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Functional Communication Training During Reinforcement Schedule Thinning: An Analysis of 25 Applications

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Abstract

Two principal goals of functional communication training (FCT) are to (a) eliminate destructive behavior and (b) establish a more acceptable, yet functionally equivalent, communication response (FCR). A related and critically important goal is to thin the schedule of reinforcement for the FCR to levels that are reasonably managed by caregivers. Researchers have described several approaches to thinning FCT reinforcement schedules. We summarized the results of 25 consecutive applications (amongst 20 cases) in which schedule-thinning procedures employed discriminative stimuli to signal when the FCR would and would not produce reinforcement (i.e., using multiple schedules, response restriction, or chained schedules). Results suggest schedule-thinning procedures that use discriminative stimuli can maintain the effectiveness of FCT while minimizing the need for punishment or other supplemental procedures.

Keywords

destructive behavior; functional communication training; multiple schedules; reinforcement schedule thinning

Functional communication training (FCT) is the most commonly prescribed function-based intervention for destructive behavior (Tiger, Hanley, & Bruzek, 2008). Although highly effective, FCT involves the delivery of reinforcers at high rates, which can be impractical for caregivers (Hagopian, Fisher, Sullivan, Acquisto, & LeBlanc, 1998; Kurtz et al., 2003; Matson, Dixon, & Matson, 2005; Tiger et al., 2008). As a result, researchers have investigated ways of thinning the schedule of reinforcement to more practical levels while simultaneously maintaining near-zero rates of destructive behavior.

One method of FCT schedule thinning involves the use of multiple schedules. A multiple schedule is a compound schedule in which each component is associated with both a specific reinforcement schedule and a schedule-correlated stimulus (e.g., a white card when reinforcement is available) that is alternated with at least one other component (e.g., a black card during extinction; Fisher, Kuhn, & Thompson, 1998). When used for the purpose of reinforcement schedule thinning, a multiple schedule (mult FCT) typically involves increasing the duration of the extinction component (signaled by the presence of the S^{Δ} or the stimulus associated with extinction) relative to the reinforcement component (signaled

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by the presence of the S^D or the stimulus associated with reinforcement; Hanley, Iwata, & Thompson, 2001). Multiple schedules used during FCT can preclude or mitigate the need for supplemental treatment procedures (e.g., alternative reinforcement, punishment) when FCT includes extinction of destructive behavior (Hagopian, Boelter, & Jarmolowicz, 2011).

Another method of FCT schedule thinning involves response restriction (RR). During RR FCT, response materials used to request reinforcement are withheld during times in which reinforcement is unavailable. Response restriction FCT is possible only when access to communication materials (e.g., a picture-exchange card) can be manipulated. Similar to mult FCT, times during which the communication card remains unavailable are systematically increased relative to periods in which the response card is available. When FCT is combined with extinction, RR FCT can be an effective method for FCT schedule thinning without the need for additional treatment procedures (Fisher, Greer, Querim, & DeRosa, 2014; Hagopian et al., 2011; Roane, Fisher, Sgro, Falcomata, & Pabico, 2004).

Another method of FCT schedule thinning involves the use of chained schedules (or demand fading) in which the completion of an increasing response requirement results in the opportunity to request reinforcement (Fisher et al., 1993; Lalli, Casey, & Kates, 1995). Chained schedules are most frequently used to make FCT procedures more practical when destructive behavior is maintained by negative reinforcement. Used in this manner, chained schedules during FCT require compliance with an increasing number of demands before the opportunity to request a break is provided. Chained schedules have also been shown to facilitate FCT schedule thinning without the need for additional treatment components when FCT is combined with extinction (Hagopian et al., 2011).

An alternative form of FCT schedule thinning involves requiring the individual to wait an increasing amount of time before the functional communication response (FCR) is reinforced (Fisher, Thompson, Hagopian, Bowman, & Krug, 2000; Hagopian et al., 1998; Hanley et al., 2001; Rooker, Jessel, Kurtz, & Hagopian, 2013). Although these delayed reinforcement schedules can promote FCT schedule thinning in some cases (Hagopian et al.), delayed reinforcement schedules have the potential to result in extinction of the FCR when longer and more clinically acceptable delays are programmed (Hanley et al.; Sidener, Shabani, Carr, & Roland, 2006). Additionally, use of delayed reinforcement schedules may increase other forms of problem behavior (e.g., stereotypy; Fisher et al.) and may result in the recovery of destructive behavior or treatment relapse (Hanley et al.). For these reasons, our program relies on mult FCT, RR FCT, and chained schedules to complete FCT schedule thinning.

Hagopian et al. (1998) examined the effectiveness of FCT implemented with or without extinction or punishment in 27 applications across 21 cases (multiple treatments were evaluated with some cases). They also evaluated the effects of FCT schedule thinning in a subset of these applications (70%). Chained or delayed reinforcement schedules were implemented during FCT schedule thinning in 12 applications in which destructive behavior was exposed to extinction. These schedule-thinning procedures were shown to be highly effective (i.e., producing at least a 90% reduction in destructive behavior) in only five applications (42%). Punishment was ultimately required for six applications (50%). When

used during FCT schedule thinning, punishment was effective at reducing destructive behavior by at least 90% in all applications.

Rooker et al. (2013) extended the literature on FCT by summarizing data from 58 applications of FCT, many of which included supplemental procedures, including alternative reinforcement (i.e., noncontingent reinforcement or additional differential reinforcement procedures) and punishment. Additionally, the authors presented data on a subset of applications (55%) in which they evaluated the effectiveness of different forms of FCT schedule thinning (mult FCT, chained schedules, or delayed reinforcement schedules). Rooker et al. found that supplemental procedures can facilitate schedule thinning when FCT schedule-thinning procedures alone are insufficient. For example, alternative reinforcement was later added to FCT in 14 applications, and destructive behavior decreased or remained at low levels for all of these applications (100%). Supplementing FCT with punishment was also effective in the majority of applications. Furthermore, Rooker et al. suggested that multiple schedules of reinforcement were more effective than delayed reinforcement schedules during FCT schedule thinning.

Hagopian et al. (1998) and Rooker et al. (2013) are the only studies that have examined the effectiveness of FCT as treatment for destructive behavior across large cohorts of individuals, and in doing so, they have advanced our understanding of the generality of FCT (for another notable study that included a large number of cases but did not include information on FCT schedule thinning, see Kurtz et al., 2003). However, neither study attempted FCT schedule thinning with all of its cases, and when schedule thinning was implemented, delayed reinforcement schedules were used with some cases, which have been shown to have deleterious effects when used with other individuals (Fisher et al., 2000; Hanley et al., 2001, Sidener et al., 2006). Therefore, the purpose of the current study was to extend the literature on FCT schedule thinning by evaluating its effectiveness when schedule thinning was attempted with every case and when delayed reinforcement schedules were explicitly avoided. We accomplished this by selecting cases for which mult FCT, RR FCT, or chained schedules were used to signal reinforcer availability via discriminative stimuli. Our use of discriminative stimuli for all FCT schedule-thinning applications was expected to reduce the reliance on punishment and other supplemental procedures while producing large reductions in destructive behavior. Because FCT schedule thinning is designed to produce more practical treatments for implementation by caregivers, we also extended the literature by presenting the terminal reinforcement schedules used with each application and the percentage of discriminated FCRs (i.e., the percentage of FCRs that occurred in the presence of the S^D), as well as the percentage of reduction in reinforcement deliveries.

