HHS Public Access

Author manuscript

Behav Modif. Author manuscript; available in PMC 2018 July 01.

Published in final edited form as:

Behav Modif. 2018 July ; 42(4): 472–497. doi:10.1177/0145445517742883.

Systematic Changes in Preference for Schedule-Thinning Arrangements as a Function of Relative Reinforcement Density

Adam M. Briggs, **Jessica S. Akers**, **Brian D. Greer**, **Wayne W. Fisher**, and **Billie J. Retzlaff**

University of Nebraska Medical Center's Munroe-Meyer Institute

Abstract

We treated destructive behavior maintained by both social-positive (i.e., access to tangibles) and social-negative (i.e., escape from demands) reinforcement in an individual diagnosed with autism spectrum disorder using functional communication training (FCT). We then thinned the schedule of reinforcement for the tangible function using a multiple schedule (mult FCT) and later thinned the availability of escape using a chained schedule (chain FCT). Both treatments proved effective at maintaining functional communicative responses while decreasing destructive behavior to near-zero levels. In addition, treatment effects maintained when we rapidly thinned mult FCT to the terminal schedule. Throughout chain-FCT schedule thinning, we assessed client preference for each schedule-thinning arrangement (mult FCT or chain FCT) using a concurrent-chains procedure. Client preference reliably shifted from chain FCT to mult FCT as the response requirement increased and the proportion of session spent in reinforcement began to favor mult FCT. We discuss the clinical implications of these findings.

Keywords

chained schedule; choice; concurrent-chains procedure; functional communication training; multiple schedule; preference; schedule thinning

Functional communication training (FCT) is a differential-reinforcement procedure that clinicians commonly use to reduce socially maintained destructive behavior (Fisher, Greer, & Fuhrman, 2015; Tiger, Hanley, & Bruzek, 2008). During FCT, destructive behavior results in extinction, and a functionally equivalent communication response (i.e., the functional communication response [FCR]) results in the reinforcer which previously maintained destructive behavior. When FCT is first introduced, the clinician often uses a dense schedule of reinforcement (e.g., fixed-ratio [FR] 1) to establish the FCR. After observing reductions in destructive behavior and maintenance of the FCR, the clinician then thins the reinforcement schedule for the FCR to a more practical schedule (Betz, Fisher, Roane, Mintz, & Owen, 2013; Greer, Fisher, Saini, Owen, & Jones, 2016; Hagopian, Contrucci Kuhn, Long, & Rush, 2005; Saini, Miller, & Fisher, 2016). Although a number of schedule-thinning arrangements have been described in the literature, multiple schedules and chained

Address correspondence to Jessica Akers, Baylor University School of Education, Marrs McLean Science, One Bear Place #97301, Waco, TX 76798, (jessica_akers@baylor.edu).

Jessica Akers is now at Baylor University.

schedules represent the most common procedures for schedule thinning during FCT (Fisher et al., 1993; Hagopian, Boelter, & Jamolowicz, 2011; Hanley, Iwata, & Thompson, 2001).

In a multiple schedule, the FCR produces reinforcement on an FR-1 schedule in the presence of a discriminative stimulus (S^D) in one component but results in extinction in the presence of another stimulus (S^Δ) in a separate component. Destructive behavior typically results in extinction across components. Under a multiple schedule, the transition between components typically depends on the passage of time (e.g., a 60-s S^Δ component, followed by a 30-s S^D component). In order to thin the schedule of reinforcement using a multiple schedule, the clinician increases the duration of the S^Δ component relative to the duration of the S^D component, which results in longer periods of reinforcer unavailability (Betz et al., 2013; Hagopian, Toole, Long, Bowman, & Lieving, 2004).

A chained schedule is similar to a multiple schedule in that one component signals when the FCR will result in reinforcement (S^D) and another component signals when the FCR will result in extinction (S^Δ). However, a chained schedule differs from a multiple schedule in that transitioning from the S^Δ component to the S^D component depends on the individual satisfying a response requirement (e.g., completing 5 math problems), rather than on the passage of time. Therefore, in order to thin the schedule of reinforcement using a chained schedule, the clinician increases the response requirement during the component with the S^Δ, resulting in the individual completing additional responses in order to access a period of reinforcer availability (i.e., demand fading; Fisher et al., 1993). Given this difference, chained schedules are often used when treating destructive behavior maintained by social-negative reinforcement (i.e., escape from demands), and multiple schedules are often used when treating destructive behavior maintained by social-positive reinforcement (e.g., access to tangibles; Hagopian et al., 2011; Saini et al., 2016).

One challenge that often arises in clinical settings is that destructive behavior may be evoked and maintained by multiple environmental variables (i.e., multiply controlled destructive behavior; Bachmeyer et al., 2009; Beavers & Iwata, 2011; Lalli & Casey, 1996; Smith, Iwata, Vollmer, & Zarcone, 1993). In general, when destructive behavior is multiply controlled, clinicians typically develop a function-based intervention for each individual function (e.g., Bachmeyer et al., 2009; cf. Adelinis, Piazza, & Goh, 2001 for an exception). However, when destructive behavior is maintained by both social-positive and social-negative reinforcement, combining interventions that address each function individually may be difficult when the clinician commences reinforcement schedule thinning because different schedule-thinning arrangements are indicated (i.e., using a multiple schedule for the social-positive function but using a chained schedule for the social-negative function). One option is to introduce FCT schedule thinning for each function separately (e.g., Borrero & Vollmer, 2006). Another option is to combine (or synthesize) all of the functional reinforcers into a single contingency in baseline and treatment, with all functional reinforcers delivered contingent on (a) problem behavior in baseline and (b) the FCR during treatment (e.g., Falcomata, White, Muething, & Fragale, 2012; Hanley, Jin, Vanselow, & Hanratty, 2014). With this latter option, reinforcement schedule thinning typically involves a chained schedule in which the individual is required to complete a progressively increasing number of demands before they can request the combined reinforcers via a single FCR.

Although researchers have used separate and combined interventions to treat multiply controlled destructive behavior, little is known about client preference for each option. Assessment of client preference is important for client autonomy and ensures the individual is included in the social-validation processes (Hanley, 2010). In addition, incorporating choice opportunities has been shown to increase engagement and reduce destructive behavior (Dunlap et al., 1994).

Previous research on client preference has shown that individuals may prefer FCT over response-independent schedules (Hanley, Piazza, Fisher, Contrucci, & Maglieri, 1997), and that individuals may prefer FCT with punishment compared to FCT without punishment (Hanley, Piazza, Fisher, & Maglieri, 2005). In the latter study, researchers hypothesized that participant preference for FCT with punishment resulted from a higher probability of reinforcement in this condition compared to when punishment was not included (i.e., FCT without punishment).

Researchers have extensively studied participant choices between concurrently available alternatives, and results have generally supported the hypothesis that choice behavior is a function of the relative rates of reinforcement obtained for each response option per the matching law (Baum, 1974; Herrnstein, 1961). In addition to reinforcement rate, other parameters of reinforcement (e.g., quality; Neef, Mace, Shea, & Shade, 1992) and the relative effort associated with each response option can influence choice responding (e.g., Piazza, Roane, Keeney, Boney, & Abt, 2002). We may expect that all else being equal, an individual will be more likely to prefer response options that are low effort and reliably result in an immediate and high-quality reinforcer.

The purpose of the current study was to treat destructive behavior maintained by both social-positive (i.e., access to tangibles) and social-negative (i.e., escape from demands) reinforcement in an individual diagnosed with autism spectrum disorder (ASD) using FCT and FCT schedule thinning. Additionally, at various times throughout the schedule-thinning process for the escape function, we assessed client preference for FCT arrangements that included a multiple schedule (i.e., a time-based, compound schedule) or a chained schedule (i.e., a response-based, compound schedule).

