Published in final edited form as:

*J Appl Behav Anal*. 2018 April ; 51(2): 360–373. doi:10.1002/jaba.451.

# Further Evaluation of Differential Exposure to Establishing Operations During Functional Communication Training

**Wayne W. Fisher**, **Brian D. Greer**, **Daniel R. Mitteer**, **Ashley M. Fuhrman**, **Patrick W. Romani**, and **Amanda N. Zangrillo**

University of Nebraska Medical Center's Munroe-Meyer Institute

## Abstract

Recent research findings (DeRosa, Fisher, & Steege, 2015) suggest that minimizing exposure to the establishing operation (EO) for destructive behavior when differential reinforcement interventions like functional communication training (FCT) are introduced may produce more immediate reductions in destructive behavior and prevent or mitigate extinction bursts. We directly tested this hypothesis by introducing FCT with extinction in two conditions, one with limited exposure to the EO (limited EO) and one with more extended exposure to the EO (extended EO) using a combined reversal and multielement design. Results showed that the limited-EO condition rapidly reduced destructive behavior to low levels during every application, whereas the extended-EO condition produced an extinction burst in five of six applications. We discuss these findings in relation to the effects of EO exposure on the beneficial and untoward effects of differential reinforcement interventions.

### Keywords

differential reinforcement; establishing operation; extinction; extinction burst; functional analysis; functional communication training

---

Functional communication training (FCT; Carr & Durand, 1985) is a differential reinforcement of alternative behavior (DRA) intervention that is an effective and well-established treatment for a variety of problem behaviors, including severe destructive behavior (e.g., aggression, self-injurious behavior; Greer, Fisher, Saini, Owen, & Jones, 2016; Hagopian, Fisher, Thibault-Sullivan, Acquisto, & LeBlanc, 1998; Jessel, Ingvarsson, Metras, Kirk, & Whipple, 2018; Kurtz, Boelter, Jarmolowicz, Chin, & Hagopian, 2011; Kurtz et al., 2003; Rooker, Jessel, Kurtz, & Hagopian, 2013). Functional communication training has three primary components: (a) identifying the reinforcer(s) for problem behavior via a functional analysis, (b) training the individual to emit an alternative mand that is functionally equivalent to problem behavior, and (c) establishing generalization and maintenance of the alternative response (Fisher, Greer, & Bouxsein, in press; Tiger, Hanley, & Bruzek, 2008). Functional communication training is most appropriate and effective for

---

Address correspondence to Brian D. Greer, Center for Autism Spectrum Disorders, 985450 Nebraska Medical Center, Omaha, Nebraska 68198 brian.greer@unmc.edu.

problem behavior reinforced by social consequences (e.g., attention, escape, tangible items; Greer & Fisher, 2017).

Prior research on FCT has shown that it is more effective when combined with extinction than when it is implemented alone (e.g., Hagopian et al., 1998; Shirley, Iwata, Kahng, Mazaleski, & Lerman, 1997). For example, Hagopian et al. (1998) implemented FCT alone with 11 participants who displayed severe destructive behavior reinforced by escape ($n = 4$), attention ($n = 6$), and access to tangible reinforcement ($n = 1$). Functional communication training alone resulted in no change or an increase in destructive behavior during five of these applications, and in no application did FCT alone reduce destructive behavior by 90% or more. By contrast, Hagopian et al. found that FCT with extinction reduced problem behavior much more consistently and to a greater degree than FCT alone, but they also found FCT to be most effective when combined with punishment. However, more recent large-scale studies have shown that FCT combined with extinction reduces destructive behavior as well or nearly as well as FCT combined with punishment, especially when researchers use alternative reinforcement and/or multiple schedules during reinforcement schedule thinning (Greer et al., 2016; Rooker et al., 2013) and when they arrange contingency-based progressive delays (Ghaemmaghami, Hanley, & Jessel, 2016; Jessel et al., 2018).

Extinction, when implemented alone, can result in untoward side effects like temporary response bursting, extinction-induced aggression, and negative emotional behavior (Goh & Iwata, 1994; Lerman & Iwata, 1995; Lovaas, Freitag, Gold, & Kassorla, 1965; Piazza, Patel, Gulotta, Sevin, & Layer, 2003). These extinction effects are sometimes seen when FCT with extinction is first introduced (cf. Lerman & Iwata, 1995) and when the extinction component of a multiple schedule is introduced as a means of thinning the reinforcement schedule (Briggs, Fisher, Greer, & Kimball, in press; Kuhn, Chirighin, & Zelenka, 2010; Saini, Miller, & Fisher, 2016; Shamlian et al., 2016). The limitations of extinction can be mitigated or prevented in many cases through the delivery of the reinforcement contingent on an alternative response or on a response-independent, time-based schedule (e.g., Betz, Fisher, Roane, Mintz, & Owen, 2013; Fisher, Greer, Fuhrman, & Querim, 2015; Fritz, Jackson, Stiefler, Wimberly, & Richardson, 2017).

When alternative reinforcement (e.g., FCT) is combined with extinction, each treatment component generally adds to the effectiveness of the other, but these complementary or additive effects have not been consistent across studies. For example, Shirley et al. (1997) found that adding extinction to FCT facilitated acquisition of the functional communication response (FCR) and a reduction in self-injurious behavior (SIB). However, Shirley et al.'s introduction of FCT with extinction resulted in an extinction burst during all three applications, based on the criteria specified by Lerman and Iwata (1995). In contrast, the addition of differential reinforcement components (e.g., FCT) to extinction generally mitigate the untoward side effects of extinction (Azrin, Hutchinson, & Hake, 1966; Lerman & Iwata, 1995; Lerman, Iwata, & Wallace, 1999; Piazza et al., 2003; Terrace, 1966). For example, Lerman et al. (1999) found that untoward side effects involving bursts of SIB or extinction-induced aggression occurred in 20% of applications in which the investigators combined extinction with the delivery of alternative reinforcement (i.e., DRA or noncontingent reinforcement) or antecedent interventions (e.g., demand fading). By contrast, when they implemented extinction alone, untoward side effects occurred in 60% of applications. These results show that DRA can mitigate the untoward side effects of extinction, but the fact that untoward side effects can still occur in a percentage of applications of DRA with extinction suggests that additional research is needed to elucidate the conditions under which DRA procedures (e.g., FCT) do and do not prevent extinction bursts.

The results of several basic investigations (Azrin, 1961; Azrin et al., 1966; Mowrer & Jones, 1943; Skinner, 1938) suggest that differential reinforcement interventions (e.g., FCT) may mitigate the untoward side effects of extinction by preventing or greatly limiting exposure to periods with no reinforcement. It seems reasonable to assume that differential reinforcement interventions that completely prevent exposure to periods of no reinforcement should produce rapid reductions in destructive behavior without extinction bursts, whereas those that lessen but do not eliminate periods of no reinforcement may reduce destructive behavior more slowly and be somewhat more prone to extinction-induced bursting, aggression, and/or emotional responses. A recent study by DeRosa, Fisher et al. (2015) provided data consistent with this notion.

