

Functional analysis and generalized treatment of disruptive behavior during dental exams

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Patient disruption during dental visits can impede treatment and may result in invasive approaches to care. The current study evaluated the efficacy of graduated exposure with and without extinction to decrease disruption during dental treatment for 4 young men with autism spectrum disorder (ASD). Modified functional analyses confirmed that disruption was maintained by escape from dental demands for all four young men. Initial treatment consisted of graduated exposure, whereby exam steps were initially removed and then gradually reintroduced as disruption remained low; throughout this phase, disruption resulted in a break from the exam. During the subsequent treatment phase, graduated exposure procedures continued and extinction for disruption was added. Graduated exposure alone did not result in sufficient treatment effects; however, the addition of extinction resulted in greater reductions in disruption and increases in exam completion for all 4 young men, and treatment effects generalized to a dental clinic setting.

Key words: autism spectrum disorder, dental, extinction, graduated exposure

Dental procedures can be associated with unpleasant sights and sounds, and even pain or discomfort. Thus, it is not surprising that such procedures are often met with interfering patient disruptive or resistant behavior that precludes the safe delivery of dental treatment (American Academy of Pediatric Dentistry [AAPD], n.d.-a). Prevalence estimates as high as 1 in 4 (22%) children seen by pediatric dentists are reported to engage in some form of disruptive behavior (Allen et al., 1990). Providing care to young patients with autism spectrum disorder (ASD) is reported to be particularly challenging (e.g., Fahlvik-Planefeldt & Herrstrom, 2001; Loo et al., 2008) due to common behavioral hallmarks (e.g., social and communication deficits; National Institute of Neurological Disorders and Stroke [NINDS], n.d.). One outcome of disruptive behavior during dental appointments may be the increased use of invasive procedures (e.g., premedication, general anesthesia, physical restraint) to provide care (Adair et al., 2004). Highly restrictive stabilization techniques are frequently reported with individuals diagnosed with ASD (Klein & Norwak, 1999) including restraint with papoose boards (stabilization boards with restricting cloth wrap); however due to inherent safety and restrictiveness concerns of these techniques, ethical care dictates that behavioral treatment of disruptive behavior should be attempted first (AAPD, n.d.-b).

A recent review of behavioral treatments of disruptive behavior in the context of dental care for children with intellectual and developmental disabilities indicated graduated exposure was one of the most frequently utilized treatment components (Allen & Kupzyk, 2016). Graduated exposure includes presenting a conditioned feared stimulus (e.g., dental tools) in the absence of unconditioned aversive events (e.g., pain) in order to extinguish relationships between them, and then gradually increasing the intensity of the conditioned stimulus (Hagopian & Jennett, 2008). As summarized by Allen and Kupzyk (2016), 23 studies treated disruptive behavior during medical and dental routines using graduated exposure. However, these studies incorporated a variety of other intervention components, including

differential reinforcement, modeling, and extinction. Further, in some studies these additional components were not well defined. Thus, the mechanism of behavior change in these treatments is unknown in the context of medical and dental procedures.

In 8 of the 23 studies reviewed by Allen and Kupzyk (2016), a follow-through or exam-completion procedure that has procedural similarity to escape extinction was included with graduated exposure. Extinction is an extensively studied and powerful procedure for treating disruptive behavior (Didden et al., 2006; Lerman & Iwata, 1996). Thus, understanding the role of extinction in the treatment of disruptive behavior in the dental context is important. Implementing extinction requires knowledge of the reinforcer maintaining a behavior; however, none of the studies included a functional analysis, which precludes the determination that any exam completion procedure functioned as escape extinction.¹ Further, with the exception of a study by Reimers et al. (1988), none of these studies arranged treatment in a manner that allowed for an evaluation of the individual effects of the graduated exposure and extinction components. Thus, it remains largely unclear whether: (1) extinction has ever been implemented in the context of a dental exam and (2) what role extinction plays in facilitating the effectiveness of graduated exposure during dental procedures.

Additional information on the role of extinction in these procedures can be gathered from an analogous procedure: demand fading. Similar to graduated exposure, in demand fading tasks are initially removed and then reintroduced as problem behavior remains low. Research on demand fading suggests that it is a viable treatment for escape-maintained problem behavior, especially when used as part of a

¹ Verifying the function of behavior is arguably important, as one cannot assume that the context in which behavior occurs or the topography of the behavior itself always clearly indicates the reinforcer. For example, see a paper by Vollmer et al. (1992) for an example of attention-maintained behavior evoked by demand presentation, a paper by Mace and Knight (1986) for an example of pica maintained by attention, and a paper by Thompson et al. (1998) for an example of aggression maintained by automatic reinforcement.

treatment package (e.g., Butler & Luiselli, 2007; Pace et al., 1993; Ringdahl et al., 2002). However, demand fading in isolation may not produce sufficient clinical outcomes and in those cases, the introduction of extinction may facilitate behavior reduction (see Zarcone et al., 1994, for a demonstration of the facilitative effects of extinction during demand fading). Outcomes such as Zarcone et al. (1994) suggest that demand fading approaches might be most effective as part of a treatment package that includes extinction. Demand fading approaches might also offer something of an advantage in that they typically produce immediate decreases in problem behavior and as such, may be especially useful in cases in which problem behavior is severe or when other factors make prompting physical guidance challenging (Geiger et al., 2010). This point is particularly relevant in the context of dental exams in which the risks from problem behavior are high: sharp tools and expensive equipment are present, and manual guidance of compliance is difficult and could lead to injury. Thus, an intervention that offers immediate suppression of problem behavior and requires less manual guidance may be ideally suited to this context.

The purpose of the current study was to identify the function of disruptive behavior during dental exams and to evaluate the effectiveness of a graduated exposure treatment with and without extinction. First, a methodology for distinguishing between disruption that served a broader escape function versus a specific escape-from-dental function was evaluated as a means of informing relevant treatment components and context. Next, a graduated exposure treatment was evaluated in isolation, with subsequent exposure to a nonintrusive escape extinction procedure, as needed.

