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Discriminative Stimuli Promote the Efficacy of Delay Tolerance Training

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Abstract

Schedule thinning occurs after functional communication training to teach individuals to tolerate delays to accessing functional reinforcers. One challenge that can emerge during schedule thinning is poor discriminated use of the newly taught functional communication response (FCR). Although prevalence of this treatment challenge remains largely unknown, it appears to be relatively uncommon during schedule thinning approaches that incorporate arbitrary discriminative stimuli. In contrast, several studies using naturalistic discriminative stimuli during delay tolerance schedule thinning have reported this treatment challenge. In the current study, we examined the efficacy of embedding arbitrary discriminative stimuli into delay tolerance schedule thinning to improve discriminated responding. In addition, we examined if we could subsequently transfer stimulus control properties from the arbitrary to naturalistic discriminative stimuli. The findings of this study have implications for procedural modifications to improve the efficacy of delay tolerance and systematically remove discriminative stimuli to promote generalization.

Key Words: schedule thinning, delay tolerance training, discriminative stimuli, stimulus fading

Discriminative Stimuli Promote the Efficacy of Delay Tolerance Training

Functional communication training (FCT) is efficacious at decreasing socially mediated problem behavior and increasing functional communication responses (FCRs; Carr & Durand, 1985; Ghaemmaghami et al., 2021; Saini et al., 2016). Following FCT, reinforcement schedule thinning is critical to promote generality of the intervention outside clinic settings (Hagopian et al., 1998). Fortunately, much research has been devoted to examining the efficacy of various schedule thinning approaches and procedures (see Hagopian et al., 2011; Kranak & Brown, 2023). During FCT, schedule thinning typically entails incrementally increasing the delay to access the functional reinforcer (e.g., multiple schedule; for a review, see Saini et al., 2016) or the number of alternative responses required before the reinforcer is available (e.g., chained schedule; Fisher et al., 1993; Greer et al., 2016).

One schedule thinning approach that has emerged in the past decade is probabilistic delay tolerance training (Hanley et al., 2014). This approach is derived from the delay reinforcement method, which involves gradually increasing the delay between an FCR and reinforcement which can result in a contingency-weakening effect for the FCR (Fisher et al., 2000; Hanley et al., 2001). In response to this limitation, Hanley et al. (2014) describe a modification to the delay reinforcement method, known as delay tolerance training, in which therapists (a) probabilistically reinforce some FCRs and implement extinction following remaining FCRs, (b) use naturalistic stimuli such as a vocal delay statement (e.g., “you need to wait”) to signal extinction intervals, and (c) teach the individual to emit a tolerance response (e.g., “okay”) following the delay statement. Researchers have conducted delay tolerance training using progressive time-based (e.g., Brown et al., 2021; Ghaemmaghami et al., 2016; Hanley et al., 2014) and contingency-based delays (e.g., Coffey et al., 2021; Drifke et al., 2020;

Ghaemmaghami et al., 2016; Santiago et al., 2016). Using time-based delays, clinicians progressively increase the delay between the FCR and reinforcement. In contrast, during contingency-based delays, the clinician programs either differential reinforcement of alternative behavior (DRA) or differential reinforcement of other behavior (DRO) contingencies.

Delay tolerance training is distinct from other schedule thinning approaches in several ways. First, unlike commonly used schedule thinning strategies that incorporate continuous salient arbitrary discriminative stimuli (e.g., red and green colored cards; Saini et al., 2016), the delay tolerance approach uses brief naturalistic stimuli to signal the availability or unavailability of reinforcement. Second, during delay tolerance training, FCRs contact reinforcement intermittently, whereas other schedule thinning approaches arrange for immediate reinforcement of FCRs during reinforcement components (i.e., when reinforcement is available). Third, schedule thinning via delay tolerance training is accomplished by incrementally increasing the delay from the FCR to the delivery of the reinforcer. In contrast, schedule thinning with a compound schedule (i.e., multiple and chained schedules) is accomplished by increasing the number of responses or the duration of the interval that must elapse before a response is reinforced. These distinct methodological features of delay tolerance training may improve social validity and maintenance outside clinical settings, and make this approach more ecologically valid relative to other schedule thinning approaches (Hanley et al., 2014; Ghaemmaghami et al., 2016).

Despite variations across these approaches, schedule thinning frequently results in treatment challenges such as resurgence of problem behavior (e.g., Briggs et al., 2018; Muething et al., 2021), persistent use of the FCR during extinction intervals (e.g., Brown et al., 2021; Drifke et al., 2020; Fisher et al., 2014; Tiger et al., 2006), and loss of the newly acquired FCR (e.g., Brown et al., 2021; Hanley et al., 2001). Some of these challenges almost always occur despite the schedule thinning approach used. For example, across six consecutive controlled case series (CCCS) that employed different schedule thinning approaches (Briggs et al., 2018; Falligant et al., 2022; Haney et al., 2022; Kranak & Falligant, 2021; Mitteer et al., 2022; Muething et al., 2021), resurgence of problem behavior occurred, on average, in 73% of applications. In addition, Briggs et al. (2023) directly compared the prevalence of resurgence of problem behavior during delay tolerance and compound schedule using published data sets. Researchers found resurgence occurred in 67% of delay tolerance applications and 42% of schedule thinning steps. These prevalence rates are comparable to those commonly observed in compound schedules (i.e., 76% of applications and 42% of steps; Briggs et al., 2018). Collectively, these data demonstrate resurgence of problem behavior is a highly common treatment challenge clinicians are likely to encounter, regardless of the selected schedule thinning approach. Importantly, persistent use or loss of the newly acquired FCR results contribute to resurgence of problem behavior (e.g., Briggs et al., 2018; Fisher et al., 2020), making these important treatment challenges to examine.

Discriminated responding occurs when FCRs occur during the reinforcement component, relative to extinction component (Tiger et al., 2006). Variables that contribute to poor discriminated responding, such as the persistent use or loss of the newly acquired FCR, have been reported to occur less frequently in some CCCS. For example, Greer et al. (2016) examined 25 cases of multiple and chained schedule thinning following FCT and observed poor discriminated use of the FCR (i.e., less than 80%) in only two cases. These findings are likely due to the arbitrary discriminative stimuli used in compound schedules that promote discriminated responding and mitigate contingency-weakening effects for the newly acquired

FCR (Brown et al., 2021; Fisher et al., 2000; Hagopian et al., 1998; Hanley et al., 2001; Saini et al., 2016).

Although a handful of CCCS have been conducted for the delay tolerance approach (e.g., Fiani & Jessel, 2022; Jessel et al., 2018), none report data on discriminated use of the FCR. Thus, the prevalence of this form of treatment challenge during delay tolerance training remains poorly understood. Furthermore, published studies investigating the delay tolerance approach report mixed findings, with some studies not observing this type of treatment challenge (e.g., Hanley et al., 2014; Jessel et al., 2018; Sumter et al., 2020), whereas others have (e.g., Brown et al., 2021; Drifke et al., 2020; Ghaemmaghami et al., 2016). For example, Brown et al. (2021) compared schedule thinning efficacy using a delay tolerance approach and compound schedules of reinforcement (i.e., multiple and chained schedule) with three individuals diagnosed with developmental disabilities. For all but one participant, researchers observed poor discriminated use of the FCR in only the delay tolerance condition. Importantly, these data highlight that, for some individuals, this schedule thinning approach may result in poor discriminated use of the FCR. As such, an important area for future research is to examine strategies that may mitigate this challenge, when it is observed.

Arbitrary discriminative stimuli have been widely used to facilitate gradual tolerance of delays to reinforcement while maintaining FCRs during other schedule thinning approaches (Greer et al., 2016; Rooker et al., 2013; Saini et al., 2016). Thus, it seems plausible this supplemental procedure could effectively promote discriminated responding during delay tolerance schedule thinning. However, no studies have investigated the efficacy of embedding arbitrary discriminative stimuli during delay tolerance training to promote discriminated use of FCRs. Therefore, we sought to examine this question.

