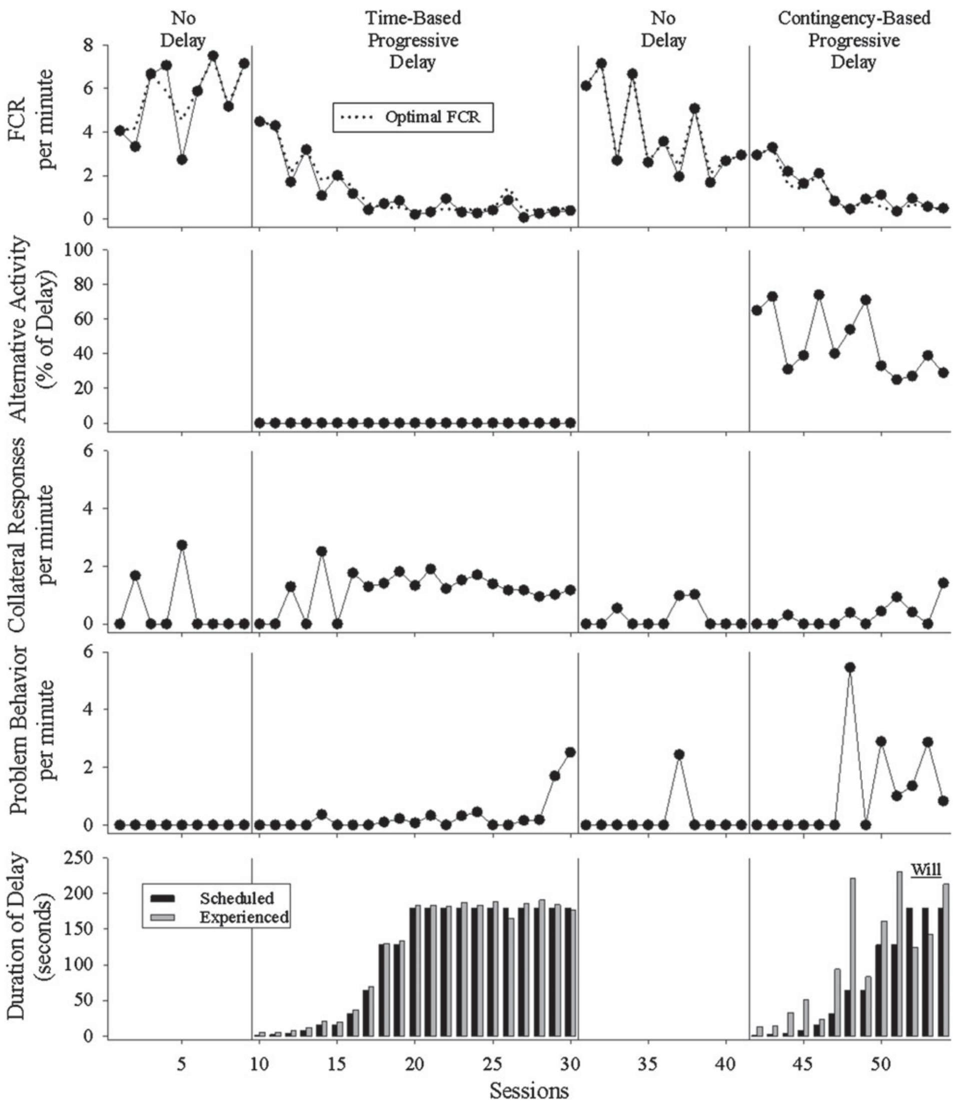

Figure 4. Results of the time-based versus contingency-based comparative analysis for Will.

contingency was more effective for increasing Will's tolerance for delayed reinforcement than a time-based or DRO-based contingency.

Jack. During the no-delay baseline in both contexts, FCRs occurred at an optimal rate, and problem behavior and collateral responses were at zero (Figure 6). With TBPD in Context 1, there was an increase in the rate of FCRs with a spike at the 16-s delay. Although some engagement in the alternative activity was observed as the delay was increased to 256 s, target FCRs were emitted at a higher than optimal rate during the majority of TBPD sessions. Problem behavior occurred at high and variable rates throughout TBPD, and collateral responses (e.g., crying) increased as the delay was increased. Problem behavior also remained at strength in Context 2. Overall, TBPD did not produce tolerance for delayed reinforcement. The return to the no-delay baseline in

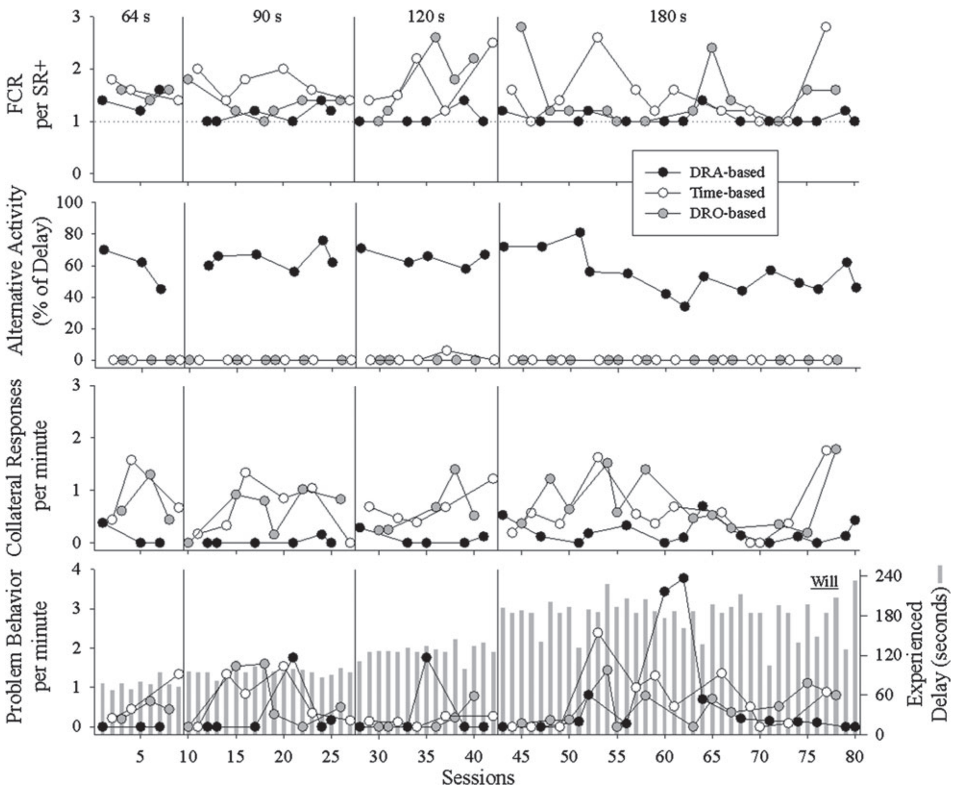

Figure 5. Results of the comparison between time-based versus DRO-based versus DRA-based delay for Will. The scheduled delay increased at each phase line.

both contexts resulted in the elimination of problem behavior and collateral responses, and optimal rates of FCRs.

After TR training, the introduction of CBPD in Context 1 resulted in near-optimal rates of FCRs and TRs, low but persistent engagement in the alternative activity, and continued zero rates of problem behavior and collateral responses as the delay was increased to 5 min. The DRA-DRO contingency during delay for Jack required him to emit the TR and then refrain from engaging in any problem behavior or collateral responses for the required amount of time (i.e., there was no requirement to engage with the alternative activity). In addition, the data from Context 2 provide evidence of the generality of CBPD training. While Jack experienced TBPD in Context 1, he consistently experienced a shorter delay than that scheduled in Context 2 because he terminated the delay through problem behavior. Despite the presence of the same "inappropriate" contingency in Context 2, Jack tolerated the scheduled delay when CBPD was programmed in Context 1, even though the delays in Context 2 could have been terminated at any point by engaging in problem behavior. The TR of "okay" as well as other appropriate play responses generalized, and presumably as a result, lower rates of problem behavior and lower rates of FCR were observed in this second context. There were, however, some residual collateral responses; these were eliminated after implementation of CBPD in Context 2. In summary, CBPD was an effective treatment for increasing Jack's tolerance for delayed

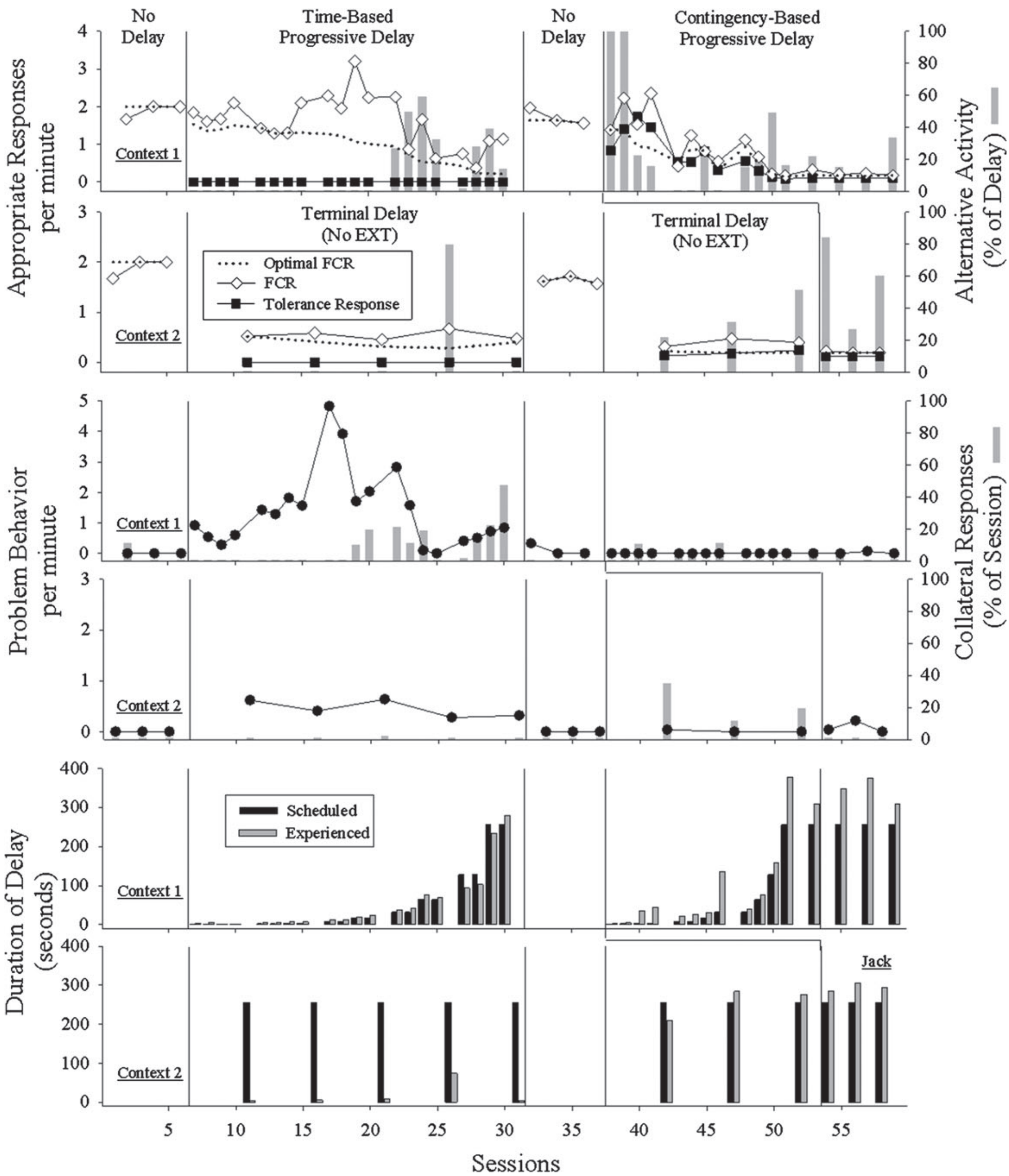

Figure 6. Results of the time-based versus contingency-based comparative analysis for Jack.

reinforcement. These treatment effects maintained when treatment was extended and implemented by Jack's father (data available from the second author).