Method

All treatment procedures were designed with a specific terminal environment in mind (a particular dental clinic), and with generalization to the dental clinic as a primary treatment goal. The investigators met with the director of the dental clinic (i.e., the last author) at the outset of the study to determine treatment goals (reduce disruptive behavior during dental exams without training dental

practitioners to follow a behavior-management protocol) and develop a series of exam steps that could be conducted in the clinic and would replicate a dental exam (see Table 1 for steps). In addition, safe materials to use during assessment and treatment sessions (e.g., a scaler with dental wax covering the tip for safety) were identified.

Participants and Settings

Four male adolescents ranging from age 14 to 16 years participated in treatment. All young men were diagnosed with ASD (in the case of Carl, ASD and Landau-Kleffner syndrome) by a pediatrician prior to admission to a residential school for children and adolescents diagnosed with ASD. A dental clinic that specialized in care for individuals with developmental disabilities provided all dental care. The first author shared study recruitment information with the school nursing department and school clinicians via email and asked for referrals for students with histories of disruption during dental exams. As part of the referral process, experimenters verified that potential participants had no known preexisting dental-related conditions that may increase the likelihood of pain associated with routine dental care (e.g., a broken tooth), and that each participant could be safely escorted into the independent dental clinic setting with one to two staff. Some individuals (Wes and Carl) were prescribed Ativan prior to an appointment at the dental clinic based on difficulty during previous appointments (i.e., frequent disruptive behavior). Dental staff prescribed medication as they felt appropriate, given the participant's presentation. David was prescribed a papoose board by the dentists at the clinic based on prior unsuccessful attempts at in-seat restraint. Other means of restraint (e.g., holding of hands) did not require a prescription and were often used on an as-needed basis at the discretion of the dental staff during appointments. See Table 2 for demographic and prescription information.

The dental operatory contained several chairs and tray stations, each equipped with lights and typical tools. Appointments at the clinic (i.e., dental clinic probes) were included to assess generalization

to the terminal context. Assessment and treatment sessions took place in therapy and dental simulation rooms at the residential school. The therapy room measured approximately 3 m by 4 m and contained a table and two chairs. The dental simulation room was of the same size and contained both the modified materials as well as other items common to the dental clinic (e.g., lights, tool trays). The experimenters wore medical scrubs and a facemask during all sessions in the dental simulation room.

Response Measurement and Interobserver Agreement

All primary dependent measures were collected using a partial interval recording procedure. Primary dependent measures included disruption and the percentage of the prescribed exam completed. Disruption included participant-specific target responses (e.g., aggression or self-injurious behavior [SIB]) identified during informal interviews with caregivers and active resistance to procedures (see Table 3). Data were also collected on therapist (i.e., master's level and graduate student researchers) presentation of exam steps and participant completion of exam steps in the absence of disruption. The number of completed steps was divided by the total number of prescribed steps to yield percentage of exam completed. Opportunities to complete exam steps differed across study phases. During graduated exposure, an instance of disruption resulted in therapist and material removal for 30 s; after this break, that same exam step was presented as a new instruction and counted towards the number of steps prescribed for that session. With the addition of extinction, the therapist persisted (i.e., continued to prompt completion of the exam step) until the step was completed in the absence of disruption or until the session duration elapsed. As such, therapist presentation of steps was influenced by the occurrence of disruption and opportunities to complete steps varied. Therapists also collected data on restraint during dental clinic probes as a secondary measure (restraint was never used during baseline or treatment sessions at the school). Trained observers (i.e., master's level and graduate student researchers trained on video-taped practice sessions) scored the occurrence of disruption (including during escape delivery), the

presentation of exam steps, the completion of exam steps, and restraint (dental clinic only) during 15-s intervals.

Interobserver agreement (IOA) was determined for at least 30% of all sessions by calculating the number of interval agreements between observers on the occurrence and nonoccurrence of target measures, dividing by the number of agreements plus disagreements, and multiplying by 100. Mean IOA across assessment and treatment was 99% for Wes (range, 95 – 100%), 99% for David (range, 90 – 100%), 99% for Carl (range, 94 – 100%), and 99% for Billy (range, 93 – 100%). The mean IOA score across all sessions was 99%.

Functional Analysis

Each young man participated in a functional analysis prior to treatment to determine if disruption in this context was specific to escape from dental stimuli and dental-related demands. A modified dental demand condition similar to the medical demand condition included by Iwata et al. (1990) was alternated with a typical demand condition and a no-interaction control condition. A typical demand condition was included as a comparison for the dental demand condition, for the purpose of determining whether each participant's behavior was generally sensitive to escape or specifically sensitive to escape from dental-related demands. Responding exclusively in the dental demand condition, as compared to the typical demand and control conditions, would suggest the need for treatment specific to this context (i.e., treatment of escape-maintained behavior in a dental context, in contrast to treatment of escape-maintained behavior that might occur across several contexts such as the classroom, home, etc.).

Sessions lasted 5 min, and three conditions (demand, no-interaction control, and dental demand) were alternated in a multielement design. The demand and control conditions were similar to those described by Iwata et al. (1982/1994). The dental demand condition sessions took place in the dental simulation room. The therapist presented the identified exam steps in a random order to the extent

possible. Steps 1 through 4 (see Table 1), for example, were presented in order as they are part of a response chain. The remaining exam steps were presented randomly. The therapist signaled the initiation of each step with a brief verbal statement (e.g., “Okay, now I am going to look at your teeth”) and provided praise following steps successfully completed; the therapist used light physical guidance (e.g., guided the participant to sit in the chair or placed the relevant tool near the mouth to encourage opening) if a step was not initiated within 10 s but disruptive behavior had not occurred. The therapist provided a 30-s break from the dental examination (i.e., turned away and removed any tools) contingent on disruption and presented a different exam step after the break (with the exception of Steps 1–4, which were prerequisite responses to other dental demands). The typical demand condition included demands the participants regularly encountered during their day (e.g., academic demands, motor tasks) and took place in the research room. The therapist provided light physical guidance to complete tasks not initiated within 10 s and provided a 30-s break contingent on disruption. The no-interaction control condition took place in the same research room without dental or demand stimuli present. The therapist wore typical clothing and did not interact with the participant.