Relatedly, given the importance of using naturalistic stimuli during delay tolerance, we wanted to examine if a stimulus fading procedure could be used to transfer stimulus control from the arbitrary discriminative stimuli to naturalistic stimuli (i.e., vocal delay statements). To date, few studies have examined the efficacy of naturalistic stimuli during schedule thinning. Of these studies, researchers either initiated schedule thinning with naturalistic stimuli (e.g., Kuhn et al., 2010; Leon et al., 2010) or directly compared the use of arbitrary and naturalistic stimuli across conditions (e.g., Boyle et al., 2021; Shamlian et al., 2016). To our knowledge no study has examined if arbitrary discriminative stimuli can be used to establish discriminated responding and the stimulus properties subsequently transferred to naturalistic stimuli using stimulus fading procedures. Thus, we sought to fill this gap in the literature.

Method

Participants, Setting, and Materials

Eloise was a 3-year-old White girl diagnosed with autism spectrum disorder, unspecified attention-deficit hyperactivity disorder, and developmental coordination disorder. Eloise spoke in complete, complex sentences. Clint was a 10-year-old White boy diagnosed with autism spectrum disorder, oppositional defiant disorder, attention-deficit hyperactivity disorder, and persistent depressive disorder. He also spoke in complete, complex sentences. Both participants attended a university-based intensive outpatient clinic for the assessment and treatment of aggression and property destruction for approximately 6 hours per week. Following assessment, clinicians incorporated caregivers in selecting an evidence-based treatment approach and terminal delay schedule. Both client caregivers endorsed a preference for a schedule-thinning approach that did not incorporate arbitrary discriminative stimuli. Researchers obtained approval from Utah State University's Institutional Review Board to ensure protection of patient confidentiality during the retrospective analysis of clinically obtained data.

Sessions occurred in a 4 m by 3 m therapy room furnished with a one-way observation mirror, video recording system, sound and intercom system, table, and chairs. The therapy rooms contained relevant session materials (e.g., preferred tangibles). During conditions where discriminative stimuli were embedded, therapists used either 7.62 cm by 12.7 cm or 2.54 cm by 5.08 cm red and green colored cards.

Response Measurement

Primary dependent variables were aggression, property destruction, FCRs, and tolerance responses. Data collectors used laptop computers and specialized data collection software (DataPal ©; Bullock et al., 2017) to collect the frequency of participants' problem behavior. Problem behavior included aggression for Clint (i.e., hitting, punching, biting) and property destruction for Clint and Eloise (i.e., throwing objects, spitting, swiping objects off surfaces, tearing materials, and overturning furniture). We calculated rate of problem behavior by dividing the total count of problem behavior by session duration in minutes.

Data collectors also scored the frequency of FCRs and tolerance responses. For both participants, FCRs were vocal statements that specified the reinforcer (e.g., "iPad, please"), and tolerance responses were vocal statements that acknowledged the therapist's delay statement (e.g., "okay"). We used a discriminative index (DI) to measure discriminated use of the FCR. We calculated the DI by dividing the sum of correct FCRs by the sum of all FCRs in a given session. Data collectors scored a correct FCR for the first instance of an FCR that occurred following the removal of the reinforcer (both conditions), as well as the first FCR that occurred in the signaled reinforcement (S^D) interval following the extinction interval (S^Δ ; arbitrary discriminative stimuli condition only). All other FCRS were scored as incorrect (i.e., FCRs during extinction and reinforcement intervals). In general, a DI of 0.8 or higher is indicative of discriminated use of FCRs across reinforcement and extinction intervals (Brown et al., 2021; Tiger et al., 2006).

Data collectors also examined the percentage of trials with incorrect FCRs across sessions and conditions (trial arrangement described below). We conducted these analyses given there were a greater number of opportunities to engage in a correct FCR during the delay tolerance plus arbitrary discriminative stimuli condition, relative to the delay tolerance condition. We calculated percentage of trials with incorrect FCRs within a session by taking the total number of trials with at least one incorrect FCR, dividing by the total number of trials in that session, and multiplying by 100. Similarly, we calculated percentage of trials with incorrect FCRs in a condition by taking the total number of sessions in which at least one trial contained an incorrect FCR, dividing by the total number of sessions in that condition, and multiplying by 100.

Interobserver Agreement and Procedural Integrity

A second independent data collector scored interobserver agreement data in-vivo or via recording for 57% and 36% of sessions for Eloise and Clint, respectively. We divided sessions into 10 s intervals and scored an agreement for each interval in which both observers recorded the same number of responses or duration of the response (i.e., exact agreement within interval). We calculated agreement by dividing the number of agreement intervals by the total number of intervals within a session and converting this value into a percentage. Mean IOA was 99.2% (range, 98.3% – 100.0%) for Eloise and 99.0% (range, 98.4% – 100.0%) for Clint.

We assessed procedural integrity by determining the extent to which the therapist (a) implemented extinction following problem behavior, (b) implemented a 3 s changeover-delay

(COD; Herrnstein, 1961) following problem behavior, tolerance responses, and incorrect FCRs, (c) signaled discriminative stimuli within 5 s of programmed interval lengths (arbitrary discriminative stimuli condition only), and (d) delivered the functional reinforcer within 5 s of a correct FCR. We assessed procedural integrity for 33% and 35% of sessions for Eloise and Clint, respectively. We calculated procedural integrity by summing the total number of components implemented correctly and dividing that by the total number of components during a given session. Mean procedural integrity was 99.8% (range, 98.7% – 100.0%) for Eloise and 99.5% for Clint (range, 96.6% – 100.0%).

Procedures

Functional Analysis

For each participant, we conducted a functional analysis (FA) to determine the function(s) of problem behavior. The FAs started with a screener for automatic reinforcement (Querim et al., 2013) and proceeded to a multielement design (Iwata et al., 1982/1994) with the addition of a tangible test condition based on caregiver report of a potential tangible function. For Clint, therapists modified the FA using a reversal design (Vollmer et al., 1999) to examine further if there was a functional relation between problem behavior and the removal of tangible items. Tangible items were selected based on the results of paired stimuli preference assessments (Fisher et al., 1992). Following the multielement FA, therapists conducted a pairwise analysis (Iwata et al., 1994) with both participants to test if mand compliance maintained problem behavior (Bowman et al., 1997) based on caregivers' endorsing a potential mand compliance function. The FA results indicated Eloise's problem behavior was maintained by isolated tangible and attention contingencies and Clint's problem behavior was maintained by isolated contingencies to access tangible items and mand compliance. For both participants, therapists first intervened on the tangible function and subsequently treated other functions. The FA results are available upon request from the first author.

FCT Pretraining and Evaluation

Following the FA, therapists taught participants to engage in a vocal FCR to access the functional reinforcer. Throughout pretraining, therapists placed problem behavior on extinction and implemented a 3-s COD for any instances of problem behavior that co-occurred with the FCR. For Eloise, therapists used a progressive vocal-prompt delay (i.e., 0 s, 2 s, 5 s, 10 s, 20 s; Charlop et al., 1985) across 10-trial sessions to teach the FCR. Each trial consisted of the establishing operation (i.e., therapist's removal of the iPad), an FCR, and reinforcement interval. If Eloise did not independently engage in an FCR, the therapist waited the specified number of seconds (e.g., 5 s) before prompting Eloise to engage in the FCR. If Eloise did not comply with the vocal prompt, therapists continued emitting a vocal prompt on a fixed-time schedule matching the programmed prompt delay (e.g., a prompt was delivered every 5 s during the 5-s delay). The prompt delay increased after two consecutive sessions with 20% or less of trials with problem behavior. Contingent on the FCR, therapists immediately delivered the functional reinforcer for 30 s. Given Clint's age and advanced vocal repertoire, therapists initiated FCT pretraining by providing a rule statement that specified the contingency (e.g., If I take the iPad, you can say, "Can I please play on the iPad?" and I will give it back to you). Therapists then initiated FCT pretraining with a 20 s prompt delay. All other procedures remained the same as those described above for Eloise. Pretraining procedures continued until the participant independently emitted the FCR in 80% or more of trials, and problem behavior occurred in 20% or less of trials for two consecutive sessions. A total of nine and two FCT pretraining sessions occurred for Eloise and Clint, respectively.