Alex. During the no-delay baseline in both contexts, FCRs occurred at an optimal rate, and problem behavior and collateral responses were at zero (Figure 7). With the introduction of TBPD in Context 1, there was a gradual decrease in the rate of FCRs corresponding to the optimal rate, but compliance with demands remained at zero throughout this condition, and there was an immediate increase in the rate of problem behavior with a spike at the delay of 16 s, at which point TBPD was terminated. Collateral responses also increased starting at the delay of 4 s. Overall TBPD was not an effective treatment for increasing tolerance for delayed reinforcement with Alex. The return to the no-delay baseline in both contexts resulted in the elimination of problem behavior, and FCRs persisted. After TR training, the introduction of CBPD in Context 1 resulted in occurrences of the TR, a gradual reduction of FCRs toward an optimal rate, high but variable levels of compliance during delays, and near-zero rates of problem behavior throughout. In addition, the data from Context 2 provide evidence of the generality of CBPD training. While Alex experienced TBPD in Context 1, he complied with no demands in Context 2 and terminated the delay through problem behavior. By contrast, while Alex experienced CBPD in Context 1 and despite the presence of the same "inappropriate" contingency in Context 2, he emitted the TR and complied with almost half of the demands presented in Context 2 before he engaged in problem behavior to terminate the delay. When CBPD was introduced in Context 2, high and stable levels of compliance were achieved, FCRs and TRs persisted, and problem behavior and collateral responses occurred at zero or near-zero levels. By the end of treatment, Alex engaged in approximately 50 demands and experienced delays to reinforcement of approximately 10 min with CBPD.

GENERAL DISCUSSION

Contingency-based delays were more effective than time-based delays in developing participants' tolerance for delayed reinforcement. CBPD increased alternative activity engagement and compliance while it maintained zero or near-zero rates of problem behavior and collateral responses and optimal rates of communication. Our finding that TBPD is an ineffective method for increasing the generality of FCT treatment is consistent with previous research (Fisher et al., 2000; Hagopian et al., 1998; Hanley et al., 2001). In fact, despite the various procedural improvements to the manner in which TBPD is usually programmed, TBPD was still found to be ineffective in our study. For example, although, the addition of probabilistic reinforcement appeared to result in the maintenance of the communication response during TBPD, problem behavior resurged in all cases and within the first 16 s of delay for three of four cases. Although the recovery of problem behavior during this delayed reinforcement procedure is likely due to resurgence, as suggested by Lieving and Lattal (2003) and Volkert et al. (2009), we did not arrange for the necessary controls to label this recovery as resurgence with confidence instead of other extinction-related phenomena (Bruzek, Thompson, & Peters, 2009). Furthermore, the mere presence of an alternative activity and prompts to engage in these activities or comply with demands were not sufficient to mitigate the negative side effects of TBPD. Therefore, it appears that the response contingency during the delay is the necessary component for the effectiveness of progressive delay-tolerance training. Our finding, that the presence of a contingency in addition to the alternative activity during the delay is important for achieving delay tolerance, is consistent with the findings from translational research on self-control by Mischel, Ebbesen, and Raskoff Zeiss (1972), Dixon and Cummings (2001), and Dixon, Rehfeldt, and Randich (2003). For example, Dixon and Cummings have shown that requiring participants to engage in an alternative response during delay aids in shifting preference from the smaller immediate reinforcer to the larger

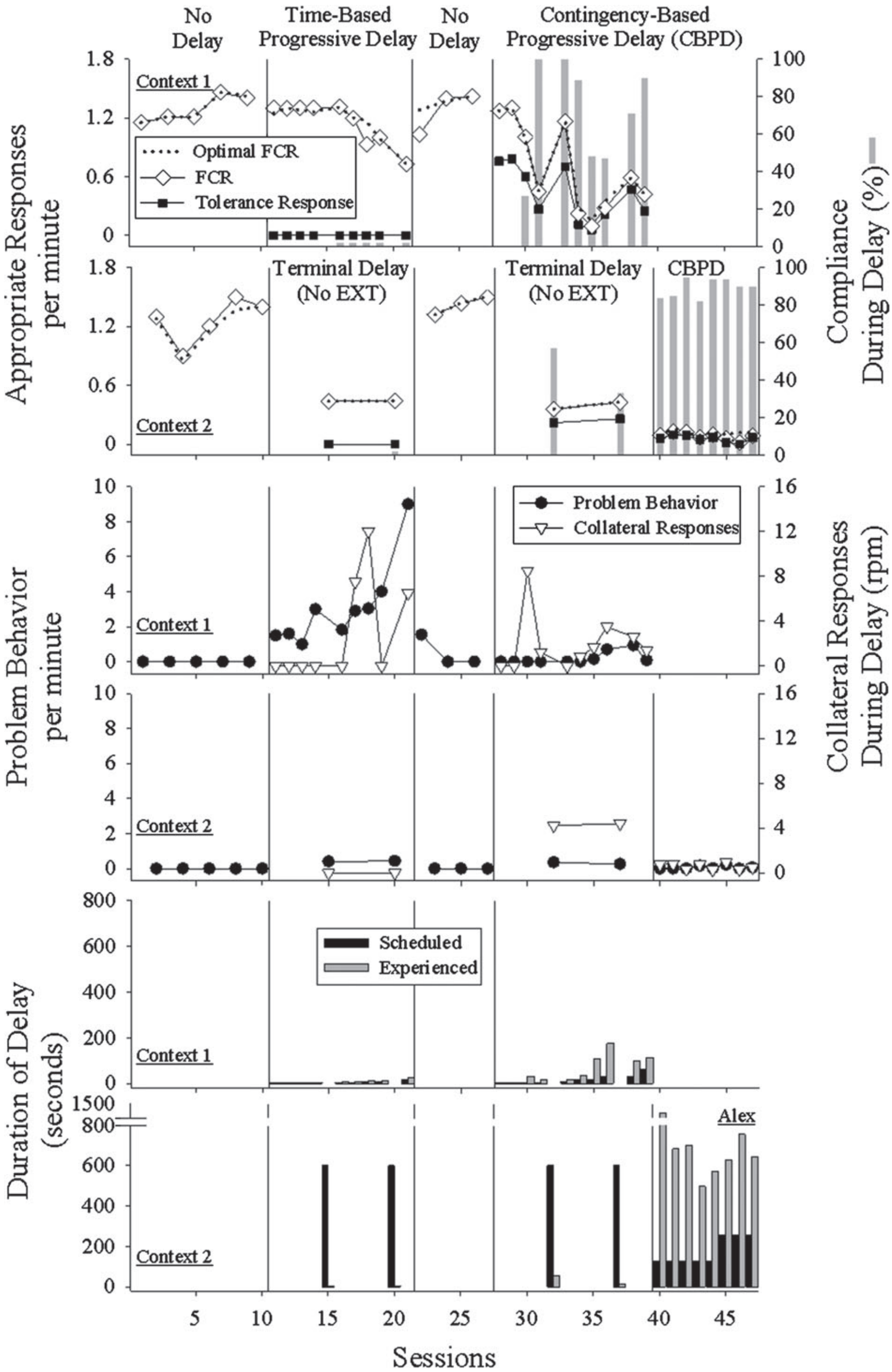

Figure 7. Results of the time-based versus contingency-based comparative analysis for Alex.

delayed reinforcer while lower levels of problem behavior are maintained.

The effects of CBPD were systematically replicated across participants aged 21 months to 30 years old, with and without developmental disabilities or autism, and across both social-positive and social-negative reinforcement contexts, replicating the results of Hanley et al. (2014). In addition to the elimination of problem behavior during treatment, CBPD resulted in the acquisition of an appropriate response to a delay signal (i.e., the TR of "okay") and a set of developmentally appropriate responses (e.g., compliance with academic demands, functional play skills) that also generalized to a context in which extinction was not fully in place. In other words, with CBPD we were able to shape a repertoire of "waiting" that generalized to contexts with an inappropriate contingency (i.e., availability of reinforcement for problem behavior during delay). This shaping of a waiting repertoire was systematically replicated across participants with varying degrees of baseline language, adaptive, and leisure skills. Desirable patterns of behavior during extended delays were produced for all participants without the need for positive punishment (Fisher et al., 1993; Hagopian et al., 1998) or additional noncontingent or differential reinforcement procedures (Hagopian, Contrucci Kuhn, Long, & Rush, 2005; Rooker et al., 2013) during the delay.

The relative speed with which these treatment effects were obtained (2 to 8 hr distributed across 4 to 24 weeks) suggests that CBPD may be a desirable alternative to long-term FCT treatment necessary for persistence of effects during extinction (Wacker et al., 2011). Wacker et al. (2011) noted that the antecedents and consequences surrounding the response in the natural environment often vary from the specific conditions used during treatment. They suggest that variables that enhance treatment persistence such as extensive experience with FCT (nearly 16 months) should be included in treatment. Another variable that may play a role in the persistence of treatment effects is the manner in which antecedents and consequences are arranged during treatment. Our findings suggest that alterations to the design of treatment such as those included in CBPD may be an efficient means of obtaining similar resistance in light of changing contexts.

Although FCT, by the nature of its design, exposes the individual to the natural maintaining contingencies of the response, exposing the individual to sufficient exemplars of antecedent conditions may also be important to ensure generalized responding (Tiger et al., 2008). Rather than relying on the use of a single, tightly controlled context with a specific task and clear discriminative stimuli for the delay, we used multiple exemplars of delay cues to signal the onset of delay, a variable array of activities and tasks based on child-selected items from the preference assessment, and adult-selected demand items that changed every two to four sessions. Within 8 hr of treatment, for example, Alex was able to engage in appropriate communication and tolerance responses in the presence of a variety of evocative situations (e.g., interruption of drawing activity, removal of toys, denial of a request) and to tolerate delays of approximately 10 to 15 min and complete roughly 50 demands that involved various academic and toy-based activities.

The specific response requirements during the delay were also closely matched to the behavioral expectations regularly experienced by the participants. The selection of the alternative activities and the most appropriate prompting procedures, in addition to the specific evocative contexts and reinforcers, were guided by the results of the open-ended interviews with caregivers. For example, Jack's mother reported that a common situation involved her preparing dinner and requiring Jack to stay away from the stove and do "something else," with very little supervision or attention. Given this context and Jack's lack of an independent play repertoire, a DRO contingency seemed the most suitable. It allowed Jack to engage in a variety of other responses without any prompting from his mother and still satisfied the mother's request that he stay away from her cooking area for a few minutes. These considerations increased the ecological validity of treatment, which may further enhance the maintenance of treatment effects. We also used delay cues that were commonly presented in the natural environment (i.e., "wait," "in a minute," "not right now") to increase the similarity of the training context and the context typically experienced by the participant. Finally, for two participants, treatment was sequentially implemented in a second context, and for all participants, treatment was extended to the relevant context and training was provided to the caregivers who would be responsible for treatment maintenance.

Although other procedures have been shown to maintain low levels of problem behavior during planned delays of practical duration, these effective procedures also rely on strong contingencies. For example, Luczynski and Hanley (2014) showed that the strong positive contingencies within multiple schedules were responsible for their efficacy. Multiple schedules are often used in the treatment of positively reinforced problem behavior (Hagopian et al., 2011), whereas chained schedules are often used to treat escape-motivated problem behavior (e.g., Hagopian et al., 1998). Multiple schedules have been shown to retain zero or low levels of problem behavior and sufficient levels of communication even when nonreinforcement periods are scheduled for up to 80% of the observation period (Betz, Fisher, Roane, Mintz, & Owen, 2013; Fisher et al., 1998; Hagopian et al., 2011; Hanley et al., 2001). Multiple schedules, however, have often been programmed using somewhat artificial stimuli (but see Kuhn, Chirighin, & Zelenka, 2010) such as different-colored cards that must be programmed in the natural environment (Hagopian et al., 2011; Hanley et al., 2001). In addition, obtaining stimulus control over the occurrence of FCR can be difficult, sometimes resulting in high rates of FCR during the extinction component and some recovery of problem behavior as the extinction component is increased (see Hanley et al., 2001, for examples). Given the current state of evidence, a direct comparison of multiple schedules and CBPD is warranted. In particular, it is important to evaluate the extent to which caregivers are able to maintain treatment integrity with each procedure and whether they prefer one over the other. The recipient's preference for these procedures should also be directly evaluated and considered.