Functional analysis results are depicted in Figure 1. Disruption occurred nearly exclusively in the dental demand condition for all four participants, confirming that their behavior was evoked specifically by the dental context and reinforced by its termination. Sensitivity to these demands rather than a more general sensitivity to all demands strengthens the need for treatment in this context specifically and supports the inclusion of treatment components specific to escape-maintained problem behavior (i.e., escape extinction).

General Treatment Methods

Treatment sessions were conducted in the dental simulation room at the school once or twice daily, about 5 days per week. Session duration was dependent on responding within the session (see

below), but no session exceeded 15 min. In baseline, the therapist presented the same dental exam steps but in a preset order (see Table 1) and the number of steps presented was determined by participant behavior (see below). In the treatment sessions, the same steps were presented in the same order, but the number of exam steps required to complete a session was first decreased and then gradually increased. Specifically, following two consecutive sessions with an 80% reduction in the average disruption from baseline and the prescribed exam completed at 80% or better, an additional dental exam step was added in the next session. Across baseline and treatment sessions, the therapist delivered a small treat or toy for participating at the end of each day's block of sessions, approximating the contingencies in the dental clinic. A nonconcurrent multiple baseline design across participants was used to demonstrate experimental control.

Dental Clinic Probes

Therapists observed at least one regularly scheduled dental appointment prior to the start of treatment and one or more follow-up appointments as regularly scheduled after the start of treatment to assess for generalization of treatment effects to the dental clinic. Residents in a postdoctoral program for pediatric dentistry and dental hygienists conducted these exams, which were overseen by the director of the dental clinic. The clinic staff received lecture-based training on developmental disabilities as a part of their residency program. The residents were invited to tour participants' residential school and receive a brief overview of the school's approach to dental hygiene; no structured training was provided by the experimenters or school staff, nor were the clinic staff aware of participants' involvement in a treatment study related to dental exams (i.e., the clinic staff were blind to the dental exam treatment). The residency program included frequent rotations; thus, it was rare for the same dentist to provide care across two probes. Staff from the residential school attended these appointments and implemented informal behavior management strategies (e.g., reminded participants about preferred activities or items available after the

dental appointment, provided small reinforcers at the conclusion of the exam). Trained observers measured disruption, delivery and completion of exam steps, and the use of restraint throughout these probes but did not collect data on procedures not targeted by the treatment (e.g., X-rays). The therapists did not provide any instructions to the dentist regarding the exam, provide any consequences for behavior, or participate in the exam in any way. Use of the papoose (David, only) and other forms of restraint (e.g., holding of the hands, head, or legs) occurred at the discretion of dental professionals during these probes. That is, participants were given the opportunity to comply with the procedures at the start of each appointment, but the dental professionals initiated the use of restraint when they felt that disruption precluded the completion of dental exam components.

Baseline

Baseline sessions took place at the school in the dental simulation room. The therapist presented all exam steps in order and provided a 30-s break from the exam contingent on disruption.

Graduated Exposure

Graduated exposure was introduced following baseline. Sessions took place in the dental simulation room at the participants' school. Demands were initially removed and then gradually reintroduced as disruption remained low and the number of prescribed exam components completed increased. Thus, during the first session, the therapist presented only the initial step to enter the simulation room. The therapist delivered praise for the successful completion of any prescribed step and allowed a 30-s break contingent on disruption; following that break, the therapist would return to the not-yet-completed step and again prompt that step. Additional exam steps were introduced based on the criteria described previously. Within each session, the therapist continued to present steps or demands until the predetermined number of demands were presented. After that, the exam portion of the session was considered finished, and the participant spent the remainder of the 15-min session in a waiting area with

reading material available. Target response measurement continued throughout the remainder of the 15-min session.

Graduated Exposure with Extinction

Extinction was implemented if criteria to introduce additional steps were not met across 10 consecutive sessions. Sessions were identical to those in the graduated exposure condition; however, disruption no longer produced a 30-s break. Rather, if disruption occurred during a step, the therapist continued to provide light physical guidance until the step was completed in the absence of disruption or until the 15-min session duration elapsed. Light physical guidance was selected as the extinction procedure due to the unique environmental conditions of the dental simulation (e.g., sharp tools inside the mouth) and was successful in avoiding physical injury.

Terminal Probes

Terminal probes were conducted after three consecutive step increases (i.e., six consecutive sessions with an 80% reduction in the average disruption from baseline and the prescribed exam completed at 80% or better). The probes included a complete exam (i.e., all exam steps) under current treatment conditions and served to test if gradual exposure to each step of the exam was necessary. Maintenance commenced following two consecutive probes with an 80% reduction in average disruption from baseline and the prescribed exam completed at 80% or better.

Maintenance

The schedule of sessions was reduced by about half per week (e.g., sessions typically conducted four times per week decreased to two per week, then one per week) after each participant successfully completed all steps of the exam during treatment. This final schedule, one session about every 2 weeks, was selected as one that the participants' clinical teams might be able to continue after completing treatment. The therapists used an informal behavior skills training approach to teach each participant's

school staff about treatment procedures after the study concluded. More specifically, identified team members reviewed session materials, observed sessions, and rehearsed the exam procedures with feedback from the therapist. The teams were not required to complete sessions, nor did the experimenters formally follow up with teams after training was completed.

Results

Results are depicted in Figure 2. An initial dental clinic probe was not scheduled for Wes based on clinical report that severe disruption precluded regular appointment attendance. David's initial probe lasted 12 min, and he engaged in disruption during 77% of intervals despite continuous restraint with a papoose board. The dentist completed only 15% of exam steps. Carl engaged in disruption during 45% of intervals during an initial 9.5 min dental clinic probe, and the dentist completed only 33% of the prescribed exam. Billy engaged in disruption during 60% of intervals during an initial dental probe. His visit lasted 9.5 min, and the dentist completed only 14% of the prescribed exam.

