THE EUROPEAN SOCIETY OF MEDICINE
Medical Research Archives, Volume 14 Issue 5

RESEARCH ARTICLE

Incorporating Naturally Occurring Discriminative Stimuli Within Multiple Schedule Arrangements: An Evaluation of Two Instructional Methods

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OPEN ACCESS

PUBLISHED
31 May 2026

CITATION
DeBrine, JE., Zangrillo, AN., et al., 2026. Incorporating Naturally Occurring Discriminative Stimuli Within Multiple Schedule Arrangements: An Evaluation of Two Instructional Methods. Medical Research Archives, [online] 14(5).

ISSN
2375-1924

ABSTRACT

We evaluated two methods to increase the generality of functional communication training by incorporating naturally occurring stimuli within a multiple schedule thinning arrangement. In the present study, we used a stimulus control transfer procedure to determine the degree to which discriminated responding can be transferred from arbitrary to naturally occurring stimuli while maintaining high levels of functional communication and low rates of destructive behavior. Following the acquisition of discriminative control in the presence of an arbitrary stimulus, we transferred discriminative properties to naturally occurring activities that signal the unavailability of reinforcement. We compared rates of acquisition of discriminated functional communication responses and rates of destructive behavior using the stimulus control transfer procedure to direct discrimination training of naturally occurring stimuli. Results of the evaluation support the efficacy of both teaching strategies; however, directly teaching discrimination resulted in higher levels of discriminated responding, lower rates of destructive behavior, and fewer sessions to reach mastery criteria relative to stimulus fading.

Keywords: multiple schedules, stimulus control transfer, functional communication training, naturally occurring stimuli, stimulus fading

Introduction

Functional communication training (FCT) is one of the most widely researched and efficacious treatments for reducing socially maintained destructive behavior[1]. During FCT, a therapist arranges reinforcement for a functional communication response (FCR) while simultaneously arranging extinction for destructive behavior. Optimal implementation of FCT often produces near-zero levels of destructive behavior and efficient rates of FCRs.[2] At the onset of FCT, clinicians establish the FCR by arranging a dense schedule of reinforcement (e.g., a fixed-ratio 1 [FR-1]).[3] The initially dense schedule of reinforcement may produce FCRs rates that are not manageable or sustainable in the natural environment.[1,2,4]

Clinicians and researchers often employ several strategies to reduce the FCR rate and reinforcement schedule to better approximate those occurring in the natural environment and endorsed as manageable by relevant caretakers.[5] These procedures are referred to as schedule thinning procedures as they thin reinforcement schedules from dense to leaner schedules, thus reducing higher rates of FCRs. By means of schedule thinning, periods of reinforcement availability are systematically and progressively decreased while periods of reinforcement unavailability (i.e., extinction) are systematically increased. According to a review of schedule-thinning methods, Hagopian et al[5] identified multiple schedules and chained schedules as two of the most used schedule-thinning procedures.

Chained schedules are often used to thin reinforcement schedules when destructive behavior is maintained by social-negative reinforcement.[5-7] Chained schedules involve the sequential presentation of two schedule components, each correlated with distinct presence or absence of a schedule correlated stimulus. For example, the first component may include an extinction schedule for the FCR and schedule-correlated stimulus (i.e., stimulus delta; S^{Δ}) and the second component may include a predetermined reinforcement schedule for the FCR and schedule correlated stimulus (i.e., discriminative stimulus; S^{D}). In addition, during the extinction component, completion of an arranged response requirement for an alternative response (e.g., compliance with a demand) produces termination of the extinction component and initiation of the second component. The response requirement for the alternative response in the extinction component is progressively increased until a terminal response requirement is met.[6] For instance, the clinician may initially set the reinforcement schedule for demand compliance at an FR-1 schedule during the extinction component. Following the completion of the demand, the therapist then signals availability of reinforcement for the FCR by presenting the S^{D}. The learner then can request reinforcement by emitting an FCR. After the learner consistently completes the FR-1 schedule with little to no destructive behavior, the therapist may increase the response requirement to an FR-2, VR-2, VR-5, and so forth.

Multiple schedules are often employed to thin the schedules of reinforcement for destructive behavior maintained by social-positive reinforcement.[4,5,8] Like the chained schedule, multiple schedule thinning procedures involve alternation between schedule components signaled by distinct schedule correlated stimuli.[8] More specifically, reinforcement availability for the FCR is signaled by the discriminative stimulus after an allotted time-period has elapsed during which reinforcement is unavailable (i.e., extinction). Following the predetermined extinction period, reinforcement availability is signaled, and the reinforcer is delivered immediately following the FCR in the absence of destructive behavior.[4] Thereafter, the relative duration of the extinction component is systematically increased until a terminal delay criterion is met.

A vital component to both the chained and multiple schedule procedures, distinguishing the schedules from tandem and mixed schedules, is the use of schedule correlated stimuli to signal reinforcer availability and unavailability (i.e., periods of extinction).[3,4,8] In a review of the multiple schedule literature, Saini et al.[9] identified that 72% of studies included in the review programmed arbitrary (i.e., therapist contrived) stimuli to signal S^{D} and S^{Δ} intervals. These arbitrary stimuli typically included colored cards[4], clothing[2], and leis[10]. According to Saini et al[9], incorporating arbitrary stimuli as signals likely serves two benefits. First, the arbitrary stimuli have a lower likelihood of an associated learning history (i.e., a prior history of differential reinforcement in their presence or absence). Second, the salience of the arbitrary stimuli compared to naturalistic stimuli may increase the probability that a response comes under the discriminative control of the arbitrary stimulus. Thus, practitioners and researchers often initially incorporate arbitrary stimuli to establish and maintain discriminated responding during schedule thinning procedures.

Although there is evidence to suggest arbitrary stimuli are more effective than naturalistic stimuli in establishing discriminative responding[5], there may be drawbacks to using arbitrary stimuli relative to their naturally occurring counterparts. For instance, the use of arbitrary stimuli requires implementers maintain frequent and ready access to materials that are not typically found in the natural environment. Unplanned treatment challenges (e.g., loss of materials) may expose the FCR to inadvertent periods of unsignaled extinction or reinforcement which may lead to either resurgence of destructive behavior[11] or weakened stimulus control. For instance, if a caregiver misplaces the stimuli typically used to signal S^{D} and S^{Δ} intervals (e.g., red and green cards) it would be difficult or impossible to implement the multiple or chained schedule until the stimuli were found or recreated. Additionally, the increased salience of arbitrary signals may draw unwanted attention in community environments leading to potential stigma of the individuals undergoing and implementing the intervention.

To address the noted limitations of arbitrary signals, researchers have specifically evaluated the use of naturally occurring discriminative stimuli within multiple schedule arrangements.[12-15] Naturally occurring discriminative stimuli are stimuli that are present within the environment which signal naturalistic periods of reinforcement availability and non-availability. Incorporating naturally occurring discriminative stimuli within multiple schedule arrangements may address the limitations associated with arbitrary signals by reducing the need to transport stimuli, eliminate potential stigma for those receiving or implementing the intervention, and increase treatment fidelity outside the training environment.

Kuhn et al[13] sought to teach two individuals with attention-maintained destructive behavior to discriminate between periods of reinforcement unavailability and availability using naturally occurring discriminative stimuli instead of arbitrary stimuli. The authors identified overt behaviors related to common activities that naturally signaled reinforcement availability (e.g., sitting doing nothing) and reinforcement unavailability (e.g., talking on the phone). Following the acquisition of the FCR, the participants underwent discriminated functional communication training (DFCT). This procedure included naturalistic S^D and S^Δ periods alternated across a multiple-schedule arrangement. Participants were exposed to pairs of busy and non-busy therapist activities alternating every 2.5 minutes across a 10-minute session. Results showed successful discrimination across therapist-signaled busy and non-busy periods while maintaining suppression of destructive behavior at clinically acceptable levels for both participants. Notably, each participant received supplemental treatment components (e.g., free access to moderately preferred items during extinction periods, acquisition of an observing response) due to persistence of destructive behavior in the presence of the naturally occurring S^Δ.

Shamlian et al[15] replicated and extended Kuhn et al[13] by comparing the acquisition of discriminative control across naturally occurring and arbitrary stimuli during schedule thinning for three children with autism spectrum disorder with destructive behavior maintained by access to social-positive reinforcement. The authors sought to determine the efficiency (i.e., trials to acquisition) of discrimination training across arbitrary and naturally occurring signaled reinforcement periods. For 2 of 3 participants, discriminated responding was achieved at greater efficiency during the arbitrary condition, although discriminative control was eventually observed across both participants during each condition. For the third participant, acquisition of stimulus control was comparable across conditions. Further, two participants displayed discriminated responding in the presence of novel naturally occurring reinforcement and extinction periods following training. However, destructive behavior resurged for two participants during extinction components across naturally occurring and arbitrary conditions. Similar to Kuhn et al[13], Shamlian and colleagues[15] included an additional teaching procedure that could have impacted the efficacy of findings. That is, the therapist provided participants a rule statement (e.g., “when the bracelet is red, I cannot play with you”) during the arbitrary condition, which may have facilitated faster acquisition of stimulus control.

Boyle et al[12] replicated and extended Shamlian et al[15] by evaluating the degree to which discriminative responding would maintain during rapid schedule thinning in a naturalistic signal and arbitrary signal condition following FCT for three participants with destructive behavior maintained in part by social-positive reinforcement. The three participants acquired differentiated responding in the presence of naturally occurring stimuli during rapid schedule thinning in a multiple schedule arrangement. Similar to Shamlian et al[15], the acquisition of discriminated responding reflected slightly higher efficiency during the arbitrary condition for two participants. The third participant mastered discriminations across conditions at a similar rate.

The growing evidence surrounding the inclusion of naturalistic stimuli in multiple schedule arrangements suggests the acquisition of discriminated responding can be acquired in the presence of naturalistic discriminative stimuli but may occur less efficiently in comparison to arbitrary discriminative stimuli.[12,15] Additionally, rates of destructive behavior varied across both arbitrary and naturally occurring discriminative stimuli multiple schedule arrangements.[12,13,15] Thus, selection of the stimulus arrangement within a multiple schedule remains idiosyncratic and researchers and clinicians may consider teaching discriminative responding during schedule thinning that incorporates both arbitrary and naturally occurring signals to determine the degree to which discriminated responding is acquired and the effects on severe destructive behavior.

Stimulus fading procedures may serve as a viable strategy to sequentially transfer the discriminative properties of an arbitrary stimulus to a naturally occurring stimulus within a learner’s environment. Stimulus fading is described as successive changes in a stimulus property (e.g., shape, size, position, color) that define a discriminated operant.[1,16] One stimulus fading procedure, described as “fading out,” is defined as gradually attenuating the salience of the controlling stimulus over a series of trials to transfer control to a novel target stimulus.[18] Following the acquisition of discriminative control, discriminative features from the controlling stimulus are superimposed on the target stimulus. Thereafter, the controlling discriminative properties are progressively faded out until differential responding is observed in the presence of the target stimulus alone.[18-20]

For example, Brown and Nercesian[21] evaluated whether embedding arbitrary discriminative stimuli within delay tolerance schedule thinning would improve discriminated responding and permit subsequent transfer to naturalistic cues. Following the establishment of discriminated FCRs, the authors implemented a systematic fading procedure in which the salience and presence of the arbitrary stimuli were gradually reduced. Across the two participants, delay tolerance training with naturalistic stimuli alone produced higher levels of challenging behavior and lower rates of discriminated FCRS compared to delay tolerance training sessions with the inclusion of arbitrary stimuli. During the subsequent stimulus fading phase, outcomes differed across participants. For one participant, problem behavior remained at or near zero and discriminated responding maintained. For the second participant, problem behavior increased during the initial stages of stimulus and discriminated responding occurred at low rates. These findings suggest that arbitrary discriminative stimuli can establish robust stimulus control over FCRs, and stimulus control can be transferred to naturalistic cues through systematic fading procedures.