DeRosa, Fisher et al. (2015) implemented FCT with extinction in two conditions with two participants in Study 1. A card touch served as the FCR in one condition and a vocal response served as the FCR in the other condition. In the card-touch condition, the investigators greatly limited exposure to the establishing operation (EO) by introducing the EO, prompting the card touch, and delivering the reinforcer in rapid succession (e.g., issuing a demand, prompting the card touch, and allowing escape from the demands all within a few seconds). By contrast, in the vocal-response condition, the EO for problem behavior often remained in effect for longer periods because the investigators could prompt the FCR (using a modeled prompt) but could not guarantee its quick emission by the participants. The card-touch condition produced less response bursting, larger and more rapid reductions in problem behavior, and faster acquisition of the alternative mand relative to the vocal-response condition. Despite the differences in FCR topography across FCT conditions, these results suggested that controlling and limiting exposure to the EO for problem behavior promoted rapid treatment effects and prevented the untoward side effects associated with extinction. DeRosa, Fisher et al. provided additional support for this hypothesis in Study 2 by delivering alternative reinforcement on time-based schedules yoked to the card-touch and vocal-response conditions from Study 1, with one of the participants. The time-based schedule yoked to the card-touch condition (i.e., the condition associated with a limited exposure to the EO) produced lower rates of problem behavior than the time-based schedule yoked to the vocal-response condition (i.e., the condition associated with greater exposure to the EO).

In the current study, we aimed to replicate and extend the findings of DeRosa, Fisher et al. (2015) by directly testing whether limiting exposure to the EO for problem behavior during initiation of FCT with extinction would promote rapid treatment effects and prevent the untoward side effects of extinction. We eliminated the major limitation of Study 1 in the DeRosa, Fisher et al. study (i.e., that the observed differences resulted from response variables rather than EO exposure) by directly manipulating the duration of exposure to the EO while holding response variables constant (i.e., we implemented an equivalent card-touch or card-exchange FCR in both conditions). Unlike Study 2 in the DeRosa, Fisher et al. study, we evaluated differential exposure to the EO across two otherwise identical FCT conditions and not across two time-based schedules.

## Method

### Subjects and Settings

Carson, a 4-year-old boy diagnosed with autism spectrum disorder (ASD) and alpha-thalassemia X-linked intellectual disability (ATRX) syndrome, engaged in SIB (head hitting with hand or shoulder), which resulted in tissue damage to his face and chin. For Carson's safety, we conducted a rapid-restraint evaluation similar to the procedures described by Wallace, Iwata, Zhou, and Goff (1999) and with the modifications suggested by DeRosa, Roane, Wilson, Novak, and Silkowski (2015) to quickly identify a level of restraint rigidity that would minimize the occurrence of hand-to-head SIB (i.e., the more injurious of his two topographies of SIB), without interfering with activities of daily living. We specifically placed Carson in arm splints with varying levels of rigidity and assessed levels of SIB, item interaction, and compliance across multiple contexts (i.e., while self-feeding, during toy play, and with gross- and fine-motor demands) We determined that Carson's SIB remained lowest without impeding his ability to engage in adaptive responses while he wore protective sleeves (splints) without stays. Carson remained in these protective sleeves without stays throughout all sessions, with periodic breaks from the sleeves between sessions. The arm sleeves controlled Carson's hand-to-head SIB but not his shoulder-to-head SIB. Thus, we conducted the current analyses using his shoulder-to-head SIB as the target response. Carson communicated using gestures.

Alan, a 3-year-old boy diagnosed with ASD, engaged in SIB (i.e., head hitting, body slamming) and aggression (i.e., hitting, pushing, kicking, biting). Alan also participated in a previous study (Fisher, Greer, Romani, Zangrillo, & Owen, 2016) that compared two approaches to functional analysis and that did not involve FCT. Unlike Carson, the topography and frequency of Alan's SIB did not require the use of restraints. Alan communicated primarily using gestures and picture exchanges. Both children walked without assistance.

In addition to the protective sleeves worn by Carson, we minimized the risk of each child's SIB using the safety precautions described by Betz and Fisher (2011). We conducted all sessions in clinic therapy rooms (approximately 3 m by 3 m) that contained padding on the floors and walls. Additional safety precautions included the use of session-termination criteria. No session was terminated prematurely due to SIB resulting in reddening of the skin or bleeding. A Board Certified Behavior Analyst supervised all sessions. We equipped each room with a one-way observation mirror, two-way intercom system, and any necessary session materials (e.g., preferred toys, instructional materials).

## Measurement and Interobserver Agreement

Trained data collectors observed sessions from behind the mirror in an adjacent observation booth and used laptop computers to measure the frequency of destructive behavior (SIB for Carson; SIB and aggression for Alan) and FCRs, as well as the duration of reinforcer deliveries. *Destructive behavior* consisted of self-injurious behavior (i.e., head banging, self-hitting, body slamming) for Carson and Alan and aggression (i.e., hitting, kicking, pushing, biting others) for Alan. The *FCR* consisted of touching an index card (Carson) that measured 7.6 cm by 12.7 cm and contained a picture of the child consuming the identified reinforcer or handing the card to the therapist (Alan). *Reinforcer delivery* consisted of the therapist providing the child access to the putative reinforcer (i.e., providing the tangible item or escape).

A second, independent observer collected data simultaneously with the primary data collector during 22% and 63% of functional analysis sessions for Carson and Alan, respectively and during 27%, 65%, and 33% of FCT-evaluation sessions for Carson, Alan (tangible), and Alan (escape), respectively. We calculated exact interobserver agreement within 10-s intervals for destructive behavior and proportional interobserver agreement within 10-s intervals for reinforcement deliveries. We computed grand means across assessments and participants for destructive behavior (*GM* = 96%; range, 70% to 100%), FCRs (*GM* = 95%; range, 70% to 100%), and reinforcer deliveries (*GM* = 94%; range 75% to 100%).

Because it was critically important for the therapist to control exposure to the EO across FCT conditions, we also calculated procedural fidelity for all FCT sessions. We considered the reinforcer to be delivered correctly if the therapist provided it within 5 s of its scheduled delivery (i.e., following a prompted or independent FCR for Carson or following an independent FCR for Alan). If destructive behavior preceded (within 3 s) or co-occurred with the FCR, the therapist waited 3 s, and then prompted (Carson) or continued waiting (Alan) for an additional FCR without preceding or co-occurring destructive behavior. In these situations, we considered the reinforcer to be delivered correctly if the therapist withheld the reinforcer following the destructive response and then delivered it within 5 s of a subsequent FCR that occurred without preceding or simultaneous destructive behavior. All reinforcers were delivered with 100% fidelity across all FCT sessions for both participants.

## Functional Analysis

We conducted functional analysis sessions using procedures similar to those described by Iwata, Dorsey, Slifer, Bauman, and Richman (1982/1994) with the following modifications. Functional analysis sessions lasted 5 min. Prior to beginning the multielement functional analysis, we screened for the presence of automatically reinforced destructive behavior by conducting a series of consecutive ignore sessions (Querim et al., 2013). Rates of destructive behavior remained low (Alan) or decreased across sessions (Carson), suggesting that neither child displayed destructive behavior maintained by automatic reinforcement (data not shown in the figure). Within the multielement functional analysis, we equated the reinforcer durations across test conditions (Fisher, Piazza, & Chiang, 1996). We used paired-stimulus preference assessments informed by caregiver nomination (Fisher, Piazza, Bowman, & Amari, 1996; Fisher et al., 1992) to identify preferred stimuli for Carson and Alan.

**Ignore—**We conducted additional ignore sessions with Carson. The therapist remained alone with Carson in a barren therapy room and ignored all instances of destructive behavior.