To demonstrate FCT was effective at reducing problem behavior we conducted an FCT evaluation using an ABAB reversal design with both participants. All sessions were 5 min. Initial baseline data (A1) were derived from the last three sessions of each participant's FA tangible condition. Baseline contingencies were identical to the tangible FA test condition in that each instance of problem behavior resulted in 20-s access to the functional reinforcer. In the FCT phase, therapists placed problem behavior on extinction and reinforced FCRs on a fixed-ratio 1 schedule.

Tolerance Response Training

Following FCT, therapists taught participants to emit a tolerance response following a delay statement using procedures similar to Ghaemmaghami et al. (2016). In four of the 10 trials, FCRs resulted in immediate reinforcement. In the remaining six trials, FCRs resulted in the therapist emitting a varied delay statement (e.g., "not right now," "you need to wait"). Following the delay statement, therapists used a vocal progressive prompt delay (using similar procedures described above for FCT pretraining) to teach the participant to engage in a tolerance response (e.g., "okay"). Contingent on a tolerance response, the therapist delivered the functional reinforcer for 30 s. Therapists terminated tolerance response training contingent on two consecutive sessions with 80% or greater independent tolerance responses and FCRs and zero instances of problem behavior. A total of five and eight sessions occurred during tolerance response training for Eloise and Clint, respectively.

Treatment Evaluation

Baseline

Baseline data were derived from all sessions conducted in the final baseline phase (A2) of the FCT evaluation. Baseline procedures are described above.

Schedule Thinning

We used a reversal design to examine the efficacy of delay tolerance schedule thinning with and without arbitrary discriminative stimuli (i.e., red and green colored cards). Throughout schedule thinning, therapists implemented a 3-s COD between incorrect FCRs, tolerance responses, and problem behavior and the delivery of a reinforcer, as well as presentation of the S^D (plus arbitrary discriminative stimuli condition). The purpose of the COD was to prevent adventitious reinforcement of incorrect FCRs, tolerance responses, and problem behavior. For example, if the programmed delay interval was 5 s and the participant engaged in problem behavior at 4 s, therapists would wait until 3 s had elapsed without any problem behavior before signaling the S^D interval.

Each session consisted of five trials, two immediate and three delay trials. Each trial consisted of the presentation of the relevant establishing operation, FCR, tolerance response and delay interval (if a delay trial), and the reinforcement interval. The duration of the reinforcement interval started at 30 s and systematically increased such that the reinforcement interval was always 25% of the programmed delay interval. The duration of the delay interval began at 2 s for both participants and progressively increased until we reached their terminal delay interval. We thinned the reinforcement schedule (i.e., increased the duration of the delay interval) following at least two consecutive sessions at an 80% or greater reduction in problem behavior relative to baseline and an FCR DI at or above 0.8. We regressed to the previous schedule thinning step contingent on at least three (Eloise) or two (Clint) consecutive sessions that did not meet one or more of the above criteria.

For Clint, when the S^Δ interval was 5 min, we decreased the number of trials to two delay and one immediate trial per session. Similarly, when the S^Δ interval reached 11 min for Clint and

5 min for Eloise, we moved to a one-trial per session arrangement, with a five-session block comprising the initial five-trial arrangement (i.e., three delay sessions and two immediate sessions). These modifications were made to circumvent excessively long session durations while keeping the probability of immediate reinforcement for the FCR over the five-session block similar to the initial five-trial block sessions. When we moved to a one-trial-per-session arrangement for both participants, we decreased the FCR DI criteria from 0.8 to 0.6. We selected 0.6 and made this modification because it allowed participants to engage in a single incorrect FCR during the session. Thus, when we moved to the one-trial-per-session arrangement, the FCR DI criteria to thin the schedule of reinforcement was 0.6.

During schedule thinning, therapists did not provide prompts for FCRs or tolerance responses and implemented extinction for problem behavior. Therapists implemented a 10 min session cap to prevent excessive exposure to the establishing operation if the participant failed to emit the FCR or tolerance response. We implemented the session cap once for Eloise in the delay tolerance without discriminative stimuli condition (session 20).

Delay Tolerance Training. At the beginning of each trial, the therapist removed the functional reinforcer. Contingent on the FCR, the therapist either delivered the reinforcer for the specified reinforcement interval (immediate trials) or emitted a delay statement (delay trials). Therapists terminated session if the participant failed to emit the tolerance response after 10 min. The programmed delay interval began following a tolerance response. After the specified delay interval, therapists delivered the functional reinforcer.

Delay Tolerance Training plus Arbitrary Discriminative Stimuli. Sessions were identical to the condition above, with the exception that therapists incorporated the use of arbitrary discriminative stimuli to signal reinforcement (S^D) and extinction (S^Δ) intervals.

Therapists signaled the S^D at the beginning of each trial when they removed the functional reinforcer. During immediate trials, contingent on an FCR, the therapist provided the reinforcer and continued to signal the S^D for the specified reinforcement interval. During delay trials, contingent on an FCR, therapists emitted the delay statement while simultaneously signaling the S^Δ for the specified extinction interval, at which time the delay interval began. If the participant engaged in a tolerance response, therapists did not provide any programmed consequences. After the delay interval elapsed, the therapist signaled the $S^{D,}$ and contingent on an FCR provided the functional reinforcer. Consistent with compound schedule arrangements, a tolerance response was not required in this condition.

Procedure Modifications. Beginning at session 43, due to continued elevated rates of problem behavior, therapists provided Clint noncontingent access to moderately preferred leisure items (e.g., puzzle, yoga ball, sensory toys, magnet tiles) identified via a paired-choice preference assessment (Fisher et al., 1992). This modification was maintained through the remaining sessions. This supplemental procedure has been found to decrease the amount of problem behavior that occurs during schedule thinning (e.g., Miller et al., 2022).

Stimulus Fading. We conducted stimulus fading of the arbitrary discriminative stimuli once we observed three consecutive sessions a) at the terminal schedule thinning step (5 min for Eloise and 15 min for Clint), b) with maintained reductions of problem behavior at 80% or greater, relative to baseline and c) a FCR DI at or above 0.6. Session procedures were identical to those described above, with the exception that therapists implemented the following stimulus fading procedure: smaller discriminative stimuli (step 1), S^Δ-only stimulus (step 2), S^Δ in every other session (step 3), and no arbitrary discriminative stimuli (step 4). That is, at step 4, the only discriminative stimuli that remained were the varied delay statements. Prior to the first session of each stimulus fading step, therapists provided a contingency-specifying statement (e.g., "When you see the smaller green card, you can still ask and get the iPad; when you see the smaller red card, you still need to wait."). Therapists progressed across stimulus fading steps contingent on two consecutive sessions with problem behavior maintained at or below an 80% reduction and the FCR DI at or above 0.6.

Results

The top panel of Figure 1 depicts Eloise's results from the FCT evaluation. All behaviors are reported as responses per minute. During the initial baseline phase, Eloise engaged in moderate and increasing rates of problem behavior (*M* = 1.1, range = 0.2 – 1.8). During FCT, Eloise engaged in moderate and stable rates of FCRs (*M* = 2.4) with zero rates of problem behavior. These findings were replicated when therapists returned to baseline (problem behavior, *M* = 1.9, range = 1.0 – 2.2; FCRs, *M* = 1.0, range = 0.2 – 2.8) and FCT (problem behavior, *M* = 0.1, range = 0 – 1.0; FCRs, *M* = 2.2; range = 1.4 – 2.6).