We are unclear how programming a fading out stimulus control transfer from arbitrary to naturally occurring stimuli may impact acquisition of discriminated responding in comparison to teaching learners to behave discriminatively to naturalistic signals in isolation. According to Stokes and Baer[22], making the experimental setting closely resemble the generalization setting by incorporating stimuli commonly found in the natural environment can function to control generalized responding. Thus, teaching learners to behave discriminatively in the presence of an arbitrary stimulus and successively transferring control to stimuli that occur in their natural environment may address limitations related to the generality of effects using arbitrary signals, feasibility of treatment implementation across caretakers, and reduce stigmatization outside the experimental setting. To our knowledge, no previous literature exists which systematically program the transfer of arbitrary S^D and S^Δ intervals to naturally occurring discriminative stimuli within multiple schedule arrangements.

Therefore, the current study aimed to systematically examine the extent to which discriminated responding can be transferred from arbitrary to naturally occurring stimuli using fading out stimulus procedure. Additionally, we compared rate of acquisition of discriminated responding using the fading out procedure[21] in comparison to teaching discrimination of naturally occurring discriminative stimuli using similar procedures described by Shamlian et al[15] and Boyle et al.[12]

Method

Schedule thinning interventions for destructive behavior maintained by social-positive reinforcement require that the therapist delivers the reinforcer (e.g., attention or tangibles) to the participant following the FCR in the presence of an establishing operation (EO; e.g., a period of deprivation from attention and/or tangibles). As noted in both Shamlian et al[15] and Boyle et al[12] a person preoccupied with other activities (e.g., caring for another child, typing on a computer, talking on the phone) may naturally create an EO for tangibles and attention and periods of extinction. Further, children unable to discriminate between naturally occurring periods of reinforcer unavailability may engage in high rates of destructive behavior in the presence of an EO and prosocial behaviors such as asking for preferred items may contact extinction.

In contrast, schedule thinning interventions for destructive behavior maintained by social-negative reinforcement require that the therapist deliver the reinforcer (i.e., escape, avoidance) to the participant following the FCR in the presence of an EO (e.g., presentation of demands). A person delivering instructions (e.g., prompting through a tooth brushing routine) may not naturally display clear periods of reinforcer availability and unavailability similar to social-positive procedures, particularly when considering unavailability of attention as prompting may continue throughout the demand interval. Therefore, only participants whose destructive behaviors were maintained in part by social positive reinforcement (indicated by results of a functional analysis) were included to capitalize on the naturally occurring periods of reinforcer unavailability.[12]

Participants and Setting

Five children referred for the assessment and treatment of severe destructive behavior participated in the study (see Table 1 for a full description of participant characteristics and referral concerns). Malcom was a 7-year-old African American male diagnosed with autism spectrum disorder (ASD), pica, and other specified disruptive, impulse-control, and conduct disorder. Malcom's caretakers spoke primarily Amharic in the home. Malcom displayed limited vocal-verbal behavior and primarily communicated in one-word phrases using an assisted augmentative communication (AAC) device. He could follow simple, single-step instructions. Jacob was a 5-year-old African American male diagnosed with other specified disruptive, impulse-control, and conduct disorder and receptive and expressive language disorder. Jacob spoke in one-to-two-word phrases and could follow multiple-step instructions. Dominic was a 7-year-old Asian American male diagnosed with ASD with an accompanying language disorder and other specified disruptive, impulse-control, and conduct disorder. Dominic communicated using short sentences and could follow multi-step directions. Amanda was an 11-year-old Hispanic female diagnosed with hypotonia, Rhett's syndrome, ASD, and moderate intellectual disability. Amanda communicated using gestures and could follow simple, 1-step directions. Amanda's caregivers spoke primarily Spanish in the home. Jose was an 11-year-old Hispanic male diagnosed with ASD, other specified disruptive, impulse-control, and conduct disorder. He communicated using one-to-three-word phrases and could follow 2-step directions.

Table 1: Participant characteristics

Participant	Age	Diagnosis	Race/Ethnicity	Primary Language Spoken In-Home	Referral concerns	Communication level
Malcom	7	ASD, other DBDs	African American	Amharic	Self-injury, aggression, disruptive behavior, PICA	One-word phrases using AAC device
Jacob	5	DBDs, receptive and expressive language disorder	African American	English	Aggression, self-injury, disruptive behavior	One-to-two-word phrases, gestures
Dominic	7	ASD with accompanying language impairment, DBDs ADHD	Asian American	English and Chinese	Aggression, elopement, climbing, property destruction	Two-word phrases, short sentences
Amanda	11	Hypotonia Rhett's Disorder ASD Moderate ID	Hispanic	Spanish	Aggression, property destruction, self-injury	Gestures, non-vocal
Jose	11	ASD, DBDs	Hispanic	English	Aggression, elopement, school refusal, disruptions, non-compliance	Two-word spoken phrases and short sentences

Note. Autism spectrum disorders is abbreviated to ASD. Disruptive behavior disorders including Other specified disruptive, impulse-control, and conduct disorder is abbreviated to DBDs. Intellectual disability is abbreviated to ID and Attention deficit-hyperactivity disorder is abbreviated to ADHD.

All patients were ambulatory. Malcom, Jacob, and Dominic attended a university-affiliated program that specialized in the assessment and treatment of severe destructive behavior 5 days per week for 3 hours per day and Amanda and Jose attended the same program 5 days per week for 6 hours per day. Sessions were conducted in a 3-m by 3.5-m room equipped with a one-way observational window and two-way intercom system.

Response Measurement, Interobserver Agreement, and Procedural Integrity

Trained data collectors collected frequency measures of FCRs (correct, incorrect, prompted, and blocked) and destructive behavior using laptop computers with a specialized data-collection program (DataPal).[23] The primary dependent measures included the rates of destructive behaviors and percentage correct of discriminated FCRs.

Data collectors summed the frequencies of aggression, self-injury, and disruptive behavior and divided the frequencies by the session duration to calculate the rate of destructive behavior. *Aggressive behavior* consisted of hitting, pushing, grabbing, pinching, scratching, or throwing objects at others. *Disruptive behavior* consisted of throwing or destroying objects, and overturning or climbing on furniture. *Self-injury* consisted of head banging, body-slamming, or head and body hitting.

Data collectors calculated the percentage of total correct FCRs by dividing the frequency of correct FCRs by the summed number of incorrect, correct, prompted FCRs, and blocked FCRs (for Malcom and Amanda) and then converted the quotient to a percentage. Data collectors scored a *correct FCR* if the participant emitted the FCR independently during the S^D component and an *incorrect FCR* if the participant emitted the FCR independently during either the S^Δ component or during the reinforcement interval if the putative reinforcer had already been delivered. Data collectors scored a *prompted FCR* if the participant emitted the FCR immediately following a therapist's prompt. Due to Malcom and Amanda continuing to engage in the *FCRs* during the S^Δ component, response blocking was included and therefore data collectors scored the frequency of blocked FCRs. *Blocked FCRs* were scored if Malcom or Amanda attempted to emit the FCR during either the S^D or S^Δ component.

Interobserver agreement across participants can be found in Table 2. To calculate interobserver agreement, a second data collector simultaneously and independently collected data for at least 33% of sessions across each phase of the study. We calculated agreement scores by dividing each session into successive 10-s intervals. The interval was scored as an agreement if both observers recorded the same number of responses in that interval. The total number of agreements was divided by the total number of 10-s intervals and then converted into a percentage.

Table 2: Average percentage of Interobserver Agreement across dependent variables. Range presented in parentheses

Participant	Aggression	Disruptive behavior	Self-injurious behavior	Correct FCRs	Incorrect FCRs
Malcom	100%	100%	100%	97% (93-100%)	97% (96-98%)
Jacob	99% (94-100%)	99% (96-100%)	100%	95% (75-100%)	98% (88-100%)
Dominic	99% (95-100%)	99% (95-100%)	100%	95% (85-100%)	99% (88-100%)
Amanda	99% (93- 100%)	99% (95-100%)	99% (95-100%)	95% (93-100%)	99% (98-100%)
Jose	99% (98-100%)	100%	100%	100%	98% (92-100%)

Procedural integrity across participants can be found in Table 3. We calculated procedural integrity during at least 30% of sessions across each phase of the study. During baseline, we calculated procedural integrity throughout the session by scoring whether the therapist: (a) removed the putative reinforcer, (b) engaged in the naturalistic S^{Δ} during the S^{Δ} component, (c) oriented towards the learner during the S^{D} component, (d) delivered the putative reinforcer following the FCR during the S^{D} component, and (e) implemented extinction for instances of destructive behavior. We calculated procedural integrity across each opportunity during baseline sessions by dividing the number of correct steps implemented by the number of correct plus incorrect steps implemented and then converted the quotient to a percentage.

Table 3: Procedural integrity during the multiple schedule + naturally occurring stimuli evaluation. Range presented in parentheses.

Participant	Baseline	Stimulus Fading	Direct Teaching
Malcom	98%	100%	100%
Jacob	99% (97-100%)	100	100%
Dominic	99% (97-100%)	89% (85-100%)	98% (96-100%)
Amanda	97% (97- 100%)	98% (96-100%)	95% (93-100%)
Jose	98% (98-100%)	99% (98-100%)	100%

During treatment, we assessed procedural integrity during at least 30% of stimulus fading and 30% of direct teaching sessions. We scored correct implementation across a stimulus fading session if the therapist: (a) presented the appropriately sized arbitrary stimulus onto the naturalistic S^{Δ} (e.g., on laptop) during the S^{Δ} component, (b) removed the putative reinforcer during S^{Δ} interval, (c) engaged in the naturalistic S^{Δ} signal during the S^{Δ} component, (d) disengaged with the naturalistic S^{Δ} signal during the S^{D} component, (d) oriented towards the learner during S^{D} interval, (e) arranged extinction for destructive behavior and incorrect FCRs, and (f) delivered the putative reinforcer contingent upon correct a FCR during the S^{D} interval. We calculated procedural integrity across each opportunity during stimulus fading sessions by dividing the number of correct steps implemented by the number of correct plus incorrect steps implemented and then converted the quotient to a percentage.

We scored correct treatment implementation across direct teaching sessions if the therapist: (a) removed the putative reinforcer during S^{Δ} interval, (b) engaged in the naturalistic S^{Δ} signal during the S^{Δ} component, (c) disengaged with the naturalistic S^{Δ} signal during the S^{D} component, (d) oriented towards the learner during S^{D} interval, (e) implemented extinction for instances of destructive behavior and incorrect FCRs, and (f) delivered the putative reinforcer contingent upon correct a FCR during the S^{D}. We calculated procedural integrity across each opportunity during direct teaching sessions by dividing the number of correct steps implemented by the number of correct plus incorrect steps implemented and then converted the quotient to a percentage.

Pre-assessments

FUNCTIONAL ANALYSIS

We conducted a functional analysis (FA) prior to FCT using procedures similar to those described by Iwata et al[24]. To facilitate discrimination between FA conditions, the therapist wore a unique color-correlated shirt across each condition.[25] We individualized FA conditions across participants according to an indirect assessment, direct observations, and a paired-stimulus preference assessment[26] conducted prior to the experimental analysis. High-preferred stimuli identified via the pair-stimulus preference assessment[26] were delivered contingent upon destructive behavior in the tangible condition and freely available during the toy play condition. Across participants, sessions began at 5-minutes in duration but were extended to 10-minutes due to low rates of destructive behavior and to increase exposure to the relative EO, when necessary.

