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RELATIONS BETWEEN RATE OF NEGATIVE REINFORCEMENT AND THE PERSISTENCE OF TASK COMPLETION

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Research has shown that differential reinforcement of alternative behavior (DRA) can be an effective intervention to address problem behavior maintained by negative reinforcement emitted by young children. However, few studies have evaluated the variables that are related to long-term maintenance (i.e., persistence) of treatment effects. Research on behavioral persistence predicts that the rate of reinforcement provided for a target behavior is correlated with its persistence when challenged. There were 2 purposes of the current investigation. First, we evaluated the effects of the rate of negative reinforcement on the persistence of task completion. Second, we applied the findings regarding rate of reinforcement to a treatment context for 3 participants who engaged in destructive behavior that was reinforced by escape from demands. Results were evaluated within a multielement design and indicated that the rate of negative reinforcement had a moderate influence on the persistence of task completion. These results contribute to the existing literature by extending analyses of persistence to treatment contexts.

Key words: behavioral persistence, maintenance, negative reinforcement

Problem behavior (e.g., passive noncompliance, aggression, property destruction) evoked by task demands is a relatively frequent and concerning problem for many families (Emerson et al., 2001). In fact, Kalb and Loeber (2003) reported that these problem behaviors are of concern for 25% to 65% of children and adolescents, as measured by the Child Behavior Checklist (Achenbach & Edelbrock, 1983). These problem behaviors also are remarkably stable across childhood and adolescence. Kalb and Loeber reported results of a study that followed 1,517 boys for 9 years and showed that parent and teacher ratings were very stable. Specifically, if participants displayed problem behaviors at a young age, they were likely to continue displaying similar behavior as they grew older. Thus, there is a clinical need for implementation of treatments that have

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long-term effects for decreasing problem behaviors evoked by task demands.

Perhaps intuitively, negative reinforcement in the form of escape from demands is the most frequently identified function for these problem behaviors (Call, Wacker, Ringdahl, Cooper-Brown, & Boelter, 2004). A commonly used function-based intervention is differential reinforcement of alternative behavior (DRA; Harding, Wacker, Berg, Winborn-Kemmerer, & Lee, 2009). DRA interventions include two components: (a) withholding the functional reinforcer for the target behavior and (b) providing that reinforcer contingent on an alternative response (e.g., Piazza, Moes, & Fisher, 1996; Vollmer, Roane, Ringdahl, & Marcus, 1999). Although function-based interventions are among the most effective treatments for problem behavior evoked by task demands (Burke, Hagan-Burke, & Sugai, 2003), a common limitation is that they need to be implemented for extended periods before maintenance is achieved (Nevin & Wacker, 2013; Wacker et al., 2011). Maintenance is observed when treatment effects continue to be exhibited under changes in antecedent or consequent stimuli (Nevin & Wacker, 2013). Few applied research studies have examined the conditions under which maintenance, which can be indicated in part by the persistence of the alternative response, is observed following a history with DRA (Mace et al., 2009, 2010; Volkert, Lerman, Call, & Trosclair-Lasserre, 2009; Wacker et al., 2011, 2013).

From the perspective of behavioral momentum theory, maintenance of treatment effects can be difficult to achieve because problem behavior may have historically been reinforced on a denser schedule of reinforcement than appropriate behavior (Nevin & Shahan, 2011). These problem behaviors may have acquired sufficient strength that they reliably occur under certain conditions under which they have previously produced reinforcement (e.g., escape from nonpreferred demands). Behaviors reinforced on high-rate schedules of reinforcement are less likely to be disrupted, at least initially, by presentations of procedures like extinction (Nevin, Mandell, & Atak, 1983); that is, responses with such histories have been shown to be more persistent (Nevin, 1974; Shahan & Sweeney, 2011). Problem behaviors with greater persistence than appropriate behaviors are of concern for caregivers and clinicians because these problem behaviors may be more resistant to behavioral interventions (e.g., Goh & Iwata, 1994; Lerman, Iwata, Shore, & Kahng, 1996; MacDonald, Ahearn, Parry-Cruwys, Bancroft, & Dube, 2013), and may show greater resurgence over time (e.g., Mace et al., 2010; Volkert et al., 2009; Wacker et al., 2013).

Although few evaluations of behavioral persistence have occurred in treatment contexts, persistence has been examined in depth in experimental studies with nonhuman subjects (e.g., Cohen, 1998; Dube, Ahearn, Lionello-DeNolf, & McIlvane, 2009; Nevin & Grace, 2000; Nevin et al., 1983). In these studies, rate of reinforcement and stimulus–reinforcement relations are two common variables that have been shown to be related to persistence. For example, in Nevin et al. (1983), rats were trained to press a lever in a multiple-schedule design to examine persistence associated with a dense or a lean schedule of reinforcement. Results showed that the schedule associated with the dense schedule increased the persistence of lever pressing when reinforcement for lever pressing was suspended (i.e., placed on extinction). Based on the results of this study, researchers have begun to study the variables (e.g., schedules of reinforcement, type of reinforcement) that affect persistence as it relates to human behavior (Ahearn, Clark, Gardenier, Chung, & Dube, 2003; MacDonald et al., 2013; Mace et al., 1990; Parry-Cruwys et al., 2011).