The bottom panel of Figure 1 depicts Clint's FCT evaluation results. During the initial baseline phase, Clint engaged in moderate and stable rates of problem behavior (*M* = 2.4, range = 2.2 – 2.8). In the initial phase of FCT, Clint's rate of problem behavior dropped to zero and FCRs were moderate and stable (*M* = 2.3, range = 2.2 – 2.4). In the return to baseline, FCRs quickly declined (*M* = 0.1, range = 0 – 0.2) and problem behavior increased to high and stable levels (*M* = 3.3, range = 3.2 – 3.4). The final phase of FCT yielded similar results to the initial FCT phase (problem behavior, *M* = 0; FCRs, *M* = 2.1, range = 2.0 – 2.4).

Figure 2 depicts the results of the schedule thinning evaluation for Eloise for rate of problem behavior (top panel), rate of FCRs (middle panel), and FCR DI (bottom panel). Following baseline, problem behavior decreased to zero and remained relatively low and stable during the delay tolerance schedule thinning condition (*M* = 0.4, range = 0 – 3.2). However, we observed a decreasing trend in Eloise's FCR DI (*M* = 0.8, range = 0.3 – 1.0). As such, we moved to the delay tolerance plus arbitrary discriminative stimuli conditioned and observed an immediate increase in the FCR DI (*M* = 0.9, range = 0.8 – 1.0). When we returned to the without arbitrary discriminative stimuli condition, we observed a temporary burst in problem behavior (*M* = 0.6, range = 0 – 2.5), likely due to the extinction of delay FCRs, and a decreasing variable DI (*M* = 0.5, range = 0 – 0.8). In the final phase, we returned to the arbitrary discriminative stimuli condition and observed maintained low rates of problem behavior (*M* = 0.1, range = 0 – 1.3) and high, stable FCR DI throughout schedule thinning (*M* = 0.9, range = 0.7 – 1.0). Figure 4 (top panel) depicts tolerance responses per minute for Eloise. Throughout schedule thinning, we observed a decreasing trend to zero correct tolerance responses. When we implemented the stimulus fading procedure, we observed zero instances of problem behavior and the FCR DI remained high and stable throughout stimulus fading (*M* = 0.9, range = 0.2 – 1.0).

Figure 3 depicts the results for Clint across rate of problem behavior (top panel), rate of FCRs (middle panel), and FCR DI (bottom panel). Following baseline, when we implemented delay tolerance schedule thinning, we observed similar outcomes to Eloise evident by relatively low rates of problem behavior (*M* = 0.1, range = 0 – 1.0) and a decreasing FCR DI (*M* = 0.6, range = 0.2 – 1.0). When we moved to the delay tolerance plus arbitrary discriminative stimuli condition, we observed an immediate increase in the FCR DI (*M* = 0.9, range = 0.8 – 1.0). A return to the delay tolerance without arbitrary discriminative stimuli produced a temporary increase in problem behavior (*M* = 1.3, range = 0.6 – 2.1), which again was likely due to the extinction of delay FCRs, and rapid decrease in the FCR DI (*M* = 0.3). Finally, when we returned to delay tolerance plus arbitrary discriminative stimuli condition, we observed low, variable rates of problem behavior (*M* = 0.3, range = 0 – 7.1) and a high FCR DI (*M* = 0.9; range = 0.5 – 1.0). Figure 4 (bottom panel) depicts tolerance responses per minute for Clint. Throughout schedule thinning, we observed a decreasing trend to near-zero rates of correct tolerance responses. When we started fading the arbitrary discriminative stimuli, we observed a sharp increase in problem behavior that decreased across subsequent schedule thinning steps (*M* = 0.3; range = 0 – 3.1). However, we continued to observe a relatively stable FCR DI throughout stimulus fading (*M* = 0.8; range = 0.14 – 1.0).

We also examined the percentage of trials with incorrect FCRs (Figure 5), as well as an aggregated analysis of these data across conditions (Figure 6). For both Clint and Eloise, more trials and sessions included an incorrect FCR during the delay tolerance without arbitrary discriminative stimuli condition relative to the condition with arbitrary stimuli.

Discussion

Schedule thinning often results in a loss of therapeutic effects. The challenge of poor discriminated use of the FCR, including loss of or high rates of the FCR during extinction intervals, has resulted in many schedule thinning approaches incorporating arbitrary discriminative stimuli (Hagopian et al., 2011; Kranak & Brown, 2023). Despite the known benefits of incorporating these stimuli, they may not be widely viewed as socially or ecologically valid (Boyle et al., 2021). The delay tolerance approach to schedule thinning relies on naturalistic vocal discriminative stimuli to address these social and ecological validity concerns, but in some cases, fails to maintain discriminated use of the FCR (e.g., Brown et al., 2021; Drifke et al., 2020; Ghammaghami et al., 2016). The present study is the first to demonstrate how arbitrary discriminative stimuli can be embedded during delay tolerance schedule thinning to address poor discriminated use of the FCR.

Two distinct challenges can occur with the FCR during schedule thinning: a) persistent, high rates of the FCR during extinction intervals (e.g., Brown et al., 2021; Drifke et al., 2020; Fisher et al., 2014; Tiger et al., 2006) and b) a contingency-weakening effect that results in loss of the FCR (e.g., Brown et al., 2021; Hanley et al., 2001). The former indicates the individual's behavior is not discriminating between reinforcement and extinction intervals. These outcomes may be due to a lack of saliency of the programmed discriminative stimuli (Saini et al., 2016), whether these stimuli are naturalistic (e.g., Brown et al., 2021) or arbitrary (e.g., Fisher et al., 2004; Hanley et al., 2001). Studies that have examined systematic variations in stimulus saliency and discriminated responding have mixed findings. For example, Pizarro et al. (2021) used a multiple schedule arrangement and found no differences in discriminated responding for any participants across three stimulus variations (topographically similar [i.e., green, red, or orange cards], topographically dissimilar [i.e., green or blue card vs. a neon-orange construction vest], and S^D-only [i.e., green or yellow card]). A similar study by Campos et al. (2023) examined discriminated responding in a multiple schedule with static (i.e., lacking movement or change) versus dynamic (i.e., consistent movement or change) stimuli. For one of two participants, dynamic stimuli improved discriminated use of FCRs. Thus, based on the extant literature it is unclear what stimulus variations (e.g., static vs. dynamic, similar vs. dissimilar) are most likely to promote discriminated responding. Another stimulus variation that may be important for promoting discriminated responding is the duration of the stimulus. It is likely that brief stimuli (e.g., saying "you need to wait" at the start of an extinction interval in the no signal condition) are less salient than continuous stimuli (e.g., visual presentation of a red card throughout the extinction interval in the signal condition). To our knowledge, no research has examined how duration of discriminative stimuli presentation may impact discriminated use of FCRs. As such, future research should further explore what procedural variations and stimulus properties may be most relevant to promote discriminated responding.

A second treatment challenge that can contribute to poor discriminated responding is a contingency-weakening effect for the FCR that results in loss of the newly acquired response (Fisher et al., 2000; Hagopian et al., 1998; Hanley et al., 2001). Although we did not observe this treatment challenge in the current study, others have observed this during delay tolerance schedule thinning (e.g., Hank in Brown et al. [2021]). Based on the extant literature, it is likely embedding arbitrary discriminative stimuli would have also recaptured treatment efficacy in the face of this treatment challenge (see Brown et al. [2021] and Hanley et al. [2001]). Nonetheless, this is an empirical question that researchers should examine.