Monitored alone or ignore. We conducted a monitored alone or ignore condition to determine whether automatic reinforcement maintained destructive behavior.[27] During the monitored alone test condition, the participant remained in the treatment room without access to leisure items. The therapist was not in the treatment room; however, the participant was closely monitored throughout the 5- or 10-minute session from behind a one-way observation mirror. In the monitored ignore condition, the therapist was present in the treatment room, but did not interact with the participant at any time during the session. Across both conditions, therapists did not interfere with destructive behavior unless the behavior posed an imminent safety risk.

Attention and Diverted Attention. During the attention test condition, the therapist provided high-quality attention to the participant for approximately 1 min prior to the start of the session. The session began when the therapist's attention was withdrawn and redirected to another activity (e.g., reading a magazine). The participant had free access to a moderately preferred item identified via paired-stimulus preference assessment[26] throughout the session. Contingent on destructive behavior, the therapist provided 30-s access to attention (e.g., reassuring comments, reprimands). The diverted attention condition[28] resembled the attention condition; however, a second therapist was present in the session room, and attention was removed from the participant and directed towards the other therapist.

Toy play. This condition served as the control. During the toy play condition, the therapist provided descriptive praise (e.g., "you're sitting so nicely!") at least every 30 s in the absence of demands and continuous access to highly preferred stimuli identified via paired-stimulus preference assessment.[26] Destructive behavior produced no programmed consequence.

Escape. During the escape test condition, the therapist presented caregiver nominated stimuli (e.g., clean toys, academic worksheets) reported to evoke destructive behavior every 15 s. The therapist used a three-step (verbal, model, physical) prompting sequence[29] to facilitate compliance. Contingent on compliance within 5 s of the verbal or model step, the therapist provided brief descriptive praise (e.g., "nice job matching") and continued with the next instruction. No praise was provided following physical guidance. Destructive behavior resulted in a 30-s break from instructions. Following the 30-s break from instructions, the therapist continued the presentation of demands and provided a 30-s break contingent on destructive behavior and repeated procedures for the remainder of the session.

Tangible. During the tangible condition, the therapist provided access to a highly preferred stimulus for approximately 1 min prior to the start of the session. The session began when the preferred item was withdrawn from the participant. Contingent on any instance of destructive behavior following item removal, the therapist provided 30-s access to the item. The therapist removed the item following 30 s and provided access contingent on destructive behavior and repeated procedures for the remainder of the session.

Synthesized attention and tangible. This condition was included for three participants (i.e., Malcom, Jacob, Ashley). During the synthesized attention and tangible test condition, the therapist provided access to a highly preferred stimulus and high-quality attention for approximately 1 min prior to the start of the session. The session began when the preferred item and attention was withdrawn. Contingent on any instance of destructive behavior after the item was removed, the therapist provided 30-s access to both attention and the tangible item. The therapist removed the tangible item and attention following 30-s and provided access contingent on destructive behavior. The therapist repeated procedures for the remainder of the session.

Mand Topography Assessment

Following the functional analysis, we conducted the mand topography assessment (MTA) using procedures like Ringdahl et al[30] and Kunnavatana et al[31] across three participants (i.e., Malcom, Jacob, Ashley) to identify proficiency and preference across mand topographies and empirically derive the FCR for FCT.

FCT EVALUATION

The FCT evaluation consisted of a baseline, FCT pretraining, and an FCT treatment implementation (described below).

Baseline. Baseline sessions were identical to the functional analysis test condition that evoked the highest levels of destructive behavior. Sessions resembled the synthesized attention-tangible for participants Malcom, Jacob, and Amanda, and tangible for Dominic and Jose.

FCT Pretraining. After empirically selecting an FCR topography, we conducted FCT pretraining to teach a functionally equivalent communication response while simultaneously arranging extinction for destructive behavior. Prior to initiating session, the therapist provided approximately 1 minute access to the putative reinforcer (e.g., tangible items, preferred attention). To begin session, the therapist presented the EO (i.e., removal of attention or items) while simultaneously prompting the participant to engage in the FCR. Each occurrence of the FCR resulted in 30s access to the reinforcer. The FCT pretraining sessions consisted of ten trials with an embedded progressive prompt delay.[32] To transfer stimulus control from the controlling prompt to the EO, the prompt delay was increased (e.g., 0s, 2s, 5s, 10s, 20s) following two consecutive sessions with low rates of destructive behavior and continued until the participant emitted at least 80% correct independent FCRs across two consecutive sessions.

FCT. Following FCT pretraining, we conducted FCT across 10-minute sessions as described by Fisher et al. (2015)[2] to determine the efficacy of FCT as a treatment to reduce destructive behavior maintained by social-positive reinforcement. The FCT sessions resembled procedures described in FCT pretraining, however sessions were conducted across 5 minutes instead of trial-by-trial. The progressive prompt delay was removed. The evaluation was conducted using an ABAB reversal design, alternating between baseline (A phase) and FCT (B phase) conditions.

DISCRIMINATED RESPONDING EVALUATION ACROSS ARBITRARY AND NATURALISTIC STIMULI

Experimental Design

The evaluation contained four distinct sub-phases: (a) naturalistic MULT 60s/60s baseline, (b) MULT 60s/60s + arbitrary signal, (c) MULT 60s/60s + stimulus fading, and (d) MULT 60s/60s + direct teaching. We used an alternating treatments design[33] to evaluate the efficiency and effectiveness across the two teaching procedures containing the naturally occurring discriminative stimuli (i.e., MULT 60s/60s + direct teaching and MULT 60s/60s + stimulus fading) for Malcom and Jacob. Due to potential treatment interference observed during Malcom and Jacob's evaluation, we used a multiple baseline design[34] across naturally occurring stimuli with an embedded alternating treatment design to evaluate the efficiency and effectiveness of the two teaching procedures across Amanda, Dominic, and Jose.

Naturally Occurring Stimuli Selection

Prior to initiating the evaluation, each participant's caretakers nominated two to three naturally occurring contexts and stimuli for the evaluation. Caregivers were asked to describe frequently encountered situations (i.e., "busy activities") in which attention and/or tangible items are unavailable because caregivers were occupied with a competing activity. These activities were used to approximate the naturally occurring S^{Δ} intervals within the learner's environment. Malcom's caretaker nominated washing dishes and talking on a cellphone and Jacob's caretaker nominated typing on a laptop computer and talking on a cell phone as common activities which signaled the unavailability of social-positive reinforcers.

We selected three naturally occurring contexts and stimuli per participant for those that experienced the multiple baseline design. Amanda's caretaker nominated washing dishes, talking on a cell phone, and cooking. Dominic's caretaker nominated cooking, talking on a cell phone, and typing on a laptop. Jose's caretaker nominated talking on a cell phone, typing on a laptop, and engaging in conversation with other adults. To assign naturalistic S^{Δ} signals across each condition for Amanda and Jose, we first randomly assigned one naturalistic S^{Δ} signal to the MULT 60s/60s + stimulus fading condition and one naturalistic S^{Δ} signal to the MULT 60s/60s+ direct teaching condition. Then, the condition that reached mastery criteria at the most efficient rate (i.e., three consecutive sessions at 80-100% correct responding and an 80% reduction in destructive behavior) was then introduced across the third naturalistic S^{Δ} signal. For Jose, following mastery criteria across the two teaching procedures, we conducted a concurrent choice assessment across treatment types. After we empirically derived Jose's preference for a treatment, we introduced the preferred treatment across the final naturalistic S^{Δ} signal.

Naturalistic MULT 60s/60s Baseline

The purpose the naturalistic multiple schedule baseline conditions were to test for discriminated responding in the presence of the naturally occurring discriminative signals prior to introducing the two teaching procedures. No arbitrary signal was included across multiple schedule components. During the S^{Δ}, the therapist engaged with the naturalistic activity (e.g., typing on a computer, washing dishes) for 60 s. During the S^D, the therapist disengaged from the activity and oriented towards the client for 60 s. If the learner emitted FCRs during either the S^{Δ} or S^D intervals this resulted in 30-s access to the functional reinforcer (i.e., FR1/FR1 schedule of reinforcement). Destructive behavior across both components resulted in extinction. Following three consecutive sessions with 40-60% of total FCRs occurring across both components (i.e., no discriminated responding), we progressed to the treatment evaluation. Baseline sessions discontinued if patterns in responding suggested a change in motivation (e.g., FCR rates dropped below 1 to 2 responses per session for 3 consecutive sessions), or three consecutive sessions occurred with 80% of total FCRs occurring during the S^D (i.e., discriminative responding).

MULT 60s/60s + Arbitrary Signal

Following naturalistic multiple baseline sessions, we conducted multiple schedule sessions in the presence of an arbitrary signal. The purpose of the MULT + arbitrary signal was to establish discriminated FCRs in the presence of the arbitrary signal before conducting the naturally occurring stimuli teaching evaluation. We established discriminated responding in the presence the arbitrary signal in isolation prior to introducing teaching in the presence naturally occurring stimuli due to the nature of stimulus fading procedure (i.e., reducing the size of the colored card) used during the naturally occurring stimuli teaching evaluation. Throughout sessions, therapists alternated across S^D and S^{Δ} components across 10-minute sessions. No naturally occurring stimuli were present across multiple schedule components. During the S^{Δ}, the therapist signaled the unavailability of reinforcement by the presence of a 12.5 cm x 7.5 cm red card. During the S^D, the therapist signaled the availability of reinforcement by removing the arbitrary signal. No other programmed signals (i.e., orienting towards or away from the client, contingency specifying rule statements) during either component.

Prior to the session beginning, the therapist provided 60-s access to the functional reinforcers. Thereafter, the therapist alternated the between S^D and S^{Δ} components for the remainder of the 10-min session. Each component was 60-s in duration. Correct FCRs emitted in the S^D component resulted in 30-s access to the functional reinforcer. FCRs emitted during the S^{Δ} contacted extinction. Destructive behavior emitted across both components resulted in extinction. Following three consecutive sessions with 80% of total correct FCRs occurring during the S^D (i.e., discriminative responding), the participant proceeded to the multiple schedule naturalistic stimuli treatment evaluation. If patterns in responding suggested a change in motivation (e.g., FCR rates dropped below 1 to 2 responses per session for 3 consecutive sessions), or a lack of discriminative responding, (e.g., three consecutive sessions occurred with 80% or more of total percent correct FCRs occurring in the presence of the S^{Δ}) therapists employed additional teaching procedures (e.g., response blocking, competing items) as clinically relevant.

MULT 60s/60s + Stimulus Fading

The purpose of the stimulus fading condition was to: (a) test discriminated responding during a naturalistic activity in the presence of the arbitrary stimulus and the programmed contingencies, and (b) sequentially transfer discriminative properties of the arbitrary stimuli to the naturally occurring stimuli across components of a multiple schedule. During the S^{Δ} component, the therapist gathered materials related to naturalistic baseline sessions to signal periods when reinforcement was unavailable (e.g., cellphone, dishes). The arbitrary stimulus (i.e., red card) used across the MULT 60s/60s + arbitrary condition was superimposed on the naturalistic S^{Δ} associated with the unavailability of reinforcement. For example, therapists placed the 12.5 cm x 7.5 cm red card onto a bin of dishes to emulate the presence of a sink. During the S^{Δ} interval, therapists began to "wash dishes" by standing in front of the bin and scrubbing dishes with a dish sponge and towel.