Mace et al. (2010) provided one translation of behavioral persistence of destructive behavior following DRA in a treatment context. Three participants who had been diagnosed with

developmental disabilities participated. A functional analysis of destructive behavior showed that each participant's destructive behavior was maintained by positive reinforcement. After the functional analysis of destructive behavior, either extinction or DRA was implemented to decrease destructive behavior. Results showed that destructive behavior was less persistent when extinction followed the functional analysis than when the DRA treatment followed the functional analysis. These researchers hypothesized that reinforcing an alternative response that was in the same response class as destructive behavior during DRA subsequently strengthened destructive behavior. Thus, the overall rate of reinforcement allocated to a particular response class was shown to be related to the persistence of behaviors within that response class.

Wacker et al. (2011) showed similar effects with children with developmental disabilities whose destructive behavior was maintained by negative reinforcement. After a functional analysis of destructive behavior, a functional communication training (FCT) program was implemented according to a chained schedule of reinforcement. The participants completed a brief work task and then were provided with an opportunity to mand for an enriched break (i.e., break with tangible items and attention). After increased task completion and manding were shown, FCT was withdrawn and extinction was programmed for task completion, manding, and destructive behavior. Results showed that extended periods (e.g., up to 12 to 18 months) of FCT treatment were necessary for task completion to persist and destructive behavior not to show resurgence during these extinction challenges. These data supported Mace et al. (2010)'s findings of the paradoxical effect of DRA treatment and extended previous work on behavioral persistence to negative reinforcement.

In sum, research has shown that rate of positive reinforcement (e.g., Mace et al., 2010; Nevin et al., 1983) can affect the persistence of behavior. Limited research to date has shown this effect with the class of negative reinforcement (Wacker et al., 2011). In the current study, we manipulated the rate of negative reinforcement in a multielement design for three children who engaged in destructive behavior to escape from demands. After we established unique histories of reinforcement, we evaluated the effect of rate of negative reinforcement on the persistence of task completion during an extinction challenge.

METHOD

Participants and Setting

Three children participated in the current study. Isaac was a 3-year-old boy who had been diagnosed with an autism spectrum disorder. He communicated using two- to three-word utterances. His destructive behaviors were aggression and property destruction. At the time of his participation, his mother reported that he was learning to match shapes, colors, and animals at school and home. Aida was a 7-year-old girl who had been diagnosed with attention deficit hyperactivity disorder, dyslexia, dysnomia, and disruptive behavior disorder. Her destructive behavior was property destruction. At the time of this study, her mother reported that Aida was working on copying sentences, simple subtraction problems, picture identification, and counting by twos at school and home. Aida was also a participant in Romani, McCoy, Wacker, and Padilla-Dalmau (2014), but there are no overlapping data with those published in that article. Joshua was a 4-year-old boy who had been diagnosed with disruptive behavior disorder. His destructive behaviors were aggression and property destruction. His parents reported that he was working on tracing at school when he began participation in this study.

All experimental sessions were conducted in either clinic therapy rooms at a university-based clinic (Isaac) or the participant's home (Aida and Joshua). Clinic therapy rooms contained a table, four chairs, and a camera connected to a closed-circuit television in an adjacent room.

Leisure items and work activities were present in the room. Aida's and Joshua's homes contained a kitchen table, four chairs, and leisure items. Experimental sessions were recorded using a handheld video recording device.

A member of the research team conducted all sessions. Graduate students who had received training in behavioral observation and had demonstrated high interobserver agreement with other data collectors served as observers. Observations were conducted using a behavioral data-collection computer program that allowed both frequency (e.g., individual instances of behavior, e.g., aggression) and duration (e.g., amount of time a behavior occurred) behaviors to be recorded. Data were collected either in vivo using a closed-circuit camera (Isaac) or from video recordings (Aida and Joshua). Sessions were conducted one to three times per week for 1 hr.