Method

Record Review

Two types of records were reviewed at a university-affiliated program that specialized in the assessment and treatment of severe destructive behavior. First, we created a preliminary list of cases by reviewing clinical-outcome data, which were updated for all cases upon discharge from the program and contained information on the type and effectiveness of the final treatments used with each case. Second, we amended the original list of cases by

reviewing individual clinic records for every individual who had been admitted to the program. This ensured that each application of FCT schedule thinning (not just the final treatment) was included for analysis. The list of cases was then modified accordingly.

We included applications in the study if (a) the results of a functional analysis indicated that destructive behavior was maintained by socially mediated consequences (e.g., access to attention, escape, or tangibles), (b) FCT was evaluated using signaled components (programmed discriminative stimuli or the presence and absence of response materials), which indicated when reinforcement was and was not available, (c) reinforcement availability decreased across sessions (i.e., FCT schedule thinning was attempted), and (d) interobserver agreement data were assessed for at least 25% of all sessions. We excluded applications if the individual engaged in near-zero rates of destructive behavior during baseline (preventing a comparison of FCT effectiveness) or if the individual was discharged from the program prematurely (e.g., due to family relocation). All applications that met the inclusion criteria (and did not meet the exclusion criteria) were included for analysis, regardless of the effectiveness of FCT.

Subjects and Setting

The results of the record review indicated that FCT schedule thinning was evaluated in 25 consecutive applications across 20 cases[1]. Table 1 displays the age, diagnosis, level of intellectual disability, and target behavior for each case and application. Each case received a level of service deemed clinically appropriate for the severity of destructive behavior. Three levels of service were available – outpatient, intensive outpatient, and day treatment. Consequently, appointment times ranged from one and a half to six hours per day across two to five days per week. The provision of service for each case was based on a tiered model of service delivery. A licensed psychologist or a Board Certified Behavior Analyst® supervised each case, which included a senior staff member who in turn supervised the direct-care staff.

Most sessions took place in 3-m by 3-m therapy rooms that contained a one-way observation mirror and session materials. Individuals who engaged in self-injurious behavior (SIB) were treated in similar-sized padded therapy rooms. Sessions for Case 20 (Applications 24 and 25) occurred in two adjacent therapy rooms to allow for repeated measures of elopement. All therapy rooms contained a two-way intercom that enabled data collectors positioned inside an observation booth to communicate with individuals located in the therapy rooms and vice versa.

Response Measurement

Trained data collectors used laptop computers to record instances of destructive behavior and FCRs. Target behaviors were operationally defined for each case. Despite this, prevailing topographies of destructive behavior included aggression, disruptions, SIB, and inappropriate vocalizations. Aggression included hitting, kicking, pushing, and pulling on or throwing objects at other individuals. Disruptions included throwing, hitting, or kicking

[1]Cases 7, 11, 17, and 20 are Henry, Mikey, Gordon, and Casey (respectively) in Betz, Fisher, Roane, Mintz, and Owen (2013). Cases 10 and 14 are John and Dan (respectively) in Fisher, Greer, Querim, and DeRosa (2014). Case 10 is also John in DeRosa, Fisher, and Steege (2015). Case 15 is Derek in Fisher, Rodriguez, and Owen (2013).

objects, turning over furniture, and swiping materials off tables or desks. SIB included head banging, self-hitting, and body slamming. Inappropriate vocalizations included making insults or threating remarks. Other target behaviors included elopement, inappropriate touching, and screaming.

We also collected data on the frequency of the FCR during FCT. Functional communication responses typically took the form of a card touch or exchange. Communication cards varied in size and color but often included a picture of the individual consuming the reinforcer shown to maintain destructive behavior during the functional analysis. A vocal FCR (e.g., "toy please") was evaluated in some cases. The percentage of correct FCRs was calculated for each session by dividing the frequency of correct FCRs (i.e., FCRs that could result in reinforcement) by the total number of FCRs.

Interobserver Agreement

A second observer collected data simultaneously with, but independently of, the primary data collector on at least 25% of all sessions throughout assessment and treatment phases for each case. Sessions were divided into 10-s intervals, and an agreement was recorded for each interval in which both observers measured the same number of responses. We summed the number of agreement intervals and then divided this number by the total number of intervals within the session. These fractions were then converted to a percentage. Only those sessions analyzed for the purposes of the current study (e.g., last five functional analysis sessions, last five FCT sessions) are reported below.

We collected interobserver agreement across 35% (range, 0% to 75%) of analyzed sessions. Agreement averaged 98% (range, 83% to 100%) for aggression, 96% (range, 78% to 100%) for disruptions, 99% (range, 98% to 100%) for SIB, 98% (range, 90% to 100%) for inappropriate vocalizations, 99% (range, 96% to 100%) for elopement, 100% for inappropriate touching, 100% for screaming, and 94% (range, 87% to 100%) for FCRs.

Procedure

Functional analysis—We conducted a functional analysis with each case using the procedures described by Iwata, Dorsey, Slifer, Bauman, and Richman (1982/1994) with the procedural modifications discussed by Fisher, Piazza, and Chiang (1996). The specific conditions included in each functional analysis were dependent on the information gathered from indirect assessments, which included questions on the conditions under which destructive behavior was and was not likely to occur. Despite this, most functional analyses included conditions that tested for automatic reinforcement, escape from demands, access to attention, and access to tangibles. The control condition used throughout most functional analyses was a toy play condition. A mand analysis (Bowman, Fisher, Thompson, & Piazza, 1997) was evaluated with Cases 4, 7, and 12 because the results of these individual's indirect assessments suggested that destructive behavior was most common when caregivers denied mands (e.g., to play a different way, to talk only about preferred topics). Destructive behavior during the mand-analysis sessions resulted in the therapist honoring the individual's most recent mand and allowing the individual to control the therapist's behavior (within reason) by honoring additional mands for a programmed period of time (e.g., 20 or

30 s). We listed cases with elevated rates of destructive behavior in this condition (relative to those in the toy play condition in which the individual could direct all therapist behavior) as having a social-control function of destructive behavior.

Additionally, a single functional analysis was used with individuals who presented with multiple topographies of destructive behavior unless evidence suggested the responses were maintained by separate consequences. Separate functional analyses were arranged for these cases. Multielement, pairwise, and reversal designs were most commonly used to demonstrate experimental control. Functional analysis sessions typically lasted 5 or 10 min.