Chained schedules have historically been referred to as *demand fading* and have been used to treat negatively reinforced problem behavior (Hagopian et al., 2011; Lalli et al., 1995). Although supplemental strategies (including punishment) have often been necessary to achieve the desired outcomes with demand fading (Hagopian et al., 1998), more recent evaluations by Falcomata et al. (2013) and Falcomata, Roane, Muething, Stephenson, and Ing (2012) have been conducted in which various elements of both multiple schedules (the discriminative stimuli) and chained schedules (the contingency-based alternation of the component change) were used to treat problem behavior maintained by a synthesis of both positive and negative reinforcement. The contingency arranged in the traditional chained schedules is somewhat different than the arrangement used in CBPD. Chained schedules used by Hagopian et al. (1998), Lalli et al. (1995), and Falcomata et al. (2013) can be represented as an FR x FR 1 schedule, in which a certain number of demands are completed, after which the communication response is reinforced immediately. CBPD, by contrast, can be represented as an FR 1 FR x schedule, in which the communication response is followed by a chain of responses that are progressively increased to accommodate the length of delay necessary, including unplanned delays that may naturally occur. This arrangement also allows the recursive implementation of treatment. This is important, given the continuous nature of interactions between individuals and their caregivers. For example, a child may request a break from work and be told to wait and finish his homework first. After he is done, the child is provided with a break with his toys. During this break, however, the child may ask that his mother play along with him. At this point, the mother can again repeat the treatment procedure and ask the child to wait and play alone while she finishes her cooking. When the mother joins the play, however, the child may make another request for a drink, which the mother may immediately reinforce. In this way, CBPD can be practiced continuously because it has a natural fit with common situations.

The CBPD procedure, as described in this study, is not without its limitations. Some participants' performance, in particular when demands were presented, required monitoring during the delay. For example, Will required intermittent prompting to continue beading. Alex's treatment included discrete presentation of demands and three-step prompting (instruction, model, physical). The need for continuous monitoring may present a barrier to implementation when caregivers are busy with other tasks or other individuals. One possible extension of this research could involve evaluating the use of product monitoring as the criterion for the contingent delivery of reinforcement. Another strategy that could improve the practicality of CBPD involves the addition of self-monitoring of performance (Connell, Carta, & Baer, 1993). Individuals could be taught to self-assess and to recruit reinforcement when a task is complete. This strategy could reduce the amount of monitoring that caregivers must provide and increase an individual's independent task engagement during delays. Finally, the efficacy of a DRA-based contingency using momentary and sporadic monitoring remains to be assessed.

Some additional questions arise from the manner in which CBPD was programmed in this study. One question concerns the predictability of the delay. *Predictability* can be defined in various ways. One aspect is related to the relative proportion of delayed and immediate reinforcement for FCRs. A second aspect relates to the extent to which the duration of each delay requirement is fixed or variable. Predictability may also involve cues that inform the participant of the ensuing delay requirement (e.g., contingency-specifying statements or visual cues such as token boards). Future research should examine the impact of predictable versus unpredictable delay termination requirements.

The main advantage of CBPD lies in its ability to create desirable patterns of behavior while it emulates situations that involve unplanned delays and in its ability to yield generalizable patterns of behavior that appear to protect individuals from mismanaged contingencies (see also Luczynski & Hanley, 2013). Future investigations into the procedural variations that may enhance the efficacy of this treatment, its generality, and its social validity are still warranted.

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MINIMIZING RESURGENCE OF DESTRUCTIVE BEHAVIOR USING BEHAVIORAL MOMENTUM THEORY

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The resurgence of destructive behavior can occur during functional communication training (FCT) if the alternative response contacts a challenge (e.g., extinction). Behavioral momentum theory (BMT) suggests that refinements to FCT could mitigate resurgence of destructive behavior during periods of extinction. Following a functional analysis and treatment with FCT, we combined three refinements to FCT (i.e., the use of a lean schedule of reinforcement for destructive behavior during baseline, a lean schedule for the alternative response during FCT, and an increase in the duration of treatment) and compared the magnitude of resurgence relative to a condition in which FCT was implemented in a traditional manner. Results suggested that the combination of these three refinements to FCT was successful in decreasing the resurgence of destructive behavior during an extinction challenge. We discuss the implications of these findings, as well as areas for future research.

Key words: behavioral momentum theory, destructive behavior, functional communication training, relapse, resurgence, translational research

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Epidemiological studies and meta-analyses have revealed that interventions based on the results of a functional analysis (FA; Iwata, Dorsey, Slifer, Bauman, & Richman [1982/1994]) are more effective than similar behavioral interventions not based on the results of an FA (Campbell, 2003; Didden, Duker, & Korzilius, 1997; Iwata, Pace, et al., 1994). One such intervention informed by the results of an FA is functional communication training (FCT), which combines differential reinforcement of alternative behavior (DRA) with extinction to teach an alternative form of communication (i.e., functional communication response [FCR]) that replaces destructive behavior. Numerous studies have shown FCT to be an effective strategy for decreasing destructive behavior reinforced by social consequences (Carr & Durand, 1985; Greer, Fisher, Saini, Owen, & Jones, 2016; Hagopian, Fisher, Sullivan, Acquisto, & LeBlanc, 1998; Kurtz et al., 2003; Matson, Dixon, & Matson, 2005; Rooker, Jessel, Kurtz, & Hagopian, 2013).

Despite its widespread effectiveness, FCT is not without limitations. For example, inadvertent lapses in treatment integrity may result in the FCR contacting unplanned and extended periods of extinction (e.g., caregivers are unable to provide the reinforcer because they are on the telephone; Fisher et al., 1993). Results of recent studies suggest that these situations may increase the likelihood of treatment relapse, wherein destructive behavior increases following successful treatment with FCT when the FCR contacts extinction (Fuhrman, Fisher, & Greer, 2016; Mace et al., 2010; Volkert, Lerman, Call, & Trosclair-Lasserre, 2009; Wacker et al., 2011). Researchers call this form of treatment relapse *resurgence*, defined as an increase in a response previously reduced via alternative reinforcement and extinction (e.g., FCT) when alternative reinforcement terminates.

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Volkert et al. (2009) observed resurgence of destructive behavior in four of five participants when the FCR contacted extinction or a thin schedule of reinforcement (i.e., abruptly transitioning from fixed-ratio [FR] 1 to FR 12) following FCT. Mace et al. (2010) observed greater resurgence and persistence of destructive behavior following treatment with FCT plus extinction than following extinction alone. Finally, Wacker et al. (2011) showed patterns of resurgence similar to those of Volkert et al. and Mace et al. when the FCR went unreinforced during extinction probes that followed phases of FCT.

The data from these and other studies reveal a significant untoward side effect of FCT—although FCT tends to result in an immediate reduction in the level of destructive behavior, providing alternative reinforcement (e.g., for the FCR) can increase the likelihood of resurgence of destructive behavior if alternative reinforcement is later suspended (e.g., when the FCR contacts periods of extinction). It is important to note that this unfortunate side effect is not readily observable during the initial stages of FCT but can become increasingly problematic when behavior analysts attempt to generalize FCT treatment effects to caregivers in the individual's home, school, and community settings. In these contexts, caregivers may not adhere to the FCT procedures, and the newly learned FCR may go unreinforced for extended periods. Results from these initial clinical and translational investigations of resurgence following treatment with FCT suggest that it may be prudent to periodically program times throughout treatment during which reinforcement for the FCR is temporarily suspended to evaluate treatment durability (Fuhrman et al., 2016; Greer, Fisher, Romani, & Saini, 2016; Nevin & Wacker, 2013; Wacker et al., 2011).

Many researchers studying treatment relapse have employed behavioral momentum theory (BMT) as a guiding metaphor to conceptualize the behavioral processes that contribute to the resurgence of destructive behavior (Fuhrman, et al., 2016; Greer, Fisher, Romani, et al., 2016; Mace et al., 2010; Marsteller & St. Peter, 2014; Nevin & Shahan, 2011; Nevin & Wacker, 2013; Pritchard, Hoerger, & Mace, 2014; Wacker et al., 2011; 2013). In the behavioral momentum metaphor, the momentum of a response is a function of its reinforcement rate (which is equivalent to the mass of a moving object) times its baseline response rate (which is equivalent to the velocity of a moving object). In particular, an increasing number of authors have applied the quantitative models of resurgence developed by Shahan and Sweeney (2011) that predict the degree to which target responding (e.g., destructive behavior) resurges following treatments composed of extinction and alternative reinforcement (e.g., FCT, noncontingent reinforcement). Nevin and Shahan (2011) later presented the following adapted model for applied researchers, students, and practitioners:

$$\frac{B_t}{B_o} = 10^{\left(\frac{-t(c + dr + pR_a)}{(r + R_a)^{0.5}}\right)}. \tag{1}$$

Quantitative models like those developed by Shahan and Sweeney and discussed in detail by Nevin and Shahan provide guidance on potential treatment refinements that may improve clinical outcomes by mitigating or preventing treatment relapse in the form of resurgence of destructive behavior. That is, Equation (1) makes specific and precise predictions about how the parameters of reinforcement during baseline and treatment affect the probability of the target response during each treatment session and each session in which alternative reinforcement is suspended or terminated, including whether resurgence of destructive behavior is likely to occur.

Equation (1) predicts responding at different times in extinction as a proportion of baseline responding ($\frac{B_t}{B_o}$); B_t represents the rate of the target response at time t in extinction, and B_0 represents the mean rate of the target response during baseline. According to Equation (1), multiple variables affect the likelihood of destructive behavior when extinction is in place for both destructive behavior and the FCR following treatment with FCT. First, the parameter c represents the effects of terminating the contingency between destructive behavior and its reinforcer. Second, the parameter d represents the discriminability of the change from contingent reinforcement to extinction for destructive behavior, which Nevin, McLean, and Grace (2001) also have called the generalization decrement resulting from reinforcer omission. In Equation (1), parameter d scales the disruptive impact of terminating baseline reinforcement when FCT begins (with the rate of baseline reinforcement represented in Equation (1) by the parameter r). Third, the reductive effects of contingency termination and contingency discriminability on responding increase with the passage of time (captured by parameter t).

Behavioral momentum theory predicts that whereas operant extinction reduces the target response, the respondent relation between reinforcers and the prevailing context increases the persistence of the target response. For example, BMT predicts that a high rate of reinforcement for destructive behavior in a given context during baseline, captured by r in Equation (1), increases the persistence of that response when it contacts extinction.

It is important to note that BMT predicts that the respondent relation between reinforcers and the prevailing context increases the persistence of destructive behavior, even when the reinforcers are delivered contingent on an alternative response (as in FCT) or on a time-based schedule (as in noncontingent reinforcement). That is, alternative reinforcement (e.g., delivered contingent on an FCR) acts to suppress destructive behavior during treatment, but it also may strengthen the persistence of destructive behavior through the respondent pairings of reinforcers and the stimulus context. However, this strengthening effect becomes apparent only when alternative reinforcement ceases and its suppressive effects are therefore no longer in place. Both basic studies involving nonhuman species and translational studies involving individuals with developmental disabilities have demonstrated this strengthening effect of alternative reinforcement (e.g., Mace et al., 2010; Nevin, Tota, Torquato, & Shull, 1990). Equation (1) captures the effects of alternative reinforcement with the parameter R_a.