To date, CCCS on schedule thinning have largely focused on the reduction and resurgence of problem behavior, with less discussion and reporting of FCR data. Although resurgence of problem behavior during schedule thinning is of great importance, reductions in problem behavior are thought to primarily be the result of extinction, a behavioral process common to almost all schedule thinning approaches. For example, Greer et al. (2019) examined the role of arbitrary discriminative stimuli when transferring FCT treatments across implementers by comparing responding across multiple and mixed schedule conditions. Researchers found the absence of arbitrary discriminative stimuli disrupted correct use of the FCR, but did not impact reductions in problem behavior. Thus, based on the existing data it seems plausible the efficacy and appropriateness of various schedule thinning approaches differ not in terms of efficacy at reducing problem behavior, but rather maintaining FCRs and other appropriate behavior. Given this, we encourage future CCCS to report FCR data such that researchers can conduct analyses of treatment challenges pertaining to FCRs that can arise within and across schedule thinning approaches. A better understanding of conditions that promote discriminated use of the FCR across schedule thinning conditions may allow for less restrictive practices, such as implementing response restriction (e.g., Fisher et al., 2014) in which clinicians restrict access to the FCR due to poor discriminated use.

Outside of procedural variations across schedule thinning approaches, such as saliency of discriminative stimuli or probability of reinforcement, it is also probable there are unique behavioral capacity markers (Hagopian et al., 2018) that predict the extent to which an individual will or will not respond to specific schedule thinning treatments. One suggested behavioral capacity marker is an individual's language repertoire, with more advanced language skills promoting discriminated responding (Saini et al., 2016, Shamlian et al., 2016; Pizarro et al., 2021). Pizarro et al. (2021) evaluated this correlation and found some language skills (i.e., listener and tact) were strongly correlated with discriminated responding in a multiple schedule. These early data suggest one potential predictive behavioral marker for discriminated responding in multiple schedules is an individual's language skills. Of interest, both participants in our study had complex language skills with no known deficits yet failed to discriminate during delay tolerance schedule thinning. These findings are consistent with previous delay tolerance studies that report similar outcomes for individuals with advanced language repertoires (e.g., Alex in Brown et al., 2021). Further research is needed to investigate behavioral capacity predictive behavioral markers for schedule thinning treatments and should closely monitor for potentially different predictors between schedule thinning approaches. This important line of inquiry is likely to result in individualized treatments that are more effective, efficient, and durable (Wacker et al., 2017; Wacker et al., 2011)

Although clinicians often use arbitrary discriminative stimuli during schedule thinning given its empirical support (Hagopian et al., 2011; Kranak & Brown, 2023; Saini et al., 2016), these stimuli can have broad social and ecological validity concerns (Boyle et al., 2021). As a result, clinicians may find themselves in a predicament if naturalistic stimuli are not effective for a given client, but socially valid for the client and/or the stakeholders. This study adds to the small body of literature on naturalistic stimuli during schedule thinning (e.g., Boyle et al., 2021; Kuhn et al., 2010; Leon et al., 2010; Shamlian et al., 2016) by demonstrating the efficacy of a stimulus fading procedure to transfer control from arbitrary to naturalistic discriminative stimuli. Given this study is the first to examine this question, future studies should replicate our procedures with more participants to examine the generality of our findings and examine other important questions. For example, future research should examine if the stimulus fading procedure can be used without contingency-specifying rules to successfully transfer stimulus control from arbitrary to naturalistic stimuli. In addition, future research should explore if the stimulus fading procedure should occur before or after generalization to novel implementers (e.g., caregivers) and settings (e.g., home). Based on previous research that has found arbitrary discriminative stimuli facilitate generalization (Greer et al., 2019), it may be most appropriate to conduct stimulus fading after generalization.

In the current study we selected a time-based progressive delay tolerance training. However, several studies have found DRA-based delays can promote greater discriminated use of the FCR during delay intervals, relative to DRO-and time-based delays (Drifke et al., 2020; Ghaemmaghami et al., 2016). This effect is presumably due to response competition during extinction intervals. Thus, had we selected a DRA-based approach in the current study, we may have observed greater FCR discrimination and mitigated the need for embedding arbitrary discriminative stimuli. It is also possible that embedding noncontingent activities during extinction intervals with Clint, a supplemental procedure found to mitigate resurgence of problem behavior during schedule thinning (Greer et al., 2016; Miller et al., 2022), may also have facilitated higher FCR discrimination during longer delay intervals during the time-based delay procedure than we would have observed without these noncontingent activities.

Despite the growing body of schedule thinning research that demonstrates contingency-based approaches promote schedule thinning treatment outcomes (Drifke et al., 2020; Greer et al., 2016; Ghaemmaghami et al., 2016; Miller et al., 2022), caregiver and client preference of these approaches remains largely unexamined. It is plausible the most ecologically and socially valid schedule thinning treatment would incorporate multiple of these approaches. For example, a caregiver may prefer a DRA-based arrangement for times in which the individual cannot have access to a highly preferred tangible (e.g., video game system), but can access other non-electronic tangibles in the environment. Then, there may be times in which the caregiver is unable to provide access to any tangibles (e.g., waiting in a doctor's office, riding in a vehicle) and a time-based arrangement would be most applicable. As such, an important area of future research is to examine the ecological and social validity of various schedule thinning approaches. In addition, researchers should continue to examine how to mitigate resurgence and promote discriminated use of FCRs during DRO- and time-based schedule thinning approaches for cases that warrant a non-DRA-based approach.

There are some limitations of the current study. First, we did not gather formal social validity measures of participant and caregiver satisfaction. Our setting uses a family-centered care approach to the assessment and treatment of clinical cases (see Brown et al., 2022) and uses a variety of ongoing informal social validity measures (e.g., structured questionnaire, interview) to monitor social validity throughout each participants' intensive outpatient treatment. Nonetheless, formal research and social validity measures for schedule thinning approaches and its supplemental procedures (e.g., arbitrary discriminative stimuli) is needed. Another potential limitation of the current study was the use of previously collected baseline data in lieu of obtaining new baseline response rates. We opted for the former given a) there was a relatively short time span between when baseline data were obtained and treatment initiated, b) to reduce the time to treatment, and c) prevent further reinforcement of problem behavior as a potential resurgence mitigation strategy (Fisher et al., 2022). To date, a handful of empirical studies indicate using data from previously conducted baseline conditions does not influence the reliability of clinical decision-making (Falligant et al., 2020; Scheithauer et al., 2020). Nonetheless, additional research is needed to better understand the conditions under which discrepancies could occur. Third, there were procedural variations across participants (e.g., number of sessions for progression and regression criteria). Although consistent with making individualized clinical treatment decisions for each client, it remains plausible one or more of these procedural variations across participants could have impacted our outcomes. Finally, it is worth noting we only required the emission of a tolerance response in the delay tolerance condition of this study. Similar to previous studies (e.g., Fiani & Jessel, 2022; Jessel et al., 2018), it is likely this response would have maintained had we incorporated an intermittent reinforcement contingency. In conjunction with caregiver preference, clinicians opted to forego embedding this additional response requirement and a corresponding contingency in the final treatment procedures. Future research may consider exploring if emission of the tolerance response promotes treatment efficacy by decreasing problem behavior or promoting discriminated use of the FCR. If this contingency does not promote efficacy, we encourage researchers and clinicians to consider client and caregiver preference (ethics standard 2.09; Behavior Analyst Certification Board [BACB], 2020) and cultural considerations (BACB, 1.07).

Schedule thinning is a critical component of FCT for socially mediated forms of problem behavior. An advantage of delay tolerance schedule thinning is the use of naturalistic discriminative stimuli that promotes generalizable outcomes outside clinic settings. However, in some cases, this approach can result in treatment challenges for the FCR. Therefore, the procedures we used to promote treatment efficacy during delay tolerance schedule thinning may constitute one method of mitigating these FCR treatment challenges and subsequently transfer stimulus control to more naturalistic stimuli. Overall, these findings suggest several possible areas of future investigation that may help elucidate variables that promote and diminish discriminated responding during schedule thinning.