Baseline sessions at the school were associated with relatively frequent disruption and low percentages of the prescribed exam completed for David, Carl, and Billy. These results are similar to those observed in the dental clinic. Wes engaged in low to moderate disruption (i.e., an average of 21% of intervals) and moderate exam completion (i.e., an average of 60%) in baseline. The introduction of graduated exposure produced immediate decreases in disruption and increases in the percentage of the prescribed exam completed for all four participants. However, upon introduction of additional exam steps, disruption increased and/or the percentage of the prescribed exam completed decreased quickly for all participants. Wes met criteria for a terminal probe after Step 3 but an increase in disruption (i.e., 8% of intervals) and decrease in the prescribed exam completed (i.e., 79%) was observed. Wes' success in the earlier portion of graduated exposure led to within-session analysis of probe data. These data indicated disruption never occurred prior to Step 6; thus, a second probe was not conducted, and instead graduated

exposure resumed at Step 6. Wes, David, and Carl met criteria for the introduction of extinction after advancing to only Step 6, Step 2, and Step 3, respectively. In contrast, Billy advanced to Step 12 before meeting criteria for extinction.

The introduction of extinction was not associated with increases in disruption for Carl. Small but temporary increases in disruption were observed for Wes and David, and an extinction burst lasting about nine sessions occurred for Billy. Immediate increases in the percentage of the prescribed exam were observed for all participants following the introduction of extinction. David and Billy reached the maximum session duration without completing the prescribed number of steps during this phase in less than 10 sessions. With the introduction of Step 7 (Mock Scaling Upper Right Side) in early extinction sessions, for example, David successfully avoided the new exam step by hiding under the dental chair for the duration of the session. In Session 40, the therapist began to deliver the dental exam instructions and any required extinction procedures on the floor next to David; by Session 42, David no longer attempted to climb under the chair and remained in seat during the dental exam. Billy similarly avoided some exam steps by moving throughout the room and engaging in aggression during the burst, but after nine sessions, remained seated and aggression diminished. Wes again met criteria for a terminal probe after training on Step 12 during extinction sessions but did not meet maintenance criteria. Wes, Carl, and Billy completed successful terminal probes under extinction (i.e., all 24 steps of the exam were presented for two consecutive sessions with an 80% reduction in the average disruption from baseline and the prescribed exam completed at 80% or better) following Steps 15, 12, and 16, respectively, eliminating the need to train each exam step. Treatment gains continued during maintenance, and the therapists trained the participants' clinical team members to assume session procedures.

All four participants attended follow-up dental clinic probes as appointments were regularly scheduled. Wes attended two scheduled dental clinic probes (i.e., one during treatment and one following

training of the clinical team) despite previous restriction from the dental environment. Wes engaged in disruption during 30% of intervals, but the dental professionals completed over 60% of the exam successfully in the first probe. Wes attended an additional dental clinic probe after the clinical team assumed responsibility for conducting maintenance sessions. Disruption increased, and the dental professionals completed fewer exam components than during the previous probe attended during treatment. David attended two additional dental clinic probes over the course of treatment. Disruption occurred during 19% and 25% of intervals, and the dental professionals completed 76% and 80% of the prescribed exam steps, respectively, showing improvement relative to the initial dental clinic probe (i.e., 77% of intervals with disruption and only 15% of the prescribed exam completed). Carl completed a follow-up dental clinic probe during treatment; disruption was relatively low (i.e., 21% of intervals), and the dentist completed a high percentage of the prescribed exam (i.e., 86%) relative to 45% of intervals with disruption and only 33% of the prescribed exam completed in the initial probe. Billy also completed an additional dental clinic probe with low disruption (i.e., 20% of intervals) and a high percentage of the exam completed (i.e., 90%). In a direct comparison of before- and after-treatment levels of disruption and exam completion during initial (i.e., pretreatment) and final follow-up (i.e., after exposure to treatment) dental probes, Figure 3 illustrates that disruption decreased, and the percentage of the prescribed exam completed increased for David, Carl, and Billy.

Restraint data were collected during dental clinic probes. A comparison of the percentage of intervals with restraint during initial and final follow-up probes is depicted in Figure 4 for David, Carl, and Billy. David's initial probe lasted 12 min and continuous restraint with a papoose board was required. David's follow-up probes (only the final follow-up probe is depicted in Figure 4), however, were conducted without the use of any restraint following years of prescribed papoose use. Carl required restraint by two to three individuals for nearly half of the initial 10-min appointment. At follow up, robust

decreases in disruption and increases in the percentage of the prescribed exam completed occurred with only the use of light restriction of movement during 10% of intervals. Billy's initial visit lasted 9.5 min, and three individuals applied physical restraint. Billy required no restraint in the follow-up probe.

Discussion

The results suggest that extinction was a facilitative component in treating escape-related disruption in a dental context. Graduated exposure produced immediate decreases in disruption and increases in the percentage of the prescribed exam completed for all four participants, but this effect was limited to the first few steps of the exam. The introduction of additional exam steps quickly resulted in increases in disruption and decreases in the percentage of the exam completed for Wes, Carl, and David. With the introduction of extinction, these participants successfully progressed through additional steps of the exam, demonstrating the facilitative effects of extinction to meet treatment goals and the importance of knowing the function of behavior prior to treatment. Billy initially progressed further during the graduated exposure condition without extinction, relative to other participants. However, disruption and the percentage of the prescribed exam completed remained variable, and Billy eventually met criteria for extinction. Billy's treatment gains were gradual following the introduction of extinction, thus, the potential influence from variables other than extinction (e.g., continued exposure to the dental exam steps) is harder to rule out.

Terminal probe outcomes suggest that graduated exposure to all steps may not be necessary and highlight the potential facilitative effect extinction may play. Wes met criteria for a terminal probe twice (once during graduated exposure and once during extinction) but did not meet criteria to begin maintenance. Wes did successfully complete subsequent terminal probes during graduated exposure with extinction, as did Carl and Billy. Later terminal probes may have been more successful because of cumulative effects of extinction. However, previous exposure to all instructions may have also reduced

the aversiveness of later exam steps (i.e., duplication of steps on the opposite side of the mouth; see Table 1). Thus, probes conducted later in the exam may have been more successful because participants had already experienced those steps, albeit on the other side of the mouth.