Method

Participant, Setting, and Materials

Samantha, a 12-year-old girl diagnosed with ASD and mild intellectual disability referred for the assessment and treatment of aggression, self-injury, and property destruction, participated. We conduced all sessions in a therapy room at a university-affiliated program that specializes in the assessment and treatment of severe destructive behavior, which Samantha attended 5 days per week for 3 hours per day. We conducted sessions in a 3-m by 3-m padded therapy room equipped with a one-way observation window and two-way intercom system. Each context contained a table, chairs, and leisure items or demand materials depending on the condition. We included preferred leisure items in some conditions (described below) that we identified based on the results of a paired-stimulus preference assessment (Fisher et al., 1992), which was informed by caregiver report (Fisher, Piazza, Bowman, & Amari, 1996). Finally, we included demand materials in the escape condition (also described below) based on demands the caregiver reported to be delivered in the home and at school.

Response Measurement, Interobserver Agreement, and Procedural Integrity

Trained observers used a specialized data-collection program (Bullock, Fisher, & Hagopian, 2017) on laptop computers to collect data on participant and therapist behavior. The primary dependent variables included the frequencies of destructive behavior, correct FCRs, and compliance. *Destructive behavior* consisted of aggression (hitting, grabbing, pushing, kicking, or scratching), self-injury (head banging, biting hand or arm, or head or body hitting), and disruption (kicking or hitting surfaces or overturning objects). For each session, we summed the frequencies of aggression, self-injury, and disruption and divided the total by the session duration (in min) to calculate the rate of destructive behavior. *FCRs* consisted of Samantha placing in the therapist's hand a picture the size of an index card showing Samantha consuming the targeted functional reinforcer for destructive behavior.

Data collectors scored a *correct FCR* if Samantha emitted the FCR independently during the S^D component and an *incorrect FCR* if Samantha emitted the FCR independently during either the S^Δ component or during the reinforcement interval. Therapists calculated the percentage of correct FCRs by dividing the frequency of correct FCRs by the number of correct plus incorrect FCRs and then converting the resulting quotient to a percentage. *Compliance* consisted of Samantha responding correctly within 5 s of either an initial demand or the immediately following demand with a model prompt when therapists implemented two-step (verbal, model) prompting. We calculated the percentage of demands with compliance per session by dividing the frequency of compliance by the total number of demands and then converting the resulting quotient to a percentage.

A second independent observer collected data simultaneously with the primary observer on 32% of sessions. To calculate interobserver agreement (IOA), we first divided each session into successive 10-s intervals and scored an agreement for only those intervals in which both observers scored the same number of responses (i.e., exact agreement within the interval). We then divided the number of intervals with agreement by the total number of intervals for each session and then converted the resulting quotient to a percentage. Agreements averaged 100% for aggression, 100% for self-injury, 96% (range, 70% to 100%) for disruption, 98% (range, 93% to 100%) for correct FCRs, 100% for incorrect FCRs, and 96% (range, 63% to 100%) for compliance.

We assessed procedural integrity during an average of 31% (range, 28% to 43%) of sessions in each condition selected at random using the random-number generator available at www.random.org. During baseline sessions, we scored the therapist's delivery of the targeted functional reinforcer within 5 s of destructive behavior as a correct reinforcer delivery. We scored failing to deliver the functional reinforcer within 5 s of destructive behavior or delivering that reinforcer at another time as an incorrect reinforcer delivery in baseline sessions. We calculated procedural integrity for baseline sessions by dividing the number of correct reinforcer deliveries by the number of correct plus incorrect reinforcer deliveries and then converting the resulting quotient to a percentage.

During treatment, we scored a correct implementation if the therapist delivered the targeted functional reinforcer within 5 s of a correct FCR and if they also withheld the targeted functional reinforcer for at least 3 s following any destructive behavior or incorrect FCRs (e.g., during the S^{Δ}). If the therapist failed to implement either of these contingencies correctly, we scored this as an incorrect implementation. Additionally, if the therapist delivered the targeted functional reinforcer following a correct FCR that occurred within 3 s of destructive behavior (during a changeover delay [COD; see below]), we also scored this as an incorrect implementation. We calculated procedural integrity for treatment sessions by dividing the number of correct implementations by the number of correct plus incorrect implementations and then converting the resulting quotient to a percentage.

For baseline, FCT, and schedule-thinning sessions for treating the tangible function, procedural integrity averaged 98.6% (range, 95.8% to 100%). For baseline, FCT, and schedule-thinning sessions for treating the escape function, procedural integrity was 100%.

Functional Analysis

We implemented functional-analysis (FA) procedures similar to those described by Iwata, Dorsey, Slifer, Bauman, and Richman (1982/1994) with the reinforcer-duration modifications described by Fisher, Piazza, and Chiang (1996). Several therapists conducted FA sessions, and we programmed condition-correlated stimuli (i.e., unique shirt colors worn by the therapist) for each condition (Conners et al., 2000). Prior to each session, the therapist prompted Samantha to label the color of the shirt by asking, “What color is my shirt?” If Samantha failed to respond accurately within 5 s, the therapist labeled the shirt color (e.g., “My shirt is red”) and began session. All FA sessions lasted 5 min.

Toy Play—Throughout the toy-play condition, the therapist delivered continuous attention without demands and access to high-preference items (i.e., iPad, Thomas the Tank Engine books, and stuffed animals). Approximately every 30 s, the therapist provided descriptive praise for appropriate play (e.g., “I like how nicely you are playing with the iPad, Samantha”). The therapist provided no programmed consequences for destructive behavior.

Tangible (standard)—Prior to the tangible (standard) condition, the therapist provided Samantha approximately 1-min access to preferred leisure items. The tangible (standard) condition began with the therapist removing the leisure items and informing Samantha that it was, “My turn.” The therapist did not interact with the leisure items during this time. Contingent on destructive behavior, the therapist redelivered the leisure items for 20 s.

Tangible (enhanced EO)—We used procedures for this condition identical to those in the tangible (standard) condition, except the therapist interacted with Samantha’s preferred leisure items when the therapist retained access to them. Specifically, the therapist interacted with the preferred leisure items in ways that Samantha did not typically engage with them and did so enthusiastically in an attempt to enhance the relevant establishing operation (EO) for terminating therapist leisure-item interaction and/or acquiring the leisure item.

Attention—Prior to the attention condition, the therapist delivered approximately 1-min access to preferred forms of attention (e.g., conversations of or singing about preferred activities). The attention condition began with the therapist removing their attention and telling Samantha that they had work to do but that she could play with the moderately preferred toy in the room. Contingent on destructive behavior, the therapist resumed their attention delivery for 20 s.

Escape—The therapist presented demands (e.g., clean-up toys, fold clothes, two-digit addition and subtraction) reported by the caregiver to evoke destructive behavior using a two-step (verbal, model) prompting sequence. If Samantha complied with the demand, the therapist provided brief descriptive praise (e.g., "Nice job writing your name"). Contingent on destructive behavior, the therapist said, "Okay, you can take a break," removed all demand materials, and provided a 20-s break.