During the S^{Δ}, the therapist signaled the unavailability of reinforcement by engaging in the naturalistic S^{Δ} signal with the superimposed arbitrary stimuli for 60 s. Any FCRs emitted during the S^{Δ} resulted in extinction. During the S^{D}, the therapist signaled the availability of reinforcement by removing the arbitrary signal (i.e., no arbitrary signal was present or superimposed during the S^{D}), disengaging from the busy activity and orienting towards the learner for 60 s. Any FCRs emitted during the S^{D} component resulted in 30-s access to the functional reinforcer. Destructive behavior across S^{Δ} and S^{D} components resulted in extinction. Reinforcement and extinction components were alternated across the 10-minute session.

Following 80% correct responding in the presence of the S^{D}, and an 80% reduction in CIs from baseline sessions, we then proceeded to fade the size of the arbitrary signal using similar progression as described by Akers et al[35]. Table 4 depicts the stimulus fading progression sequence. Due to discrimination errors identified in the MULT 60s/60s + arbitrary phase, Amanda's stimulus fading sequence began using a 27 cm x 22 cm red card. Following one session at 80-100% correct responding and an 80% reduction in destructive behavior, participants proceeded to the next fading step. Following two consecutive sessions where the participant did not meet criterion to progress to the next stimulus fading step, the therapist regressed to the previous step. To test for rapid acquisition of discriminated responding in the presence of the naturally occurring signal, we conducted naturalistic multiple schedule probes (e.g., generalization probes) following steps 2 and 4. Probes were identical to the above arrangement; however, the arbitrary card was no longer superimposed on the naturalistic S^{Δ}.

Table 4: Stimulus fading steps with corresponding card sizes

Step	Card Size
1	12.5 cm x 7.5 cm
2	8.5 cm x 6.5 cm
3	8.5 cm x 6 cm
4	7 cm x 5 cm
5	5.5 cm x 4 cm
6	4 cm x 3.5 cm
7	No signal present

The final stage of the fading procedure tested for discriminated responding in the presence of the naturalistic S^{Δ} interval with no arbitrary stimulus present. Stimulus fading sessions concluded following three consecutive sessions at 80%-100% correct responding and an 80% reduction in destructive behavior.

MULT 60s/60s + Direct Teaching

During the MULT 60s/60s + direct teaching, we used procedures like those described by Shamlian et al., (2016) and Boyle et al., (2020). During the multiple schedule + direct teaching sessions, therapists alternated across S^{D} and S^{Δ} components of a multiple schedule. Materials related to naturalistic baseline sessions were included (i.e., cellphone up to ear, laptop open). These sessions were identical to the above sessions with the exception that no arbitrary signal was present. For example, therapists signaled the unavailability of reinforcement by engaging with the naturalistic S^{Δ} for 60s and signaled the availability of reinforcement by disengaging from the busy activity and oriented towards the learner for 60s. Any FCRs emitted during the S^{Δ} resulted in extinction. During the S^{D}, the therapist signaled the availability of reinforcement by disengaging from the busy activity and orienting towards the learner for 60 s. Any FCRs emitted during S^{D} resulted in 30-s access to the functional reinforcer. Destructive behavior across S^{Δ} and S^{D} resulted in extinction. Discriminated responding in the presence of the naturalistic S^{Δ} was determined following three consecutive sessions at 80% - 100% correct responding and an 80% reduction in destructive behavior.

TREATMENT CHOICE ASSESSMENT

For two participants (i.e., Jose and Dominic), we conducted a choice evaluation using similar procedures described by Hanley et al[36] to empirically derive client preference across treatment options. Jose completed the choice assessment during the multiple schedule + naturally occurring stimuli evaluation, while Dominic completed the choice assessment after completing the evaluation.

Results

FUNCTIONAL ANALYSIS

Each participant displayed elevated levels of destructive behavior in either the attention, tangible, and/or synthesized attention tangible test conditions relative to the control condition. Participants who displayed sensitivity to the escape condition relative to the control condition were treated for a social negative function later in their admission. Results indicated a synthesized attention/tangible function for Malcom, Jacob, and Amanda. Results indicated a tangible function for Jose and Dominic, respectively. Functional Analysis data are available upon request.

FCT EVALUATION AND MTA

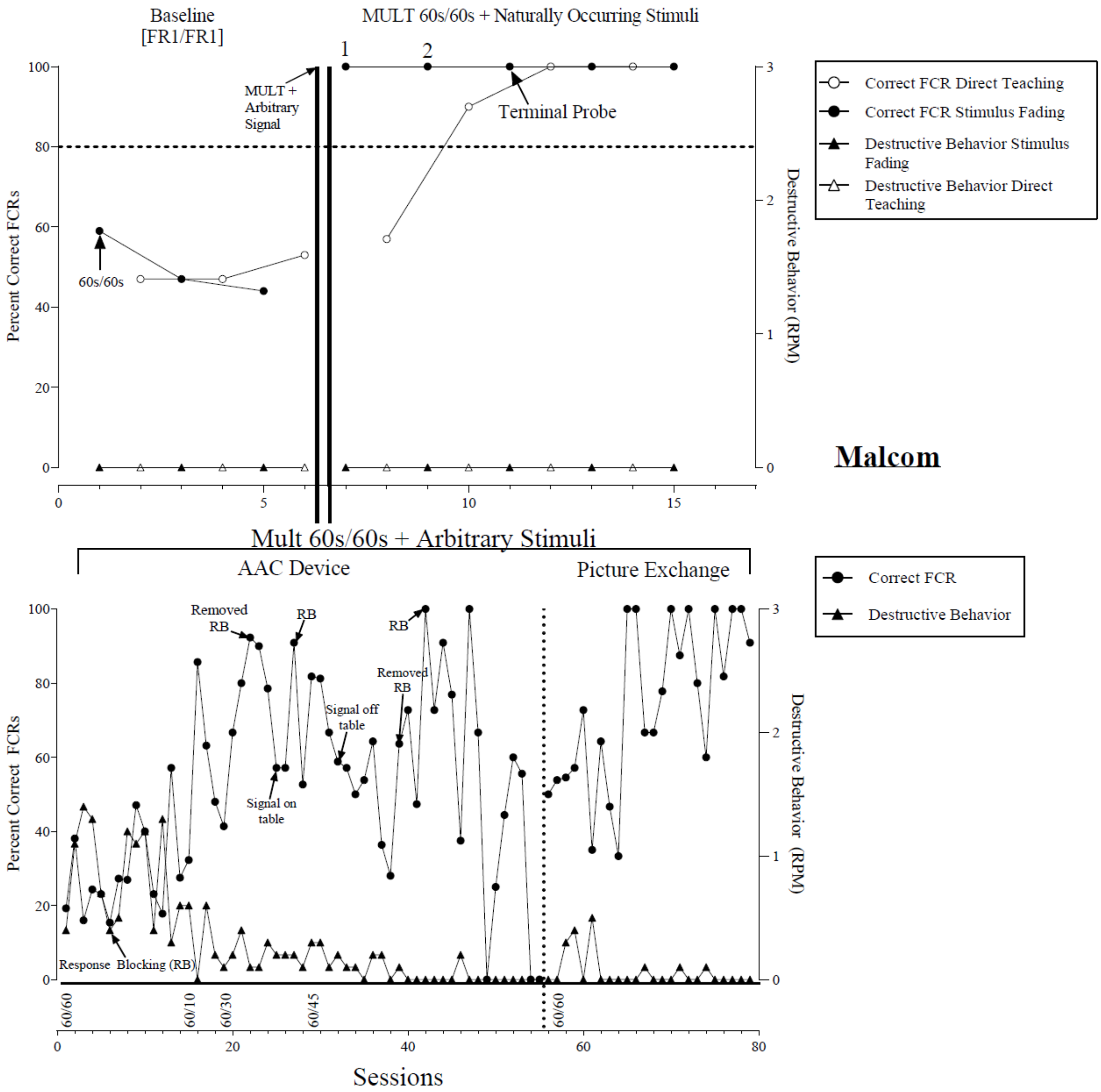
The MTA revealed that Malcom's most preferred FCR topography was the AAC device (i.e., "play"). Jacob preferred using a vocal FCR, (i.e., "play please"), while Amanda preferred "mas" (Spanish for "more") using an AAC device. Dominic and Jose demonstrated high levels of vocal verbal behavior. Therefore, as a replacement for the MTA, we simply asked what they would say to receive their preferred items when removed by a therapist. Dominic nominated, "Can I have my stuff back" and Jose nominated, "Can I have my iPad back."

After empirically selecting an FCR topography, we conducted an FCT evaluation to teach a functionally equivalent communication response while simultaneously arranging extinction for destructive behavior. Results of the FCT evaluation demonstrated the efficacy of FCT as a treatment to reduce destructive behavior across all participants (data available upon request).

MULT 60s/60s + ARBITRARY STIMULI EVALUATION

Results of Malcom's MULT 60s/60s + arbitrary signal evaluation are depicted in bottom panel of Figure 1. Initially, we observed low levels of correct FCRs due to persistent rates of FCRs throughout the S^{Δ} interval. Therefore, the therapists introduced response blocking to decrease the probability of incorrect FCRs during the presence of the S^{Δ}. Response blocking was used as opposed to response restriction to allow for the opportunity to engage incorrect FCRs in the presence of the S^{Δ}, thus allowing incorrect FCRs to contact extinction. Due to the persistence of blocked FCRs in the presence of the S^{Δ}, the duration of the S^{Δ} interval was progressively increased from 10s, 30s, and 45s to the terminal schedule of 60s. This progressive schedule was informed via within-data analysis using the latency to blocked FCRs.

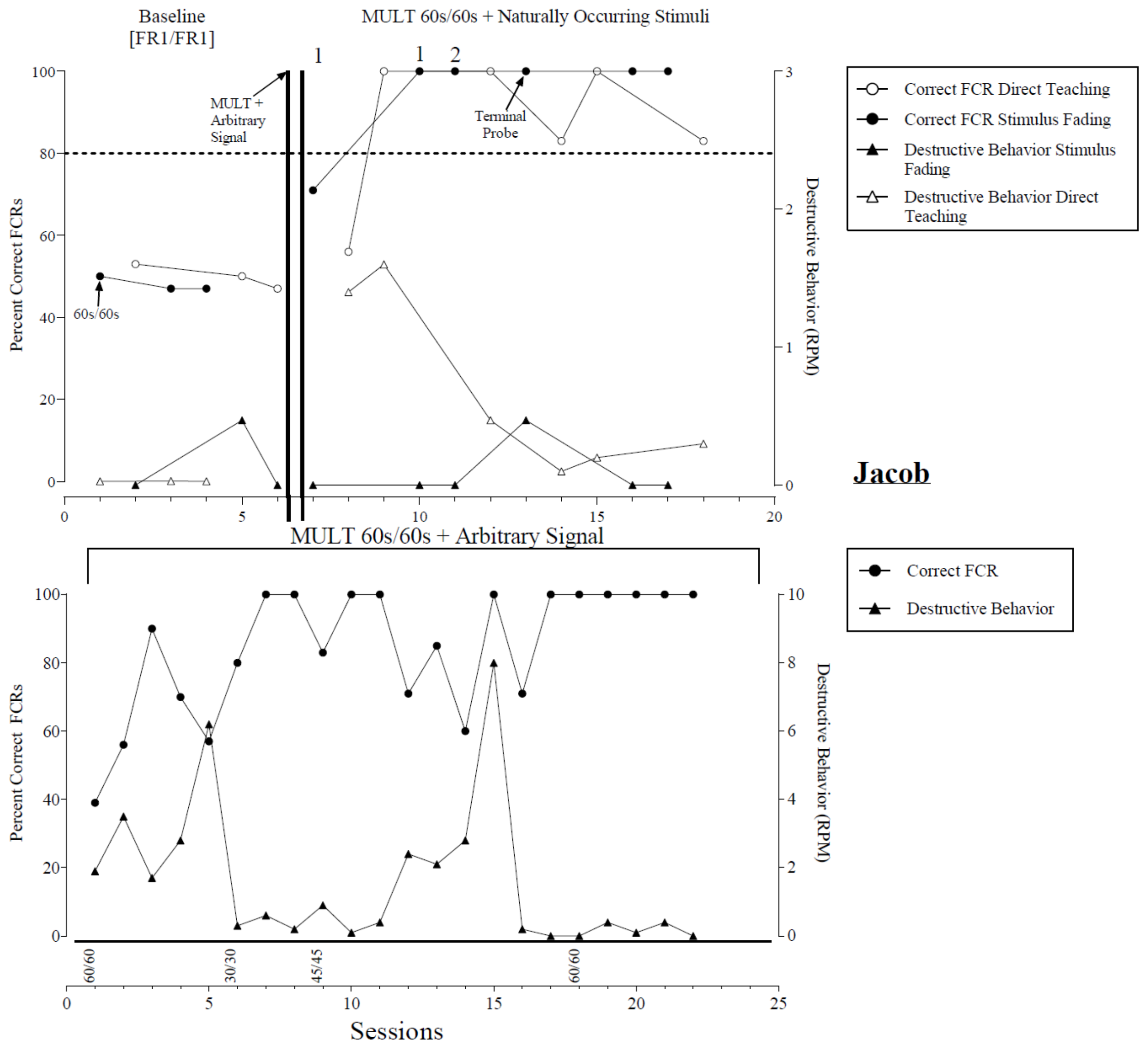
Figure 1: Results from Malcom's MULT + Arbitrary Signal (bottom panel) and MULT + Naturally Occurring Stimuli Evaluation