This study supports the existing body of literature demonstrating the efficacy of graduated exposure techniques with individuals with developmental disabilities (Hagopian & Jennett, 2008). The findings also extend the literature on the treatment of medical and dental disruption by attempting to determine the relative contributions of graduated exposure alone versus graduated exposure with extinction, which is often omitted from common graduated exposure treatment packages (Allen & Kupzyk, 2016). The facilitative effects of extinction observed with all four participants further supports the findings from Reimers et al. (1988) and suggests benefits to including extinction with graduated exposure. Further, relatively few studies have demonstrated generalization of graduated exposure treatment packages to natural settings (see Cuvo, Godard, et al., 2010; Cuvo, Reagan, et al., 2010 for exceptions). In the current study, treatment was delivered in a simulated dental context and treatment effects then generalized to the actual dental exam. That is, disruption decreased between 24% and 52% of intervals from initial to final probes, and exam completion increased between 53% and 76% of intervals among all three participants who attended initial and follow-up dental probes while collateral decreases in the use of restraint were also observed (see Figure 4).

The facilitative effects of extinction seen in parallel literature (e.g., demand fading) have implications in this context. The need to include extinction may represent a clinical limitation, for example, as the procedure may not be ideal or even possible in some situations. In the current study, the extinction procedure was relatively noninvasive, as it consisted of continuing to present the dental stimuli (when applicable) with a light physical prompt. At no time did the therapist attempt to insert dental tools into the participants' mouths against active resistance (or pry open their mouths). Further, few extinction

bursts were observed (disruptive behavior occurred for the full duration in some sessions with Billy, but this was temporary) and there were no injuries. Nonetheless, extinction may not be feasible in contexts that would pose a high risk to participants, related to their movements (e.g., during restorative care), or for some individuals with severe problem behavior.

It is also possible that the escape extinction procedure used here functioned to punish, rather than extinguish, disruption. Related research in food refusal, for example, has interpreted rapid reductions in behavior that follow the presentation of an aversive stimulus (i.e., nonremoval of the spoon) as possibly more indicative of punishment than extinction (Piazza et al., 2003). However, one might argue that continued prompting (unchanged by the emission of problem behavior) does not constitute a stimulus change contingent on behavior, and as such is better conceptualized as an extinction procedure. Although a better understanding of the exact mechanism (i.e., punishment versus extinction) responsible for the changes seen is important from a conceptual standpoint, the procedure appeared effective in producing therapeutic changes in behavior.

The modified functional analysis played a small but important role in the current study. The referral process itself may have eliminated potential participants with other functions of behavior (e.g., attention-maintained behavior), as the referrals came from clinicians familiar with each young man's presentation across home, school, and medical environments. However, each participant had a history of problem behavior that occurred across multiple contexts and as such, it was quite possible that the referral process would have resulted in identification of individuals whose behavior was not sensitive specifically to escape from dental demands. Thus, a functional analysis designed to compare the evocative nature of dental demands and potentially aversive features of other demands (i.e., verbal or physical prompting to complete academic or self-care tasks) was included. A second important contribution of the functional analysis was a demonstration that the continued prompting procedure was indeed an extinction procedure.

Although several prior studies have included a similar prompting procedure, the mechanism involved in behavior change was not clearly identified because those studies lacked a functional analysis.

Several potential limitations should be noted when considering the outcomes. First, changes in performance should be cautiously interpreted in light of the use of medication during initial and follow-up dental clinic probes. For example, Carl did not receive Ativan in the initial dental clinic probe but did prior to the follow-up dental clinic probe; thus, decreases in disruption and increases in exam completion (see Figure 3) may have been due merely to changes in medication. In contrast, Wes was given Ativan in the first follow-up appointment and performed better at a subsequent appointment when Ativan was not given. Second, restraint was administered at the discretion of dental professionals throughout the study. It is possible that the observed reductions in restraint use during later appointments were due to improved behavior (less disruption, more cooperation) at the outset of the exam, but this cannot be confirmed. Further, restraint itself could evoke problem behavior and it is possible that the use of restraint during early appointments increased the overall level of disruption and decreased cooperation during those appointments. In any case, each participant had some opportunity to cooperate with the exam before the dentist would issue the instruction to use restraint and as such, their behavior early in the dental exam likely impacted the dentists' decision as to whether to recommend restraint. The outcomes from the dental clinic probes in this study are preliminary; it is the authors' hope that improved behavior would eventually lead to less reliance on medications and highly restrictive restraint to complete appointments successfully.

There were some limitations in the study's design. It is possible that condition sequence affected outcomes. For each participant, graduated exposure alone was followed by graduated exposure with extinction. The introduction of extinction often led to immediate and persistent increases in the percentage of the prescribed exam completed (see Wes, Carl, Billy). However, three of four of the

participants that were exposed to extinction engaged in disruption during initial or early sessions following the addition of extinction (i.e., Wes, David, and Billy). These findings decrease the likelihood that treatment effects were due merely to graduated exposure and rather suggest that extinction most likely played a critical role in meeting treatment goals.

Finally, the prescribed exam completion measure poses limitations in the demonstration of experimental control. First, the opportunities to complete exam steps differed between baseline and treatment. The entire exam (24 steps) was presented during baseline, but during treatment, a smaller, prescribed number of instructions were delivered; as such, small changes in number of steps completed would result in large changes in the percentage of exam steps completed between phases. Further, disruption that occurred during graduated exposure resulted in escape and a loss of the opportunity to complete that step or comply with that demand (i.e., the therapist turned away for 30 s and then presented the same step until the programmed number of instructions was delivered). With the addition of extinction, the therapist persisted (i.e., continued to present the exam step) until the step was completed in the absence of disruption or until the session duration elapsed. Thus, there were more opportunities for exam step completion during graduated exposure with extinction than there were during graduated exposure alone.