**Attention—**The therapist provided 1- to 2-min of vocal (e.g., talking with or singing to the child) and physical (e.g., tickles, rubs on the back) attention prior to starting the session. The attention session began with the therapist terminating the delivery of attention and moving away from the child who retained access to a less preferred toy. Destructive behavior resulted in attention delivery in the form of verbal reprimands for 20 s.

**Toy play—**During toy play, the therapist provided the child with the same forms of attention as in the attention condition, but did so noncontingently and continuously throughout the session, and the child retained access to his most highly preferred materials (i.e., a musical toy for Carson and a backpack and truck for Alan). The therapist delivered no programmed consequences for destructive behavior.

**Escape—**The therapist presented demands (e.g., stack blocks, pick up toys, get dressed) to each child using a least-to-most (i.e., vocal, model, physical) prompting hierarchy. We selected demands for both boys based on caregiver nomination. Destructive behavior resulted in a 20-s break (escape) from instructions. Compliance following the vocal or model prompt resulted in brief praise (e.g., "Nice job stacking the blocks") and presentation of the next demand. For the purposes of another study, half of Alan's escape sessions included preferred demands, and the other half included less preferred demands. Only data from the sessions with less preferred demands are presented in this study.

**Tangible—**Prior to the tangible condition, the therapist provided 1- to 2-min access to the child's most highly preferred materials. The tangible condition began with the therapist removing the preferred materials, and destructive behavior resulted in the delivery of those materials for 20 s.

### FCT Evaluation

Following each child's functional analysis, we evaluated the effects of FCT when initiated as treatment for destructive behavior using two variations of FCT that differed only according to the level of exposure to the EO for destructive behavior. In one version of FCT (limited EO), the therapist limited the EO by guiding the child to emit the FCR (Carson) or providing the response card (Alan) immediately after introduction of the EO, whereas in the other version of FCT (extended EO), the therapist imposed a fixed duration of EO exposure by either waiting to physically guide the FCR upon presenting the EO (Carson) or by presenting the EO while withholding the availability of the FCR materials (Alan). The FCR always resulted in the immediate delivery of the identified reinforcer, regardless of whether the FCR was prompted. Additionally, both variations of FCT targeted the same FCR modality (i.e., card touch for Carson, card exchange for Alan) to allow for a more direct comparison between the effects of EO exposure and rates of destructive behavior associated with each version of FCT than the comparison in DeRosa, Fisher et al. (2015).

We used an ABAB reversal design in which baseline sessions comprised the "A" phases, and both "B" phases consisted of a multielement, pairwise comparison between the two variations of FCT. This design allowed us to determine (a) whether either variant of FCT reduced rates of destructive behavior below those in baseline and (b) whether one variant of FCT proved more effective than the other. Because Alan's functional analysis results suggested two functions of his destructive behavior, we conducted this ABAB design for both functions of Alan's destructive behavior, but we staggered the implementation of phases across functions, creating a concurrent multiple-baseline-across-functions design.

**Baseline—**The tangible condition of the functional analysis served as the baseline for Carson and Alan's (tangible) FCT evaluations, and the escape condition of the functional analysis served as the baseline for Alan's (escape) FCT evaluation. We conducted baseline sessions separate from the functional analysis using the procedures described above. All baseline sessions lasted 5 min.

**Selecting the EO-exposure durations—**We initially attempted to teach the FCR to both Carson and Alan using clinic-standard teaching procedures that consisted of presenting the EO for destructive behavior, immediately guiding the FCR, and then immediately delivering the functional reinforcer, across 10-trial sessions. Following every two consecutive sessions with low levels of destructive behavior, the therapist increased the delay to physically guiding the FCR using the following progression: 0 s, 2 s, 5 s, and 10 s or until the child began emitting the FCR independently on 90% or greater of trials with low levels of destructive behavior.

Carson rarely emitted the FCR without physical guidance and often displayed destructive behavior within 2 s to 5 s after introducing the EO. Therefore, we set his extended-EO duration at 5 s and his limited-EO duration at 0 s. Alan learned to emit the FCR independently, but he rarely did so without also displaying destructive behavior. Therefore, we conducted two progressive interval (PI) assessments with Alan, one in the escape context and one in the tangible context. At the start of the first trial of each PI assessment, we presented the EO by removing the tangible item or initiating a demand and then terminated the EO by presenting the tangible item or by providing escape after a preset period of time (e.g., 2 s). We then progressively increased the duration of the EO exposure after two trials at a given EO duration according to the following schedule until Alan emitted a destructive response (two trials at each of the following durations: 2 s, 5 s, 10 s, 20 s, 40 s). The PI assessment ended once Alan emitted a destructive response, at which point we provided the tangible item and then used the current interval as the EO duration for the extended-EO duration in the following treatment analysis (i.e., we set the extended EO at 10 s in the tangible condition and 40 s in the escape condition). As with Carson, we set the limited-EO duration at 0 s for both of Alan's FCT evaluations. Destructive behavior for Carson and Alan resulted in extinction in all subsequent FCT sessions.

**Limited EO—**Prior to the start of each limited-EO session conducted with Carson, the therapist provided him with brief (i.e., 1- to 2-min) access to the tangible reinforcer. We divided each session into ten 30-s trials. At the start of each trial, the therapist introduced the EO by withdrawing the tangible reinforcer. The therapist then immediately physically guided Carson to emit the FCR and returned the tangible reinforcer, so that exposure to the EO was as short as physically possible. Carson retained access to the tangible reinforcer for the remainder of the trial following the FCR. Carson's FCR card remained available throughout all FCT sessions.

We conducted Alan's limited-EO sessions in a similar manner, except that we did not divide the sessions into 30-s trials, and we provided 20-s access to the reinforcer following the FCR, regardless of how much time expired between the EO presentation and the FCR. At the start of each session for the tangible condition, the therapist introduced the EO by withdrawing the tangible reinforcer and placing the FCR card in or immediately next to Alan's hand. If Alan emitted the FCR, the therapist immediately returned the tangible reinforcer for 20 s. The EO remained in place until Alan emitted the FCR or until 10 min elapsed from the start of the session, at which point the session terminated. In addition, if destructive behavior occurred as the therapist was providing the FCR card, the therapist implemented a changeover delay by withholding the FCR card for 3 s. All sessions ended after 10 reinforcer deliveries.

At the start of each session for the escape condition, the therapist introduced the EO by presenting a demand and placing the FCR card in or immediately next to Alan's hand. Compliance following the vocal or model prompt resulted in brief praise and presentation of the next demand. If Alan emitted the FCR, the therapist immediately terminated the demand for 20 s. The EO remained in place until Alan emitted the FCR or until 10 min elapsed from the start of the session. All sessions ended after 10 reinforcer deliveries.

**Extended EO—**For Carson, we conducted this condition identical to his limited-EO tangible condition, except that during each trial, the therapist withdrew the tangible reinforcer, waited 5 s, and then physically guided Carson to emit the FCR and returned the tangible reinforcer (so that exposure to the EO lasted about 5 s longer than in the limited-EO condition for Carson). If destructive behavior occurred when the 5 s elapsed, the therapist implemented a 3-s changeover delay prior to prompting the FCR.