For Malcom, the addition of supplemental teaching components did not produce high levels of percent correct FCRs in the presence of the arbitrary signal (M = 51%) across a total of 55 sessions. More specifically, Malcom engaged in high rates of AAC scrolling in addition to incorrect FCRs throughout sessions. These instances of non-intended engagement with the AAC device potentially contained additional reinforcing properties that competed with engaging in the FCR in the presence of the S^D. Therefore, we removed the AAC device and re-introduced the card exchange FCR taught during the MTA to control for potential reinforcing effects and learning history associated with the AAC device. We conducted one booster session to demonstrate card exchange FCR maintenance in the presence of the relevant EO. Following the booster session, we removed response blocking and introduced the arbitrary signal at the terminal MULT 60s/60s schedule. In contrast to the AAC device FCR, Malcom demonstrated high levels of percent correct FCRs (M = 78%) using the card exchange FCR across 23 sessions. Additionally, we observed lower rates of destructive behavior during the MULT 60s/60s using the picture exchange FCR (M =. 07 RPM) compared to the AAC FCR (M =.3 RPM).

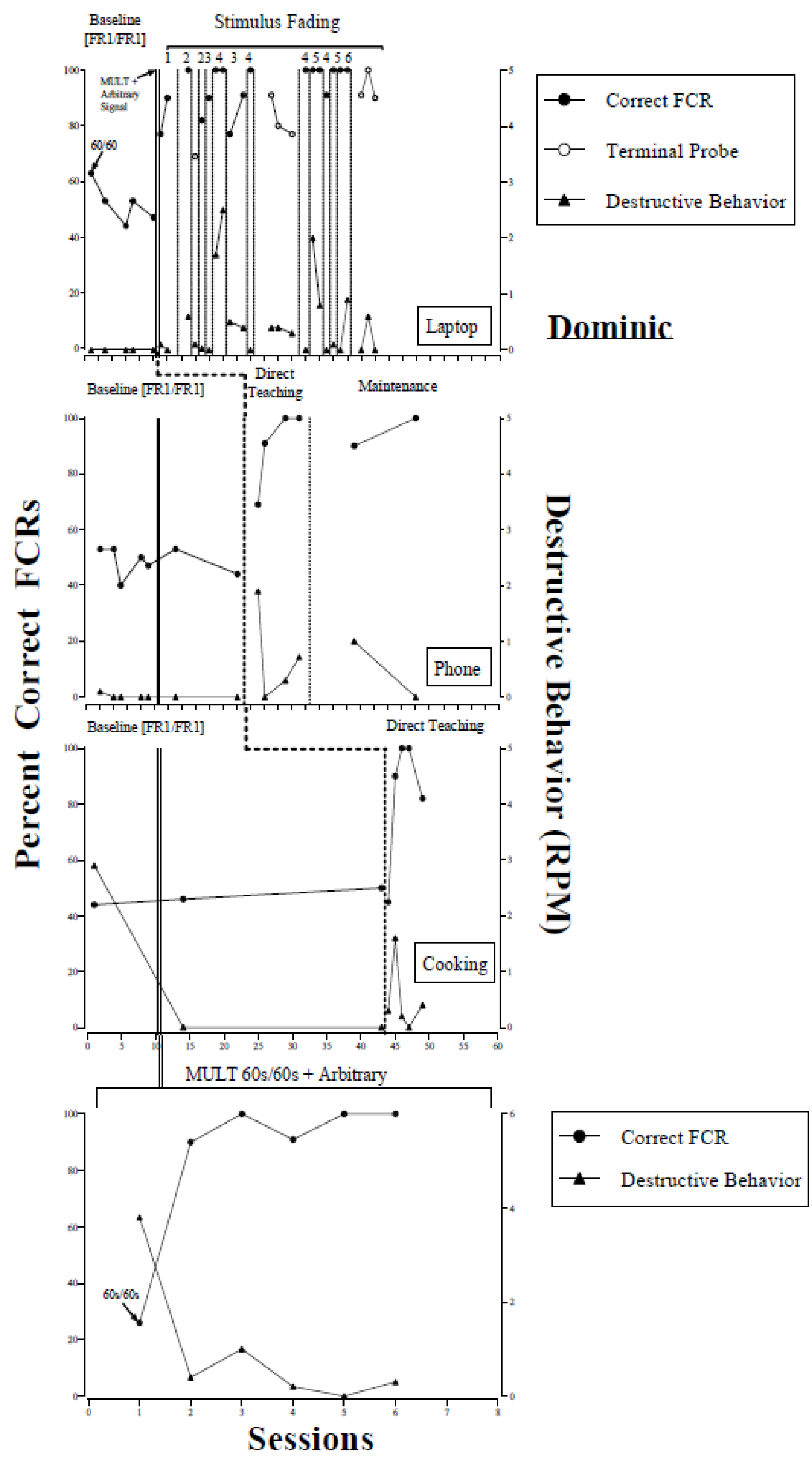
The bottom panel of Figure 2 depicts the results of Jacob's MULT 60s/60s + arbitrary stimulus evaluation. Jacob displayed elevated levels of destructive behavior following the presentation of the terminal schedule. Therefore, we decreased the duration of the S^{Δ} interval from 60 s to 30 s to establish discrimination under a less potent EO. We progressively increased the duration of the S^{Δ} interval from 30 s to 45 s, to the terminal schedule of 60 s. Following the progressive introduction of the S^{Δ} interval, Jacob displayed moderate rates of destructive behavior (M = 1.1 RPM) and high levels of percent correct FCRs (M = 85%) until mastery criteria was met in 22 sessions.

Figure 2: Results from Jacob's MULT + Arbitrary Signal (top panel) and MULT + Naturally Occurring Stimuli Evaluation



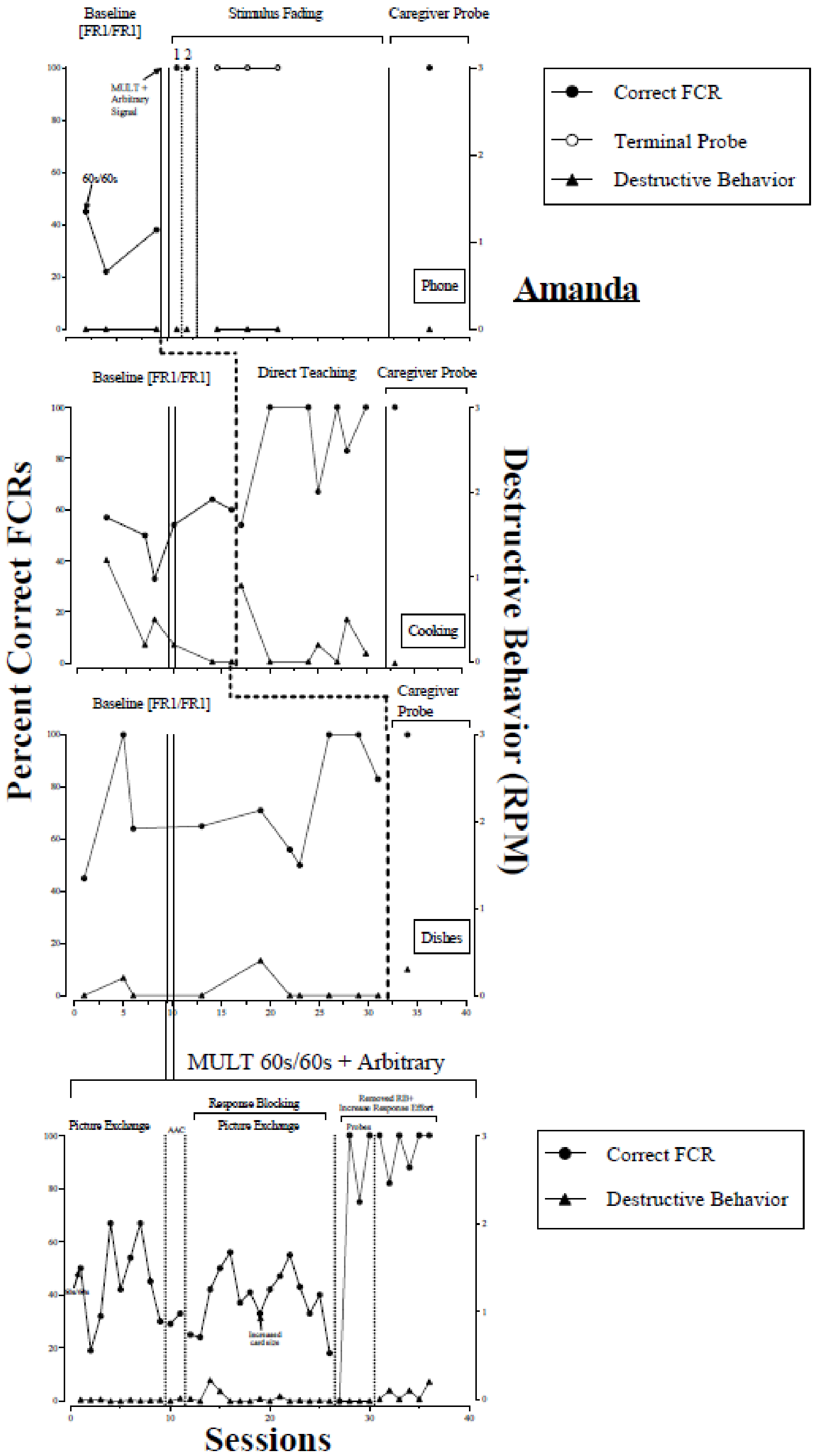
The bottom panel of Figure 3 depicts the results of Dominic's MULT 60s/60s + arbitrary stimulus evaluation. After an initial increase in destructive behavior following the presentation of the extinction component at the terminal schedule, Dominic displayed rapid discrimination of the FCR (M = 85%) and low levels of destructive behavior (M= .96 RPM). Dominic reached mastery criteria in 6 sessions.