To summarize, Equation (1) predicts greater resurgence following (a) relatively higher rates of reinforcement (r) in baseline, (b) relatively higher rates of alternative reinforcement (R_a) in treatment, (c) short exposures to treatment (t), and (d) less discriminable transitions from reinforcement to extinction (d). These same predictions also imply procedural refinements to FCT that should minimize the resurgence of destructive behavior during periods when the FCR contacts either unplanned periods of extinction (e.g., when a parent is busy and unable to reinforce the child's FCRs) or planned periods of extinction (e.g., when an experimenter introduces an extinction challenge). For example, Equation (1) predicts greater resurgence during an extinction challenge if destructive behavior results in a high reinforcement rate in baseline (i.e., a large value of r).

In clinical practice, destructive behavior is often associated with a high rate of reinforcement in baseline because clinicians typically provide the functional reinforcer for destructive behavior on an FR 1 schedule to mimic the contingencies programmed in the corresponding test condition of the FA. Equation (1) suggests that this practice of arranging a dense reinforcement schedule in baseline will increase the likelihood of observing resurgence if the FCR later results in extinction. Therefore, one potential refinement of FCT based on Equation (1) would be to provide a lean schedule of reinforcement for destructive behavior during baseline (i.e., reducing the value of r).

Another refinement of FCT suggested by Equation (1) involves the rate of alternative reinforcement delivered for the FCR during FCT. Equation (1) predicts greater resurgence when the FCR produces a high rate of alternative reinforcement (i.e., a large value of R_a). In clinical practice, FCT often begins with an FR 1 schedule in which each instance of the FCR results in the delivery of the functional reinforcer. Such dense reinforcement schedules produce a high rate of alternative reinforcement, which according to Equation (1) increases the likelihood of resurgence. Thus, an additional refinement of FCT would be to provide reinforcement for the FCR on a lean schedule of reinforcement during FCT (i.e., reducing the value of R_a).

Equation (1) also predicts differential levels of resurgence following short and long exposures to FCT, with greater resurgence following treatments implemented in a fewer number of sessions or shorter amount of time (i.e., a small value of t). In clinical practice, behavior analysts may too quickly assess for the generalization of FCT treatment effects, doing so once the treatment appears effective in the context in which it was first implemented. Therefore, another refinement of FCT would be to provide a longer exposure to (or greater dosage of) treatment than standard of care would otherwise suggest (i.e., increasing the value of t).

To summarize, Equation (1) identifies at least three refinements to FCT that should each reduce the likelihood of resurgence of destructive behavior if the newly acquired FCR contacts periods of extinction. Programming a lean schedule of reinforcement in baseline and throughout FCT, as well as increasing the dosage of FCT by conducting additional sessions of treatment should minimize the likelihood of resurgence. However, Equation (1) further suggests that combining these three refinements within a single evaluation of FCT (i.e., arranging a low rate of reinforcement in baseline followed by a lengthy exposure to FCT implemented with a low rate of alternative reinforcement) should result in less resurgence than would any of these refinements implemented alone. In the present study, we combined these three refinements to FCT and compared the degree to which destructive behavior resurged following FCT procedures with and without these three refinements.

GENERAL METHOD

Four individuals referred to a university-based severe behavior disorders clinic participated. Erica, a 16-year-old girl, Corey, a 3-year-old boy, Jaden, an 8-year-old boy, and Derek, a 7-year-old boy, each were diagnosed with autism spectrum disorder (ASD). Erica also carried the diagnosis of attention deficit hyperactivity disorder (ADHD). All participants engaged in self-injurious behavior (SIB) and aggression. Corey, Jaden, and Derek also engaged in property destruction. All participants communicated using utterances of one-to-four words. We conducted all study procedures under the oversight of a pediatrics institutional review board and followed the safety precautions described by Betz and Fisher (2011) to protect the safety of the participants.

Settings and Materials

All sessions took place in 3-m by 3-m therapy rooms equipped with a two-way intercom system and a one-way observation window. Therapy rooms for Corey, Jaden, and Derek contained padding on the walls and floors to minimize the risk of injury associated with their SIB. Furniture (e.g., table, chairs, desk) remained present in the therapy rooms for all participants except Derek. Sessions for Derek occurred in an empty therapy room due to the risk of injury associated with his topography of

SIB (i.e., slamming knees and elbows against hard surfaces).

Response Measurement, Interobserver Agreement, and Blinding Procedures

Trained observers collected data on laptop computers behind the observation window. We collected frequency data on SIB, aggression, property destruction, and the FCR. *Self-injurious behavior* included self-biting, body slamming, self-hitting, self-scratching, and head banging. *Aggression* included hitting, kicking, pushing, pinching, scratching, or throwing objects at the therapist. *Property destruction* included hitting or kicking furniture or the walls or floor of the therapy room, throwing objects not meant to be thrown (but not at the therapist), tearing one's own clothing, swiping materials, and turning over furniture. *Functional communication responses* consisted of the individual touching (Erica) or exchanging (Corey, Jaden, and Derek) an index-sized card that contained a picture of the child consuming their functional reinforcer (i.e., the FCR card).

We obtained interobserver agreement (IOA) by having a second independent observer collect data simultaneously with the primary data collector on a minimum of 26% of sessions. For the experiment proper, we required the second observer to be blind to the study purpose and hypotheses for a minimum of 27% of the sessions for which we collected IOA. We divided each session into 10-s intervals and scored an agreement for each interval in which both observers measured the same number of responses (i.e., exact agreement). We then summed the number of agreement intervals and divided by the number of agreement intervals plus disagreement intervals. Finally, we converted each quotient to a percentage. We calculated IOA on at least 33% of sessions of each participant's functional analysis and initial FCT evaluation. Coefficients averaged 98% (range, 67%-100%) for Erica, 99% (range, 80%-100%) for Corey, 99% (range, 87%-100%) for Jaden, and 97% (range, 50%-100%) for Derek. We calculated IOA on at least 26% of sessions for each participant in the experiment proper. Coefficients averaged 97% (range, 73%-100%) for Erica, 98% (range, 72%-100%) for Corey, 99% (range, 67%-100%) for Jaden, and 95% (range, 50%-100%) for Derek.

Functional Analysis and Initial Evaluation of Functional Communication Training

Functional analysis. We conducted FAs of each participant's destructive behavior to identify its maintaining variables using procedures similar to those described by Iwata, Dorsey, et al. (1982/1994). Our procedures differed from Iwata, Dorsey, et al. in that (a) we did not include avoidance contingencies in the escape condition, (b) we included a tangible (test) condition (Day, Rea, Schussler, Larsen, & Johnson, 1988), (c) we equated reinforcer-access durations across test conditions (Fisher, Piazza, & Chiang, 1996), and (d) we began each FA by screening for the presence of automatically reinforced destructive behavior (Querim et al., 2013). In some test and control conditions of the FA, we also used the results of a paired-stimulus preference assessment to identify the stimuli used in those conditions (Fisher et al., 1992). A trained therapist conducted all FA sessions with the exception that Corey's mother and caregiver conducted portions of his FA. Each FA session lasted 5 min.

In the alone condition (Erica only), the participant remained alone in the therapy room without any toys or materials. Destructive behavior produced no programmed consequence. In the ignore condition (Corey, Jaden, and Derek), the participant and therapist remained in the therapy room together without any toys or materials. The therapist ignored all instances of destructive and appropriate behavior throughout the session. Prior to the attention condition, the therapist provided the participant with 1-min access to physical and vocal attention (e.g., playing a game and providing high fives). The attention condition began with the therapist withdrawing and diverting their attention to a magazine. The participant retained free access to a low-preference toy throughout the attention condition, and destructive behavior resulted in the therapist returning their attention to the child for 20 s. In the escape condition, the therapist delivered academic or household-related demands using a least-to-most (i.e., verbal, model, physical) prompting hierarchy. Destructive behavior produced a 20-s break from instructions in which the therapist removed all instructional materials. Prior to the tangible condition, the therapist provided 1-min access to a high-preference toy, and the tangible condition began with the therapist restricting access to that toy. The therapist redelivered the high-preference toy for 20 s contingent on destructive behavior. In the toy-play condition, the participant had continuous access to a high-preference toy, and the therapist provided physical and vocal attention at least every 30 s. The therapist provided no programmed consequences for destructive behavior.

Initial evaluation of FCT. We conducted an initial evaluation of FCT using a reversal design to determine the effectiveness of FCT as a treatment for each participant's destructive behavior following the completion of each participant's FA. We treated the tangible function of Erica's, Jaden's, and Derek's destructive behavior and the attention function of Corey's destructive behavior in this and all subsequent implementations of FCT.

Baseline. The baseline condition of the initial FCT evaluation was identical to the tangible (Erica, Jaden, and Derek) or attention (Corey) condition of the FA. Sessions lasted 5 min.

Pretraining (data not displayed). Following the initial baseline phase, we used a progressive-prompt delay (0 s, 2 s, 5 s, 10 s) to teach each participant to emit the FCR to gain access to the reinforcer maintaining destructive behavior. Instances of the destructive response resulted in no programmed consequences (i.e., extinction). Each 10-trial session consisted of the therapist presenting the establishing operation for destructive behavior (e.g., by withholding the preferred toy or attention), prompting the FCR using physical guidance if necessary, and delivering the functional reinforcer for 20 s on an FR 1 schedule. The FCR for all participants consisted of touching (Erica) or exchanging (Corey, Jaden, and Derek) a picture card that contained an image of the participant consuming the functional reinforcer. Delays to the therapist prompting the FCR increased every two consecutive sessions with no destructive behavior. Pretraining terminated following two consecutive sessions with no destructive behavior and independent FCRs in 80% or greater of trials. We used a 3-s changeover delay (COD; Herrnstein, 1961) to prevent adventitious reinforcement of destructive behavior. If destructive behavior occurred within 3 s of the participant emitting the FCR, the therapist withheld the reinforcer until the participant emitted another FCR without destructive behavior occurring within 3 s. Pretraining session durations varied depending on the prompt delay, as well as on the presence and efficiency of independent FCRs.

FCT. We implemented FCT using procedures identical to pretraining except that we discontinued all prompts to emit the FCR, and sessions lasted 5 min.

Results

Erica (top left panel of Figure 1) displayed no destructive behavior in the final four consecutive-ignore sessions. Erica then engaged in elevated rates of destructive behavior during the tangible condition and near-zero rates in the attention and toy-play conditions. Because we observed variable rates of destructive behavior across sessions of the escape condition, we conducted a pairwise analysis with the escape and toy-play conditions. Variability persisted following this change in experimental design, at which point we conducted a reversal design between the escape and toy-play conditions to better determine whether escape from demands reinforced Erica's destructive behavior. Erica emitted higher rates of destructive behavior in the escape condition relative to the toy-play condition in the reversal design. Erica's FA results suggest that access to preferred tangible items and escape from demands reinforced her destructive behavior. We treated the tangible function of Erica's destructive behavior using the procedures described in this paper and later treated her escape function using a separate protocol.