The generalization environment was the exact environment of care, in which blinded dental professionals made on-the-spot decisions about how to present demands and whether to utilize mechanical or physical restraint, and which consequences to implement for compliance and disruption (they varied widely across the exams). This increases the applicability and significance of the findings. However, testing the intervention in this setting was not without cost. These variables also could have influenced behavior, and the compromises necessary to bring the treatment to the exact environment of care limited experimental control. The procedures were tested in the environment of care because there is

a pressing clinical need to provide intervention for severe problem behavior that interferes with adequate dental care, and to do so in a way that yields meaningful outcomes in an extra-experimental terminal environment. In the current study, the dental staff (members of a specialty dental clinic for children with developmental disabilities) were often unable to accomplish their treatment goals (even with the use of physical restraint, pre-exam medication, and mechanical restraint) and referred participants for subsequent exams under general anesthesia prior to participation in the study. Thus, the goals, procedures, and metrics for success in this study were all designed with this in mind. Though this inherently limits the generality of the study, this investigation was an attempt to ameliorate a real clinical need and further advance a behavioral understanding of a critical social problem, a fundamental principle of applied behavior analysis and applied sciences (Critchfield & Reed, 2017).

Several considerations for future research are warranted. Positive reinforcement for approach or tolerance is a common component in graduated exposure packages (Allen & Kupzyk, 2016). The role of targeted intervention for approach or tolerance was not evaluated because the primary purpose of this study was to evaluate graduated exposure as a stand-alone intervention and to evaluate the need for extinction to meet end of treatment goals. It is possible, however, that programming for participant-specific, potent reinforcers for tolerance or approach alone could complement graduated exposure in such a way that would preclude the need for extinction. Future research should evaluate the impact of graduated exposure with programmed differential reinforcement versus the addition of extinction to consider which is most beneficial to meet end of treatment goals in a dental setting.

Additionally, although treatment effects generalized to the exact environment of care, disruption decreased, and exam completion increased more in the treatment setting than the dental clinic. For example, during Carl's final follow-up dental clinic probe disruption was relatively low (i.e., 21% of intervals) and the dentist completed a high percentage of the prescribed exam (i.e., 86%). In contrast,

maintenance sessions at the school were associated with 0% disruption and full exam completion. Future research should consider how to increase generalization through programming additional and more salient stimuli in practice conditions, increasing frequency of sessions, etc. This may, in turn, help to increase the generality of the findings.

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Table 1*Dental Exam Steps*

Step	Component	Operational Definitions of Participant Behavior
1	Enter Room	Enters room
2	Lay down in chair	Lays down in chair
3	Bib application	Allows application of bib
4	Bite blocker L side	Allows application of bite blocker to L side of mouth
5	Visual check UR	Allows therapist to look at each tooth in UR quadrant with mirror for 15 s
6	Visual check LR	Allows therapist to look at each tooth in LR quadrant with mirror for 15 s
7	Mock scaling UR	Allows therapist to lightly touch each tooth in UR quadrant for 15 s
8	Mock scaling LR	Allows therapist to lightly touch each tooth in LR quadrant for 15 s
9	Cleaning UR	Allows therapist to brush teeth in UR quadrant with brush and paste for 15 s
10	Cleaning LR	Allows therapist to brush teeth in LR quadrant with brush and paste for 15 s
11	Flossing UR	Allows therapist to floss between at least 2 teeth in UR quadrant
12	Flossing LR	Allows therapist to floss between at least 2 teeth in LR quadrant
13	Fluoride U/L R	Allows therapist to apply mock fluoride gel to U/L R teeth
14	Bite blocker R side	Allows therapist to move bite blocker over to R side of mouth
15	Visual check UL	Allows therapist to look at each tooth in UL quadrant
16	Visual check LL	Allows therapist to look at each tooth in LL quadrant
17	Mock Scaling UL	Allows therapist to lightly touch each tooth in UL quadrant for 15 s

18	Mock scaling LL	Allows therapist to lightly touch each tooth in LL quadrant for 15 s
19	Cleaning UL	Allows therapist to brush teeth in UL quadrant with brush and paste for 15 s
20	Cleaning LL	Allows therapist to brush teeth in LL quadrant with brush and paste for 15 s
21	Flossing UL	Allows therapist to floss between at least 2 teeth in UL quadrant
22	Flossing LL	Allows therapist to floss between at least 2 teeth in LL quadrant
23	Fluoride U/L L	Allows therapist to apply mock fluoride gel to U/L L teeth
24	Remove bite blocker	Tolerates removal of bite blocker

Note. All steps considered complete if in absence of disruption. L = left side; UR = upper right side; LR = lower right side; U/L R = upper and lower right side; R = right side; UL = upper left side; LL = lower left side; U/L L = upper and lower left side.

Table 2

Participant-Specific Demographic Information

Participant	Assigned Sex	Age	Diagnosis	Communication	Medication	Restraint
Wes	M	14	ASD	Vocal-verbal speech	Ativan	—
David	M	16	ASD	Sign Language AAC device	—	papoose
Carl	M	16	ASD Landua-Kleffner syndrome	Sign Language PECS book AAC device	Ativan	—
Billy	M	14	ASD	Vocal-verbal speech	—	—

Note. Other forms of restraint remained at the discretion of dental professionals. M = male; ASD = autism spectrum disorder; AAC = augmentative and alternative communication.

Table 3

Participant-Specific Dependent Measure Definitions

Participant	Active Resistance and Restraint
All	<p>Active Resistance: Any instance of pulling away from or pushing against therapist, attempted blocking of physical guidance with any body part, or turning head or body away from therapist or dental stimuli</p> <p>Aggression: Any instance of an actual or attempted bite, hair pull, head butt, punch, slap, scratch, pinch, hit, or kick to another person</p> <p>Restraint: Any physical holding by another person or papoose wrap of any part of the young men's bodies for the purpose of restricting movement</p>
Wes	<p>SIB: Any instance of contact between hand and face from a distance of 3 inches or greater, or any contact between head and another object from a distance of 3 inches or greater</p>

David	Active Resistance: Any instance of attempted blocking of physical guidance with any body part or turning the head or body away from therapist or stimuli
	Aggression: Any instance of forceful pushing, pulling, or shoving against any part of the therapist or any instance of an actual or attempted bite, hair pull, head-butt, punch, slap, scratch, hit or kick to another person

Note. Active resistance, aggression, and restraint definitions were identical for all participants unless otherwise indicated. SIB = self-injurious behavior.