For Alan, we conducted his extended-EO tangible condition identical to his limited-EO tangible condition, except that when the therapist withdrew the tangible reinforcer, Alan was unable to emit an FCR until the therapist placed the FCR card in or immediately next to Alan's hand after 10 s. If destructive behavior occurred when the 10 s elapsed, the therapist implemented a 3-s changeover delay before making the FCR card available. If Alan emitted the FCR, the therapist immediately provided the tangible reinforcer for 20 s. All sessions ended after 10 reinforcer deliveries, except for Session 17, which ended at 10 min, with nine reinforcer deliveries.

We conducted Alan's extended-EO escape condition identical to his limited-EO condition, except that when the therapist presented a demand, Alan was unable to emit an FCR until the therapist placed the FCR card in or immediately next to Alan's hand after 40 s. If destructive behavior occurred when the 40 s elapsed, the therapist implemented a 3-s changeover delay before making the FCR card available. If Alan emitted the FCR, the therapist immediately terminated the demand for 20 s. All sessions ended after 10 reinforcer deliveries.

### Data Analysis

To more clearly quantify the effects that the limited- and extended-EO exposures had on each child's destructive behavior, we calculated the rate of destructive behavior and the percentage of session duration in which the EO was in place for each session of the FCT evaluation. We obtained the percentage of session duration with EO exposure by summing the durations of all reinforcer deliveries within each session and subtracting these durations from each session's total duration, yielding the duration that the EO was in place for destructive behavior for each session. We then divided this number by the session duration and converted the resulting quotient to a percentage, which produced the percentage of session duration with EO exposure. This calculation enabled us to easily compare the relative difference in EO exposures across sessions and conditions of the FCT evaluation, which when combined with the rate of destructive behavior per session, allowed for a more direct examination of how changes in EO exposure affected rates of destructive behavior.

We also evaluated the extent to which the introduction of each treatment resulted in an extinction burst, using the criteria reported by Lerman and Iwata (1995). These investigators defined an extinction burst as an increase in the response rate during any of the first three treatment sessions above that observed in all of the previous five baseline sessions (or all baseline sessions when there were fewer than five).

## Results

Figure 1 depicts the relevant portions of the functional analysis results for Carson and Alan. Carson engaged in consistently high levels of SIB during the tangible condition, suggesting that his SIB was reinforced by access to preferred stimuli. Carson also engaged in variable rates of SIB during the attention and escape conditions. We addressed the tangible function of Carson's SIB in the current study. We replotted Alan's first functional analysis from Fisher et al. (2016) for the purposes of this study. Alan engaged in elevated rates of destructive behavior in both the escape and tangible conditions. We addressed both functions of Alan's destructive behavior in the current study.

Figure 2 depicts the rates of destructive behavior, as well as the corresponding percentages of session duration with EO exposure during the baseline and FCT conditions of the FCT evaluation, for Carson. During the initial baseline, Carson displayed relatively efficient rates of SIB (*M* = 2.7 responses per min [RPM]) and was exposed to the EO for SIB for an average of 18% of baseline-session durations. Rates of SIB decreased (*M* = 0.3 RPM) when the EO for SIB was minimized (*M* = 7.8% of session duration) by the therapist immediately guiding the FCR in the limited-EO condition, whereas response rates increased beyond baseline levels (*M* = 7.7 RPM) when the therapist inserted a 5-s delay before physically guiding the FCR in the extended-EO condition, which produced additional exposure to the

EO for SIB (*M* = 20.7% of session duration). We obtained similar results across the final two phases. Due to the prompting procedure we used with Carson, we observed high rates of prompted FCRs across all FCT sessions (not displayed). On five occasions, Carson emitted an independent FCR before the therapist physically guided this response after the 5-s prompt delay in the extended-EO condition. All of these instances occurred in the final phase of FCT.

Alan's FCT evaluation showed similar results to those described above for Carson across both functions of his destructive behavior. Alan displayed moderate yet efficient rates of destructive behavior (*M* = 2.5 RPM) during the initial tangible baseline, which correlated with moderate exposures to the EO for destructive behavior (*M* = 20.7% of session duration). When we implemented FCT in the tangible context, Alan displayed low and decreasing rates of destructive behavior in the limited-EO condition (*M* = 0.4 RPM), which was associated with slightly less exposure to the EO for destructive behavior (*M* = 16.9% of session duration) and high and increasing rates of destructive behavior during the extended-EO condition (*M* = 5.9 RPM), which corresponded with greater exposure to the EO for destructive behavior (*M* = 58.1% of session duration). We replicated these findings across the final two phases of the tangible context.

Alan engaged in moderate rates of destructive behavior during the initial escape baseline (*M* = 1.5 RPM) in which the EO for destructive behavior was controlled only by the occurrence of Alan's destructive behavior (*M* = 58.4% of session duration). During FCT, Alan's destructive behavior decreased to near-zero rates in the limited-EO condition (*M* = 0.2 RPM) in which the EO for destructive behavior was minimized (*M* = 34.5% of session duration) by the therapist providing immediate access to the FCR card. Rates of Alan's destructive behavior increased in the extended-EO condition (*M* = 2.3 RPM) in which the therapist temporarily withheld the FCR card, which produced relatively greater exposure to the EO for destructive behavior (*M* = 74% of session duration). We obtained similar results across the final two phases of the escape context. Alan's FCR data (not displayed) indicated high levels of independent FCRs across all FCT conditions for both functions of destructive behavior, with 10 FCRs occurring in all but one FCT session.

We observed the lowest rates of destructive behavior across sessions in the three limited-EO conditions (*M*s = 0.3, 0.2, and 0.4 RPM for Carson, Alan [tangible], Alan [escape], respectively), which coincided with the lowest levels of exposure to the EO (*M*s = 7%, 17%, and 33% of session duration) for Carson, Alan (tangible), and Alan (escape), respectively. By contrast, we observed the highest rates of destructive behavior across sessions in the extended-EO condition (*M*s = 5.1, 5.7, and 1.7 RPM for Carson, Alan [tangible], and Alan [escape], respectively), and this coincided with the highest levels of exposure to the EO for Alan's tangible and escape functions (*M*s = 58% and 73% for tangible and escape, respectively), but not for Carson (*M* = 22%). Nevertheless, levels of exposure to the EO correlated highly with rates of destructive behavior during the treatment phases for all three applications (*r* = .70, .95, and .85, for Carson, Alan [tangible], and Alan [escape], respectively).

Based on the criteria reported by Lerman and Iwata (1995), we observed an extinction burst in five of the six treatment phases in the extended-EO condition (83.3%). By contrast, we observed an extinction burst in zero of the six treatment phases in the limited-EO condition. In addition, Lerman and Iwata observed the prevalence of extinction bursts to be 12.2% (i.e., 7 of 59 applications) when extinction is combined with alternative procedures, which is much lower than the 83.3% of applications in which we observed an extinction burst in the extended-EO condition.

## Discussion

In this investigation, we directly tested the hypothesis that limiting exposure to the EO for destructive behavior produces more rapid reductions in destructive behavior and prevents extinction bursts during initiation of DRA interventions (e.g., FCT). Results showed that the limited-EO condition produced more rapid and consistent reductions in destructive behavior relative to the extended-EO condition, and the extended-EO condition produced an extinction burst in five of six applications, whereas the limited-EO condition did so in zero applications.