Target Behaviors, Data Collection, and Interobserver Agreement

Two independent observers collected data on the occurrence of destructive behavior and task completion exhibited by Isaac, Aida, and Joshua. For Isaac, destructive behavior was aggression (e.g., hitting, kicking, and scratching) and property destruction (e.g., throwing toys or other experimental materials, tearing paper, kicking experimental materials). For Aida, destructive behavior was property destruction (e.g., slamming her pencil against the table). For Joshua, destructive behavior was aggression (e.g., biting, spitting, hitting, kicking) and property destruction (e.g., throwing toys or experimental materials, tearing paper). Aggression and property destruction were recorded as a frequency measure and represented as responses per minute. Task completion was defined as each work task that the participants completed independently or after a vocal prompt (e.g., "Put the red piece on.") from the experimenter. Task completion was not recorded if a model prompt (i.e., showing the child how to complete the task) or physical guidance (i.e., using hand-over-hand prompting with the participant to complete the task) was needed for the participants to complete the work task. Task-completion data were scored as frequency of occurrence and represented as a number (e.g., nine instances of task completion after a vocal prompt).

Observers also collected data on experimenter behavior. Experimenter behaviors recorded were delivery of reinforcement (i.e., breaks from the work activities) and task prompts. Delivery of reinforcement was defined as the experimenter removing the work activity and was represented as responses per minute. Task prompts were defined as the experimenter vocally prompting the participants to complete a work task (e.g., "Put the red piece on."). Task prompts were recorded only after the initial vocal prompt (i.e., model prompts or physical guidance were not scored as task prompts).

We calculated interobserver agreement coefficients using a block-by-block method. Specifically, data from the two independent observers were placed in 10-s bins to be compared. Agreement percentages of each target behavior (i.e., those behaviors recorded by both observers during the same 10-s interval) and the nonoccurrence of the target behaviors (i.e., target behaviors not scored by either observer during the same 10-s interval) were collected based on an interval-by-interval comparison of each observer's records. The interobserver agreement score was calculated based on mean occurrence per interval (Cooper, Heron, & Heward, 2007). Within each interval, the number of agreements was divided by the number of agreements plus disagreements to obtain the percentage of interobserver agreement for the specific interval. Interobserver agreement for each interval was then averaged to obtain the percentage of interobserver agreement for each session.

For Isaac, interobserver agreement was collected for at least 30% of all experimental phases and averaged 98% (range, 74% to 100%).

Aggression was 100%; destruction averaged 98% (range, 80% to 100%); task completion averaged 97% (range, 74% to 100%); delivery of reinforcement averaged 97% (range, 87% to 100%); and task prompts averaged 96% (range, 74% to 100%).

For Aida, interobserver agreement was collected for at least 30% of all experimental phases and averaged 97% (range, 80% to 100%). Destruction averaged 97% (range, 89% to 100%); task completion averaged 96% (range, 87% to 100%); delivery of reinforcement averaged 97% (range, 90% to 100%); and task prompts averaged 96% (range, 80% to 100%).

For Joshua, interobserver agreement was collected for at least 30% of all experimental phases and averaged 96% (range, 63% to 100%). Aggression averaged 97% (range, 71% to 100%); destruction averaged 95% (range, 63% to 100%); task completion averaged 98% (range, 92% to 100%); delivery of reinforcement averaged 97% (range, 73% to 100%); and task prompts averaged 94% (range, 73% to 100%).

Materials

For Isaac, each work activity required him to match animals, shapes, and colors to their corresponding pictures. Task completion was recorded when Isaac matched one animal, shape, or color. On the animal folder, Isaac was required to match eight animals (rabbit, bird, fish, cow, pig, cat, dog, and horse). On the shapes folder, he was required to match four shapes (squares, rectangles, circles, and triangles), repeated twice on the folder. On the colors folder, he was required to match eight colors (green, purple, black, blue, yellow, pink, orange, and red). The folders were 22.9 cm by 15.2 cm. During the functional analysis of destructive behavior, he completed work tasks mounted on identical manila folders. During subsequent parts of the study, he completed these work tasks mounted on either green or red folders. The locations of the pictures were the same across each of the work folders.

Four different academic tasks were presented to Aida. Tasks were copying sentences, completing simple subtraction problems (e.g., $3 - 2 = 1$), picture identification problems, and fill-in-the-blank problems (i.e., counting by two). Tasks were cut into strips, so that one task was presented at a time. For example, one task consisted of writing one sentence, answering one subtraction problem, identifying one picture, or completing one count-by-two problem. The task strips were approximately 5.1 cm by 15.2 cm. During the functional analysis, Aida completed these tasks on white paper. During subsequent parts of the study, she completed these tasks on red or green paper.

Joshua was presented with tracing tasks. Tasks were tracing four to five words and were cut into strips (5.1 cm by 15.2 cm) so that he was presented with one task at a time. During the functional analysis, he completed these tasks on white paper. During subsequent parts of the study, he completed these tasks on red or green paper.

Design and Analysis

The current study was conducted in five phases. Each phase was conducted within a multielement design. Data were presented as responses per minute (destructive behavior and reinforcer delivery), frequency of task completion, and cumulative frequency of task completion during extinction. Frequency of task completion was selected because sessions for both conditions were the same duration in each phase of the study. Task completion during extinction was depicted as a cumulative responses to further analyze differences between the dense and lean stimulus conditions.