Corey (top right panel of Figure 1) displayed low, variable rates of destructive behavior across only the attention and toy-play conditions of the multielement FA. Between FA sessions, however, therapists observed that Corey frequently engaged in destructive behavior with his mother and caregiver. Therefore, we had each of these individuals serve as therapist in subsequent FA sessions and sequenced those sessions based on the availability of each individual. We observed consistently elevated rates of destructive behavior in the tangible condition across both Corey's mother and caregiver. We then returned to the therapist-conducted

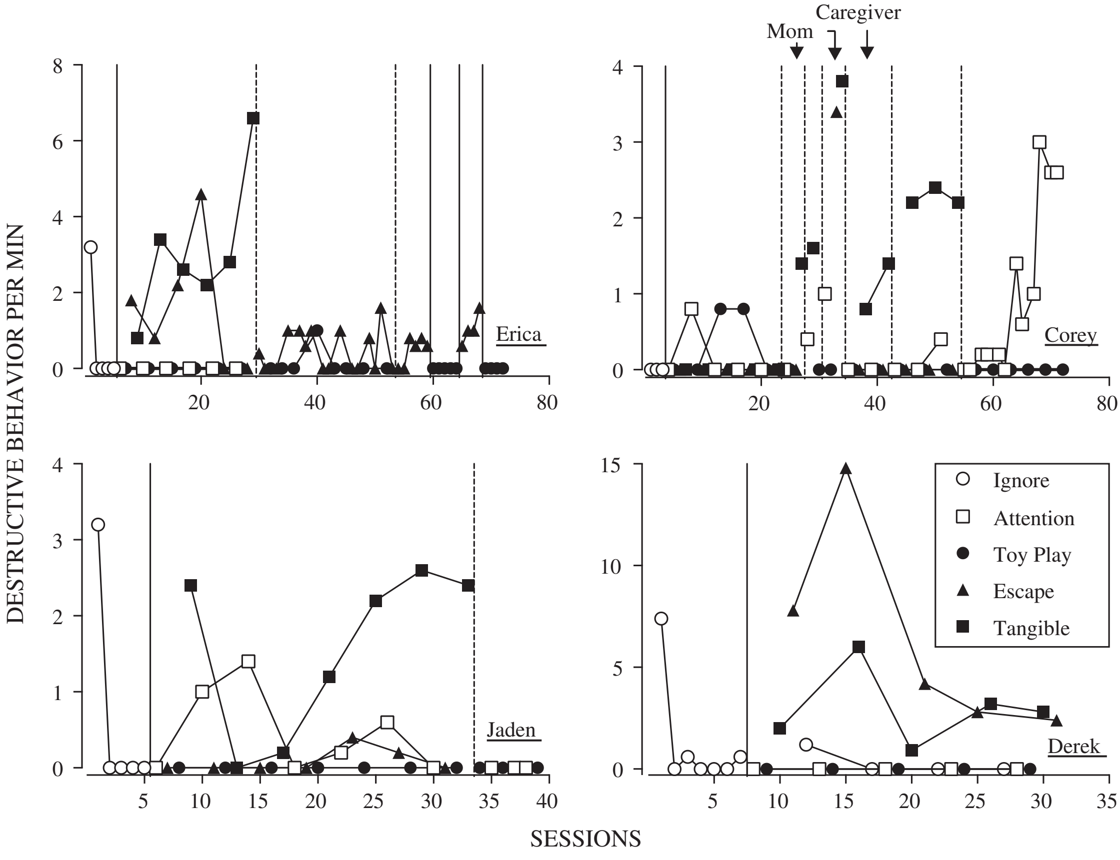

Figure 1. Functional-analysis results for Erica, Corey, Jaden, and Derek. A therapist conducted all sessions with Corey other than in those phases labeled otherwise.

multielement FA and replicated this same pattern of responding. Due to the variable rates of Corey's destructive behavior across individuals in the attention condition, we conducted a pairwise analysis with the attention and toy-play conditions and observed an increasing trend in the rates of destructive behavior in the attention condition and no instances in the toy-play condition. Corey's FA data suggest that access to preferred tangible items and adult attention reinforced his destructive behavior. We treated the attention function of Corey's destructive behavior using the procedures described in this paper and addressed his tangible function using a separate protocol. We targeted the attention function of Corey's destructive behavior to increase the variety of functions targeted across participants.

Jaden (bottom left panel of Figure 1) displayed no destructive behavior in the final four consecutive-ignore sessions preceding his multielement FA. Thereafter, Jaden engaged in destructive behavior during the tangible, attention, and escape conditions with consistently elevated rates in only the final three sessions of the tangible condition. Jaden displayed no destructive behavior in the toy-play condition. A pairwise analysis between attention and toy-play conditions produced no destructive behavior. Jaden's FA results suggest that access to preferred tangible items maintained his destructive behavior.

Derek (bottom right panel of Figure 1) emitted near-zero rates of destructive behavior in the final six consecutive-ignore sessions that preceded his multielement FA. Derek's multielement FA produced consistently elevated rates of destructive behavior in both the tangible and escape conditions and no instances in the toy-play condition. Derek's FA results suggest that access to both preferred tangible items and escape from demands maintained his destructive behavior. We treated the tangible function of Derek's destructive behavior using the procedures described in this paper and addressed his escape function using a separate protocol. We targeted the tangible function of Derek's destructive behavior due to observing more consistent rates of responding in this condition relative to the escape condition.

All four participants displayed elevated rates of destructive behavior prior to FCT pretraining. During FCT pretraining (not displayed in Figure 2), all participants engaged in low rates of destructive behavior and increasingly high rates of independent FCRs. Pretraining lasted 23 sessions for Erica, 9 sessions for Corey, 14 sessions for Jaden, and 17 sessions for Derek. Following pretraining, we observed marked reductions in rates of destructive behavior for all four participants and high rates of the FCR during FCT; these effects were then replicated.

BMT-INFORMED REFINEMENTS TO FCT

We evaluated the combined effects of reinforcement rate (during baseline and treatment) and the dosage of treatment on the resurgence of destructive behavior by programming a lean schedule of reinforcement for destructive behavior in baseline, a lean schedule of reinforcement for the FCR during FCT, and triple the number of FCT sessions in the test condition. We tested for resurgence within the context of a multielement ABC resurgence paradigm in which we reinforced destructive behavior in baseline (Phase A), placed destructive behavior on extinction and reinforced the FCR during FCT (Phase B), and then arranged extinction for both the destructive behavior and the FCR in the final phase (Phase C). Across these three phases, we programmed two separate conditions (i.e., lean–long [test condition], dense–short [control condition]). In the lean–long condition, we delivered a lean schedule of reinforcement across baseline and FCT phases, and we provided a longer exposure to FCT (i.e., a larger dose) than in the dense–short

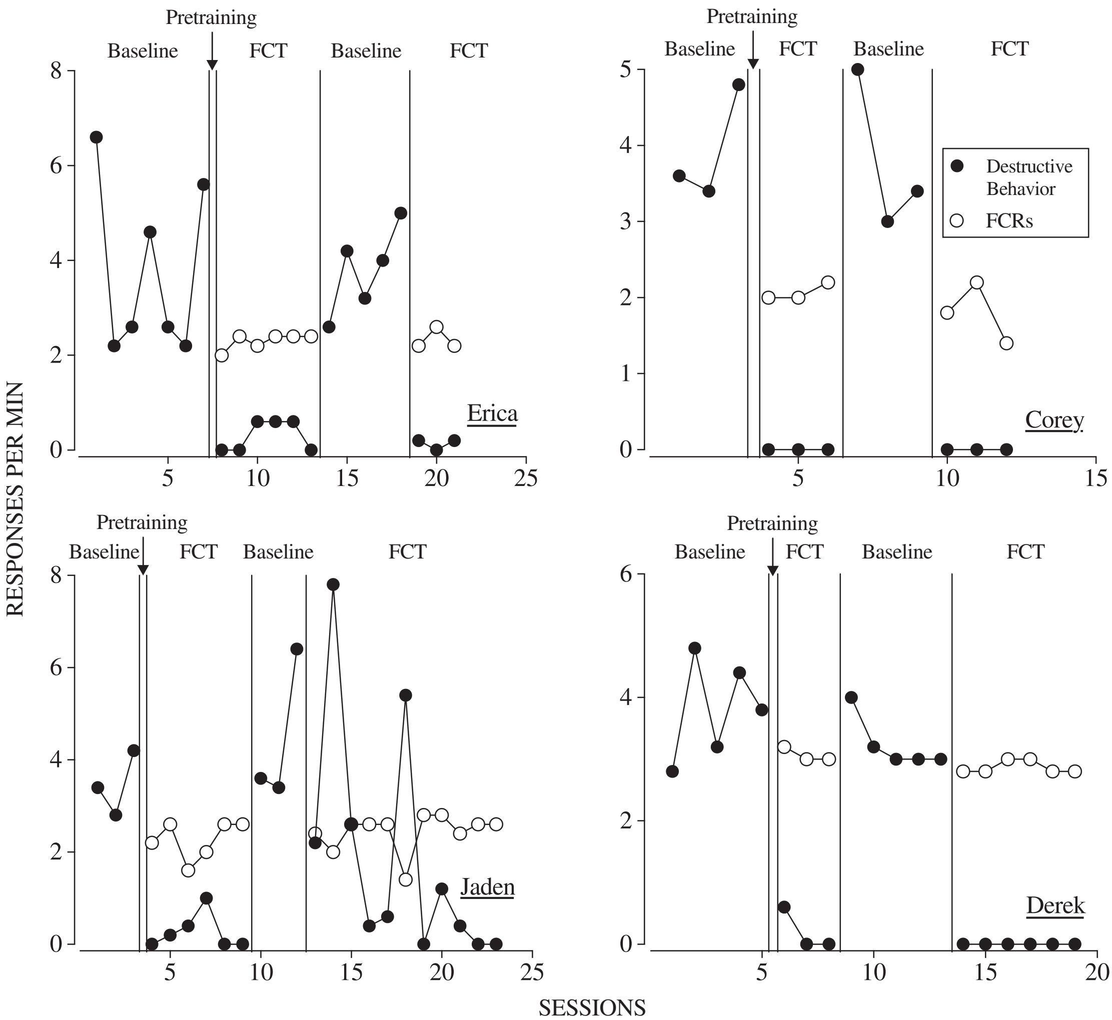

Figure 2. Results of the initial evaluation of functional communication training (FCT) for Erica, Corey, Jaden, and Derek.

condition. By contrast, we delivered a dense schedule of reinforcement across baseline and FCT phases in the dense–short condition, and we provided a shorter exposure to FCT (i.e., a smaller dose) than in the lean–long condition. To facilitate discrimination between these two FCT conditions, we assigned each condition a unique therapist and unique color-correlated stimuli. For example, in one condition (e.g., lean–long), we included blue light filters and a blue FCR card, and Therapist A conducted sessions wearing a blue scrub top. In the other condition (dense–short), we included yellow light filters and a yellow FCR card, and Therapist B conducted sessions wearing a yellow scrub top (Conners et al., 2000; Mace et al., 2010).

Progressive-Interval Assessment

We conducted a progressive-interval assessment (PIA) similar to that described by Findley

(1958) with each participant to empirically identify an optimally lean schedule of reinforcement for use in the lean–long condition that did not extinguish responding or result in adverse effects (e.g., bursts of destructive behavior; Knutson & Kleinknecht, 1970). We also used the results of the PIA to select the relatively dense reinforcement schedule for use in the dense–short condition. The results of the PIA for all participants suggested two variable-interval (VI) schedules of reinforcement that remained constant across baseline and FCT phases yet differed across lean–long and dense–short conditions. We used the constant-probability distribution described by Fleshler and Hoffman (1962) for all VI schedules.

Each trial of the PIA began with the therapist presenting the establishing operation for destructive behavior (i.e., by removing a preferred item [Erika, Jaden, and Derek] or by withdrawing attention [Corey]) and then terminating the establishing operation after the first instance of destructive behavior that followed expiration of the current fixed interval (FI). Exposure to the establishing operation increased following two trials at each of the following FIs: 2 s, 4 s, 8 s, 10 s, 15 s, 20 s, 30 s, 45 s, 65 s, 90 s, 120 s, 150 s, and 180 s. The PIA terminated following (a) a burst of destructive behavior (i.e., three instances within 5 s) or negative emotional responding (i.e., 5 s of continuous negative vocalizations or crying) or (b) after the second trial at FI 180 s, whichever came first. The PIA lasted one continuous session and terminated due to a burst of destructive behavior for each participant.

With the first two participants who experienced the PIA (Erica and Jaden), we used the PIA results to select the leanest schedule of reinforcement that did not evoke untoward side effects (i.e., a burst of destructive behavior or negative emotional responding). For example, if untoward side effects, as defined above, occurred at the FI 45-s schedule during the PIA, we selected the preceding PIA schedule (i.e., the FI 30-s schedule) for use in the lean–long condition (i.e., a VI 30-s schedule). We used FI schedules during the PIA to promote schedule discrimination and VI schedules for the baselines to promote relatively high and steady responding during baseline.