FCT Evaluation and Schedule Thinning

Samantha's therapist conducted baseline sessions consisting of the tangible and escape conditions from Samantha's FA. Therapists then taught Samantha to request tangibles and escape during each respective FCT evaluation by exchanging FCR cards specific to each functional reinforcer. Following FCT, Samantha progressed to FCT schedule thinning. We conducted schedule thinning in separate contexts across the tangible and escape functions, each of which was associated with a unique, condition-correlated stimulus. Throughout schedule thinning, therapists placed destructive behavior on extinction, while FCRs produced 20-s access to the functional reinforcer (i.e., access to tangible or escape from demands). In both the tangible and escape contexts, therapists signaled the availability (S^D) and unavailability (S^Δ) of the targeted functional reinforcer across all FCT sessions and thinned the reinforcement schedule following two consecutive sessions with destructive behavior at or below an 85% reduction from its respective baseline mean. Schedule thinning progressed first in the tangible context and ended when Samantha reached an S^Δ component duration of 4 min. Schedule thinning in the escape context progressed later and ended when she complied with demands that corresponded to a FR-40 schedule. Throughout schedule thinning, the S^D component lasted 1 min in both contexts.

Baseline—Samantha's therapist implemented all tangible and escape sessions as described for the FA conditions above. Sessions lasted 5 min.

FCT—Pretraining each FCR consisted of teaching Samantha to exchange one FCR card to access leisure items and to exchange another FCR card to escape demands. The therapist did this by presenting the EO for destructive behavior (i.e., withholding the leisure items or presenting demands) while simultaneously prompting Samantha to emit the FCR. Samantha's FCR consisted of handing the therapist one of two index-sized cards showing Samantha consuming each respective reinforcer (i.e., playing with leisure items or receiving a break from demands). Each FCR resulted in 20-s access to the corresponding functional reinforcer. FCT pretraining sessions lasted ten trials each, and we used a progressive prompt delay to transfer stimulus control from the controlling prompt (i.e., physical guidance) to the presentation of the EO. Destructive behavior was placed on extinction during pretraining and extinction continued throughout treatment for all cases. To prevent adventitious reinforcement, therapists implemented a 3-s COD (Herrnstein, 1961) between instances of destructive behavior and the delivery of the functional reinforcer following the FCR. We increased the prompt delay after every two consecutive sessions with low to zero levels of destructive behavior until Samantha emitted the FCR independently for at least 80% of trials for at least four consecutive sessions. We discontinued all prompts for Samantha to emit the FCR following FCT pretraining. Subsequent FCT sessions lasted 5 min.

FCT Schedule Thinning—We conducted FCT schedule thinning for both FCRs in separate contexts, each associated with unique, condition-correlated stimuli. Therapists wore a yellow shirt and we covered the lights in the room with a yellow filter, resulting in the walls and floor reflecting a yellow hue in the tangible context. Therapists wore a blue shirt and we covered the lights with a blue filter in the escape context. We arranged mult FCT for schedule thinning the FCT intervention for the tangible function and chain FCT for schedule thinning the FCT intervention for the escape function. In addition to the COD described above, we added a second 3-s COD to prevent adventitious reinforcement of destructive behavior or the FCR produced by the transition from the S^{Δ} to the S^{D} following the occurrence of either response. Therapists delayed the presentation of the S^{D} if either destructive behavior or the FCR occurred within 3 s of a scheduled transition. Sessions lasted 5 min.

Mult FCT: During mult-FCT sessions, therapists signaled the availability of the leisure items for the FCR by displaying the pink side of a rubber bracelet worn around the therapist's wrist (i.e., the S^{D}). Therapists signaled the unavailability of the leisure items by flipping the bracelet from the pink to the black side (i.e., the S^{Δ}). Thinning the multiple schedule consisted of increasing the duration of the S^{Δ} component while holding the duration of the S^{D} component constant at 60 s. FCRs resulted in access to preferred leisure items for the remainder of the S^{D} component. We programmed the initial S^{Δ} component to last 2 s. Following at least two consecutive sessions with levels of destructive behavior at or below an 85% reduction from baseline levels, we systematically increased the duration of the S^{Δ} component. Following mastery at each schedule-thinning step, we conducted terminal-schedule probes (i.e., 240 s) to determine whether rapid schedule thinning could be accomplished without disrupting the efficacy of the FCT intervention. Once we observed low levels of destructive behavior with the terminal-schedule probe, all subsequent S^{Δ} durations lasted 240 s. Sessions lasted 5 min.

Chain FCT: During chain-FCT sessions, therapists signaled the unavailability of escape for the FCR by displaying the white side of a rubber bracelet worn around the therapist's wrist (i.e., the S^{Δ}). Thinning the chained schedule consisted of increasing the number of demands with which Samantha needed to comply before escape became available for the FCR, which therapists signaled by flipping the bracelet from the white to the pink side (i.e., the S^{D}). The duration of the S^{D} component remained 60 s throughout schedule thinning. FCRs resulted in a break with preferred leisure items for the remainder of the S^{D} component. We began with an FR-1 schedule for compliance and systematically increased the response requirement using a geometric progression (FR 1, FR 2, FR 5, FR 10, FR 20, and FR 40) following at least two sessions with low levels of destructive behavior and moderate-to-high levels of compliance. The final chain-FCT schedule of 60 s spent in the S^{D} component and an S^{Δ}

component consisting of an FR 40 closely approximated the final mult-FCT schedule of 60 s spent in the S^D component and 240 s spent in the S^Δ component; however, some chain-FCT sessions extended beyond a 240-s S^Δ to ensure that Samantha met the FR-40 response requirement and contacted reinforcement. Therefore, some of the session durations during chain FCT at the FR-40 response requirement exceeded the typical 5-min session duration (i.e., up to 10 min in duration).

Assessing Preference for Treatment Condition—Throughout chain-FCT schedule thinning, we assessed Samantha's preference for either the terminal mult-FCT condition (i.e., 60-s S^D/240-s S^Δ) or the chain-FCT condition with the current response requirement (i.e., 60-s S^D/FR-1, FR-2, FR-5, FR-10, FR-20, or FR-40 S^Δ). Preference-assessment trials consisted of two therapists standing side by side outside of the session room, each wearing the condition-correlated discriminative stimuli associated with the two FCT interventions (i.e., Therapist 1 wearing a yellow shirt with black and pink bracelet for mult FCT; Therapist 2 wearing a blue shirt with white and pink bracelet for chain FCT). A third, neutral therapist guided Samantha to face the session room door and stand between the other two therapists. We counterbalanced therapist assignment and condition across left and right locations. The neutral therapist prompted Samantha to label the color of the shirt and the discriminative stimuli and to describe the associated contingencies for each alternative. For the mult-FCT condition, the neutral therapist prompted Samantha to label the color, "Yellow" and describe, "When the bracelet is pink, I can exchange the card and get my toys. When the bracelet is black, I have to wait." For the chain-FCT condition, the neutral therapist prompted Samantha to label the color, "Blue" and describe, "When the bracelet is white, I need to work. When the bracelet is pink, I can exchange the card and get my toys." If Samantha incorrectly described the colors or the rules, the neutral therapist required Samantha to restart the process of labeling the color and describing the contingencies until she accurately described them both within a single attempt. Following the accurate labeling of colors and contingencies for each condition, the neutral therapist prompted Samantha to, "Pick a color."

Guided choice: We initially conducted three guided-choice trials for each treatment condition for a total of six guided-choice trials. During guided-choice trials, immediately after the neutral therapist instructed Samantha to "Pick a color," the therapist guided her to the pre-determined condition and vocally stated the color (e.g., "We are going to choose Yellow") before Samantha could respond. The session therapist then guided Samantha to the session room and conducted the procedures for the pre-determined condition. These initial six guided-choice trials provided Samantha with a recent exposure to the terminal mult-FCT condition (i.e., 240 s S^Δ and 60 s S^D) and to the FR-1 response requirement of the chain-FCT condition. We conducted subsequent guided-choice trials following each free-choice trial. During these subsequent guided-choice trials we always guided Samantha to select the chain-FCT schedule in order to expose her to the current response requirement. Data from guided-choice trials are available upon request but are not displayed in the results.