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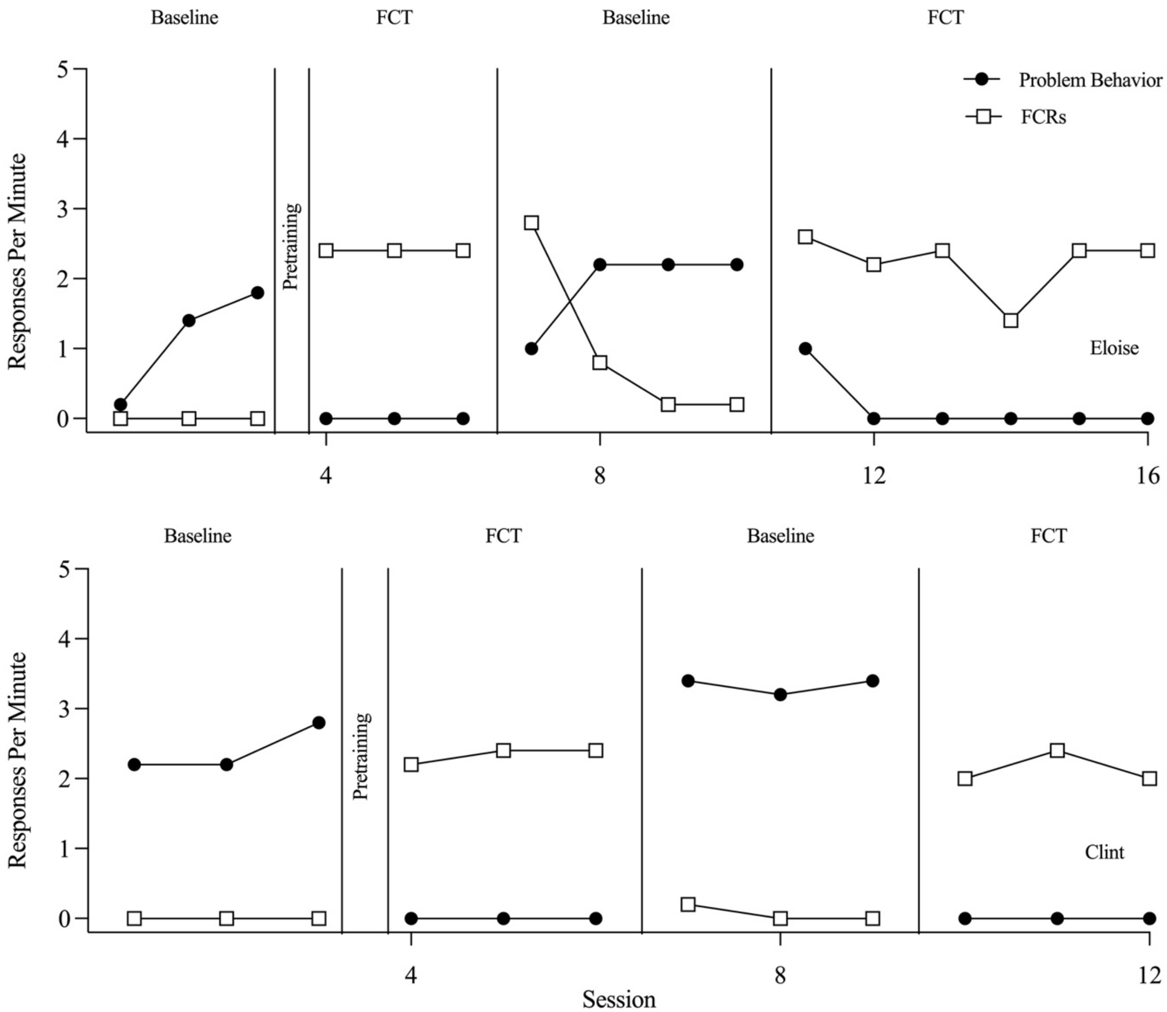
Figure 1

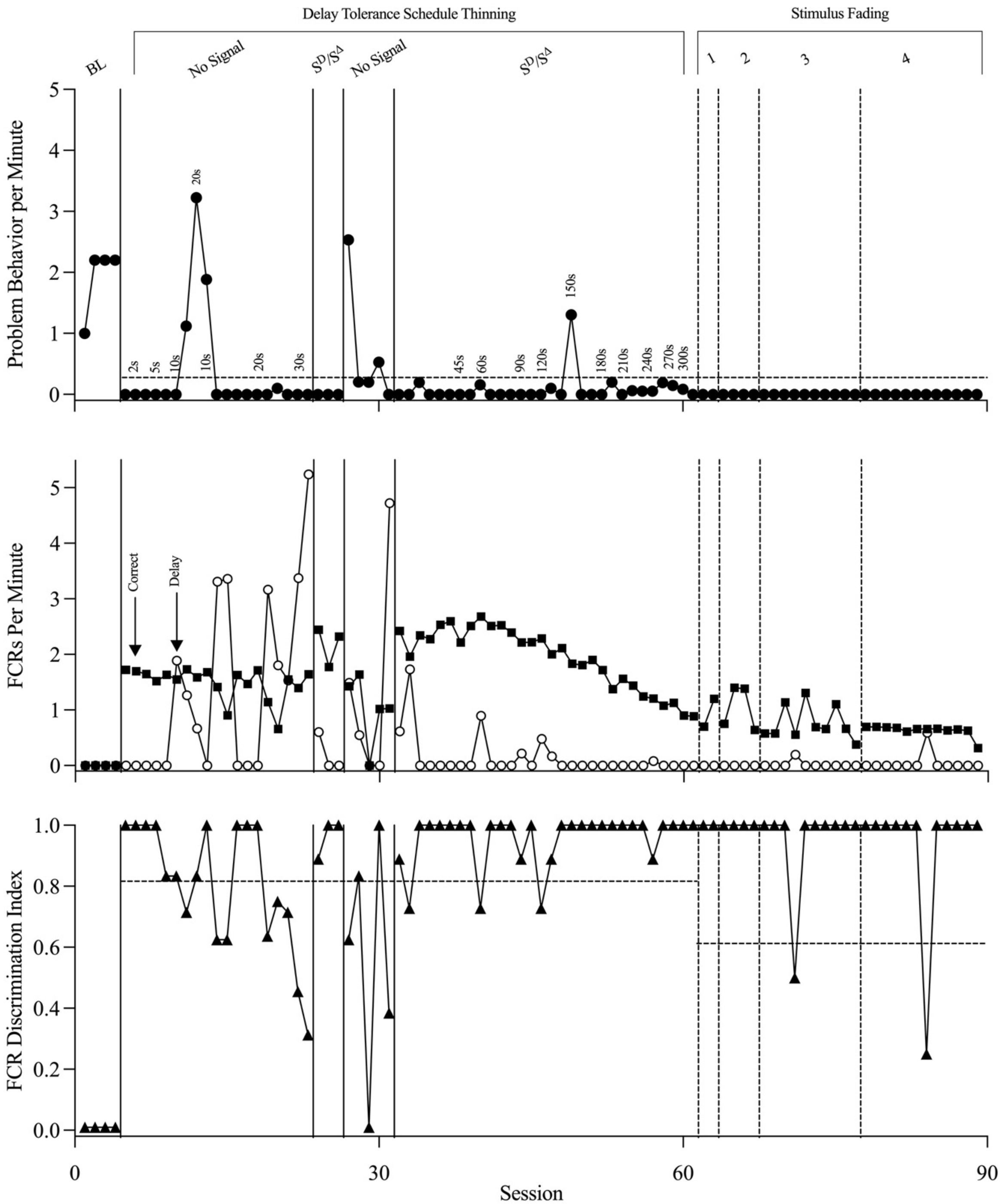
FCT Evaluation



Note. Responding for Eloise (top panel) and Clint (bottom panel) during the FCT evaluation. FCR = functional communication response; FCT = functional communication training.