Baseline—Baseline sessions began following the functional analysis and consisted of 5- or 10-min sessions in which the reinforcer shown to maintain destructive behavior was provided for 20 or 30 s following each instance of destructive behavior (fixed ratio [FR] 1 schedule). All other responding resulted in no programmed consequence (i.e., extinction).

FCT pretraining—Pretraining for FCT began following baseline and consisted of teaching the individual to request reinforcement using an alternative form of communication. The individual was taught to use the FCR independently by arranging the establishing operation for destructive behavior and then quickly guiding the individual to emit the FCR, followed immediately by delivering the functional reinforcer (e.g., attention). Throughout all conditions, when reinforcement was programmed for the FCR, it was delivered on an FR 1 schedule. A progressive prompt-delay (or time-delay) procedure modeled from Charlop, Schreibman, and Thibodeau (1985) was used to facilitate independent use of the FCR. Prompt delays increased across sessions, provided that levels of destructive behavior remained low. The progression often followed a 0-s, 2-s, 5-s, 10-s, and (if required) 20-s prompt delay with at least two sessions at each level. Pretraining sessions were typically 10 trials. Supplemental procedures were used on an individual basis as deemed clinically necessary to teach the FCR. Examples included (a) response blocking to decrease FCRs that occurred while the individual accessed reinforcement and (b) prompt fading, which was used to transfer stimulus control from a controlling prompt (e.g., physical guidance that reliably occasioned the FCR) to the presentation of the establishing operation for destructive behavior.

Destructive behavior was placed on extinction during pretraining sessions and extinction continued throughout treatment for all cases. Furthermore, a short (3- or 5-s) changeover delay was used with the majority of cases to prevent the adventitious reinforcement of destructive behavior by briefly delaying the delivery of reinforcement if destructive behavior occurred when reinforcement would have otherwise been delivered. Pretraining with RR FCT included teaching the individual to discriminate between two concurrently available response cards (one FCR card and one control card; see Fisher et al., 2014 for a detailed description of the RR-FCT training procedure). Response and stimulus prompts were used to teach this simultaneous discrimination.

FCT—Functional communication training was typically evaluated after the newly acquired FCR was taught during pretraining. During FCT, reinforcement was delivered following FCRs according to an FR 1 schedule. Prompting strategies used to occasion the FCR during

pretraining were typically removed during FCT (for exceptions, see Cases 10 and 6 in Figures 1 and 2, respectively). Supplemental procedures were implemented on an individual basis as needed to improve the efficacy of FCT. Sessions typically lasted 5 or 10 min.

To evaluate the efficacy of FCT, we compared response rates of destructive behavior during FCT to those observed during baseline. A reversal design was frequently used to demonstrate experimental control and was typically conducted prior to thinning the schedule of reinforcement for the FCR. This ensured that FCT was an effective treatment before making FCT feasible for implementation by caregivers. Once reliable reductions in destructive behavior and high levels of correct FCRs were measured during FCT sessions, we programmed periods of time during which reinforcement for the FCR was unavailable.

FCT schedule thinning—The practicality of FCT as a treatment for destructive behavior was enhanced during FCT schedule thinning by increasing the time duration during which reinforcement remained unavailable. Functional communication training took the form of one of three schedule-thinning procedures, each of which incorporated discriminative stimuli to signal when reinforcement was and was not available for the FCR: (a) mult FCT, (b) RR FCT, or (c) chained schedules (chained FCT). Schedule-thinning procedures were typically selected based on clinical judgment (e.g., repeated incorrect FCRs suggested that response restriction would be an appropriate method for schedule thinning) or were informed by the results of a pre-evaluation comparison between two FCT schedule-thinning procedures in which the individual's performance was compared using each type of schedule-thinning procedure. Regardless of the type of FCT schedule thinning, the time during which reinforcement was unavailable was initially brief (e.g., 2 s for mult FCT and RR FCT; 1 response requirement for chained FCT) and increased contingent on low levels of destructive behavior (e.g., a 90% or greater decrease from baseline) and high levels of correct FCRs (e.g., 70% or greater percentage of correct FCRs). Prior to demonstrating that rapid jumps in schedule thinning could be accomplished using discriminative stimuli in mult FCT (Betz, Fisher, Roane, Mintz, & Owen, 2013), schedule thinning proceeded slowly with many cases (see Case 6 in Figure 2 for an example). In contrast, schedule thinning proceeded rapidly with others (see Cases 17 and 10 in Figure 1 and Case 5 in Figure 2).

The availability (S^D) and unavailability (S^Δ) of reinforcement was signaled during mult FCT. The signals varied across cases; however, common signals included colored cards, wristbands, or the location of a hat or lei (to indicate "my turn" or "your turn"). Schedule thinning during RR FCT differed in that the therapist removed the communication materials (e.g., the FCR card) while reinforcement was unavailable. The therapist re-presented the communication materials when reinforcement was again made available. Some applications of RR FCT incorporated a second set of communication materials (i.e., a control card) for experimental control purposes, and touches to the control card were scored as incorrect FCRs and resulted in no programmed consequence (i.e., extinction). These otherwise unnecessary materials were removed during the final stages of treatment. Chained schedules were used only with cases in which destructive behavior was negatively reinforced by escape. Chained schedules differed from mult FCT and RR FCT in that reinforcement (escape) was available only following compliance. Initially, one instance of compliance (FR 1) produced the opportunity to request a break (e.g., the break card was placed near the

individual for those cases who used a card touch or exchange for the FCR). The number of required instances of compliance increased as FCT schedule thinning continued. Similar to mult FCT, however, chained schedules used discriminative stimuli to distinguish "work" time from times during which breaks could be requested. For all applications in which chained schedules were used to thin the reinforcement schedule, the chained schedule was later converted to a multiple schedule at the completion of schedule thinning by calculating the average duration of the work component and converting the chained schedule to a comparable multiple schedule. For example, when an individual was consistently working for 240 s, which produced a 60-s break using a chained schedule, the therapist converted the chained schedule to a multiple schedule in which the child would continue to work for 240 s for a 60-s break, but the break would become available irrespective of compliance (i.e., on a time-based schedule). Therapists signaled work and break times with discriminative stimuli. This more closely approximated the types of reinforcement schedules used in each individual's classroom.