Figure 1

Percentage of Intervals with Disruption During Functional Analyses

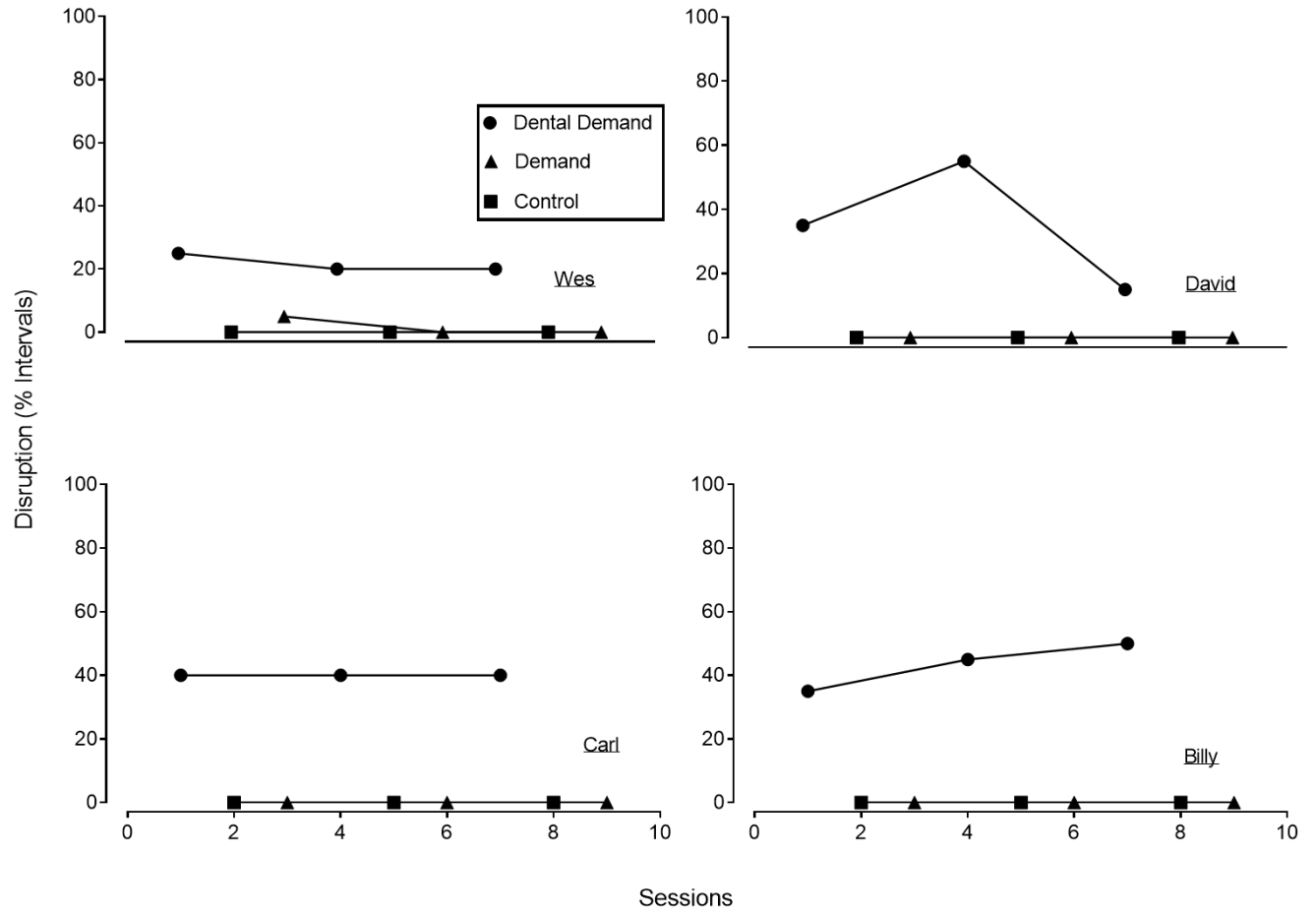


Figure 2

Percentage of Prescribed Exam Completed, Percentage of Intervals with Disruption, and Exam Steps During Baseline (BL), Graduated Exposure (GE), and Maintenance (Mt)