Free choice: During free-choice trials, the neutral therapist instructed Samantha to, "Pick a color." Following Samantha's selection, the session therapist guided Samantha to the session room and conducted the procedures for the selected condition. If Samantha selected the chain-FCT condition, the programmed response requirement was the same as that experienced in the immediately preceding guided-choice trial.

Results

Figure 1 depicts the results of Samantha's FA of tangible items (top panel) and her FA of escape and attention (bottom panel). These data suggest that both access to preferred tangibles and escape from demands reinforced Samantha's destructive behavior. Figure 2 depicts the results of Samantha's FCT evaluations in which we taught two FCRs – one to access tangibles (top panel) and another to escape demands (bottom panel). These data suggest that FCT was effective at reducing rates of destructive behavior and at maintaining moderate rates of the FCR across Samantha's tangible and escape functions.

Figure 3 depicts the results of baseline and mult-FCT schedule thinning in the yellow context. During baseline, we observed high rates of destructive behavior. During mult-FCT schedule thinning, we observed low rates of destructive behavior and an initially decreasing percentage of correct FCRs, as the S^{Δ} component increased from 0 s to 2 s. We then conducted a probe of the terminal S^{Δ} component (i.e., 240 s) following mastery at the 2-s S^{Δ} component, which produced an increased rate of destructive behavior and a low percentage of correct FCRs. We then continued with schedule thinning by increasing the S^{Δ} component to 4 s and observed zero instances of destructive behavior and high levels of correct FCRs. Following another failed terminal schedule probe, we continued with schedule thinning by programming an 8-s S^{Δ} component, which reestablished the treatment effects. We conducted another terminal schedule probe following mastery at the 8-s S^{Δ} component and observed maintained low rates of destructive behavior and high levels of correct FCRs across the final eight sessions at the terminal schedule. These data indicate that treatment effects maintained even as mult FCT was rapidly thinned from an 8-s S^{Δ} component to the terminal, 240-s S^{Δ} component.

The top two panels of Figure 4 depict the results of Samantha's performance under (a) schedule thinning of the chain-FCT condition (top panel) and (b) the terminal schedule of the mult-FCT condition (middle panel). As can be seen in the top panel, Samantha showed (a) high percentages of compliance (M = 96.7%; range, 75% to 100%); (b) zero rates of destructive behavior, except for the last session (Session 42); and (c) decelerating rates of the FCR, which negatively correlated with the response requirement in effect for the chained schedule. As indicated in the middle panel, Samantha showed zero destructive responses and low but stable rates of the FCR (M = .2) throughout the multiple schedule. In addition, during the guided-choice trials Samantha displayed zero rates of destructive behavior in all but three of the sessions (data available from the corresponding author). Thus, both the multiple and chained schedule effectively maintained zero or near-zero levels of destructive behavior and maintained practical levels of the FCR.

The bottom panel of Figure 4 shows Samantha's preferences for the chained and multiple schedules when we held the multiple schedule constant at the terminal schedule (60-s S^{D} periods alternated with 240-s S^{Δ} periods) and progressively increased the response requirement for the chained schedule. In the first phase, we started with an FR 1 and ended with an FR 40 (FR 1, FR 2, FR 5, FR 10, FR 20, FR 40). In the second phase, we started with an FR-5 schedule and ended with an FR 40. White bars indicate that Samantha chose the chained schedule during that session and black bars indicate that she chose the multiple schedule. The height of each bar depicts the proportion of time spent in reinforcement during the selected condition. As can be seen, during the sessions with low response requirements (FR 1, FR 2, FR 5), Samantha always chose the chained schedule, as the chained schedule produced a higher proportion of time spent in reinforcement at these low response requirements. However, as the response requirement increased further (FR 10, FR 20, FR 40), Samantha increasingly chose the multiple schedule, as the multiple schedule produced a higher proportion of time in reinforcement than the chained schedule at these higher response requirements. Finally, we calculated a Pearson correlation coefficient between the schedule requirements of the chained schedule (FR 1 to FR 40) and the proportion of times Samantha chose the multiple schedule, which produced a correlation coefficient of .89 ($p < .05$), indicating that as the schedule requirement increased, so did the probability that Samantha chose the multiple schedule.

Finally, when Samantha chose the multiple schedule, she accessed reinforcement during an average of 17.6% (range, 15.4% to 20.0%) of the session. When she chose the chained schedule, she accessed reinforcement during 64.1%, 63.9%, 42.6%, 28.0%, 21.8%, and 17.4% of the sessions for the FR 1, FR 2, FR 5, FR 10, FR 20, and FR 40, respectively. Thus, Samantha showed a clear preference for the chained schedule when it produced more than twice as much session time in reinforcement (i.e., with an FR 1, FR 2, or FR 5). However, once the chained schedule produced only 53.8% and 19.7% more reinforcement time than the multiple schedule, during the FR 10 and FR 20, respectively, Samantha showed a slight preference for the multiple schedule despite the fact that the multiple schedule resulted in less reinforcement time. Thus, Samantha's preference shifted toward the multiple schedule before it produced a higher amount of reinforcement time than the chained schedule. Finally, when the chained schedule produced .2% less reinforcement time than the multiple schedule (i.e., with an FR 40), Samantha showed a clear and sustained preference for the multiple schedule, even though it produced only slightly more reinforcement time than the chained schedule.

Figure 5 shows the relation between the proportion of reinforcement time produced by choosing the multiple schedule (x-axis) and the proportion of multiple-schedule choices (y-axis). As can be seen, as the relative proportion of reinforcement time produced by choosing the multiple schedule increased, the proportion of choices allocated to the multiple schedule increased in a linear fashion.

We also conducted a least-squares regression analysis on logarithmic transformations of these data using the generalized matching law (i.e., $log\left(\frac{B_1}{B_2}\right) = a_r log\left(\frac{R_1}{R_2}\right) + log\ b$). Results showed a significant effect for the slope of the regression line (parameter *a*; $t = 5.6$; $p < .005$), indicating that the observed linear relation between the relative proportion of reinforcement time produced by the multiple schedule and the proportion of choices Samantha allocated to the multiple schedule reached statistical significance. In addition, results failed to show a significant effect for the intercept of the regression line (parameter *b*;

$t = 1.6$; $p > .15$), indicating that the small observed bias for the multiple schedule over the chained schedule did not reach statistical significance. Overall, the generalized matching law accounted for 89% of the variance in the relative proportions of choices between the multiple and chained schedules made by Samantha.

Discussion

Teaching separate FCRs to escape demands and access preferred leisure items effectively reduced multiply maintained destructive behavior for one participant diagnosed with ASD and mild intellectual disabilities. The treatment effects maintained even as we thinned the schedules of reinforcement for the FCR using a multiple schedule for the tangible function and a chained schedule for the escape function. Additionally, we periodically assessed the participant's preference for the two schedules (i.e., multiple schedule and chained schedule) as we conducted reinforcement schedule thinning for the chain-FCT schedule. With low response requirements for the chained schedule (FR 1 through FR 5), Samantha always chose chain FCT rather than mult FCT, which we conducted at the terminal schedule (60-s S^D/240-s S^Δ) throughout this analysis. However, once the response requirement within chain FCT reached an FR 10, Samantha began to alternately select chain FCT and mult FCT. Moreover, when the response requirement for the chained schedule reached an FR 40, Samantha chose mult FCT over chain FCT over 80% of the time.