FCT schedule thinning with supplemental procedures—If FCT failed to produce an average 80% or 90% reduction in destructive behavior prior to or during FCT schedule thinning, we added supplemental procedures to further reduce destructive behavior. Therefore, we used supplemental procedures on an individual basis, and these procedures took the form of delivering either alternative reinforcement or punishment. Alternative reinforcement was delivered either on a time-based schedule (i.e., noncontingent reinforcement or NCR) irrespective of whether the functional reinforcer was or was not available or only when the functional reinforcer was available. Only one individual (Case 6) was exposed to noncontingent reinforcement to further decrease destructive behavior that occurred when the functional reinforcer was unavailable during FCT schedule thinning. With some individuals who engaged in negatively reinforced destructive behavior, access to a break alone was insufficient to treat destructive behavior. With two individuals (Cases 1 and 19), alternative reinforcement in the form of a preferred tangible item was provided during the break intervals, thereby allowing escape to a preferred item. We used a variation of this procedure with Case 3. This individual could access a preferred tangible item and therapist attention during break intervals; however, we required the individual to emit an additional FCR for each type of alternative reinforcement. Punishment was implemented infrequently (only with Case 5) but consisted of response blocking and timeout. This was done because SIB persisted throughout pretraining (i.e., even while exposure to the establishing operation for SIB was controlled and minimized).

Results

Table 2 displays the summarized functional analysis results for each case and application. Responses per minute of destructive behavior measured during the relevant test and control conditions are listed in the third and fourth columns, respectively. These values represent the mean response rate obtained over the last five sessions of each condition (i.e., during the portion of the functional analysis in which responding in each condition was compared). We often collected additional functional analysis data to rule in or out other functions of destructive behavior after we identified an initial function. We excluded these additional data

from the current manuscript. For all cases and applications, higher levels of responding occurred during a test condition relative to that in the control condition. Few, if any, instances of destructive behavior occurred during the final five control sessions. Access to preferred tangibles was the most common function of destructive behavior targeted for reduction during FCT (10 of 25 applications), followed by escape (8 of 25), attention (4 of 25), and social control (3 of 25).

Table 3 displays treatment information and results expressed as a percentage of reduction from baseline for each case and application. We analyzed the percentage of reduction in destructive behavior using the methods described by both Hagopian et al. (1998) and Rooker et al. (2013). We divided the mean of the last five sessions during treatment by the mean of the last five baseline sessions. We then subtracted this proportion from 1.0 and then converted it to a percentage. Functional analysis data were used as baseline data when separate baselines were not conducted during treatment. We used all available data when fewer than five data points existed for comparison.

We used mult FCT for schedule thinning in the majority of applications (18 of 25), with RR FCT used in the remaining applications (7 of 25). For four applications (1, 2, 22, and 23), a chained schedule was used to increase compliance with an increasing number of demands prior to transitioning behavior to a multiple schedule. We used a differential reinforcement of other behavior (DRO) contingency with one mult FCT application (9) and two RR FCT applications (20 and 21) during periods in which reinforcement was unavailable. We implemented this DRO contingency to ensure that destructive behavior did not contact adventitious reinforcement by presenting the opportunity to request reinforcement (i.e., presenting the S^D in mult FCT or providing the response materials in RR FCT) following instances of destructive behavior. During mult FCT with DRO, reinforcement was unavailable until a programmed period of time elapsed without destructive behavior. We signaled these programmed periods using the S^Δ or the absence of the response materials in mult-FCT and RR-FCT sessions, respectively. We added alternative reinforcement to FCT schedule thinning in six applications and punishment in only one application. We added supplemental procedures prior to FCT schedule thinning in three applications (1, 6, and 23) and after beginning FCT schedule thinning in four applications (2, 4, 7, and 22). Regardless of the type of FCT schedule thinning, overall reductions in destructive behavior exceeded 75% for all applications, and the use of supplemental procedures was correlated with improvements in the efficacy of FCT schedule thinning.

Table 4 displays the overall outcomes of FCT schedule thinning for each case and application. The total number of assessment and treatment sessions conducted across applications averaged 144 (range, 61 to 330). Reductions in destructive behavior from baseline averaged 96% (range, 77% to 100%) following FCT schedule thinning, at which point the majority of individuals emitted a relatively high percentage of discriminated FCRs (M = 92%; range, 69% to 100%). Finally, the overall reduction in reinforcement deliveries from the first five FCT sessions to the final five FCT sessions was 82% (range, 46% to 97%), indicating that the average FCT treatment was made considerably more practical for implementation by caregivers as a result of schedule thinning.

Figures 1 and 2 depict representative FCT schedule thinning results in which supplemental procedures either were unnecessary (Figure 1) or were required to successfully thin the reinforcement schedule (Figure 2). We selected these specific cases for depiction to reflect the relative distribution of reinforcement functions identified by the functional analysis results (i.e., tangible functions of destructive behavior were most commonly treated, followed by escape, attention, and social control). Therefore, representative results included two cases in which we treated a tangible function of destructive behavior (Case 17 in Figure 1 and Case 5 in Figure 2), one case in which we treated an escape function (Case 10 in Figure 1), and one case in which we treated an attention function (Case 6 in Figure 2).

The top panel of Figure 1 displays treatment data for Case 17. This individual engaged in lower rates of aggression and disruptions during FCT pre-training and FCT phases as compared to those observed in baseline and consistently high levels of FCRs. Reinforcement schedule thinning for Case 17 took the form of mult FCT, in which we made preferred tangibles available only during approximately half of the 60-s components. When we used stimuli to signal the availability and unavailability of reinforcement during mult-FCT sessions, Case 17 continued to display near-zero rates of destructive behavior and high levels of FCRs. At Session 38, we rapidly lengthened the reinforcement-unavailable component from mult FCT 60/60 to mult FCT 60/240, and the treatment effects maintained across sessions with the leaner reinforcement schedule, even following a medication decrease at Session 55.

The bottom panel of Figure 1 displays treatment data for Case 10 in which mult FCT was ineffective at maintaining reductions in destructive behavior. Similar to the results for Case 17, FCT produced rapid and consistent decreases in destructive behavior prior to mult FCT schedule thinning. At the mult FCT 60/60 schedule, however, the individual emitted numerous incorrect FCRs (as evidenced by the sharp decrease in the percentage of correct FCRs), and destructive behavior reemerged across sessions. We then replaced the mult FCT schedule with RR FCT in which the response materials were removed during the 60-s components when reinforcement was unavailable. This modification prevented FCRs from occurring while reinforcement was unavailable, and rates of destructive behavior declined across sessions. We rapidly thinned the mult FCT 60/60 schedule to a mult FCT 60/240 schedule at Session 103, and the treatment effects maintained across multiple sessions.

Some individuals required the use of supplemental procedures to reduce destructive behavior below baseline levels. The top panel of Figure 2 displays treatment data for one such individual (Case 6). Although FCT reduced SIB before schedule thinning, RR FCT schedule thinning progressed slowly with many sessions producing rates of SIB in the range of baseline. Alternative reinforcement in the form of continuous access to a preferred tangible item enabled us to rapidly thin the reinforcement schedule from RR FCT 30/120 to RR FCT 60/240 without increases in destructive behavior. Although a control card was presented along with the FCR card when reinforcement was available, the individual made few incorrect FCRs in the final stages of treatment.