Figure 2

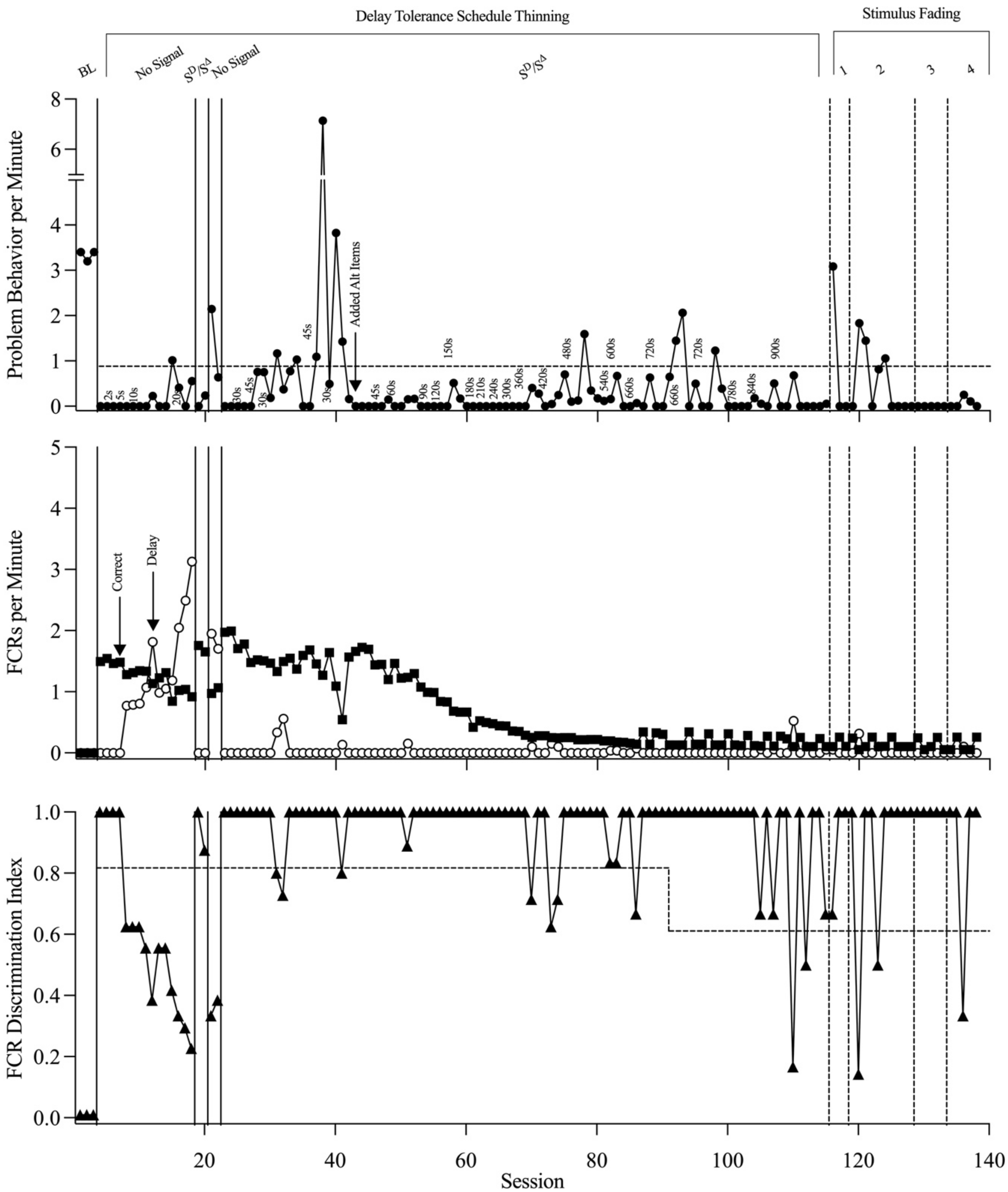
Eloise's Intervention



Note. Problem behavior, FCRs and the FCR discrimination index (DI) for Eloise across baseline, delay tolerance training without arbitrary discriminative stimuli, delay tolerance with arbitrary discriminative stimuli, and stimulus fading phases. Increases in the delay interval are denoted by the text above corresponding sessions. The dashed line in the top panel represents an 80% reduction in problem behavior relative to the baseline average. The dashed line in the bottom panel depicts the DI criterion. BL = baseline; S^D/S^Δ = S^D and S^Δ signals present during the procedures. Stimulus fading numbers correspond to each stimulus fading step (1– 4).

Figure 3

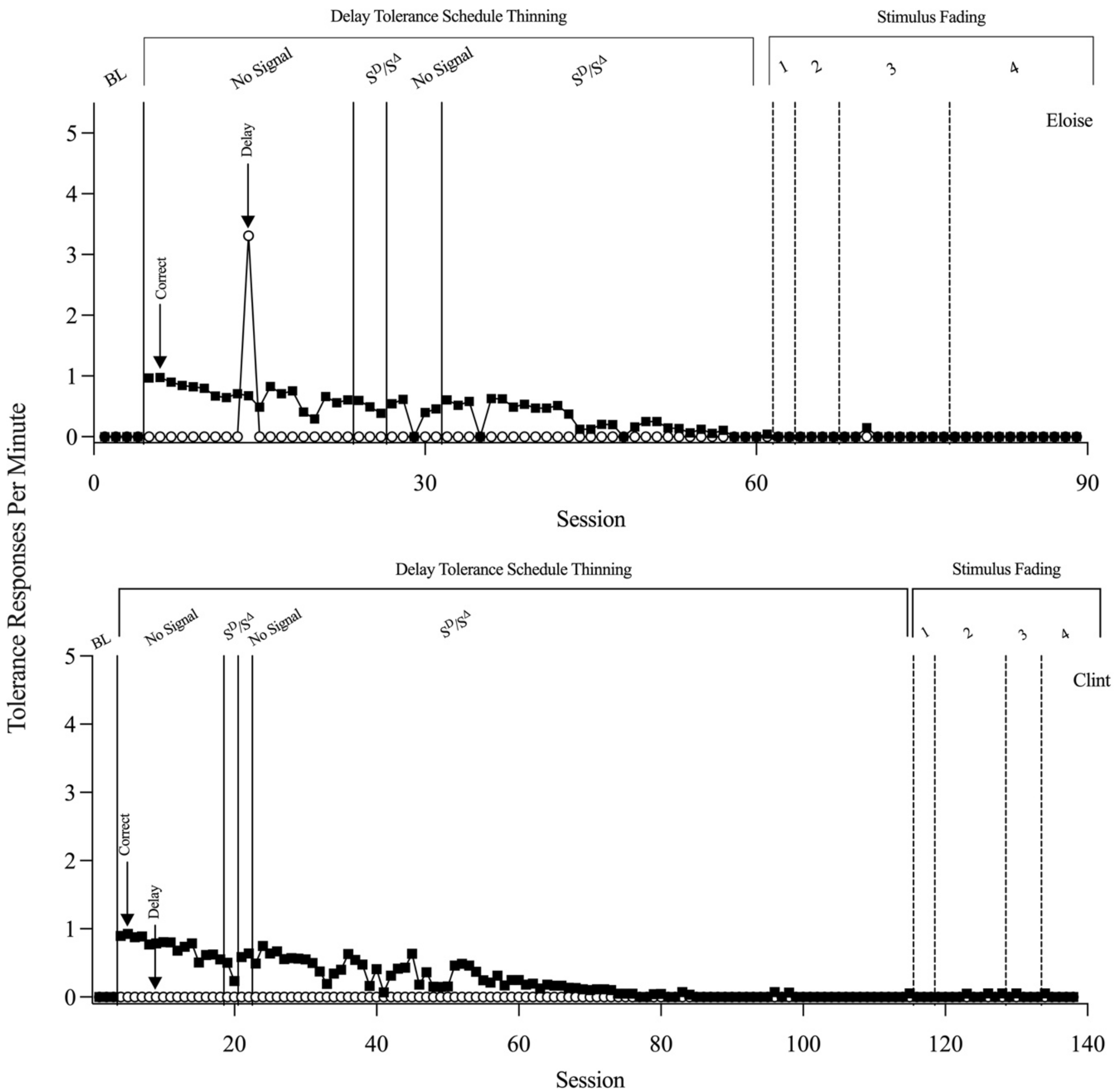
Clint's Intervention



Note. Problem behavior, FCRs, and the FCR discrimination index (DI) for Clint across baseline, delay tolerance training without arbitrary discriminative stimuli, delay tolerance with arbitrary discriminative stimuli, and stimulus fading phases. Increases in the delay interval are denoted by the text above corresponding sessions. The dashed line in the top panel represents an 80% reduction in problem behavior relative to the baseline average. The dashed line in the bottom panel depicts the DI criterion. Alt items = alternative items; BL = baseline; S^D/S^Δ = S^D and S^Δ signals present during the procedures. Stimulus fading numbers correspond to each stimulus fading step (1– 4).