Interestingly, Samantha's choices for the two compound schedules closely corresponded to the relative amounts of reinforcement produced by the two response options, per the generalized matching law, but she showed a somewhat uncommon form of deviation from the matching law referred to as overmatching (Baum, 1974, 1979; Fisher & Mazur, 1997). Overmatching is said to occur when relative response rates (Response A, 75%; Response B, 25%) are further from the midpoint (50%) than their associated reinforcement rates (Reinforcer A, 60%; Reinforcer B, 40%). When overmatching is present, the regression line for the participant's choice allocation has a greater slope than the matching line and that choice-allocation line crosses the matching line (i.e., the matching line is the 45° line corresponding to perfect matching in which each increase in the relative rates of reinforcement produces an equal increase in the relative response rates (see Figure 5; Baum, 1974, 1979; Fisher & Mazur, 1997).

That is, Samantha exclusively chose the chain-FCT condition when the available magnitude of reinforcement favored that compound schedule by a factor of two to three (i.e., when the response requirement ranged from an FR 1 to an FR 5). She showed a slight preference for the multiple schedule when the available magnitude of reinforcement actually slightly favored the chained schedule (choosing the multiple schedule 57% and 55% of the time during the FR 10 and FR 20 chained schedules, respectively, when that schedule produced 39% and 45% of the obtained reinforcement, respectively). Finally, Samantha primarily chose mult-FCT when the available magnitude of reinforcement slightly favored that compound schedule (choosing the multiple schedule 80% of the time when it produced 50.2% of the obtained reinforcement with an FR 40 response requirement in chain FCT). As mentioned above, this pattern of choice allocation is consistent with the behavioral phenomenon referred to as overmatching.

We hypothesize that Samantha's preference for the multiple schedule over the chained schedule is related to the escape function for her destructive behavior (recall that her destructive behavior was maintained by both positive [tangible] and negative [escape] reinforcement). That is, given that she engaged in destructive behavior to escape nonpreferred demands, it is not surprising that she also chose the multiple schedule (which did not include nonpreferred demands) over the chained schedule (which did include nonpreferred demands), even when the chained schedule produced somewhat more positive-reinforcement time than the multiple schedule.

The current findings have several implications for clinical practice that are worthy of discussion. For instance, multiply maintained destructive behavior can pose a special challenge for clinicians. When destructive behavior is maintained by social-positive reinforcement, schedule thinning is often achieved using a multiple schedule (e.g., Hanley et al., 2001). However, using a multiple schedule when behavior is maintained by social-negative reinforcement may be problematic because alternation between the schedule components is time dependent rather than response dependent. Without a response contingency, compliance may not increase because compliance is not necessary in order to access reinforcement in a multiple schedule (cf. Lomas, Fisher, & Kelley, 2010; Mevers, Fisher, Kelley, & Fredrick, 2014). Therefore, a chained schedule is generally the preferred compound schedule for thinning the schedule of reinforcement for destructive behavior maintained by social-negative reinforcement.

In the present evaluation, we chose to treat each function separately based on information provided by Samantha's caregivers (i.e., we used mult FCT to target the tangible function and chain FCT to target the escape function of Samantha's destructive behavior). That is, her caregivers reported that they wanted Samantha to learn to wait calmly for access to a preferred item at certain times (e.g., during unstructured play) and to complete work activities before gaining access to preferred items at other times (e.g., during structured learning activities). Therefore, we initially introduced FCT to address Samantha's tangible function in isolation, and then we rapidly increased the length of the S^{Δ} from 8 s to 240 s using a multiple schedule in order to teach her to wait calmly during unstructured play.

Once we observed low and stable rates of destructive behavior at the terminal schedule during mult FCT, we then introduced chain FCT to treat Samantha's escape function in order to teach her to complete work activities prior to accessing preferred items. Although we systematically thinned the chained schedule to an FR 40, we observed the most consistent treatment effects at an FR 20. After consultation with Samantha's caregivers, we determined that the FR 20 was a sufficiently lean schedule to meet demand requirements typically placed on Samantha at home and in school. These findings replicate previous research demonstrating that both mult FCT and chain FCT represent effective procedures for thinning the schedule of reinforcement to a practical level (i.e., one that can be maintained by caregivers in the natural environment) while maintaining low levels of destructive behavior (e.g., Betz et al., 2013; Greer et al., 2016; Saini et al., 2016).

Throughout schedule thinning with chain FCT, we periodically assessed Samantha's preference for either mult FCT (at the terminal schedule) or chain FCT (at the current response requirement). When two or more treatments effectively reduce destructive behavior under lean and practical schedules of reinforcement, assessment of client preference for the alternative treatments has a number of important clinical implications. First and foremost, assessment of client preference provides an opportunity for the client's preference to be considered when deciding on the final treatment recommendations. In addition, assessing client preferences for various treatment options provides an important measure of social validity (Wolf, 1978). Further, because Samantha's caregivers deemed it necessary for her to calmly wait during some reinforcer-unavailable periods and to work in others, we included both mult FCT and chain FCT in her final recommendations. Despite this caregiver requirement, we still used the outcomes from the concurrent-chains procedure to inform our final recommendations. Samantha's almost exclusive preference for mult FCT, once the response requirement was an FR 40 in chain FCT, combined with caregiver input and observed levels of destructive behavior, informed the final response requirement for chain FCT.

In addition, Samantha's destructive behavior appeared to be slightly less probable when we allowed her to choose between the two compound schedules, consistent with prior research (e.g., Vaughn & Horner, 1997). That is, we observed that during sessions in which we allowed Samantha to choose the treatment (mult FCT or chain FCT), she rarely displayed destructive behavior (i.e., she displayed destructive behavior in just one session in which she chose chain FCT). The other three sessions in which we observed increased levels of destructive behaviour followed guided-choice trials for chain FCT at lean schedules after Samantha had previously selected away from this condition. Therefore, it is possible that clinicians could use concurrent-choice arrangements similar to the one used in the current investigation to identify the relevant "break point" of a chained schedule used for reinforcement schedule thinning during FCT (i.e., the point at which a chained schedule no longer exclusively maintains the appropriate alternative response; cf. Johnson & Bickel, 2006). Identifying and avoiding break points in this manner may be particularly useful for clinicians working in settings where clients engage in dangerous instances of severe destructive behavior. As previously mentioned, Samantha's choice allocation corresponded reasonably well to the predictions of the generalized matching law. A number of previous researchers have suggested that clinicians may use the matching law in everyday practice (Fisher & Mazur, 1997; Reed & Kaplan, 2011). Our findings suggest the matching law may provide valuable insight into strategies that may be used to increase the likelihood that an individual will choose to work, even if the individual has a history of destructive behavior maintained by escape from demands.

Samantha was an older and physically larger client; thus, implementing traditional escape extinction with her proved extremely difficult and not feasible for her caregivers. Therefore, instead of implementing traditional escape extinction using three-step guided compliance, which includes physical guidance to ensure compliance, we used a modified two-step prompting procedure which did not include physical guidance. Previous research has demonstrated that manipulating various dimensions of reinforcement can lead to a decrease in destructive behavior even in the absence of extinction (e.g., Athens & Vollmer, 2010). Our findings align with and extend previous research by demonstrating that chain FCT, using two-step prompting, can effectively reduce multiply maintained destructive behavior, and may also be preferred by a client when completion of the response requirement produces escape and access to a highly preferred positive reinforcer. Therefore, the procedures used in the current investigation may be useful for clinicians when working with clients for which physical guidance may be dangerous or difficult to implement.