We used punishment with only one individual (Case 5) whose data are displayed in the bottom panel of Figure 2. Following an unsuccessful attempt at decreasing SIB during FCT

pretraining, we implemented a 30-s timeout from reinforcement, which we later increased to 60 s. Neither FCT with timeout procedure was effective. Therefore, we added response blocking, which reduced SIB to clinically acceptable levels when compared to baseline. We rapidly thinned the reinforcement schedule from a 60/60 schedule to a 60/540 schedule at Session 150 using mult FCT with timeout and response blocking, and treatment effects maintained across multiple sessions.

In Figure 3, we summarized the data across the supplemental procedures used to accomplish FCT schedule thinning. Specifically, the data in Figure 3 indicate the percentage of applications in which FCT schedule thinning occurred (top panel), the percentage of those applications in which FCT schedule thinning reached at least a 4-min period during which reinforcement was unavailable (middle panel), and the percentage of reduction in destructive behavior from the most recent baseline during the last five sessions of FCT schedule thinning (bottom panel). As previously noted, some individuals experienced more than one type of FCT schedule thinning (i.e., FCT without supplemental procedures preceded FCT with alternative reinforcement for Applications 2, 4, 7, and 22). All applications of FCT schedule thinning are depicted.

Data on the top panel of Figure 3 indicate that FCT schedule thinning was used with all applications. Schedule thinning was attempted without the use of supplemental procedures in 22 of 25 applications (88%). Six applications required alternative reinforcement (24%), and only one application required the use of punishment (4%). Schedule thinning reached at least a 4-min period during which reinforcement was unavailable (middle panel) in 22 of 25 applications (88%), with similar percentages across the different types of FCT schedule thinning. The percentage of reduction in destructive behavior across the different types of FCT schedule thinning (bottom panel) was large, regardless of whether FCT schedule thinning included supplemental procedures.

Discussion

We summarized the results of 25 consecutive applications of FCT schedule thinning (amongst 20 cases) in which we used discriminative stimuli to signal when the FCR would and would not produce reinforcement using mult FCT, RR FCT, or chained schedules. When these signaled, compound schedules were employed to thin the schedule of reinforcement for the FCR without alternative reinforcement or punishment, they produced a mean reduction in destructive behavior of 96% relative to baseline. In addition, the signaled, compound schedules employed in the current study produced at least a 90% reduction in destructive behavior without or prior to alternative reinforcement or punishment in 73% of applications and at least an 80% reduction in 91% of applications. Supplemental procedures were required in only 28% of applications, with punishment used in just one application (4%).

We successfully thinned the reinforcement schedule for the FCR to a point where individuals tolerated periods of at least 4 min in which reinforcement was unavailable without producing significant increases in destructive behavior in 88% of applications. In many of these applications, 10-min sessions were conducted in which two 4-min extinction periods were

programmed consecutively, producing an 8-min block in which reinforcement was unavailable. These longer periods in which reinforcement remained unavailable did not produce significant increases in destructive behavior. Saini, Miller, and Fisher (in review) reviewed the published literature on multiple schedules and found that among the 52 cases in which reinforcer schedule thinning was implemented, the terminal schedule of 1 min of reinforcement and 4 min of extinction used by Hanley et al. (2001) was achieved in 31 of those published cases (60%). By contrast, we were able to achieve this terminal schedule in 22 of 25 applications (88%), which represents a significantly higher percentage ($Z = 3.24$, $p < .01$) than reported by Saini et al.

The current findings extend the literature on reinforcement schedule thinning during FCT in several ways. First, the current study is the only large-cohort investigation of consecutive cases (to date) in which schedule thinning was implemented with each case and every application of FCT. By conducting schedule thinning in each and every case, we essentially eliminated the possibility that case selection biases affected the results (e.g., the possibility that schedule thinning was less likely to be implemented with more difficult or challenging cases).

Second, the current investigation provided data exclusively on applications in which discriminative stimuli were used to signal periods in which reinforcement was and was not available for the FCR. That is, we specifically avoided the use of delayed reinforcement schedules to thin the reinforcement schedule for the FCR. In a review of the literature by Hagopian et al. (2011), the authors recommended avoiding delayed reinforcement schedules if the goal of FCT schedule thinning is to maintain low levels of destructive behavior when the individual is expected to tolerate relatively long periods in which reinforcement is unavailable (which they defined as 1 min or more) because lengthening the delay between a response and its reinforcer incrementally weakens the response-reinforcer relation (Lattal, 1984). Therefore, we exclusively used mult FCT, RR FCT, and chained schedules with all cases in the current study and found large reductions in destructive behavior across cases while also reaching more practical treatment endpoints in the majority of applications.

Although research suggests that delayed reinforcement schedules may be the least preferred option for reinforcement schedule thinning, Vollmer, Borrero, Lalli, and Daniel (1999) provided evidence to the contrary. Vollmer et al. extended the literature on delayed reinforcement schedules used during FCT schedule thinning by evaluating signaled and unsignaled delays on the destructive behavior of two young boys and found that signals (a timer or hand gesture) facilitated reductions in destructive behavior while maintaining high rates of the FCR for both boys. The procedures used by Vollmer et al. differed from the delayed reinforcement schedules used by Hagopian et al. (1998) and by Rooker et al. (2013) in that the signal was present and salient throughout the delay interval in Vollmer et al., whereas a brief signal (“That’s nice asking, but you need to wait”) was employed in Hagopian et al. and Rooker et al. Thus, the continuous signals present during the delayed reinforcement procedure in Vollmer et al. bare some resemblance to the continuous signals used during most mult FCT, RR FCT, and chained schedules. Future research should evaluate whether salient and continuous signals, like those used by Vollmer et al., would

increase the effectiveness of reinforcement schedule thinning using delayed reinforcement schedules in a large cohort of patients.

Future studies should also compare mult FCT, RR FCT, and chained schedules with delayed reinforcement schedules during FCT schedule thinning using within-subject methods (e.g., a multielement comparison). Hanley et al. (2001) compared several approaches to FCT schedule thinning (including variations of schedule thinning not addressed in the present study). However, they compared mult FCT with delayed reinforcement schedules during FCT schedule thinning with only one case (Karen). Future research should compare the efficacy and efficiency of delayed reinforcement schedules during FCT schedule thinning while simultaneously evaluating other forms of FCT schedule thinning. We have recently begun such a study in our program. The results of this and similar studies should better enable detection of the conditions under which delayed reinforcement schedules do and do not facilitate successful FCT schedule thinning.