These findings replicate and extend the findings of DeRosa, Fisher et al. (2015). First, the current findings closely align with those of DeRosa, Fisher et al. in that both investigations found that limited exposure to the EO produced less response bursting and larger and more rapid reductions in destructive behavior. However, DeRosa, Fisher et al. used a card-touch response as the FCR in their limited-EO condition and a vocal response as the FCR in their extended-EO condition. This arrangement left open the possibility that the type of FCR (card touch or vocal) contributed to the observed differences in responding, to some degree. The current investigation controlled for this limitation by using the same FCR in both the limited- and extended-EO conditions (i.e., touching a picture card in both conditions for Carson, exchanging a picture card in both for Alan). Further support for the interpretation that duration of exposure to the EO produced the differential outcomes for the limited- and extended-EO conditions in the current investigation comes from the fact that duration of exposure to the EO correlated highly with rates of destructive behavior across the two treatment conditions for all three applications.

One interesting finding from our results was that mean rates of destructive behavior in baseline fell between those in the extended- and limited-EO conditions for two of the three applications (the tangible and escape evaluations conducted with Alan). This may have been due in part to the fact that the participants' destructive responses controlled the duration of EO exposure in baseline, whereas the extended-EO condition imposed a fixed duration of EO exposure each time the therapist presented the EO, which for Alan's applications extended EO exposure beyond that in baseline. By contrast, the therapist lessened the overall duration of EO exposure in the limited-EO condition to levels generally lower than in baseline by physically guiding the FCR (Carson) or by making the FCR cards continuously available (Alan).

We divided Carson's FCT sessions into ten, 30-s trials in which the FCR (independent or prompted) resulted in the therapist delivering Carson's preferred tangible item for the remainder of the 30-s trial. We did this to yoke the total number of reinforcer deliveries across the limited- and extended-EO conditions, while ensuring that session duration did not vary systematically across conditions. However, in doing so, Carson accessed a slightly longer duration of reinforcement (i.e., a larger magnitude) per trial in the limited-EO condition, as the therapist immediately guided Carson to emit the FCR at the start of each trial in that condition. By contrast, the therapist waited 5 s before prompting the FCR at the start of each trial in the extended-EO condition. Though reinforcer durations were shorter in the extended-EO condition, most FCRs in Carson's limited- and extended-EO conditions produced over 20-s access to the reinforcer (*M*s = 28 s and 23 s for limited- and extended-EO conditions, respectively). Nevertheless, this difference in reinforcer magnitude across trial types likely influenced the rate of Carson's SIB across FCT conditions.

Because the therapist physically guided the FCR with Carson but did not do so with Alan, this procedural difference ostensibly caused fluctuations in how precisely the therapist controlled the EO for destructive behavior across participants in the limited- and extended-EO conditions. Carson experienced a minimal duration of EO exposure in the limited-EO condition (*M* = 7% of session duration) when the therapist physically guided the FCR, whereas Alan experienced a greater duration of EO exposure (*M*s = 17% and 33% of session duration for Alan's tangible and escape functions, respectively). Unlike Carson, we required Alan to emit an independent FCR upon the presentation of the FCR card in order to terminate the EO for his destructive behavior (i.e., to access the reinforcer). As can be inferred from his data for the limited-EO conditions displayed in Figure 3, Alan did not consistently emit this independent FCR quickly, which then extended the duration of time in which the EO remained present. Nevertheless, this arrangement rapidly reduced his destructive behavior to low levels in the first treatment session in three of four applications and in the second treatment session in the fourth application.

When behavior analysts teach FCRs initially, there are two common prompting strategies from which to choose. In least-to-most prompting (Shirley et al., 1997), the behavior analyst provides the opportunity for independent FCRs to occur by programming a period of exposure to the relevant EO prior to the behavior analyst verbally or physically prompting the FCR. In most-to-least prompting (e.g., the progressive-prompt-delay procedures used to teach FCRs in Greer et al., 2016 and Jessel et al., 2018), the behavior analyst begins teaching the FCR by physically guiding the response immediately after the EO is presented and then programs progressively longer exposures (e.g., 2 s, 5 s) to the EO following low levels of destructive behavior at the previously programmed prompt delay until FCRs occur independently. In this way, least-to-most and most-to-least prompting approximate the extended-EO and limited-EO conditions in the present study, respectively. As Tiger et al. (2008) noted, least-to-most prompting allows for destructive behavior to contact extinction quickly, which may help decrease the probability of future destructive behavior, whereas most-to-least prompting can prevent destructive behavior from contacting extinction and therefore may result in future destructive behavior as treatment progresses. In the present study, however, destructive behavior often increased in the extended-EO condition and persisted despite contacting continued extinction. The limited-EO condition approximated the initial stages of most-to-least prompting and resulted in few instances of destructive behavior contacting extinction. Though a direct comparison of prompt-delay procedures and their effects on later treatment success (e.g., during reinforcement schedule thinning) is needed, our findings suggest that most-to-least prompting may be an optimal strategy for minimizing untoward side effects of extinction seen in the extended-EO condition and may be beneficial early on when initiating FCT.

It is worth noting that the duration of EO exposure that was associated with low levels of destructive behavior varied across participants and applications within a participant. That is, Carson typically displayed destructive behavior within a few seconds after presentation of the EO. By contrast, Alan's latency to destructive behavior following introduction of the EO was somewhat longer for his tangible function and much longer for his escape function. The PI assessment used with Alan might be a useful tool in determining an optimal EO exposure when teaching an FCR. For example, Alan's PI assessment indicated that he tolerated exposure to the EO for 5 s, but not for 10 s, in the tangible condition. Therefore, it probably would have been better to physically guide the FCR after 5 s of exposure to the EO without an independent FCR. Such results may inform most-to-least prompting to both mitigate destructive behavior when teaching the FCR, but also may allow the behavior analyst to progress more quickly than had she selected arbitrary prompt delays (e.g., 0 s, 2 s). The PI assessment might also be useful for identifying the initial schedule density for the commencement of reinforcement schedule thinning (e.g., the duration of the initial extinction component of a multiple schedule used for schedule thinning). This may be important because destructive behavior often recurs during reinforcement schedule thinning as FCRs contact extinction (Briggs et al., in press; Kuhn et al., 2010; Shamlian et al., 2016).

In conclusion, prior investigations have identified a variety of variables that impact the efficacy of FCT, such as response effort, reinforcer density, reinforcer delay, combining reinforcement of the FCR with extinction, and bringing the FCR under the discriminative control of a multiple schedule (e.g., Fisher et al., 2015; Greer et al., 2016; Hagopian et al., 1998; Horner & Day, 1991; Shirley et al., 1997; Wacker et al., 1990). Adding to this list, the preliminary findings of DeRosa, Fisher et al. (2015) suggest, and the current results confirm, that controlling the level of exposure to the EO can be an important variable that affects the efficacy of FCT by rapidly reducing problem behavior to low levels and preventing extinction bursts when initiating treatment with FCT.

## Acknowledgments

Grants 5R01HD079113 and 1R01HD083214 from the National Institute of Child Health and Human Development provided partial support for this research.

## References

Azrin NH. Time-out from positive reinforcement. Science. 1961; 133:382–383. DOI: 10.1126/science.133.3450.382 [PubMed: 13685461]

Azrin NH, Hutchinson RR, Hake DF. Extinction-induced aggression. Journal of the Experimental Analysis of Behavior. 1966; 9:191–204. DOI: 10.1901/jeab.1966.9-191 [PubMed: 16811286]

Betz, AM., Fisher, WW. Functional analysis: History and methods. In: Fisher, WW.Piazza, CC., Roane, HS., editors. Handbook of applied behavior analysis. New York, NY: Guilford Press; 2011. p. 206-225.