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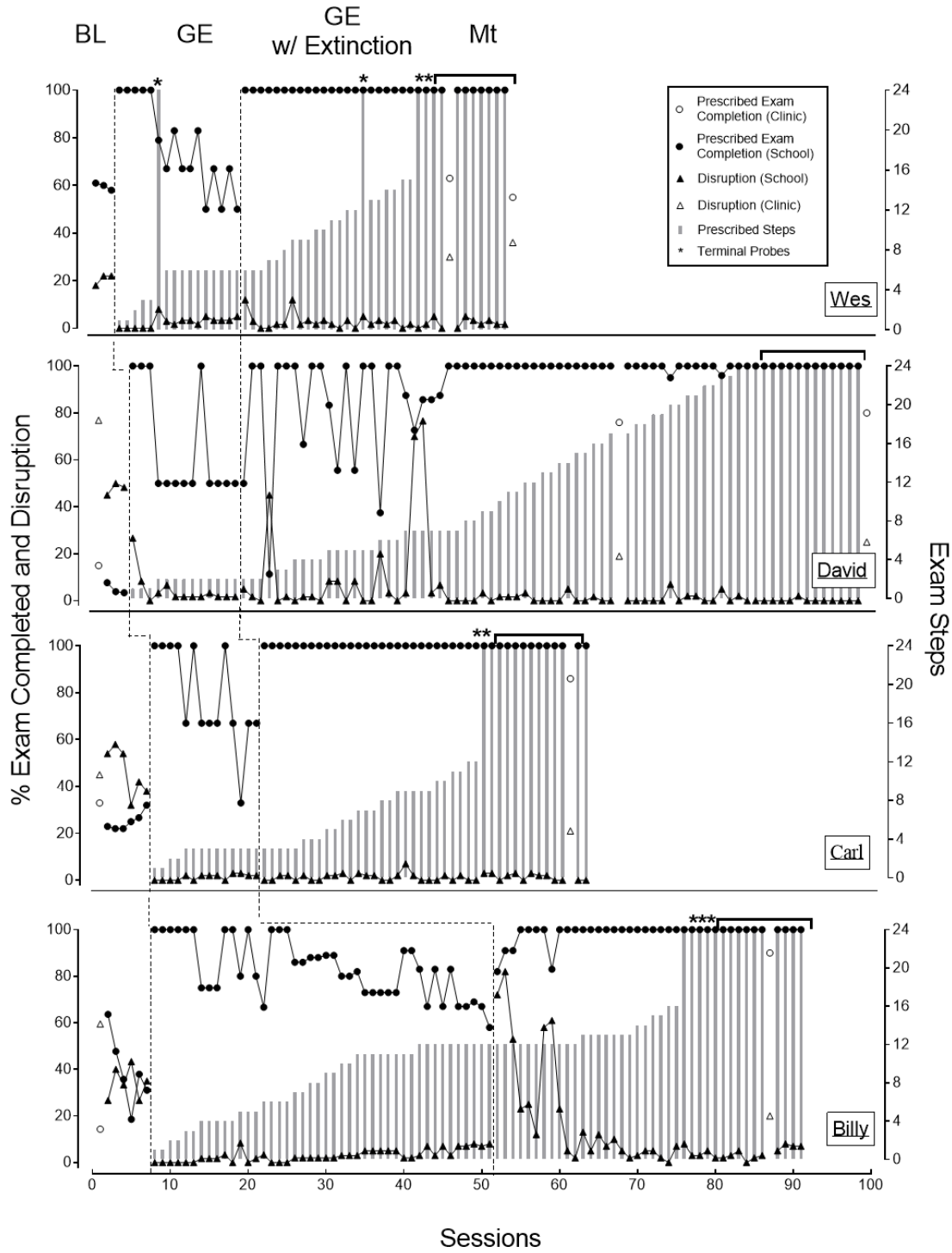
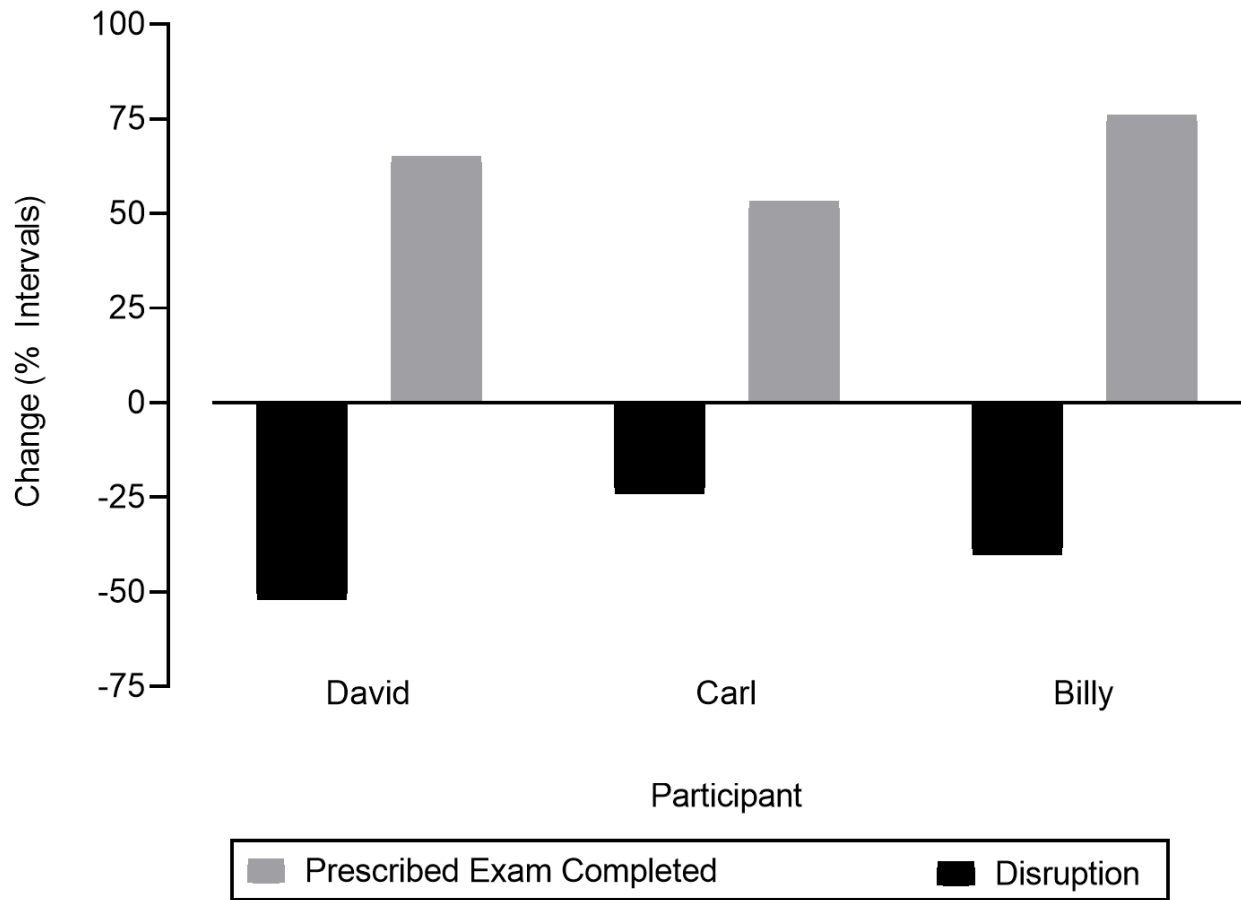


Figure 3

Change Between Initial and Final Follow-Up Dental Clinic Probes



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Figure 4

Percentage of Intervals with Restraint During Initial and Final Follow-Up Dental Clinic Probes