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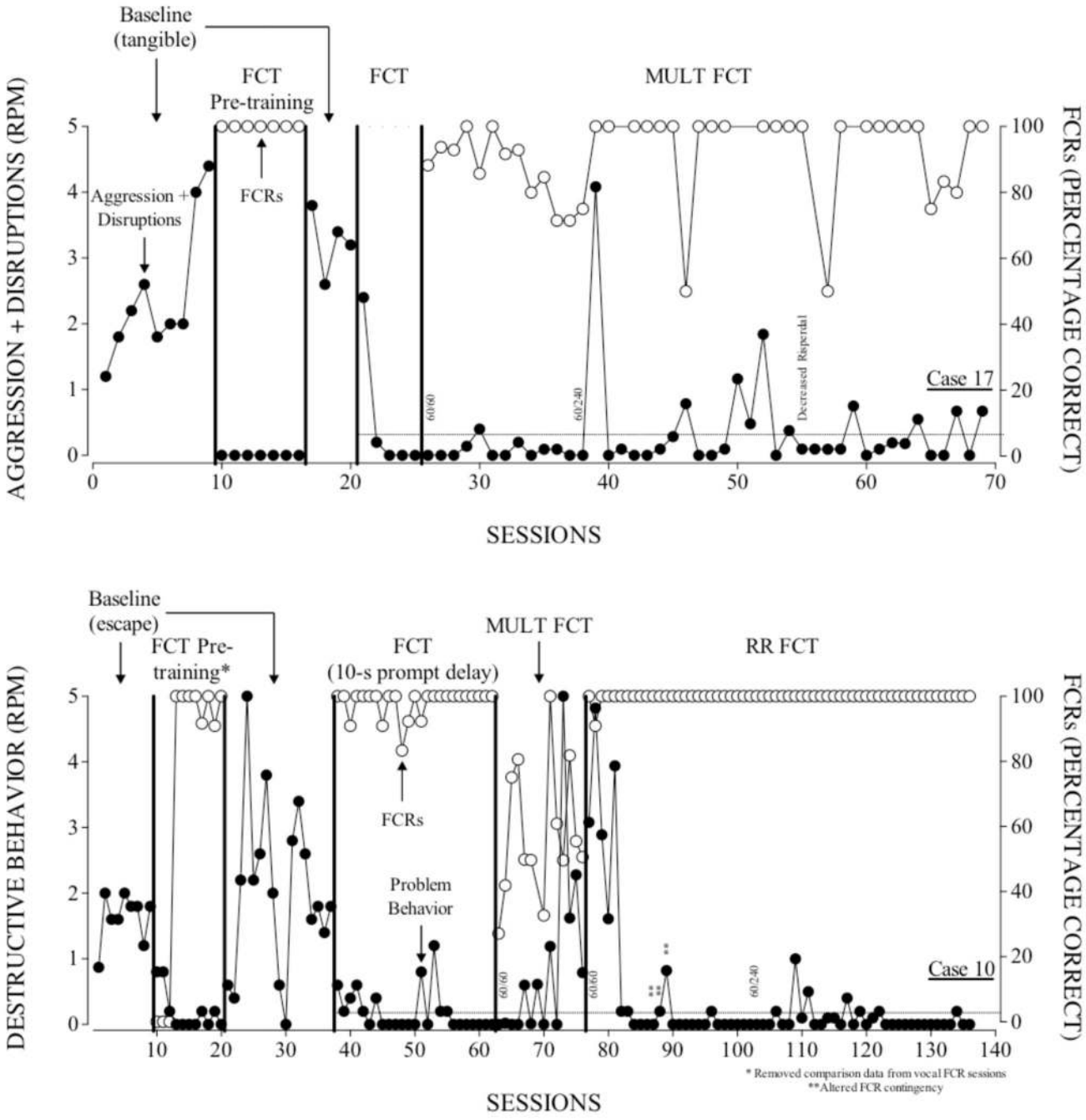

Figure 1.

FCT schedule-thinning results for two cases with whom supplemental procedures were unnecessary. Criterion lines denote a 90% reduction in destructive behavior from baseline.

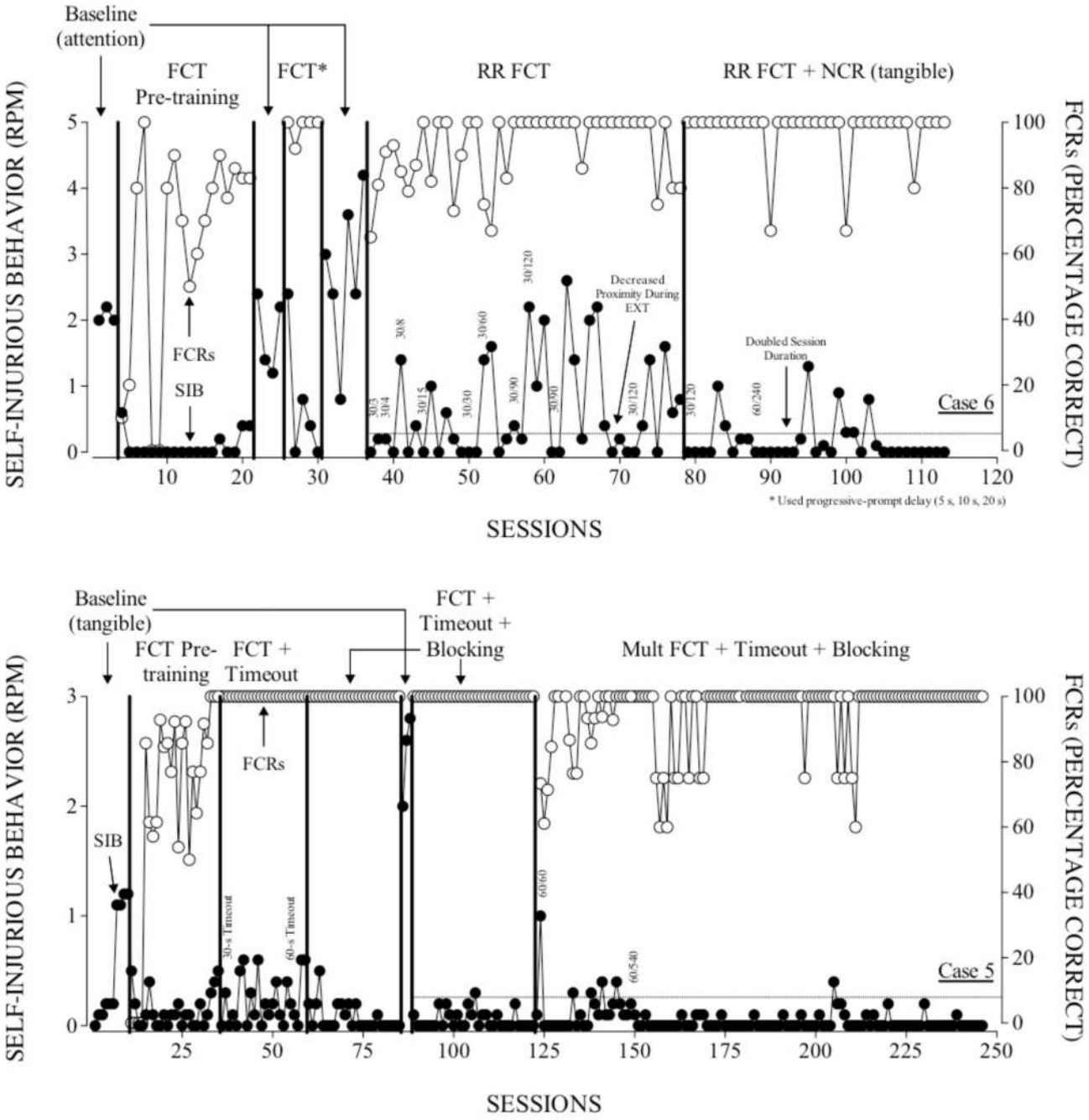

Figure 2.