Determining the appropriate density of reinforcement is another common challenge for clinicians. Although very dense schedules of reinforcement are likely to reduce destructive behavior, schedule thinning is often necessary in order for a treatment to be practical for the natural environment (e.g., continuous access to a preferred item may interfere with social interaction or other learning opportunities, reinforcing compliance on an FR 1 may result in very few demands being completed during a work interval). As the schedule is thinned it is important to consider the response requirement in relation to the amount of reinforcement delivered (i.e., unit price). Unit price is a concept stemming from the field of behavioral economics and refers to the expenditure given for a particular amount of a commodity (Roane, Falcomata, & Fisher, 2007). Specifically, it is predicted that as the unit price of a reinforcer increases, responding for that reinforcer will decrease under a concurrent-choice arrangement (Madden, Bickel, & Jacobs, 2000). Therefore, within our clinical evaluation, we consistently maintained a 4:1 ratio for the duration of S^{Δ} component relative to the duration of S^{D} component. This means that when we thinned the schedule reinforcement for the multiple schedule (i.e., increased the S^{Δ} component), we ensured the duration of the S^{D} equaled at least ¼ of the duration of the S^{Δ} (e.g., 60-s S^{D}/240-s S^{Δ}). Similarly, within chain FCT, we calculated the length of time Samantha required to complete the response requirement during the S^{Δ} component and adjusted the duration of the S^{D} component so that it lasted approximately ¼ of the duration of the S^{Δ} component.

Although this ratio of work to reinforcement time proved effective with Samantha, future researchers should conduct additional research on the effects of unit price during reinforcement schedule thinning. Finally, responding during the concurrent-chains procedure also may provide useful information related to the ideal reinforcement magnitude ratio. That is, if the clinician observes that the individual is consistently choosing the multiple schedule in order to avoid nonpreferred tasks, they could either decrease the work requirement or increase the duration of the S^{D} component of the chained schedule so that it is appreciably longer than the S^{Δ} component. Such manipulations should function to shift the individual’s choices in the desired direction so that the individual is completing a reasonable amount of work. Future researchers should evaluate procedures for manipulating response requirements and/or reinforcement magnitudes used in mult FCT and chain FCT in order to shift client-choice allocations to produce the optimal mix of multiple schedules that promote waiting behavior and chained schedules that promote task completion.

The current findings should be interpreted cautiously and in relation to several limitations of this study. First, we only included one participant in this evaluation and therefore the generality of our findings remains unknown. In particular, the procedures used in the current study may be less effective for participants with a less developed verbal repertoire than Samantha. For instance, Samantha accurately stated the contingencies in effect prior to each session, and this verbal behavior may have functioned as rule-governed behavior that effectively bridged the delay to reinforcement (Skinner, 1966, 1969). Future researchers should evaluate the efficacy of the current procedures with more participants, and in particular, with participants with more limited verbal repertoires than Samantha.

Another limitation of the current study is that we did not isolate and evaluate the effects of the preferred leisure item that we presented during the S^D component of chain FCT (cf. Piazza et al., 1997). That is, the S^D component of chain FCT involved both positive reinforcement (access to the tangible item) and negative reinforcement (escape from nonpreferred demands). We included access to the tangible item during the chained schedule because it is common for individuals to access preferred items following completion of work activities in the natural environment, and Samantha's caregivers endorsed provision of preferred items during break periods for both the home and school environments. However, future researchers should further assess these contingencies separately to more precisely determine the effects of combining positive and negative reinforcement during reinforcement schedule thinning with chain FCT.

Acknowledgments

Grants 5R01HD079113 and 5R01HD083214 from the National Institute of Child Health and Human Development provided partial support for this research.

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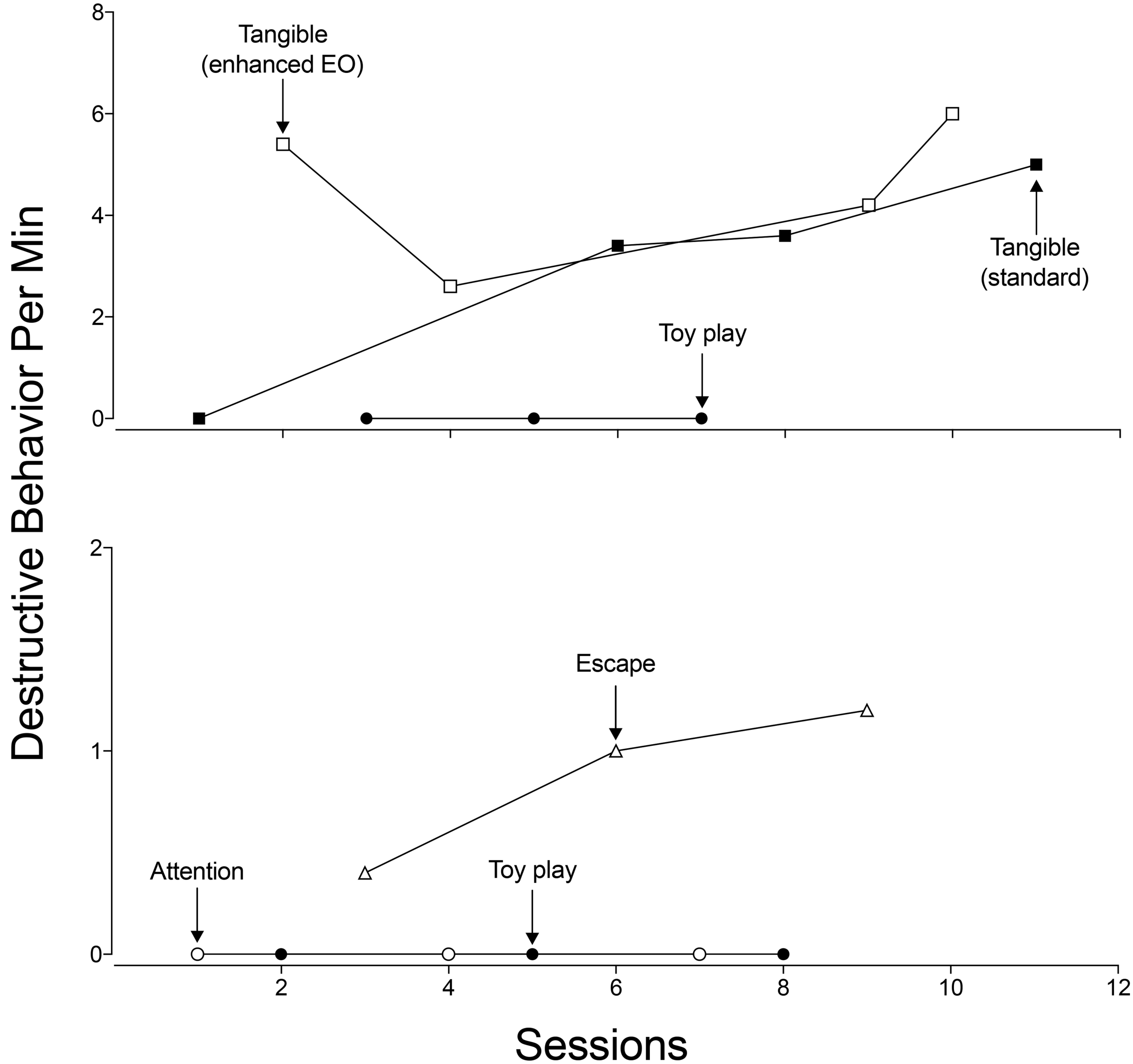

Figure 1.
Rates of destructive behavior during Samantha's FA of tangible items (top panel) and her FA of escape and attention (bottom panel).