After selecting the baseline schedule for the lean–long condition, we then divided this lean reinforcement schedule by 4.5 to determine the dense VI schedule for use in the dense–short condition. This resulted in greater than a four-fold difference in the programmed rates of reinforcement between the lean–long and dense–short conditions in the baseline and FCT phases (e.g., Shahan, Magee, & Dobberstein, 2003).

Unfortunately, this process of deriving VI schedules resulted in the premature extinguishing of Erica's destructive behavior across both the lean–long and dense–short conditions in the initial baseline (not depicted). To maintain Erica's responding, we reduced the reinforcement schedules in both conditions by half and conducted a new baseline phase. To avoid this same problem with subsequent participants (Corey and Derek), we supplemented our PIA results with data on the average latency to destructive behavior following each withdrawal of the reinforcer during the last five baseline sessions from the initial FCT evaluation. Thus, we selected the PIA-equivalent schedule that was just shorter than the average latency to destructive behavior for use as the VI schedule in the dense–short condition. For example, if the latency to destructive behavior averaged 24 s across the preceding five FCT baseline sessions, we hypothesized that a slightly denser VI schedule (e.g., VI 20 s) should circumvent most destructive behavior. We compared the results we obtained from this latency analysis with the results we obtained from the PIA for each subsequent participant and selected the denser of the two obtained durations as the reinforcement schedule for the dense–short condition. We then multiplied this reinforcement schedule by 4.5 to determine the lean reinforcement schedule for the lean–long condition. In addition, we made individual adjustments to the reinforcement schedules if the trend in response rates showed a steady decline during baseline or if obtained reinforcement rates differed greatly from those programmed.

Baseline

We conducted baseline sessions using procedures identical to those in the functional analysis and initial FCT evaluation, except (a) we derived and then implemented the reinforcement schedules for destructive behavior using the procedures described above, and (b) sessions lasted 10 min. Baseline terminated when (a) there were at least five sessions in both conditions, (b) the trend for each baseline was flat or in the direction opposite the goal for treatment, and (c) the standard deviations of responding in the last five baseline sessions of each condition were no more than 50% of their mean.

Lean–Long. We delivered the functional reinforcer for destructive behavior according to a lean VI schedule of reinforcement. Based on the PIA or latency analysis described above, we selected the following individualized lean schedules: Erica, VI 23 s; Corey, VI 23 s; Jaden, VI 90 s; and Derek, VI 14 s. Equation (1) predicts that programming a lean reinforcement schedule in baseline and in an extended treatment in which extinction is arranged for destructive behavior should decrease the likelihood of resurgence during a subsequent extinction challenge.

Dense–Short. We delivered the functional reinforcer for destructive behavior according to a VI schedule of reinforcement that was 4.5 times as dense as the lean schedule described above. Using this multiplication factor, we selected the following individualized dense schedules: Erica, VI 5 s; Corey, VI 5 s; Jaden, VI 20 s; and Derek, VI 2 s.

FCT

We implemented FCT using the same procedures from the initial FCT evaluation, except (a) the same VI schedules most recently in place for destructive behavior in the preceding baseline phase were arranged for FCRs, and (b) sessions lasted 10 min. Therapists placed destructive behavior on extinction across all FCT conditions. Additionally, we conducted three sessions of the lean–long condition for every one session of the dense–short condition to increase the dosage of FCT in the lean–long condition. Thus, we quasirandomly ordered sessions in blocks of four (i.e., one dense–short and three lean–long sessions) such that no more than two dense–short and no more than six lean–long sessions occurred consecutively. The FCT phase terminated following two consecutive sessions in each condition in which destructive behavior was at or below an 85% reduction from average responding in the corresponding baseline condition.

Extinction Challenge

We conducted identical extinction-challenge sessions across the lean–long and dense–short conditions. During the extinction challenge, we placed both the FCR and destructive behavior on extinction, and the therapist delivered 20-s access to the functional reinforcer according to a tandem variable-time (VT) 200-s schedule with a 3-s differential reinforcement of other behavior (DRO) schedule to prevent adventitious reinforcement of destructive behavior and the FCR. Thus, if destructive behavior or the FCR occurred within 3 s of the scheduled tandem VT-DRO delivery, the therapist withheld the scheduled reinforcer until the participant had not emitted destructive behavior or the FCR for 3 s. We included these occasional time-based reinforcer deliveries to decrease the discriminability between the treatment and extinction phases (see Nevin & Shahan's 2011 discussion of Koegel & Rincover, 1977; pp. 883-884).

Results and Discussion

Figure 3 displays the rates of destructive behavior (top panel) and FCRs (middle panel), as well as the number of reinforcers delivered (bottom panel) during the lean–long (i.e., VI 23-s) and dense–short (i.e., VI 5-s) conditions for Erica. Erica engaged in high rates of destructive behavior across both conditions in baseline and experienced a greater number of reinforcers during the dense–short condition (*M* = 20.0 reinforcers per session) than in the lean–long condition (*M* = 12.3 reinforcers per session). Rates of destructive behavior decreased in both the lean–long and dense–short conditions during FCT, with rates of destructive behavior being slightly higher in the dense–short condition (*M* = 1.6 responses per min [RPM]) than in the lean–long condition (*M* = 1.2 RPM). Rates of the FCR maintained across conditions at similar rates in the lean–long (*M* = 3.4 RPM) and dense–short (*M* = 3.8 RPM) conditions. We observed greater variability of both destructive behavior and FCRs during the lean–long condition of the FCT phase. Reinforcer deliveries maintained at similar levels during the FCT phase as in baseline, with higher reinforcer deliveries in the dense–short condition (*M* = 18.8 reinforcers per session) relative to those in the lean–long condition (*M* = 11.3 reinforcers per session). Despite delivering more reinforcers per session in the dense–short condition, the total number of reinforcers delivered in the dense–short condition of FCT (94 total reinforcers) was fewer than the total number of reinforcers delivered in the lean–long condition of FCT (170 total reinforcers). During the extinction challenge, we observed greater resurgence of destructive behavior in the dense–short condition (*M* = 3.0 RPM) relative to the lean–long condition (*M* = 1.0 RPM). Erica's use of the FCR declined across conditions of the extinction challenge, and the tandem VT-DRO schedule produced consistent rates of reinforcement across conditions (*Ms* = 2.2 and 2.0 reinforcers per session in lean–long and dense–short conditions, respectively).

Figure 4 displays Corey's results. Corey engaged in elevated and increasing rates of destructive behavior over the last four baseline sessions during both conditions and experienced a greater number of reinforcers during the dense–short condition (*M* = 13.6 reinforcers per session) than in the lean–long condition (*M* = 9.4 reinforcers per session) of baseline. Like Erica's results, FCT rapidly suppressed Corey's high rates of destructive behavior in both the lean–long and dense–short conditions, with a slightly higher rate of destructive behavior in the lean–long condition (*M* = 0.3 RPM) relative to the dense–short condition (*M* = 0.1 RPM). Corey emitted moderate to high rates of the FCR across both conditions of FCT, with a similar rate of FCRs in the lean–long (*M* = 1.7 RPM) and dense–short (*M* = 1.2 RPM) conditions. Corey experienced slightly more reinforcers in the dense–short condition of FCT (*M* = 11.5 reinforcers per session) relative to the lean–long condition of FCT (*M* = 7.8 reinforcers per session). Despite delivering more reinforcers per session in the dense–short condition, the total number of reinforcers delivered in the dense–short condition of FCT (69 total reinforcers) was fewer than the total number of reinforcers delivered in the lean–long condition of FCT (141 total reinforcers). The resurgence evaluation following the FCT phase showed more variable levels of resurgence of destructive behavior in the dense–short condition (*M* = 1.0 RPM) relative to the lean–long condition (*M* = 0.3 RPM). Corey's use of the FCR and the number of reinforcers delivered during the extinction challenge were similar in overall pattern to those we observed with Erica.

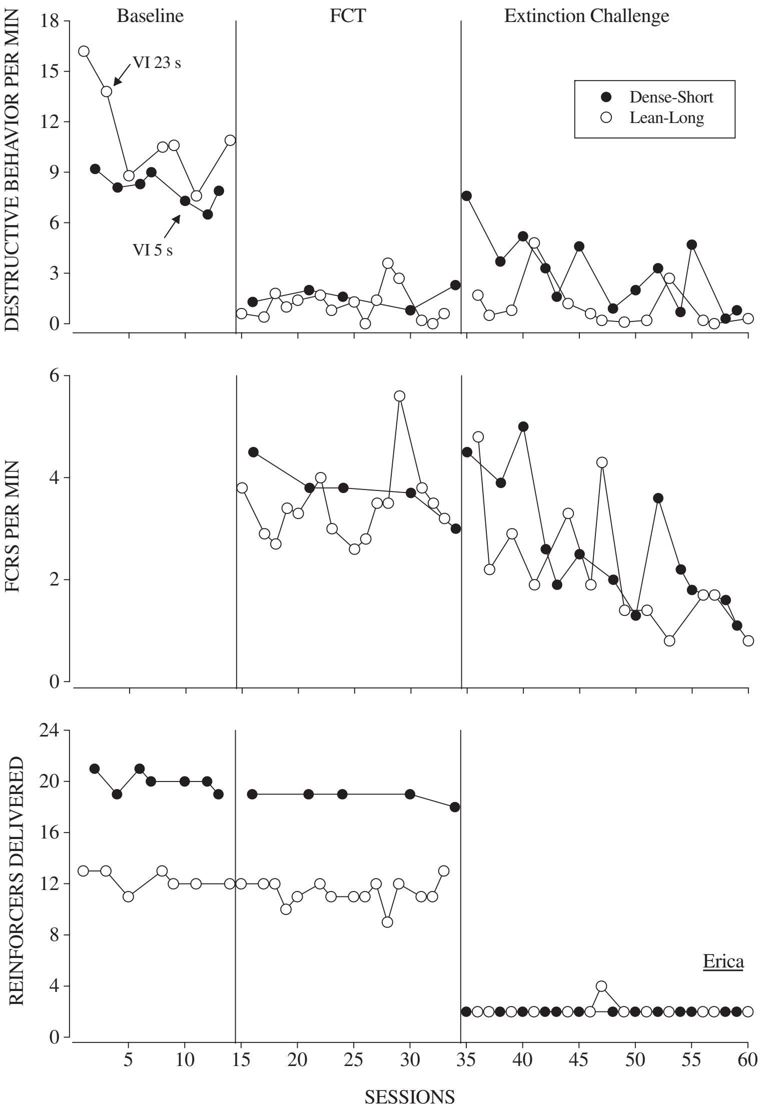

Figure 3. Erica's results during the dense–short and lean–long conditions across baseline, functional communication training (FCT), and extinction phases.