Figure 3: Results from Dominic's MULT+ Naturally Occurring and MULT + Arbitrary Stimuli Evaluation



The bottom panel of Figure 4 depicts the results of Amanda's MULT 60s/60s + arbitrary stimulus evaluation. We initially elected to use the card exchange FCR as the MTA identified this as Amanda's most preferred FCR topography. Following the presentation of the arbitrary S^{Δ} signal, we observed variable levels of percent correct FCRs and low rates of FCRs during the presentation of the S^{D} interval (suggesting low motivation). We removed the card exchange requirement because Amanda's percent correct FCR responding was not discriminated between multiple schedule components during the initial MULT 60s/60s + arbitrary sessions. Therefore, we re-introduced Amanda's second most preferred FCR topography as determined by the MTA, which was the AAC device. We observed similar patterns of FCR responding using the AAC device (i.e., high levels of FCRs in the presence of the S^{Δ} and S^{D} intervals). Therefore, response blocking was introduced to decrease the probability of incorrect FCRs during the presence of the S^{Δ}. Like Malcom, response blocking was used as opposed to response restriction to allow for the opportunity to engage incorrect FCRs in the presence of the S^{Δ}, thus contacting extinction. The introduction of response blocking did not result in a decrease of FCRs in the presence of the S^{Δ}, therefore we increased the size of the arbitrary stimulus to aid in discrimination across multiple schedule components. Following this change, blocked attempts continued to persist during the presence of the S^{Δ}.

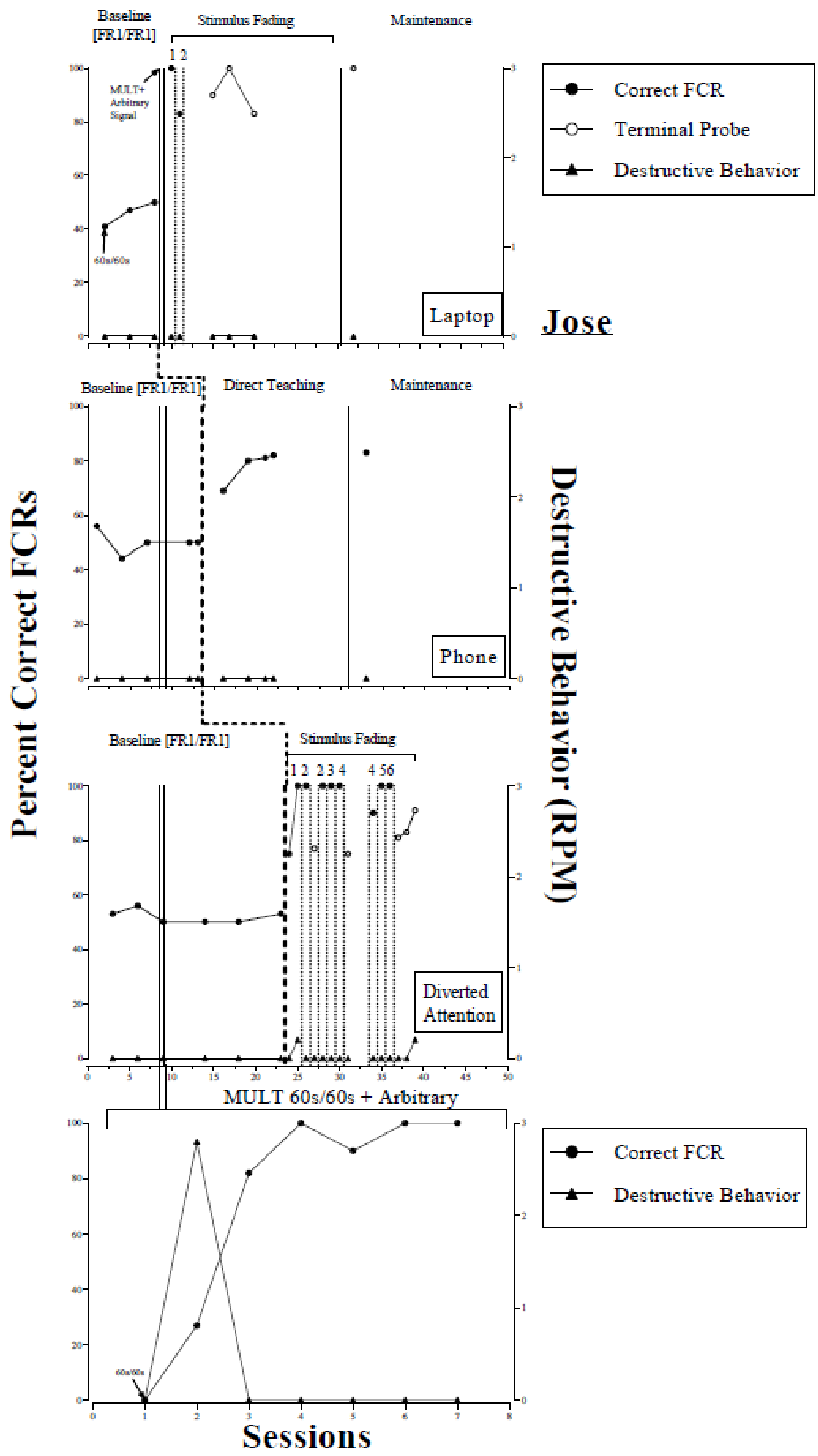
Figure 4: Results from Amanda's MULT+ Naturally Occurring and MULT + Arbitrary Stimuli Evaluation



We conducted four probe sessions in which we increased the response effort required for Amanda to engage in incorrect FCRs. More specifically, we removed response blocking and seated Amanda at the end of the table and placed the picture exchange FCR towards the center of the table, slightly out of Amanda's reach. After the modification, we saw an immediate increase in correct percent correct FCRs and low rates of destructive behavior. Thus, we continued with the response effort manipulation plus the removal of response blocking until mastery criteria was met. Amanda met mastery criteria after 36 sessions.

The bottom panel of Figure 5 depicts the results of Jose's MULT 60s/60s + arbitrary stimulus evaluation. Jose initially displayed low levels of percent correct FCRs and high rates of destructive behavior following the initial presentation of the terminal schedule. Following two sessions, Jose emitted high levels of percent correct FCRs (*M* = 71%) and low rates of destructive behavior (*M* = .95 RPM) and met mastery criteria in 7 sessions.

Figure 5: Results from Jose's MULT+ Naturally Occurring and MULT + Arbitrary Stimuli Evaluation



MULTIPLE SCHEDULE + NATURALLY OCCURRING STIMULI EVALUATION

We used two single-case research designs to evaluate the acquisition rate of discriminated FCRs and destructive behavior across stimulus fading and direct teaching. Malcom and Jacob experienced an alternating treatments design while we used a multiple baseline design + alternating treatment design for the remaining 3 participants.

The top panel of Figure 1 depicts results from Malcom's MULT 60s/60s + naturally occurring stimuli evaluation. Prior to the evaluation, we randomly assigned one caregiver-nominated stimulus across each teaching condition for each participant. During baseline, Malcom engaged in moderate levels of percent correct FCRs across both naturally occurring stimuli (direct teaching, *M* = 49%); stimulus fading, *M* = 50%). Additionally, destructive behavior remained at zero rates across both conditions. Before discrimination training, we randomly assigned one caregiver-nominated naturally occurring S^{Δ} signal to each teaching condition. During training, Malcom engaged in high levels of percent correct FCRs across both conditions (direct teaching, *M* = 87%; stimulus fading, *M* =100%). Malcom experienced two stimulus fading steps prior to the terminal probe. For Malcom, mastery criterion was achieved at similar rates across teaching conditions. More specifically, the direct teaching condition met mastery criteria in four sessions, while stimulus fading met criteria in five sessions, respectfully. Additionally, destructive behavior remained at zero rates across both conditions. These data suggest that both teaching procedures effectively taught discriminated FCRs while maintaining low rates of destructive behavior.

The top panel of Figure 2 depicts results from Jacob's MULT 60s/60s + naturally occurring stimuli evaluation. Jacob demonstrated moderate levels of percent correct FCRs across baseline conditions (direct teaching *M* = 50%; stimulus fading *M* = 48%). Like Malcom, Jacob quickly discriminated FCRs across multiple schedule components during both teaching conditions. Specifically, Jacob achieved mastery criteria in 6 sessions across both conditions. Similar to Malcom, Jacob experienced two stimulus fading steps prior to reaching mastery criteria at the terminal probe. We observed slightly lower percent correct FCRs during the direct teaching condition (*M* = 87%) in comparison to stimulus fading (*M* = 95%). However, Jacob engaged in higher rates of destructive behavior during direct teaching (*M* = .68 RPM) relative to stimulus fading (*M* = .08 RPM).

Although Malcom and Jacob displayed rapid acquisition of discriminated responding and low rates of destructive behavior across both teaching interventions, we are unclear if the demonstration of effects was due to the independent variable manipulation or an artifact of sequence effects. Therefore, we did not demonstrate a convincing comparison of effectiveness across teaching procedures. Thus, we elected to evaluate the effects of the two teaching procedures using a multiple baseline design for remaining participations. This change was made to obtain a more robust demonstration of effects and better determine the degree to which each intervention influenced responding.

The results of Dominic's MULT 60s/60s + naturally occurring stimuli evaluation are depicted by Figure 3. Three caregiver-nominated S^{Δ} signals were included across baseline conditions (i.e., laptop, phone, cooking). Following stable baseline responding, we first introduced stimulus fading to teach Dominic to engage in discriminated FCRs in the presence of the therapist typing on a laptop computer. During stimulus fading, Dominic engaged in moderate-high levels of percent correct FCRs (*M* = 92%) and low rates of destructive behavior (*M* = .5 RPM). Notably, Dominic did not meet mastery criteria across 4 terminal probe sessions throughout the stimulus fading procedure. Six subsequent stimulus fading steps were required for Dominic to reach mastery criteria across the first naturalistic stimuli in 24 sessions. We exposed talking on the phone to direct teaching as levels of percent correct FCRs emerged during stimulus fading (depicted by the middle panel). Dominic quickly met mastery criteria in 4 sessions across the direct teaching condition (*M* = 90%), while rates of destructive behavior remained relatively low (*M* = .73 RPM). Given the quick acquisition of discriminated FCRs in the presence of the therapist talking on the cellphone using direct teaching, we then introduced direct teaching to cooking, depicted by the bottom panel. Dominic met criteria in 5 sessions and emitted high levels of percent correct FCRs (*M* = 83%) and low rates of destructive behavior (*M* = .5 RPM) in the presence of the therapist cooking. These data suggest that both stimulus fading and direct teaching resulted in high levels of discriminated FCRs and low rates of destructive behavior. However, direct teaching required fewer sessions to reach mastery criteria across two naturally occurring stimuli (*M* = 4.5 sessions).