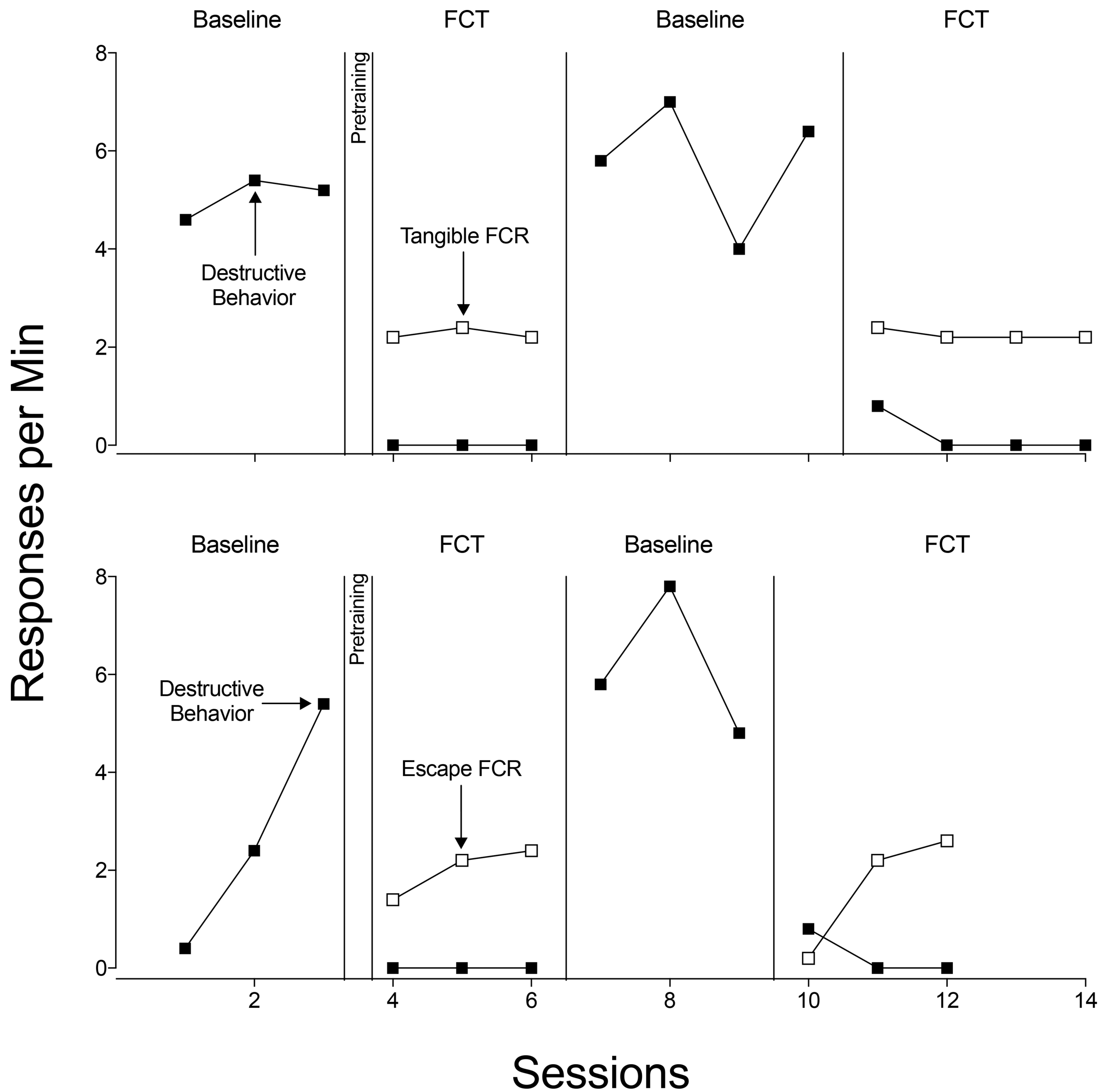

Figure 2.
Rates of destructive behavior and FCRs during FCT evaluations for Samantha's tangible (top panel) and escape (bottom panel) functions of destructive behavior.

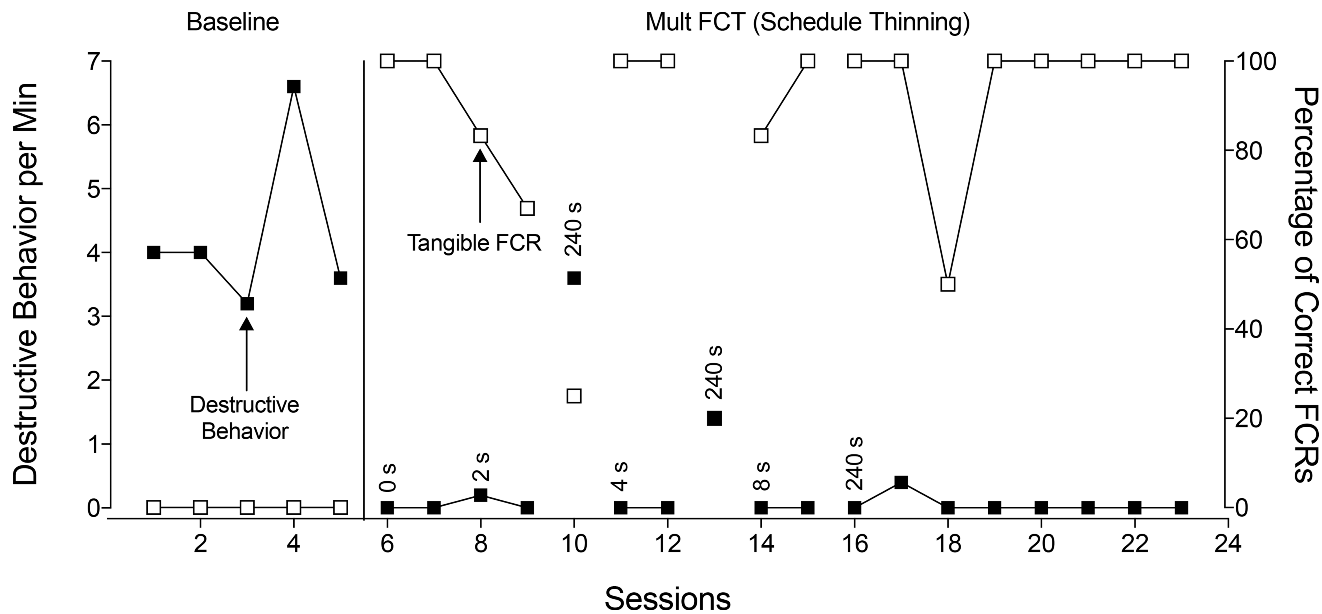

Figure 3.

Rates of destructive behavior and percentage of correct FCRs for tangible items across baseline and mult-FCT schedule thinning, as indicated by the S^{Δ} durations.