Figure 5 displays Jaden's results. Jaden engaged in elevated and sharply increasing rates of destructive behavior across both conditions in baseline, with a higher rate of destructive behavior in the lean–long condition (*M* = 7.3 RPM) than in the dense–short condition (*M* = 5.7 RPM). Jaden experienced a greater number of reinforcers during the dense–short condition (*M* = 10.4 reinforcers per session) than in the lean–long condition (*M* = 4.9 reinforcers per session) in baseline. Like results for the other participants, the lean–long and dense–short conditions during the FCT phase effectively decreased Jaden's high rates of destructive behavior, with slightly higher rates of destructive behavior occurring in the lean–long condition (*M* = 1.3 RPM) relative to the dense–short

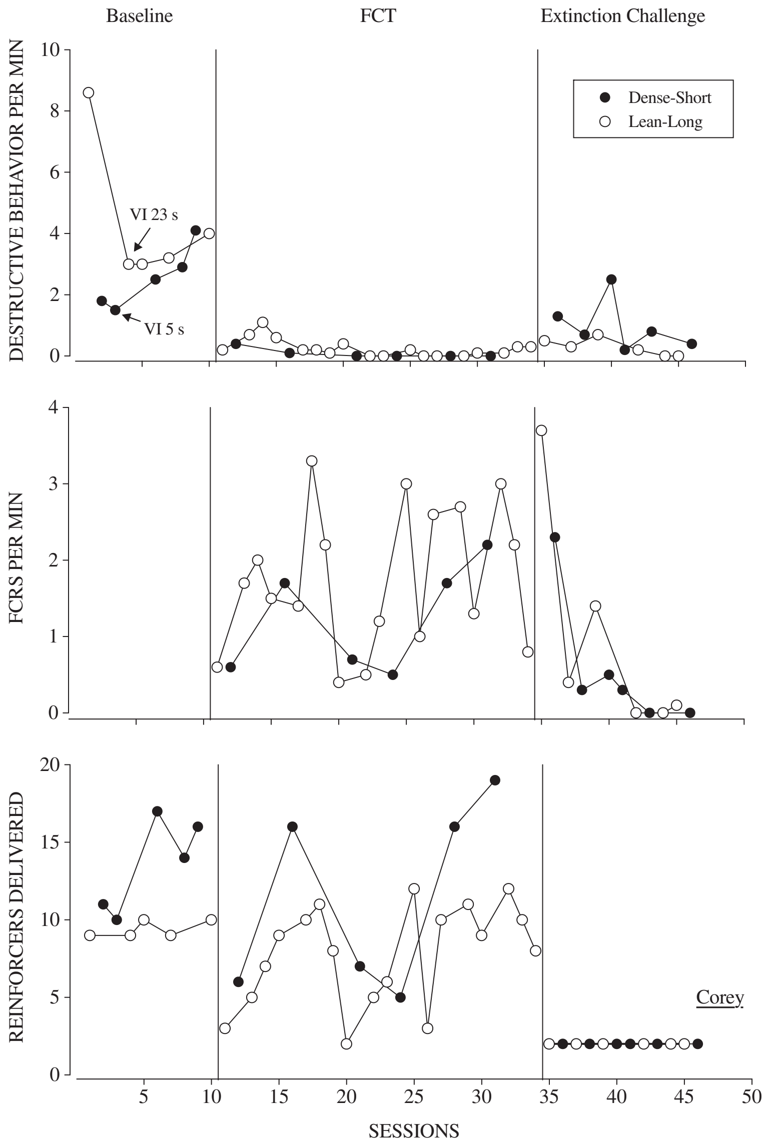

Figure 4. Corey's results during the dense–short and lean–long conditions across baseline, functional communication training (FCT), and extinction phases.

condition (M = 1.1 RPM). Jaden emitted moderate but variable rates of the FCR across both conditions of FCT, with a slightly higher rate in the dense–short condition (M = 2.9 RPM) relative to the lean–long condition (M = 1.8 RPM). Jaden experienced a greater number of reinforcers in the dense–short condition (M = 9.8 reinforcers per session) relative to the lean–long condition (M = 4.1 reinforcers per session) of FCT. Despite delivering more reinforcers per session in the dense–short condition, the total number of reinforcers delivered in the dense–short condition of FCT (39 total reinforcers) was slightly fewer than the total number of reinforcers delivered in the

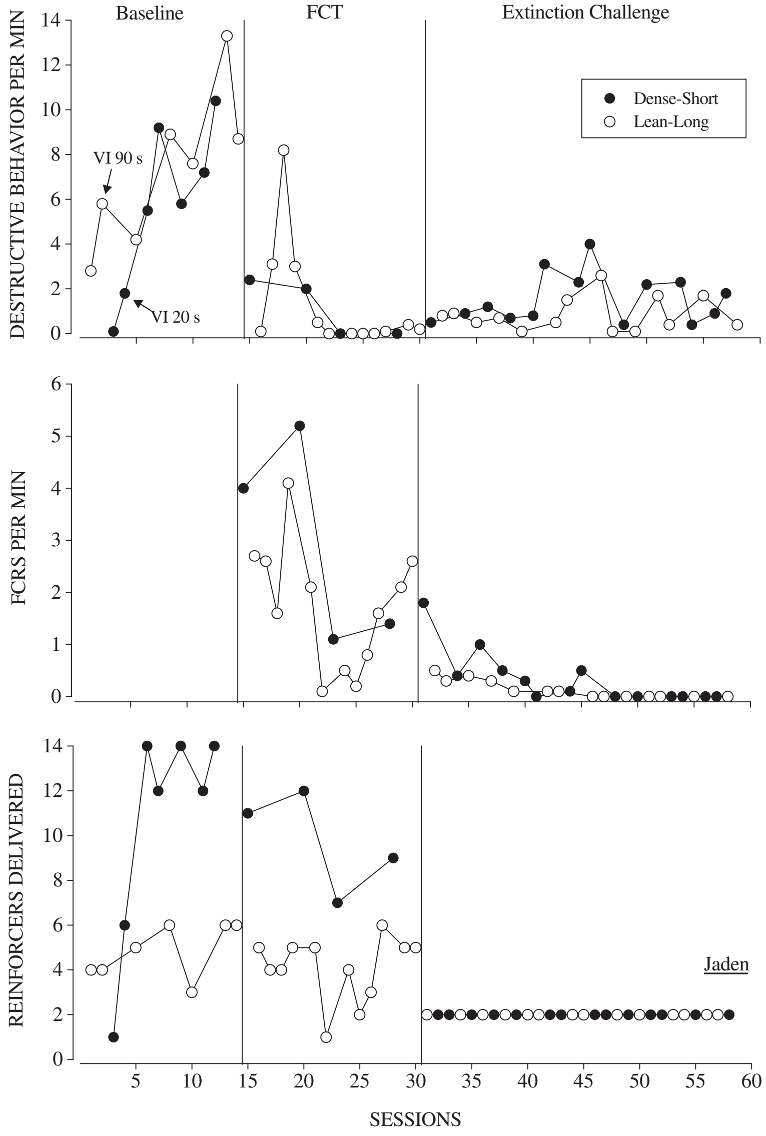

Figure 5. Jaden's results during the dense–short and lean–long conditions across baseline, functional communication training (FCT), and extinction phases.

lean–long condition of FCT (49 total reinforcers). The resurgence evaluation showed slightly more resurgence and relatively more variable levels of destructive behavior during the dense–short condition (M = 1.5 RPM) relative to the lean–long condition (M = 0.9 RPM). Jaden's declining use of the FCR and the constant number of reinforcers delivered during the extinction challenge were similar to the other participants.

Jaden's pattern of responding during the extinction challenge also is noteworthy in that he showed greater persistence of the FCR in the dense–short condition relative to the lean–long condition for the first five sessions of each condition (Ms = 0.8 RPM and 0.3 RPM for the dense–short and lean–long conditions, respectively). Thereafter, FCRs remained at near-zero rates in both conditions, and rates of destructive behavior increased in both conditions with differentially higher levels in the dense–short condition relative to the lean–long condition. That is, the data show greater persistence of FCRs during the initial sessions of the extinction challenge and greater resurgence of destructive behavior in the latter sessions of the extinction challenge, with higher rates of each response in the dense–short condition relative to the lean–long condition.

Figure 6 displays Derek's results. Derek engaged in elevated rates of destructive behavior across both baseline conditions, with significantly more destructive behavior occurring in the lean–long condition (*M* = 22.0 RPM) than in the dense–short condition (*M* = 7.3 RPM). Derek experienced more reinforcers during the dense–short condition (*M* = 25.0 reinforcers per session) than in the lean–long condition (*M* = 16.2 reinforcers per session) of baseline. FCT decreased Derek's high rates of destructive behavior across both the lean–long and dense–short conditions, as it did for other participants. Derek emitted high rates of the FCR during the lean–long condition (*M* = 9.9 RPM) and moderate rates of the FCR during the dense–short condition (*M* = 4.8 RPM) of FCT. Derek's destructive behavior decreased but remained variable in the lean–long condition of FCT and decreased steadily in the dense–short condition of FCT, despite both conditions producing equal average rates of destructive behavior (*Ms* = 7.3 RPM). Derek experienced a greater number of reinforcers in the dense–short condition (*M* = 18.8 reinforcers per session) relative to the lean–long condition (*M* = 15.0 reinforcers per session) of FCT. Despite delivering more reinforcers per session in the dense–short condition, the total number of reinforcers delivered in the dense–short condition of FCT (75 total reinforcers) was fewer than the total number of reinforcers delivered in the lean–long condition of FCT (180 total reinforcers). The resurgence evaluation following FCT showed slightly greater resurgence and greater variability of destructive behavior following the dense–short condition (*M* = 8.3 RPM) relative to the lean–long condition (*M* = 7.8 RPM). For all participants, use of the FCR declined across both conditions of the extinction challenge, whereas the number of reinforcer deliveries remained stable.

Figure 7 displays levels of resurgence of destructive behavior during the extinction-challenge phase expressed as a proportion of baseline levels of responding for Erica (top left panel), Corey (top right panel), Jaden (bottom left panel), and Derek (bottom right panel). Recall that in the behavioral momentum metaphor, the momentum of a response is a function of its reinforcement rate (equivalent to the mass of a moving object) times its baseline response rate (equivalent to the velocity of a moving object). By displaying destructive behavior as a proportion of its baseline rates, we control for the baseline response rates and thereby isolate the effects of reinforcement rate (cf. Mace et al., 2010; Nevin et al., 1990). We calculated proportion of baseline responding by dividing the rate of destructive behavior in each session of the extinction challenge by the average rate of destructive behavior measured over the last five baseline sessions for that condition (i.e., dense–short or lean–long).

During the extinction-challenge phase following the lean–long condition, Erica's destructive behavior remained at low proportional rates. However, in the extinction-challenge phase following the dense–short condition, Erica's destructive behavior persisted at higher proportional rates. The proportional rates of destructive behavior for the other three participants showed a similar pattern to Erica's proportional data, with the exception that we observed slightly less-differentiated rates across conditions for Jaden and Derek. Across the four participants, the lean–long condition produced

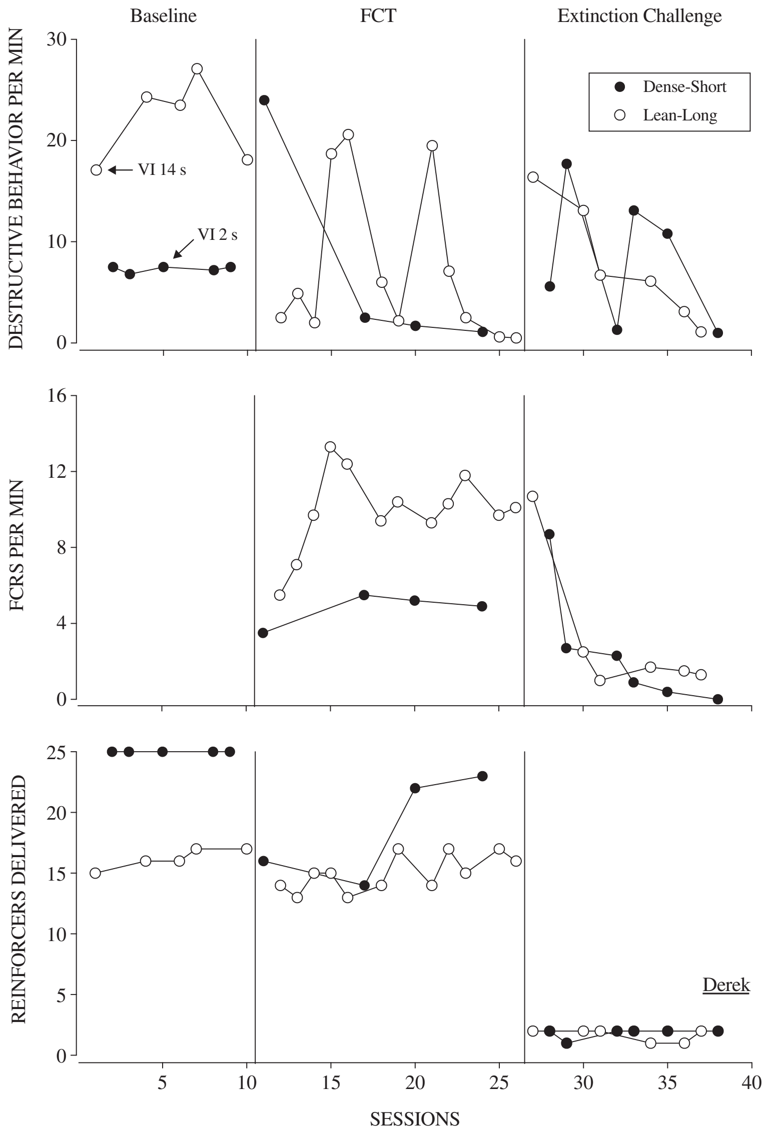

Figure 6. Derek's results during the dense–short and lean–long conditions across baseline, functional communication training (FCT), and extinction phases.

about two-thirds less destructive behavior (as a proportion of baseline) relative to the dense–short condition (*M* = 65.1% lower proportional rates in the lean–long relative to the dense–short condition, range 50.2% to 83.1%).