The results of Amanda's MULT 60s/60s + naturally occurring stimuli evaluation are depicted by Figure 4. Three caregiver-nominated S^{Δ} signals were included across baseline conditions (i.e., phone, dishes, cooking). During baseline, Amanda engaged in moderate-low levels of percent correct FCRs in the presence of the therapist talking on the phone (*M* = 35%) and low rates of destructive behavior (*M* = 0 RPM). Therefore, we began stimulus fading in this condition (depicted in the top panel). During stimulus fading, Amanda engaged in high levels of percent correct FCRs and low rates of destructive behavior across two stimulus fading steps prior to reaching mastery criterion in 5 sessions (Percent correct FCRs, *M* =100%; destructive behavior, *M* = 0 RPM). We introduced direct teaching to cooking as discriminated FCRs emerged in the stimulus fading condition and baseline remained stable (depicted by the middle panel). Following the introduction of direct teaching, Amanda engaged in high levels of percent correct FCRs (*M* = 86%) and low rates of destructive behavior (*M* = .2 RPM). Amanda reached mastery criterion during the direct teaching condition in seven sessions. These data suggest that both stimulus fading and direct teaching resulted in similar rates of acquisition across discriminated FCRs and low levels of destructive behavior. We continued baseline across cooking while the other two naturally occurring discriminative stimuli were exposed to discrimination training. We observed elevated levels of percent correct FCRs in the final baseline condition (*M* = 73%), respectively. Although levels of percent correct FCRs in this condition were lower relative to the naturally occurring stimuli exposed to discrimination training, Amanda met mastery criterion in baseline prior treatment exposure in 10 sessions. We hypothesized that this generality effect was likely due to treatment exposure across the other conditions.

Following the conclusion of the evaluation, Amanda's caregiver ran a generalization probe across each naturally occurring stimulus. During caregiver-run sessions, we observed high levels of percent correct FCRs and low rates of destructive behavior across conditions. More specifically, Amanda engaged in 100% correct responding and 0 rates of destructive behavior across the two stimuli exposed to treatment (i.e., phone and cooking). Rates of destructive behavior were relatively higher across the stimuli that did not contact discrimination training (*M* = .3 RPM). These data suggest that both programmed interventions successfully maintained discriminated FCRs and low rates of destructive behavior in the presence of Amanda's caregiver. Further, the generality of effects was maintained across the stimuli not exposed to treatment.

The results of Jose's MULT 60s/60s + naturally occurring stimuli evaluation are depicted in Figure 5. Three caregiver-nominated S^{Δ} signals were included across baseline conditions (i.e., phone, laptop, conversing amongst adults). Following three sessions of moderate-low levels of percent correct FCRs across S^{Δ} signals, we introduced stimulus fading with the laptop computer (depicted in the top panel). During stimulus fading, Jose engaged in high levels of percent correct FCRs and low rates of destructive behavior across two stimulus fading steps prior to reaching mastery criterion in 5 sessions (Percent correct FCRs, *M* = 91%; destructive behavior, *M* = 0 RPM). We introduced direct teaching to talking on the phone as discriminated FCRs emerged in the stimulus fading condition and baseline remained stable (depicted by the middle panel). Following the introduction of direct teaching, Jose engaged in high levels of percent correct FCRs (*M* = 78 %) relative to baseline and low rates of destructive behavior (*M* = 0). Jose reached mastery criterion during the direct teaching condition in four sessions. These data suggest that although both teaching procedures resulted in quick acquisition of percent correct FCRs and low levels of destructive behavior, stimulus fading resulted in higher levels of correct responding across sessions.

The bottom panel of Figure 5 depicts Jose's responding across diverted attention. In baseline, percent correct FCRs remained stable (*M* = 52%, respectively) as the other two stimuli met mastery criteria. Following the acquisition of discriminated responding across the first and second stimuli, we conducted a concurrent operant choice evaluation to identify Jose's preference for treatment type prior to discrimination training across the third stimuli. Results of the treatment choice assessment indicate that Jose's preferred method of learning involved the presence of the red stimulus card accompanied by the subsequent fading steps. Therefore, we elected to introduce stimulus fading to the third naturally occurring S^{Δ}. Jose emitted moderate-high levels of percent correct FCRs across six stimulus fading steps. Because Jose did not engage in discriminated responding in the absence of the red stimulus card (i.e., the terminal step) across two terminal probes, we continued stimulus fading until discriminated responding emerged. Jose reached mastery criteria in 14 sessions. Across stimulus fading, levels of discriminated responding remained high (M = 91%), and rates of destructive behavior remained low (*M* = .03 RPM). Given that Jose acquired discriminated FCRs at a slower rate in the diverted attention condition in comparison to talking on the phone and using a computer, we elected to conduct maintenance probes across the mastered stimuli. High levels of percent correct FCRs maintained across stimulus fading (100%) and direct teaching (83%, respectively) during probe sessions. Taken together, these data suggest that stimulus fading and direct teaching were viable teaching strategies to teach discriminated responding and suppress rates of destructive behavior across three naturally occurring S^{Δ}. However, Jose's results of the concurrent operant assessment revealed that Jose preferred stimulus fading compared to direct teaching.

EFFICACY AND EFFICIENCY OF INSTRUCTIONAL METHODS ACROSS PARTICIPANTS

Table 5 depicts the results of the multiple schedule + naturally occurring stimuli evaluation across participants. We calculated the aggregate of the total responding across relevant dependent variables during MULT 60/60 + arbitrary signal and MULT 60/60 + stimulus fading conditions. We elected to aggregate responding across these two conditions because participants were taught to discriminate FCRs in the presence of the arbitrary signal in isolation prior to the introduction of the stimulus fading procedure. Overall, direct teaching resulted in higher levels of discriminated FCRs (*M* = 85%, range = 78% – 87%) and slightly lower rates of destructive behavior (*M* = .3, range = 0% – .68%) compared to stimulus fading (FCR *M* = 78%, range = 59% – 90%; destructive behavior *M* = .5, range = .1– 1.3). Importantly, mastery criteria were met within a significantly shorter number of sessions during direct teaching across participants that experienced the alternating treatments design (*M* = 5.5, range = 5 – 6) and the multiple baseline design (*M* = 5.1, range = 4 – 7) compared to stimulus fading (alternating treatment design *M* = 56, range = 28 – 84; multiple baseline design *M* = 28, range = 13.5 – 40).

Table 5: Results of the Multiple Schedule 60s/60s + Naturally Occurring Stimuli evaluation across participants

Participant	DT Mean Correct FCR	DT Mean Sessions to Criteria	DT Mean Destructive Behavior (RPM)	SF Mean Correct FCR	SF Mean Sessions to Criteria	SF Mean Destructive Behavior (RPM)
Malcom	87%	5	0	69%	84	.22
Jacob	87%	6	.68	87%	28	1.3
Dominic	86%	4.5	.6	90%	30	.5
Amanda	86%	7	.2	59%	40	.5
Jose	78%	4	0	86%	13.5	.1

Note. Direct teaching is abbreviated by DT and Stimulus Fading is abbreviated by SF. Stimulus Fading results are depicted as an aggregate across total responding during the MULT 60/60 + stimulus fading and MULT 60/60 + arbitrary signal.

Discussion

In the current study, we taught five participants to discriminate the probability of reinforcement depending upon the environmental context by use of naturally occurring discriminative stimuli in a multiple schedule arrangement using two teaching procedures. We evaluated the degree to which each procedure established discriminated responding across caregiver nominated, naturally occurring periods of reinforcement unavailability and suppression of destructive behavior. The results of the current study were consistent with those reported by Kuhn et al[13], Shamlian et al[15], and Boyle et al[12], in that all five participants mastered the discrimination of naturally occurring discriminative stimuli using the direct teaching procedure. Furthermore, our results are consistent with Brown and Nercesian[21], such that participants were able to maintain low levels of problem behavior and high rates of discriminated responding during the stimulus fading procedure.

Although our evaluation demonstrated the efficacy on using direct teaching and stimulus fading as procedures to teach discriminations across naturally occurring periods of reinforcement availability and unavailability. Our results suggest that direct teaching may result in higher levels of percent correct FCRs and lower rates of destructive behavior. Moreover, direct teaching required a significantly shorter number of sessions to meet mastery criteria across participants. Interestingly, 3 out of 5 participants acquired discriminated FCRs during the terminal probe following two stimulus fading steps. Thus, we hypothesize that errorless learning facilitated discrimination and suppressed destructive behavior without requiring the complete stimulus fading sequence. However, participants that did not meet mastery criteria following the first terminal probe did not reach mastery criteria until experiencing each stimulus fading step. Future researchers may consider further evaluating the amount of stimulus fading steps necessary to achieve discriminated responding.

It is worth noting that participants for whom percent correct FCRs took the longest to develop in the MULT + arbitrary phase (Malcom and Amanda) were able to acquire discriminative responding in the presence of the naturally occurring discriminative stimuli in a significantly shorter number of sessions compared to the arbitrary signal in isolation. Thus, discrimination difficulties identified during the MULT + arbitrary signal phase were not predictive of later difficulties of acquisition of discriminative FCRs during the naturally occurring multiple schedule. However, it is unclear how exposure to extinction during this phase may have facilitated learning during the naturally occurring discriminative stimuli evaluation. Our findings suggest direct teaching (i.e., no arbitrary signal present) may be a sufficient treatment option for participants that demonstrate slower acquisition of discriminated responding in the presence of an arbitrary signal. Furthermore, additional teaching components used to acquire discriminated FCRs in the presence of the arbitrary signal during the MULT + arbitrary phase were removed during the evaluation of the MULT + naturally occurring stimuli. These results deviate from previous studies that embedded additional teaching components from the outset, such as contingency specifying statements, to facilitate discriminated FCR acquisition during discrimination training.

Our findings demonstrate participants learned to discriminate between overt behaviors associated with the availability and non-availability of reinforcement. We recognize that conducting discrimination training across every naturally occurring S^{Δ} period a learner may experience is unattainable. However, caregiver-nominated S^{Δ} periods were similar across participants during our investigation. More specifically, each caretaker nominated talking on the phone as a period in which they cannot deliver social positive reinforcement, three caretakers nominated typing on a laptop computer, and two caretakers nominated both cooking and washing dishes as periods in which the delivery of social positive reinforcement is unavailable. Thus, although conducting discrimination training across each naturally occurring S^{Δ} in the natural environment may be unreasonable, clinicians should consult caregivers and prioritize contexts most ecologically relevant to the learner (see Fahmie et al[37] for a review).

Given our results suggest that both teaching procedures resulted in relatively high levels of discriminated FCRs and low levels of challenging behavior, it may be adventitious for future practitioners to allow participants to select treatment options based on individual preference. Akin to previous literature emphasizing the importance of client autonomy in behavioral service delivery[38], allowing clients to experience multiple treatment options and identify preferences for teaching procedures may lend to efficacious outcomes. For these reasons, we elected to conduct a treatment choice evaluation for two participants (i.e., Dominic and Jose) to empirically derive a preference for treatment type. Results of the treatment preference evaluation indicated that Jose preferred to learn to discriminate between therapist behavior using stimulus fading, while Dominic did not indicate a clear preference. Following the study, Dominic and Jose continued discrimination training and further schedule thinning with their preferred methods of learning. We did not formally evaluate preference for treatment type across the remaining 3 participants. In hindsight, clinicians should consider intentionally assessing preference for treatment and conducting choice probes throughout behavioral treatment particularly when selecting between multiple efficacious treatment options.

Overall, our findings echo efforts put forth to increase the generality of behavioral treatment effects. Specifically, programming common stimuli akin to the natural environment from the onset of training will have maximum behavioral influence in non-training settings.[22] By intentionally teaching learners to behave discriminatively to stimuli found in the natural environment, we evaluated two practical approaches for clinicians to increase the generality of effects from the onset of treatment. Therefore, we recommend that clinicians do not solely rely on arbitrary signals to facilitate and maintain learning, as doing so may impact the durability of treatment effects. Rather, clinicians should incorporate ecologically relevant periods of reinforcement availability and non-availability within multiple schedule arrangements to promote stimulus generalization and arrange control over different environmental conditions in the natural setting. Thus, we encourage researchers and clinicians to intentionally assess for and plan for generalization at the onset of treatment.[22]

Notwithstanding to the contributions of the current study, findings should be interpreted relative to several limitations. First, it should be noted that we did not formally evaluate and report schedule thinning beyond the terminal MULT 60s/60s schedule. A primary purpose of the investigation was to determine the efficiency and efficacy of the two discrimination training procedures; thus, further schedule thinning was only formally evaluated across participants within the terminal 60s/60s schedule. Future researchers may consider schedule thinning across both teaching procedures to further evaluate the maintenance of effects on responding.