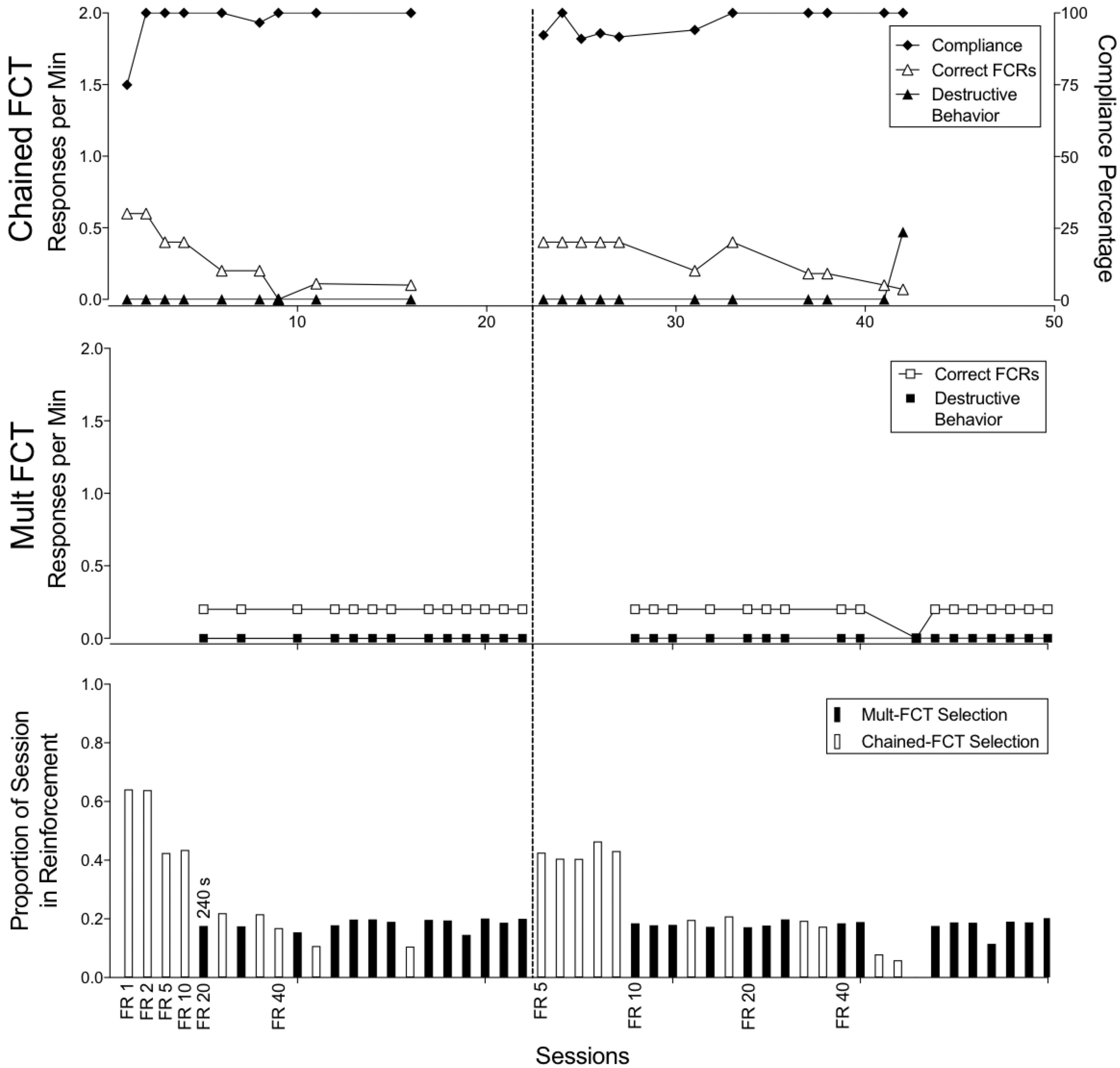

Figure 4.

Rates of destructive behavior and correct FCRs, as well as the percentage of demands with compliance during chain FCT appear in the top panel and rates of destructive behavior and correct FCRs during mult FCT appear in the middle panel. Results of Samantha's initial-link selections across free-choice trials of mult FCT (at the terminal schedule) and chain FCT (throughout schedule thinning), as well as the proportion of session duration spent in reinforcement appear in the bottom panel.

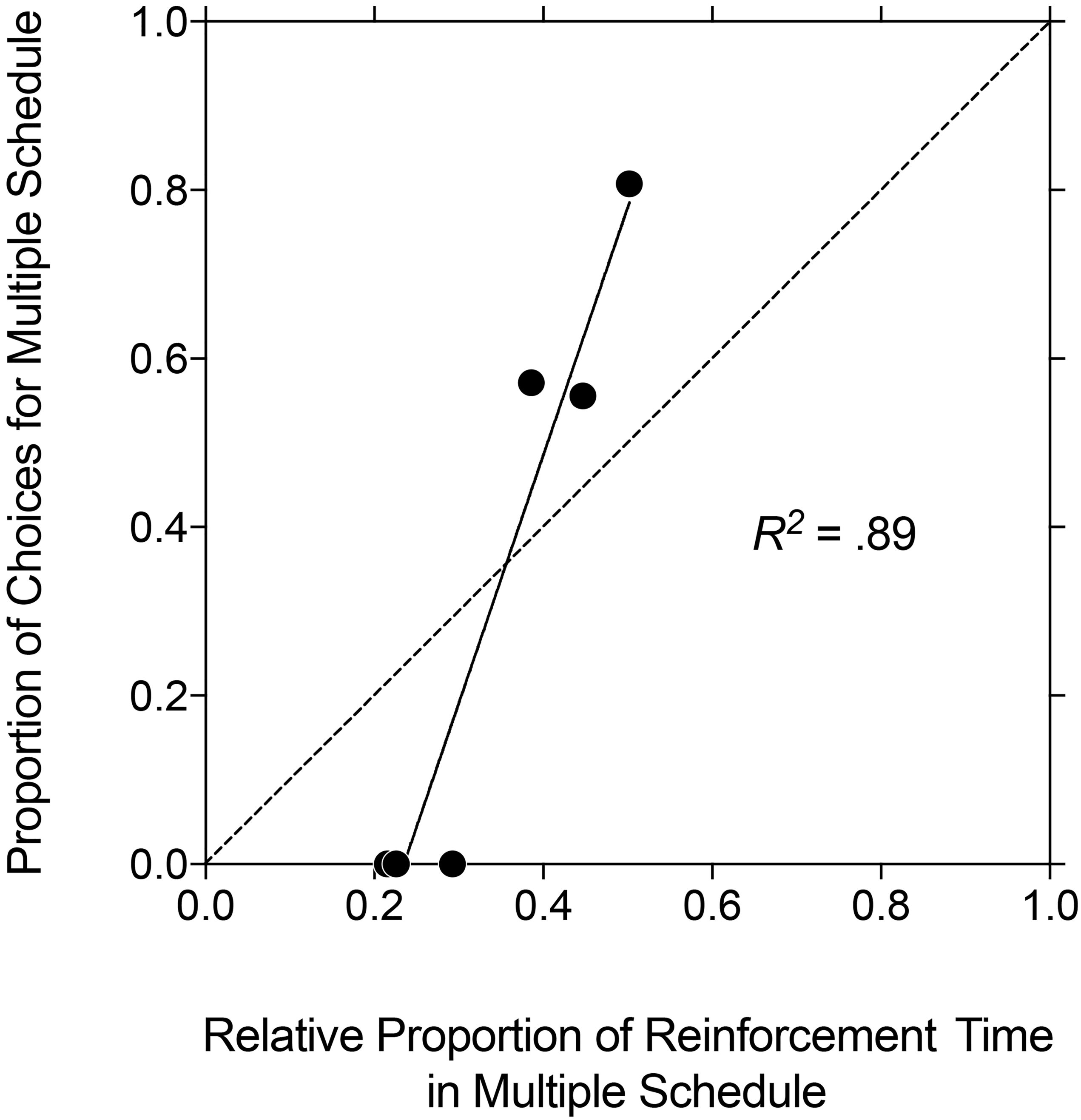

Figure 5.
Proportion of Samantha's choices for the multiple schedule as a function of relative proportion of reinforcement time in the multiple schedule across increasing response requirements of the chained schedule.