Betz AM, Fisher WW, Roane HS, Mintz JC, Owen TM. A component analysis of schedule thinning during functional communication training. Journal of Applied Behavior Analysis. 2013; 46:219–241. DOI: 10.1002/jaba.23 [PubMed: 24114096]

Briggs AM, Fisher WW, Greer BD, Kimball RT. Prevalence of resurgence of destructive behavior during reinforcement schedule thinning during functional communication training. Journal of Applied Behavior Analysis. (in press).

Carr EG, Durand VM. Reducing behavior problems through functional communication training. Journal of Applied Behavior Analysis. 1985; 18:111–126. DOI: 10.1901/jaba.1985.18-111 [PubMed: 2410400]

DeRosa NM, Fisher WW, Steege MW. An evaluation of time in establishing operation on the effectiveness of functional communication training. Journal of Applied Behavior Analysis. 2015; 48:115–130. DOI: 10.1002/jaba.180 [PubMed: 25420612]

DeRosa NM, Roane HS, Wilson JL, Novak MD, Silkowski EL. Effects of arm-splint rigidity on self-injury and adaptive behavior. Journal of Applied Behavior Analysis. 2015; 48:860–864. DOI: 10.1002/jaba.250 [PubMed: 26373351]

Fisher, WW., Greer, BD., Bouxsein, KJ. Developing function-based reinforcement procedures for problem behavior. In: Fisher, WW.Piazza, CC., Roane, HS., editors. Handbook of applied behavior analysis. 2nd. New York: Guilford Publishing; (in press)

Fisher WW, Greer BD, Fuhrman AM, Querim AC. Using multiple schedules during functional communication training to promote rapid transfer of treatment effects. Journal of Applied Behavior Analysis. 2015; 48:713–733. DOI: 10.1002/jaba.254 [PubMed: 26384141]

Fisher WW, Greer BD, Romani PW, Zangrillo AN, Owen TM. Comparisons of synthesized- and individual-reinforcement contingencies during functional analysis. Journal of Applied Behavior Analysis. 2016; 49:596–616. DOI: 10.1002/jaba.314 [PubMed: 27174563]

Fisher WW, Piazza CC, Bowman LG, Amari A. Integrating caregiver report with systematic choice assessment to enhance reinforcer identification. American Journal on Mental Retardation. 1996; 101:15–25. [PubMed: 8827248]

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. Journal of Appplied Behavior Analysis. 1992; 25:491–498. DOI: 10.1901/jaba.1992.25-491

Fisher WW, Piazza CC, Chiang CL. Effects of equal and unequal reinforcer duration during functional analysis. Journal of Applied Behavior Analysis. 1996; 29:117–120. DOI: 10.1901/jaba.1996.29-117 [PubMed: 8881352]

Fritz JN, Jackson LM, Stiefler NA, Wimberly BS, Richardson AR. Noncontingent reinforcement without extinction plus differential reinforcement of alternative behavior during treatment of problem behavior. Journal of Applied Behavior Analysis. 2017; 50:590–599. DOI: 10.1002/jaba.395 [PubMed: 28513826]

Ghaemmaghami M, Hanley GP, Jessel J. Contingencies promote delay tolerance. Journal of Applied Behavior Analysis. 2016; 49:548–575. DOI: 10.1002/jaba.333 [PubMed: 27449401]

Goh HL, Iwata BA. Behavioral persistence and variability during extinction of self-injury maintained by escape. Journal of Applied Behavior Analysis. 1994; 27:173–174. DOI: 10.1901/jaba.1994.27-173 [PubMed: 8188558]

Greer, BD., Fisher, WW. Treatment of socially reinforced problem behavior. In: Matson, JL., editor. Handbook of autism treatments. New York: Springer-Verlag; 2017. p. 171-190.

Greer BD, Fisher WW, Saini V, Owen TM, Jones JK. Improving functional communication training during reinforcement schedule thinning: an analysis of 25 applications. Journal of Applied Behavior Analysis. 2016; 49:105–121. DOI: 10.1002/jaba.265 [PubMed: 26482103]

Hagopian LP, Fisher WW, Thibault-Sullivan M, Acquisto J, LeBlanc LA. Effectiveness of functional communication training with and without extinction and punishment: A summary of 21 inpatient cases. Journal of Applied Behavior Analysis. 1998; 31:211–235. DOI: 10.1901/jaba.1998.31-211 [PubMed: 9652101]

Horner RH, Day HM. The effects of response efficiency on functionally equivalent competing behaviors. Journal of Applied Behavior Analysis. 1991; 24:719–732. DOI: 10.1901/jaba.1991.24-719 [PubMed: 1839157]

Iwata BA, Dorsey MF, Slifer KJ, Bauman KE, Richman GS. Toward a functional analysis of self-injury. Journal of Applied Behavior Analysis. 1994; 27:197–209. (Reprinted from *Analysis and Intervention in Developmental Disabilities, 2*, 3–20, 1982). DOI: 10.1901/jaba.1994.27-197 [PubMed: 8063622]

Jessel J, Ingvarsson ET, Metras R, Kirk H, Whipple R. Achieving socially significant reductions in problem behavior following the interview-informed synthesized contingency analysis: A summary of 25 outpatient applications. Journal of Applied Behavior Analysis. 2018; Advance online publication. doi: 10.1002/jaba.436

Kuhn DE, Chirighin AE, Zelenka K. Discriminated functional communication: A procedural extension of functional communication training. Journal of Applied Behavior Analysis. 2010; 43:249–264. DOI: 10.1901/jaba.2010.43-249 [PubMed: 21119898]

Kurtz PF, Boelter EW, Jarmolowicz DP, Chin MD, Hagopian LP. An analysis of functional communication training as an empirically supported treatment for problem behavior displayed by individuals with intellectual disabilities. Research in Developmental Disabilities. 2011; 32:2935–2942. DOI: 10.1016/j.ridd.2011.05.009 [PubMed: 21696917]

Kurtz PF, Chin MD, Huete JM, Tarbox RSF, O'Connor JT, Paclawskyj TR, Rush KS. Functional analysis and treatment of self-injurious behavior in young children: A summary of 30 cases. Journal of Applied Behavior Analysis. 2003; 36:205–219. DOI: 10.1901/jaba.2003.36-205 [PubMed: 12858985]

Lerman DC, Iwata BA. Prevalence of the extinction burst and its attenuation during treatment. Journal of Applied Behavior Analysis, 2. 1995; 8:93–94. DOI: 10.1901/jaba.1995.28-93

Lerman DC, Iwata BA, Wallace MD. Side effects of extinction: Prevalence of bursting and aggression during the treatment of self-injurious behavior. Journal of Applied Behavior Analysis. 1999; 32:1–8. DOI: 10.1901/jaba.1999.32-1 [PubMed: 10201100]

Lovaas OI, Freitag G, Gold VJ, Kassorla IC. Experimental studies in childhood schizophrenia: Analysis of self-destructive behavior. Journal of Experimental Child Psychology. 1965; 2:67–84. DOI: 10.1016/0022-0965(65)90016-0

Mowrer OH, Jones H. Extinction and behavior variability as functions of effortfulness of task. Journal of Experimental Psychology. 1943; 33:369–386. DOI: 10.1037/h0056182