Second, we utilized two different single-case designs to evaluate the effects across treatment types. We used an alternating treatment design for two participants (i.e., Malcom and Jacob) and a multiple baseline design for the remaining three (i.e., Dominic, Amanda, and Jose). We elected to make the change because we observed a possible carry-over effect across the two treatments using the alternating treatment design. Therefore, it is unclear if the equitable acquisition rates were an artifact of the design or outcome of the independent variable manipulation. Thus, we used a multiple baseline design to stagger the introduction of treatments across conditions following stable baseline responding to better control for threats to internal validity.

Next, our investigation was specific to destructive behavior maintained in part by social positive reinforcement. Akin to naturally occurring signals of social positive reinforcement availability and unavailability, learners are likely also contact naturalistic signals of social negative reinforcement availability and non-availability. Thus, future researchers should arrange control over different environmental conditions in the natural setting reported to evoke destructive behavior maintained by social negative reinforcement.

Finally, numerous overt behaviors exist that could be topographically similar but categorically different, providing a false signal for reinforcement availability. During our evaluation, the signal for reinforcement availability remained consistent across conditions (i.e., the therapist oriented towards the learner and disengaged from the busy activity). In the spirit of generalization, training multiple exemplars of reinforcement availability and unavailability may enhance generalization effects.

Conclusion

In summary, the current study extends prior research by demonstrating that direct teaching and stimulus fading are both effective and practical approaches for establishing discriminated functional communication across naturally occurring periods of reinforcement availability and unavailability. By programming instruction around ecologically relevant stimuli and caregiver-nominated contexts, participants learned to respond adaptively to signals embedded in the natural environment, resulting in high levels of discriminated FCRs and sustained suppression of destructive behavior. Findings further suggest that direct teaching may offer efficiency advantages for some learners, whereas stimulus fading may promote errorless acquisition for others, underscoring the importance of individualized treatment selection. Collectively, these results highlight the value of designing discrimination training that prioritizes generalization from the outset[22] and supports durable behavior change in everyday contexts. Future research should continue to refine procedures, evaluate maintenance under leaner schedules, and further examine learner preference as a variable influencing treatment effectiveness.

Ethical Approval: All procedures performed in this study were in accordance with the ethical standards of the institutional research board.

Conflict of Interest: The authors declare that they have no conflict of interest.

Funding Statement: Not applicable. No funding supported this work.

Data Availability: Data that support the findings of this study are available from the corresponding author upon reasonable request. Please address correspondence concerning this article to Jordan DeBrine. Email: jdebrine@unm.edu

Acknowledgements: This research was conducted by the first author, supervised by the second author, in partial fulfillment of the requirements of a Doctor of Philosophy degree in Applied Behavior Analysis at the University of Nebraska Medical Center. We want to thank Drs. Cynthia P. Livingston, Tara A. Fahmie, and Catalina N. Rey for their feedback on earlier versions of this manuscript.

References

1. Tiger JH, Hanley GP, Bruzek J. Functional communication training: A review and practical guide. *Behav Anal Pract*. 2008;1(1):16-23. doi:10.1007/BF03391716
2. Fisher WW, Greer BD, Fuhrman AM, Querim AC. Using multiple schedules during functional communication training to promote rapid transfer of treatment effects. *J Appl Behav Anal*. 2015;48(4):713-733. doi:10.1002/jaba.254
3. Jarmolowicz DP, DeLeon IG, Kuhn SAC. Functional communication during signaled reinforcement and/or extinction. *Behav Interv*. 2009;24:265-273. doi:10.1002/bin.288
4. Hanley GP, Iwata BA, Thompson RH. Reinforcement schedule thinning with functional communication training. *J Appl Behav Anal*. 2001;34(1):17-38. doi:10.1901/jaba.2001.34-17
5. Hagopian LP, Boelter EW, Jarmolowicz DP. Reinforcement schedule thinning following functional communication training: Review and recommendations. *Behav Anal Pract*. 2011;4(1):4-16. doi:10.1007/BF03391770
6. Greer BD, Fisher WW, Saini V, Owen TM, Jones JK. Functional communication training during reinforcement schedule thinning: An analysis of 25 applications. *J Appl Behav Anal*. 2016;49(1):105-121. doi:10.1002/jaba.265
7. Zangrillo AN, Fisher WW, Greer BD, Owen TM, DeSouza AA. Treatment of escape-maintained challenging behavior using chained schedules: An evaluation of the effects of thinning positive plus negative reinforcement during functional communication training. *Int J Dev Disabil*. 2016;62(3):147-156. doi:10.1080/20473869.2016.1176308
8. Betz AM, Fisher WW, Roane HS, Mintz JC, Owen TM. A component analysis of schedule thinning during functional communication training. *J Appl Behav Anal*. 2013;46(1):219-241. doi:10.1002/jaba.23
9. Saini V, Miller SA, Fisher WW. Multiple schedules in practical application: Research trends and implications. *J Appl Behav Anal*. 2016;49(2):421-444. doi:10.1002/jaba.300
10. Tiger JH, Hanley GP. Developing stimulus control of preschooler mands: An analysis of schedule-correlated and contingency-specifying stimuli. *J Appl Behav Anal*. 2004;37(4):517-521. doi:10.1901/jaba.2004.37-517
11. Volkert VM, Lerman DC, Call NA, Trosclair-Lasserre N. An evaluation of resurgence during treatment with functional communication training. *J Appl Behav Anal*. 2009;42(1):145-160. doi:10.1901/jaba.2009.42-145
12. Boyle MA, Bacon MT, Carton SM, et al. Comparison of naturalistic and arbitrary discriminative stimuli during schedule thinning. *Behav Interv*. 2020;36(1):3-20. doi:10.1002/bin.1759
13. Kuhn DE, Chirighin AE, Zelenka K. Discriminated functional communication. *J Appl Behav Anal*. 2010;43(2):249-264. doi:10.1901/jaba.2010.43-249
14. Leon Y, Hausman NL, Kahng S, Becraft JL. Further examination of discriminated functional communication. *J Appl Behav Anal*. 2010;43(3):525-530. doi:10.1901/jaba.2010.43-525
15. Shamlian KD, Fisher WW, Steege MW, et al. Evaluation of multiple schedules with naturally occurring and therapist-arranged discriminative stimuli. *J Appl Behav Anal*. 2016;49(2):228-250. doi:10.1002/jaba.293
16. Catania AC. *Learning*. 5th ed. Sloan; 2013.
17. Cooper JO, Heron TE, Heward WL. *Applied Behavior Analysis*. 2nd ed. Pearson; 2014.
18. Fields L. Transfer of discriminative control during stimulus fading conducted without reinforcement. *Learn Behav*. 2018;46(1):79-88. doi:10.3758/s13420-017-0294-x
19. Fields L. Fading and errorless transfer in successive discriminations. *J Exp Anal Behav*. 1978;30(3):123-128. doi:10.1901/jeab.1978.30-123
20. Touchette PE. Transfer of stimulus control: Measure the moment of transfer. *J Exp Anal Behav*. 1971;15(3):347-354. doi:10.1901/jeab.1971.15-347
21. Brown A, Nercesian J. Embedding arbitrary discriminative stimuli within delay tolerance training. *J Appl Behav Anal*. 2024;57(1):112-125.
22. Stokes TF, Baer DM. An implicit technology of generalization. *J Appl Behav Anal*. 1977;10(2):349-367. doi:10.1901/jaba.1977.10-349
23. Bullock CE, Fisher WW, Hagopian LP. Description and validation of a computerized behavioral data program: "BDataPro." *Behav Anal*. 2017;40(1):275-285. doi:10.1007/s40614-016-0079-0
24. Iwata BA, Dorsey MF, Slifer KJ, Bauman KE, Richman GS. Toward a functional analysis of self-injury. *J Appl Behav Anal*. 1994;27:197-209. doi:10.1901/jaba.1994.27-197
25. Conners J, Iwata BA, Kahng S, Hanley GP, Worsdell AS, Thompson RH. Differential responding in the presence and absence of discriminative stimuli during multielement functional analyses. *J Appl Behav Anal*. 2000;33(3):299-308. doi:10.1901/jaba.2000.33-299
26. Fisher W, Piazza CC, Bowman LG, Hagopian LP, Owens JC, Slevin I. A comparison of two approaches for identifying reinforcers for persons with severe and profound disabilities. *J Appl Behav Anal*. 1992;25(2):491-498. doi:10.1901/jaba.1992.25-491
27. Querim AC, Iwata BA, Roscoe EM, Schlichenmeyer KJ, Ortega JV, Hurl KE. Functional analysis screening for problem behavior maintained by automatic reinforcement. *J Appl Behav Anal*. 2013;46(1):47-60. doi:10.1002/jaba.26
28. Fahmie TA, Iwata BA, Harper JM, Querim AC. Evaluation of the divided attention condition during functional analyses. *J Appl Behav Anal*. 2013;46(1):71-78. doi:10.1002/jaba.20
29. Miltenberger RG. *Behavior Modification: Principles and Procedures*. Wadsworth/Thomson Learning; 2001.
30. Ringdahl JE, Falcomata TS, Christensen TJ, et al. Evaluation of a pre-treatment assessment to select mand topographies for functional communication

training. *Res Dev Disabil*. 2009;30(2):330-341. doi:10.1016/j.ridd.2008.06.002

31. Kunnavatana SS, Bloom SE, Samaha AL, Slocum TA, Clay CJ. Manipulating parameters of reinforcement to reduce problem behavior without extinction. *J Appl Behav Anal*. 2018;51(2):283-302. doi:10.1002/jaba.443
32. Charlop MH, Schreibman L, Thibodeau MG. Increasing spontaneous verbal responding in autistic children using a time delay procedure. *J Appl Behav Anal*. 1985;18(2):155-166. doi:10.1901/jaba.1985.18-155
33. Barlow DH, Hayes SC. Alternating treatments design: One strategy for comparing the effects of two treatments in a single subject. *J Appl Behav Anal*. 1979;12(2):199-210. doi:10.1901/jaba.1979.12-199
34. Hayes SC. Single-case experimental design and empirical clinical practice. *J Consult Clin Psychol*. 1981;49(2):193-211. doi:10.1037/0022-006X.49.2.193
35. Akers JS, Retzlaff BJ, Fisher WW, Greer BD, Kaminski AJ, DeSouza AA. An evaluation of conditional manding using a four-component multiple schedule. *Anal Verbal Behav*. 2019;35(1):94-102. doi:10.1007/s40616-018-0099-9
36. Hanley GP, Piazza CC, Fisher WW, Maglieri KA. On the effectiveness of and preference for punishment and extinction components of function-based interventions. *J Appl Behav Anal*. 2005;38(1):51-65. doi:10.1901/jaba.2005.6-04
37. Fahmie TA, Rodriguez NM, Luczynski KC, Rahaman JA, Charles BM, Zangrillo AN. Toward an explicit technology of ecological validity. *J Appl Behav Anal*. 2023;56(2):302-322. doi:10.1002/jaba.972
38. Veneziano J, Shea S. They have a voice; are we listening? *Behav Anal Pract*. 2023;16(1):127-144. doi:10.1007/s40617-022-00690-z