For each participant's proportional response rates, we examined the chance probability of obtaining differences as large as the obtained differences using a randomization test (Edgington, 1967), and we also calculated Cohen's *d* effect sizes. For Erica, Corey, and Jaden, the results reached statistical significance (all *p* values < .02) and for Derek, the results approached statistical significance (p = .07). All effect sizes were in the large range (*M* = 1.1; range, 0.84 to 1.4; Cohen, 1988).

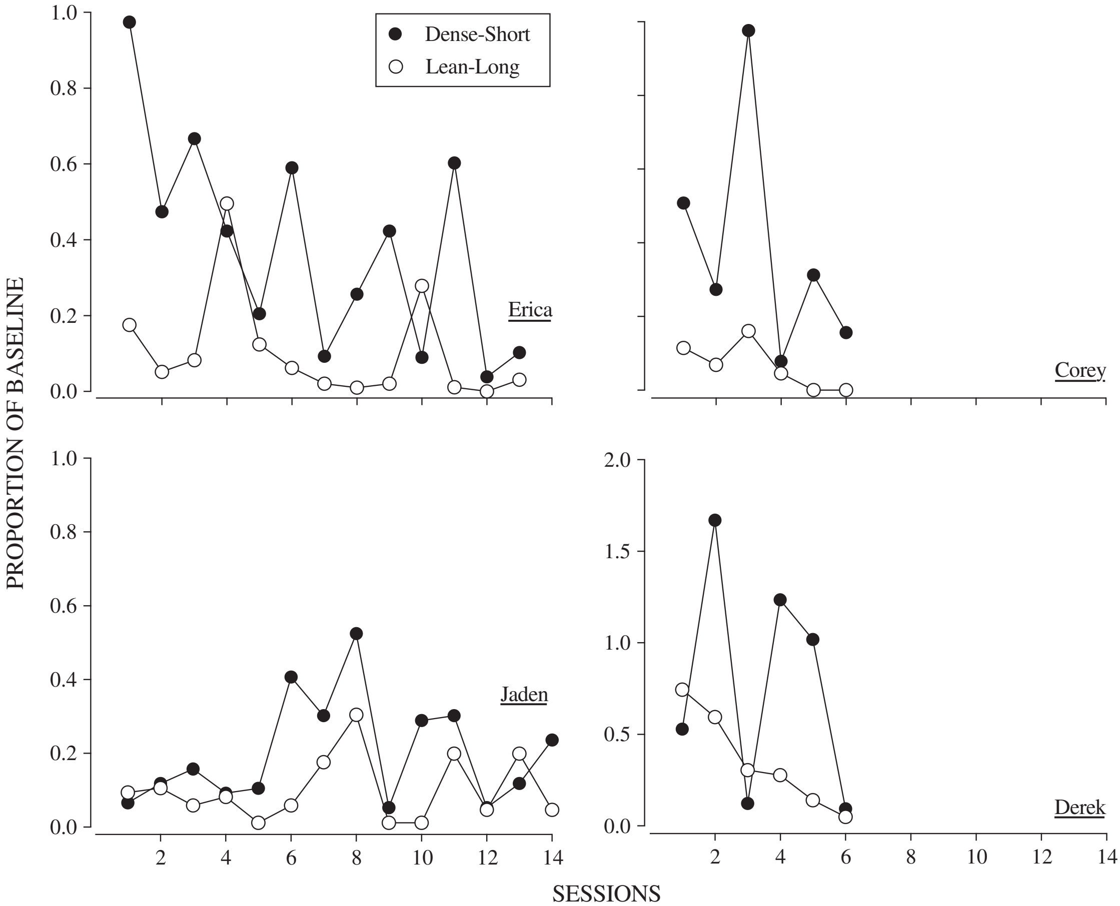

Figure 7. Destructive behavior during the extinction challenge expressed as a proportion of baseline responding for Erica, Corey, Jaden, and Derek.

We programmed a tandem VT-DRO schedule of reinforcement during the extinction challenge to decrease the discriminability of the transition from treatment to the extinction challenge and to increase overall levels of resurgence. However, delivering a lean, time-based schedule of reinforcement during the extinction challenge may have resulted in reinstatement of destructive behavior. Thus, the recurrence of destructive behavior in our study could be attributed to resurgence, reinstatement, or to a combination of the two. We should also note that although we included the tandem VT-DRO in the extinction challenge to increase overall levels of resurgence, some research has demonstrated that delivering time-based reinforcers during extinction can reduce resurgence (Lieving & Lattal, 2003; Marsteller & St. Peter, 2014), and it remains possible that doing so in our study similarly decreased overall levels of resurgence. These considerations of whether to include time-based schedules of reinforcement when testing for resurgence should be taken into account in future investigations of resurgence.

GENERAL DISCUSSION

We tested three quantitative predictions of BMT for mitigating the resurgence of destructive behavior following successful treatment. After experiencing an FA and an initial FCT evaluation, function-based treatment, which included extinction of destructive behavior, reduced destructive behavior to near-zero levels for all four participants, thereby replicating prior research findings on FCT (e.g., Greer, Fisher, Saini et al., 2016). Next, we modified FCT based on BMT using Equation (1) and decreased the proportional rates of destructive behavior by about two thirds relative to the control condition. These results provide empirical support for the specific predictions for treatment modifications suggested by Equation (1).

Because our main purpose in this investigation was to test the implications of modifying function-based, differential reinforcement interventions like FCT using Equation (1), we implemented the three primary modifications suggested by this equation simultaneously in the hopes of producing a large decrease in degree to which destructive behavior resurged when reinforcement for the FCR was discontinued; and in fact, our observed effect sizes were large by conventional standards (Cohen, 1988). Nevertheless, because we implemented these three modifications (decreased the rate of reinforcement during baseline and treatment and extended the duration of treatment) simultaneously, we are unable to determine the relative contributions of each individual treatment modification. Future investigations should examine each of the individual components separately.

Nevin et al. (2016) recently evaluated the effects of dense and lean schedules for the FCR during treatment of severe destructive behavior with FCT for four boys (ages 8 to 14) with ASD; they also conducted parallel and more extensive analyses with pigeons in another experiment within that same investigation. Results for the four boys in Nevin et al. showed similar, but perhaps less-consistent, differences between the test (lean DRA) and the control (rich DRA) condition than we did with our test (lean–long FCT) and control (dense–short FCT). The main difference between the Nevin et al. comparison and ours is that they manipulated a single variable (DRA schedule density), and we manipulated three variables simultaneously as an intervention package (baseline schedule density, DRA schedule density, and time [number of sessions] in DRA). Another difference was that Nevin et al. signaled the availability of reinforcers during DRA using visible or auditory timers (i.e., signaled the completion of each VI component). As such, it is difficult to draw firm comparisons regarding Nevin et al.'s results and those of the current investigation.

The current findings illustrate the potential benefits of using quantitative models of behavior to identify potential modifications to function-based treatments for destructive behavior that may not be intuitively obvious. For example, Hanley, Iwata, and McCord (2003) reviewed 277 studies that included pretreatment functional analyses of problem behavior and found that experimenters programmed dense reinforcement schedules (i.e., FR 1) in 90% of the functional analyses. Typically, researchers use the same dense schedule of reinforcement during the baselines for treatment analyses. Thus, the predictions of Equation (1) from BMT recommend the opposite of what clinicians and applied researchers typically do in standard clinical practice. Equation (1) recommends a low rate of reinforcement for destructive behavior during baseline, whereas clinicians and applied researchers typically deliver a high rate of reinforcement for destructive behavior during baseline. This represents a clear example in which the predictions of a quantitative model of behavior (e.g., BMT) lead to a potential refinement for function-based treatments that is not intuitively obvious, one that is at odds with current "best practices."

Similarly, Tiger, Hanley, and Bruzek (2008) reviewed 91 studies involving 204 participants treated with FCT, and in each case, the experimenters initially provided reinforcement for the FCR on a dense, FR 1 schedule. Moreover, these authors strongly recommended that behavior analysts initially deliver reinforcement for the FCR on a dense, FR 1 schedule. As is the case with baseline response rates, Equation (1) recommends a low rate of reinforcement for the FCR during treatment, just the opposite of common clinical practice and the recommendations of leading clinical researchers in the field. This represents another example in which the predictions of a quantitative model of behavior (e.g., BMT) lead to a potential refinement for function-based treatments that is not intuitively obvious and another one that is at odds with current "best practices." However, it is important to note that the present study provided each participant with a history of a dense schedule of reinforcement for destructive behavior and the FCR during the FA and initial FCT evaluation prior to providing a history of a relatively lean schedule of reinforcement for both responses. Thus, the effects of a lean schedule of reinforcement in the absence of a history of a dense schedule of reinforcement cannot be determined directly from our study.

The current investigation also contributes to the literature on mitigating resurgence of destructive behavior by providing two empirically based procedures for selecting lean schedules of reinforcement for baseline and FCT. Results from Nevin et al. (2016) indicate that decreasing the reinforcement rate for the FCR during treatment can mitigate resurgence of destructive behavior when alternative reinforcement is suspended. However, other studies have shown that relatively large and precipitous drops in reinforcement rate for the alternative response during DRA procedures like FCT can also result in resurgence of destructive behavior (Lieving & Lattal, 2003; Volkert et al., 2009). Thus, it may be important to develop empirical methods for identifying the lowest rate of reinforcement that maintains the FCR to reap the benefits described by Nevin et al. (2016) without evoking resurgence of destructive behavior when a lean schedule of reinforcement is introduced (Lieving & Lattal, 2003; Volkert et al., 2009).

Finally, we currently do not have any best-practice recommendations that can provide guidance to clinicians regarding the optimal dosage of function-based treatments for destructive behavior. One dosage question related to the problem of resurgence of destructive behavior is, "How long should we implement treatment at optimal procedural fidelity with trained therapists before introducing treatment with caregivers who may not consistently deliver reinforcement for appropriate, alternative behavior at the prescribed times?" Episodes in which caregivers do not deliver reinforcement for extended periods represent naturally occurring extinction challenges, which may result in resurgence of destructive behavior. Equation (1) predicts that longer exposures to treatment with FCT with high procedural fidelity may mitigate resurgence of destructive behavior during subsequent periods when the FCR goes unreinforced. Considering that only two levels of this factor were evaluated in the current study and in the context of other differences between conditions of different dosage (i.e., reinforcement schedule differences), future parametric evaluations of different dosages are needed to determine their impact on resurgence.

As researchers continue to investigate the conditions under which destructive behavior does and does not resurge (or relapse more broadly) and whether it does so to clinically unacceptable levels, questions regarding the risks and costs associated with any relapse-mitigation procedure will need to be addressed. Mitigation procedures that offer the prospect of long-term benefit will need to be weighed against any short-term worsening in rates or severities of destructive behavior, slower acquisition of the FCR, or procedures that might otherwise delay patient discharge. Ultimately, those mitigation procedures that become widely adopted by behavior analysts will need to strike a balance between short- and long-term benefit for patients and stakeholders. Our study served as a proof-of-concept, insofar as our objective was to evaluate whether a combination of BMT-informed modifications to baseline and FCT mitigated resurgence. We did not evaluate whether such modifications were associated with increased risk or cost. Future research should address questions along this line.

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