Piazza CC, Patel MR, Gulotta CS, Sevin BS, Layer SA. On the relative contribution of positive reinforcement and escape extinction in the treatment of food refusal. Journal of Applied Behavior Analysis. 2003; 36:309–324. DOI: 10.1901/jaba.2003.36-309 [PubMed: 14596572]

Querim AC, Iwata BA, Roscoe EM, Schlichenmeyer KJ, Virués Ortega J, Hurl KE. Functional analysis screening for problem behavior maintained by automatic reinforcement. Journal of Applied Behavior Analysis. 2013; 46:47–60. DOI: 10.1002/jaba.26 [PubMed: 24114084]

Rooker GW, Jessel J, Kurtz PF, Hagopian LP. Functional communication training with and without alternative reinforcement and punishment: An analysis of 58 applications. Journal of Applied Behavior Analysis. 2013; 46:708–722. DOI: 10.1002/jaba.76 [PubMed: 24114463]

Saini V, Miller SA, Fisher WW. Multiple schedules in practical application: Research trends and implications for future investigation. Journal of Applied Behavior Analysis. 2016; 49:421–444. DOI: 10.1002/jaba.300 [PubMed: 26990754]

Shamlian KD, Fisher WW, Steege MW, Cavanaugh B, Samour K, Querim AC. Evaluation of multiple schedules with naturally occurring and therapist-arranged discriminative stimuli following functional communication training. Journal of Applied Behavior Analysis. 2016; 49:228–250. DOI: 10.1002/jaba.293 [PubMed: 26790565]

Shirley MJ, Iwata BA, Kahng SW, Mazaleski JL, Lerman DC. Does functional communication training compete with ongoing contingencies of reinforcement? An analysis during response acquisition and maintenance. Journal of Applied Behavior Analysis. 1997; 30:93–104. DOI: 10.1901/jaba.1997.30-93 [PubMed: 9157100]

Skinner, BF. The behavior of organisms. New York: Appleton-Century-Crofts; 1938.

Terrace HS. Discrimination learning and inhibition. Science. 1966; 30:1677–1680. DOI: 10.1126/science.154.3757.1677

Tiger JH, Hanley GP, Bruzek J. Functional communication training: A review and practical guide. Behavior Analysis in Practice. 2008; 1:16–23. [PubMed: 22477675]

Wacker DP, Steege MW, Northup J, Sasso G, Berg W, Reimers T, Donn L. A component analysis of functional communication training across three topographies of severe behavior problems. Journal of Applied Behavior Analysis. 1990; 23:417–429. DOI: 10.1901/jaba.1990.23-417 [PubMed: 2150069]

Wallace MD, Iwata BA, Zhou L, Goff GA. Rapid assessment of the effects of restraint on self-injury and adaptive behavior. Journal of Applied Behavior Analysis. 1999; 32:525–528. DOI: 10.1901/jaba.1999.32-525 [PubMed: 10641306]