FCT schedule-thinning results for two cases with whom supplemental procedures were used. Criterion lines denote a 90% reduction in destructive behavior from baseline. The asterisk indicates when a progressive-prompt delay (5 s, 10 s, 20 s) was used to prompt the FCR if it had yet to occur by the specified delay.

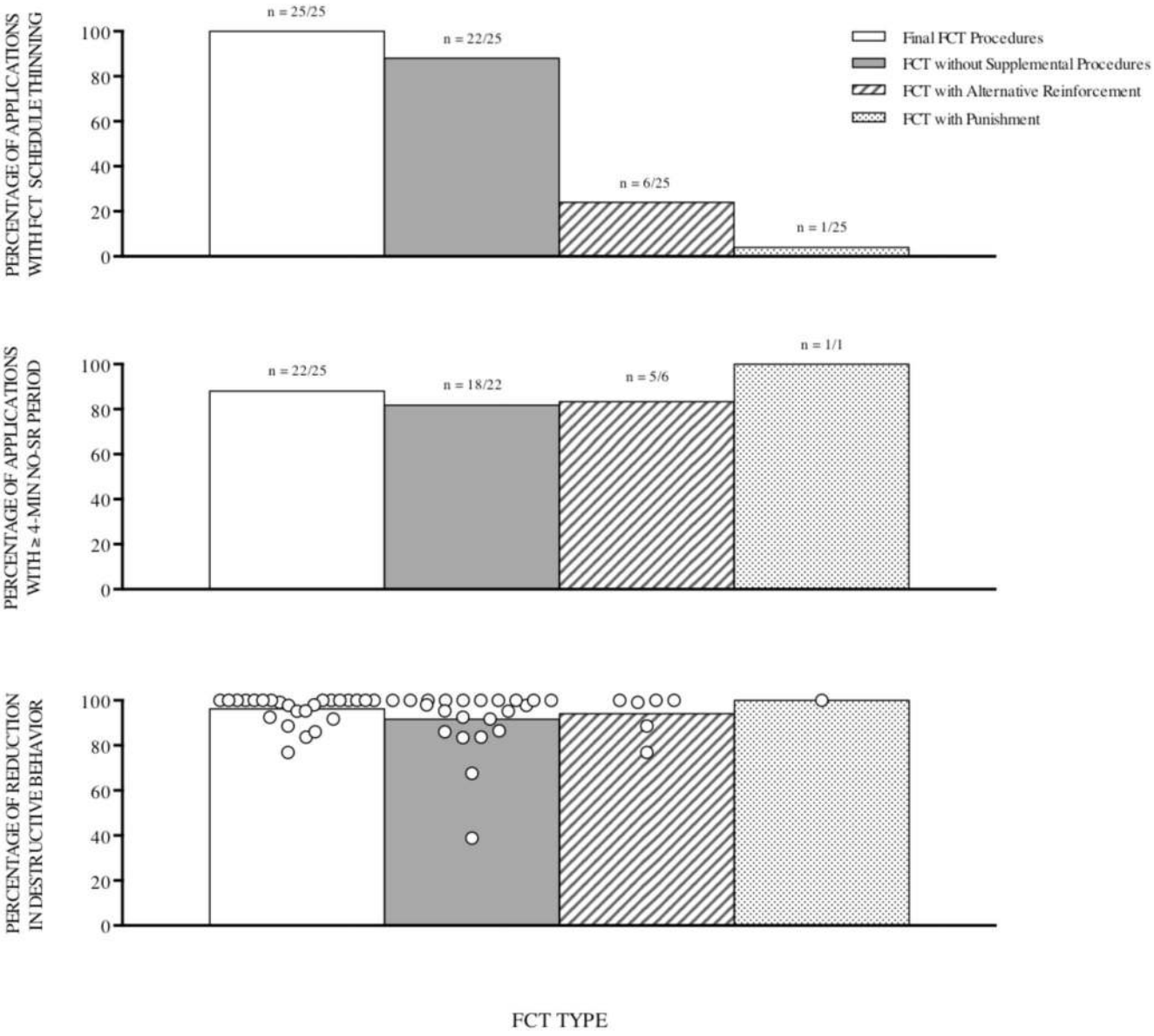

Figure 3.

Percentage of applications in which FCT schedule thinning was conducted (top panel), percentage of FCT schedule thinning applications with ≥4-min no-reinforcement period (middle panel), and percentage of reduction in destructive behavior (bottom panel) for all applications. Bar fill indicates the type of FCT schedule thinning. Data points indicate individual application results. Some cases were exposed to more than one type of FCT schedule thinning. Data from all applications of FCT schedule thinning are depicted.

