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 programming 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...
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 agitation 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, Mue-thing, Gainey, Hoffman, & Fragaile, 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

![Graphs](https://via.placeholder.com/150)

**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.
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

<table>
<thead>
<tr>
<th>Participant</th>
<th>Time-based delay</th>
<th>Contingency-based delay</th>
<th>Consequences for PB and CR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nico</td>
<td>None</td>
<td>Gestural and physical every 30 to 45 s</td>
<td>DRA-DRO: TR and continuous engagement in alternative activity without PB or CR (say “okay” then play in area with low-preference toys)</td>
</tr>
<tr>
<td>Will</td>
<td>Single vocal</td>
<td>Three-step every 15 s</td>
<td>DRA: Cumulative number of compliance responses (place all the provided beads on a string)</td>
</tr>
<tr>
<td>Jack</td>
<td>Single vocal</td>
<td>Single vocal</td>
<td>DRO: Cumulative amount of time without PB or CR (engage in any or no activity)</td>
</tr>
<tr>
<td>Alex</td>
<td>Three-step as needed</td>
<td>Three-step as needed</td>
<td>DRA-DRO: TR and cumulative amount of time without PB or CR (say “okay” and engage in any or no activity)</td>
</tr>
</tbody>
</table>

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

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**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.
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 resurfaced 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.

REFERENCES


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