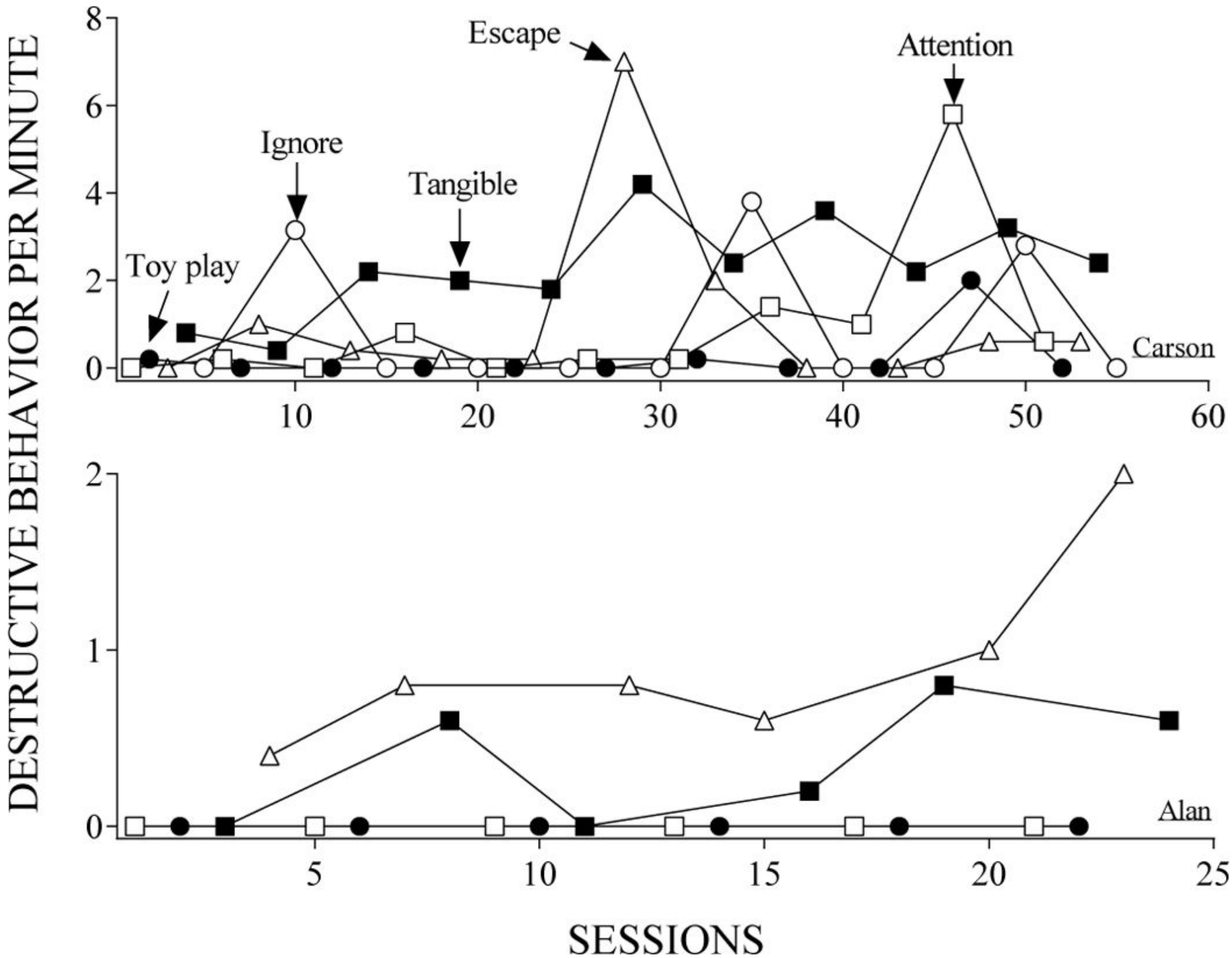


**Figure 1.**
Functional analysis results for Carson (top panel) and Alan (bottom panel).

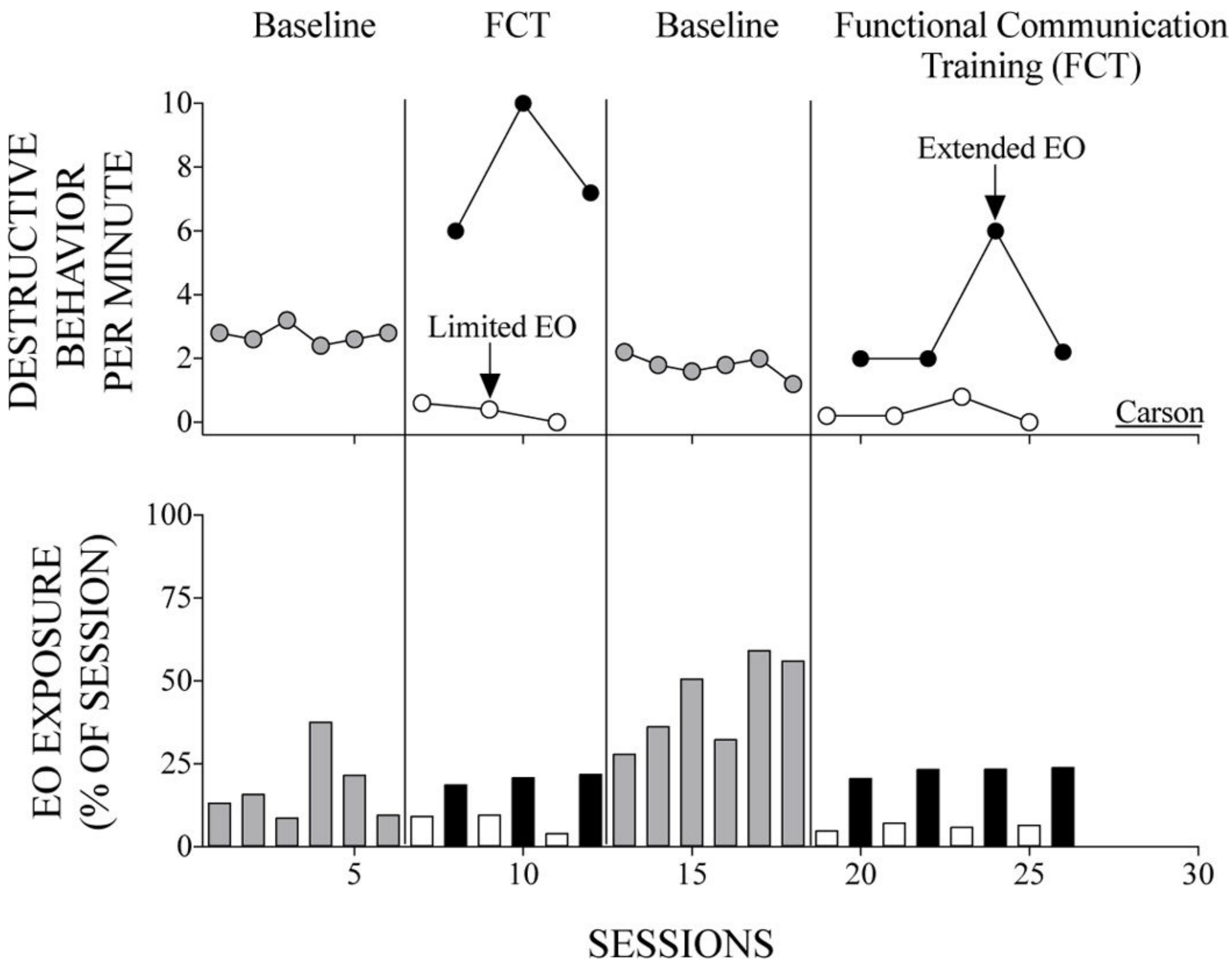


**Figure 2.**

FCT-evaluation results for Carson with destructive behavior per minute (top panel) and corresponding percentages of session duration with EO exposure (bottom panel).

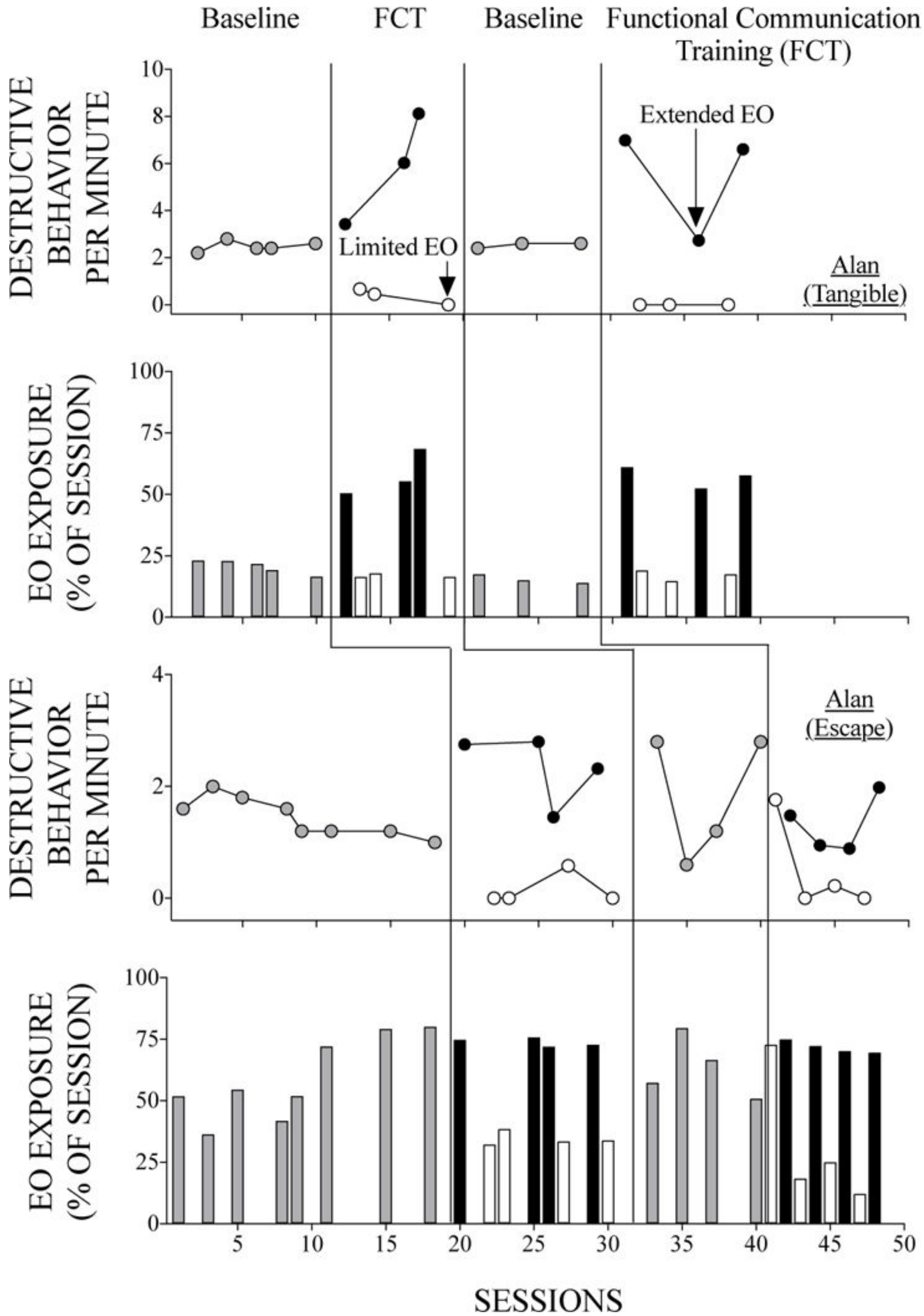


**Figure 3.**

FCT-evaluation results for Alan's tangible function (top two panels) and escape function (bottom two panels) of destructive behavior. The top panel within each panel set displays responses per min of destructive behavior, while the bottom panel within each panel set displays the corresponding percentages of session duration with EO exposure.