Table 1
Demographic Information and Target Behaviors

Case	Application	Age	Diagnosis	Level of Intellectual Disability	Target Behavior
1	1	6	Explosive; ODD; ADHD	Intellectual Development Within Normal Limits	Aggression & Disruptions
	2	6	Explosive; ODD; ADHD	Intellectual Development Within Normal Limits	Aggression & Disruptions
2	3	2	Stereo; Feed	Unspecified Intellectual Developmental Disorder	Aggression & Screams
3	4	8	Stereo; Adjust	Severe Intellectual Developmental Disorder	SIB
4	5	10	Explosive; ADHD	Intellectual Development Within Normal Limits	Aggression & Disruptions
5	6	12	Stereo; Pica	Unspecified Intellectual Developmental Disorder	SIB
6	7	6	Stereo; ASD; Unspec	Mild to Moderate Intellectual Developmental Disorder	SIB
7	8	6	Adjust; OCD	Language Delay; No Developmental Disability	Aggression & Disruptions
8	9	6	PDD	Intellectual Development Within Normal Limits	Aggression & Disruptions
9	10	19	Explosive; ASD	Intellectual Development Within Normal Limits	Aggression
10	11	4	Disrupt; ASD	Unspecified Intellectual Developmental Disorder	Aggression, Disruptions, & Screams
11	12	9	Bipolar Disorder; ADHD; OCD	Intellectual Development Within Normal Limits	Aggression
12	13	8	Seizure Disorder; ASD	Intellectual Development Within Normal Limits	Disruptions & Inappropriate Vocalizations
13	14	7	Disrupt; PDD	Borderline Intellectual Developmental Disorder	Aggression
14	15	7	Disrupt	Unspecified Intellectual Developmental Disorder	Aggression
15	16	12	Neuro; Syring; Stereo; Disrupt	Intellectual Development Within Normal Limits	Aggression & Inappropriate Vocalizations
	17	13	Neuro; Syring; Stereo; Disrupt	Intellectual Development Within Normal Limits	Inappropriate Vocalizations
16	18	12	ASD; Unspec	Unspecified Intellectual Developmental Disorder	Inappropriate Touching
17	19	6	ADHD; Adjust; Encopresis; Enuresis	Intellectual Development Within Normal Limits	Aggression & Disruptions
18	20	5	ASD; Impulse	Unspecified Intellectual Developmental Disorder	Aggression & Disruptions
	21	5	ASD; Impulse	Unspecified Intellectual Developmental Disorder	Aggression & Disruptions
19	22	7	Explosive; ASD	Severe Language Delay Without Global Intellectual Delay	Aggression & Disruptions
	23	7	Explosive; ASD	Severe Language Delay Without Global Intellectual Delay	Aggression & Disruptions
20	24	5	PDD	Intellectual Development Within Normal Limits	Elopement
	25	5	PDD	Intellectual Development Within Normal Limits	Elopement

Note. Explosive = intermittent explosive disorder; ODD = oppositional defiant disorder; ADHD = attention deficit hyperactivity disorder; Stereo = stereotypic movement disorder; Feed = feeding disorder of infancy or early childhood; Adjust = adjustment reaction disorder; Disrupt = disruptive behavior disorder; PDD = pervasive development disorder; ASD = autism spectrum disorder; Impulse = impulse control disorder; Unspec = unspecified disruptive, impulse-control, and conduct disorder; OCD = obsessive-compulsive disorder; Neuro = neurofibromatosis; Syring = syringomyelia

Table 2

Summary of Functional Analysis Results

Case	Application	Test	Control	Function Treated
1	1	4.4	0.0	Escape
	2	4.4	0.0	Escape
2	3	1.9	0.0	Tangible
3	4	6.6	0.6	Escape
4	5	1.3	0.0	Social Control
5	6	1.0	0.0	Tangible
6	7	0.7	0.1	Attention
7	8	4.2	0.0	Social Control
8	9	1.2	0.0	Tangible
9	10	2.7	0.0	Tangible
10	11	3.2	0.1	Escape
11	12	6.4	0.0	Tangible
12	13	1.8	0.1	Social Control
13	14	4.7	0.0	Attention
14	15	2.1	0.1	Escape
15	16	2.2	0.0	Escape
	17	3.8	0.0	Tangible
16	18	1.6	0.0	Attention
17	19	2.2	0.0	Tangible
18	20	1.7	0.0	Tangible
	21	1.7	0.0	Tangible
19	22	1.6	0.0	Escape
	23	1.6	0.0	Escape
20	24	2.3	0.0	Attention
	25	2.4	0.0	Tangible

Table 3
Treatment Information and Results Expressed as Percentage of Reduction From Baseline

Case	Application	Design	FCT	FCT Schedule Thinning	Supplemental Procedures	FCT Schedule Thinning + Supplemental Procedures	Final Schedule
1	1	BABCD	82.4		Tangible[ad]	99.1	Mult 600/300[b]
	2	BABCD	82.4	38.9	Tangible[a]	88.6	Mult 600/300[b]
2	3	ABABABABCBCBC	93.6	83.7			Mult 60/240
3	4	ABABCDE	74.8	86.4	Attn[e] + Tangible[e]	76.9	RR 50/150
4	5	ABAB	98.9	100			Mult 60/240
5	6	ABCDADE	72.9		Time out[c] + Blocking[c]	100	Mult 60/540
6	7	ABABACD	60.0	67.6	NCR Tangible	100	RR 60/240
7	8	ABABC	100	100			Mult 60/540
8	9	ABABC	100	100			Mult 30/540 (DRO)
9	10	ABABC	90.2	100			Mult 60/540
10	11	ABABCD	100	97.8			RR 60/240
11	12	ABABC	100	100			Mult 20/240
12	13	ABABC	95.0	100			Mult 60/240
13	14	ABABCACACAC	85.4	95.2			Mult 60/240
14	15	ABABCD	94.4	86.0			RR 60/240
15	16	BABCDC	100	100			Mult 60/240
	17	ABABC	100	100			Mult 60/240
16	18	ABABACAC	82.9	98.0			RR 60/240
17	19	ABABC	84.0	91.7			Mult 60/240
18	20	Multiple BL	91.0	92.5			RR 180/90 (DRO)
	21	Multiple BL	97.2	100			RR 180/90 (DRO)
19	22	Multiple BL	98.1	83.4	Tangible[a]	100	Mult 600/300[b]
	23	Multiple BL	98.1		Tangible[ad]	100	Mult 600/300[b]
20	24	ABABC	87	100			Mult 60/240
	25	ABABC	100	95.3			Mult 60/240

Note.

[a]Stimulus delivered with functional reinforcer.

[b]Chained schedule used for FCT schedule thinning prior to mult FCT.

[c]Procedure evaluated prior to FCT schedule thinning.

[d]Procedure included at start of FCT schedule thinning.

[e]Stimulus available while accessing functional reinforcer, but only following an additional contingency-specifying FCR.

Table 4
Overall Outcomes of FCT Schedule Thinning

Case	Application	Total Number of Sessions	Percentage of Reduction in Destructive Behavior	Percentage of Discriminated FCRs	Percentage of Reduction in Reinforcement Deliveries
1	1	330	99.1	100	96.3
	2	280	88.6	100	96.3
2	3	135	83.7	69.2	78.6
3	4	271	76.9	100*	75.0
4	5	114	100	88.9	60.4
5	6	246	100	100	76.9
6	7	113	100	100*	72.7
7	8	99	100	100	88.3
8	9	130	100	83.3	93.3
9	10	75	100	100	92.6
10	11	136	97.8	100*	88.5
11	12	107	100	100	87.0
12	13	119	100	94.8	80.0
13	14	144	95.2	97.8	96.7
14	15	163	86.0	100*	45.5
15	16	117	100	94.1	83.3
	17	61	100	90.9	72.2
16	18	129	98.0	100*	77.3
17	19	69	91.7	90.0	91.3
18	20	104	92.5	100*	86.1
	21	103	100	100*	89.5
19	22	178	100	100	94.4
	23	170	100	71.4	96.7
20	24	73	100	96.4	80.0
	25	127	95.3	85.7	54.5

Note. Asterisks denote the percentage of discriminated FCRs for RR FCT applications in which the individual was able to emit the FCR only during the S^D component.