Figure 4

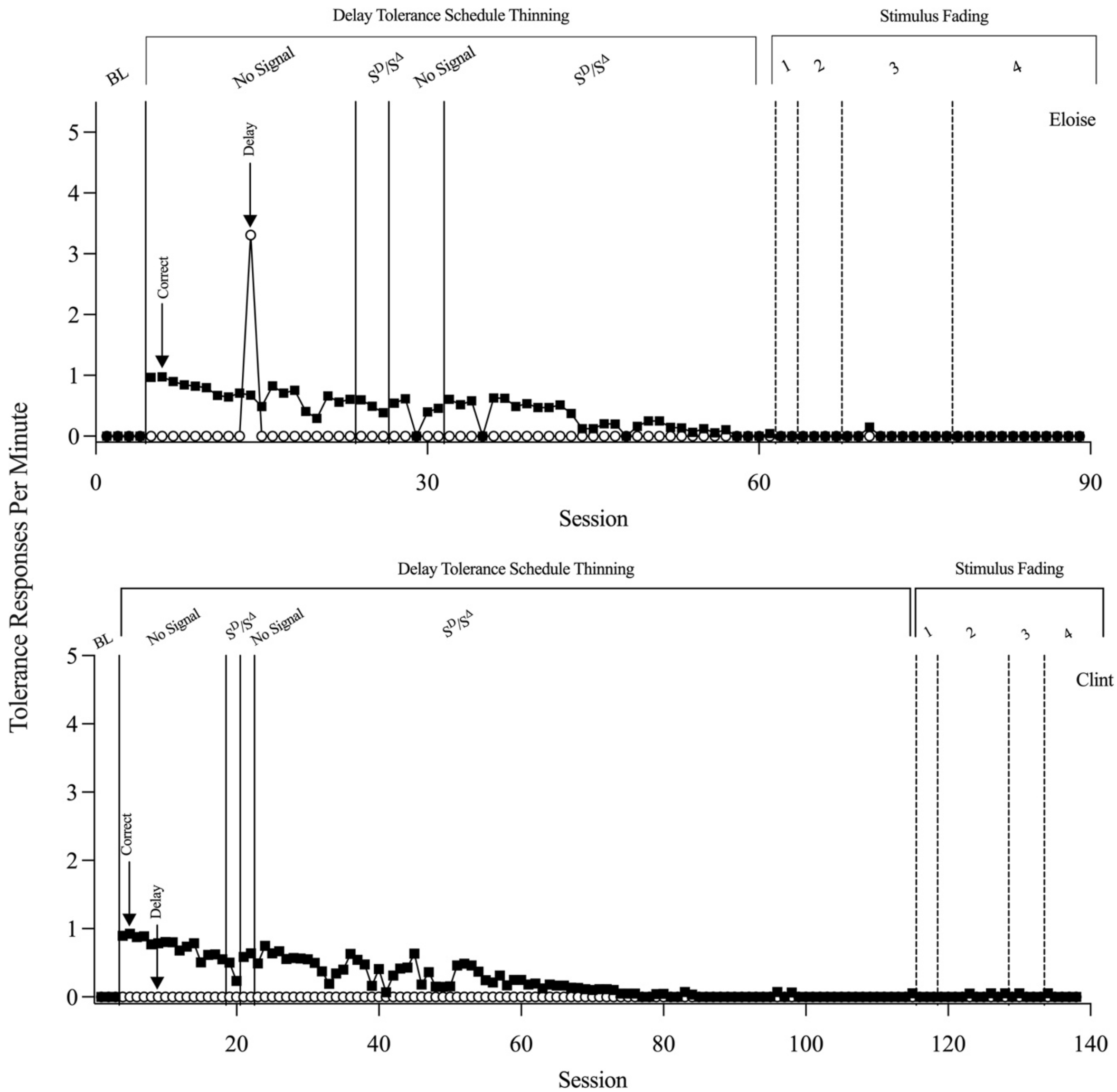
Tolerance Responding



Note. The tolerance responses per minute across baseline, delay tolerance training without arbitrary discriminative stimuli, delay tolerance with arbitrary discriminative stimuli, and stimulus fading phases. BL = baseline; $S^D/S^\Delta = S^D$ and S^Δ signals present during the procedures. Stimulus fading numbers correspond to each stimulus fading step (1– 4).

Figure 5

Percentage of Trials per Session with Incorrect FCRs

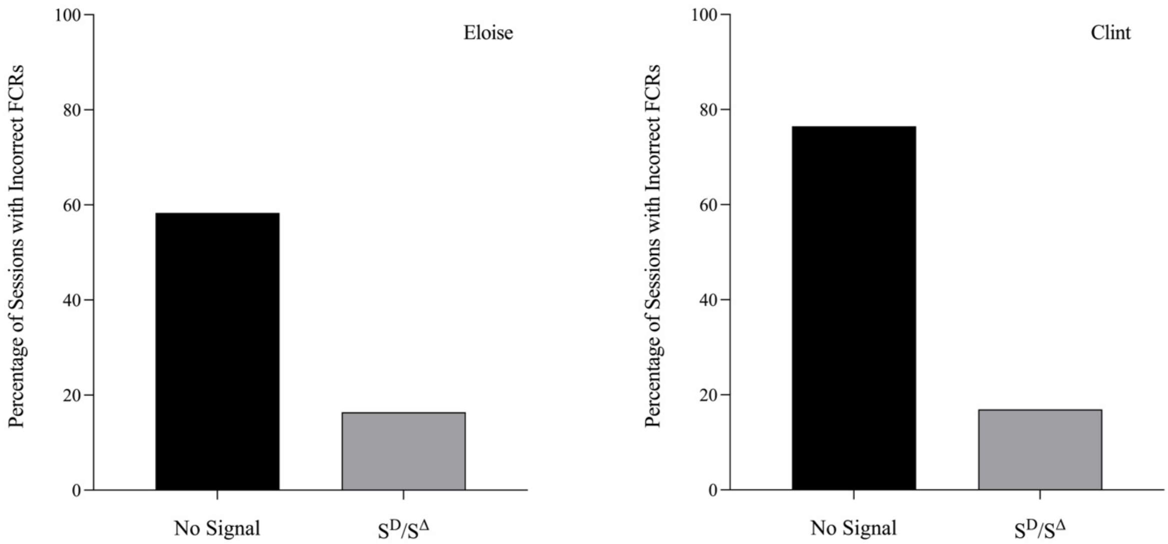


Note. The percentage of trials per session with incorrect FCRs across baseline, delay tolerance training without arbitrary discriminative stimuli, delay tolerance with arbitrary discriminative stimuli, and stimulus fading phases. Arrows and the corresponding data labels depict the number of programmed trials per session beginning at that session. BL = baseline; S^D/S^Δ = S^D and S^Δ

signals present during the procedures. Stimulus fading numbers correspond to each stimulus fading step (1– 4).

Figure 6

Percentage of Trials with Incorrect FCRs by Condition



Note. The percentage of sessions per condition with incorrect FCRs. S^D/S^Δ = S^D and S^Δ signals present during the procedures.