Procedure

Phase 1: Functional analysis of destructive behavior. A functional analysis of destructive behavior (Iwata, Dorsey, Slifer, Bauman, & Richman, 1982/1994) was conducted using control (free play), escape, attention, and tangible conditions. All sessions lasted 5 min.

Phase 2: Baseline. Baseline sessions were identical to functional analysis escape sessions. Sessions began with the experimenter instructing the participants to complete one of the work activities described in the materials section. The experimenter began the escape sessions by providing a vocal prompt (e.g., "match the dog") for the participant to complete a specific work task. If destructive behavior or task completion did not occur within 5 s of the vocal prompt, the experimenter progressed through a prompting hierarchy. The next prompt delivered was a model prompt. The model prompt consisted of the experimenter showing the participant how to complete the work task before another opportunity to complete the task was delivered. If no task completion or destructive behavior occurred within 5 s of the model prompt, the experimenter physically guided Isaac and Joshua to complete the work task. Physical guidance was not used for Aida due to parent preference. Instead, the experimenter continued to use a model prompt every 5 s until she completed the task or destructive behavior occurred. A brief 30-s break was provided contingent on destructive behavior according to a fixed-ratio (FR) 1 schedule of reinforcement. No attention or tangible items were available during these breaks. Task completion with the work task produced another work task. As noted, during baseline the color of the demands (red or green) varied but the actual tasks were the same as those from the functional analysis. Baseline sessions were conducted to demonstrate that destructive behavior and task completion were similar across distinctly colored work activities. Baseline sessions were conducted until consistent responding of both destructive behavior and task completion was obtained. Sessions lasted 5 min.

Between each 5-min work session, the participants were given a 2-min playtime. During playtime, the participants were given free access to toys and attention. There were no programmed consequences for destructive behavior. In addition, a play and work visual schedule and timer to indicate the beginning and end of the 2-min playtime were used to structure the sessions. The schedule and timer were used during all subsequent phases.

Phase 3: Compliance training. During these sessions, task completion was reinforced with a 30-s break on an FR 1 schedule of reinforcement in each condition (red or green). Destructive behavior was placed on extinction. For Isaac and Joshua, no toys or attention were available during these breaks. Aida was initially exposed to the no toys/attention contingency, but her behavior was later reinforced with enriched breaks, which consisted of access to adult attention. If task completion occurred after a model prompt or physical guidance, a new task was immediately presented without a break. Compliance training sessions were conducted to increase the participant's task completion with the work activities and to evaluate whether the unique stimuli resulted in differential levels of task completion. Compliance training sessions were conducted until consistent responding for both destructive behavior and task completion was obtained. Sessions lasted 5 min.

Phase 4: Schedule manipulation. Task completion was reinforced on a variable-interval (VI) schedule of negative reinforcement. Destructive behavior was placed on extinction. Three response-independent reinforcer deliveries were programmed in one condition. For Isaac, task completion with the red tasks was reinforced according to a VI 10-s (i.e., lean) schedule of reinforcement, and task completion with the green tasks was reinforced according to a VI 10-s fixed-time (FT) 20-s (i.e., dense) schedule of reinforcement. For Aida, task completion was reinforced according to a VI 49-s (i.e., lean) schedule for the green tasks and VI 49-s FT 98-s (i.e., dense) schedule for the red tasks. For Joshua, task completion was reinforced according to a VI 79-s (i.e., lean) schedule for the green tasks and a VI 79-s FT 158-s (i.e., dense) schedule for the red tasks.

The length of the VI schedules was calculated by dividing the sum of the interreinforcer time (time spent in demand) by the total number of tasks completed for the last three compliance training sessions for both conditions (six sessions total). The amount of time with a demand in place during this phase was based on the mean interreinforcer time for the last three compliance training sessions for both conditions (six sessions total). For Isaac, the mean time with a demand in place was 71 s. For Aida, the mean time with a demand in place was 179 s. For Joshua, the mean time with a demand in place was 279 s. Because the session duration for Aida and Joshua allowed only one response-independent reinforcer delivery, the mean time with a demand in place was doubled to 358 s and 558 s, respectively. This procedure allowed three response-independent reinforcer deliveries (the same as Isaac).

In each session, the experimenter had a sheet of paper indicating when reinforcers would be available and two timers, a session timer to measure overall session duration and a VI schedule timer to indicate when a VI schedule had expired. Each schedule was paired with one of the colored work activities. For the lean schedule, Isaac completed work with the red tasks and Aida and Joshua completed work with the green tasks. All participants received the same breaks described in the compliance training phase contingent on the first act of task completion following a specified time interval. If participants were engaging in destructive behavior when an interval expired, a new interval automatically began and task completion was reinforced if observed as the next time interval expired. The therapist delivered the tasks using model prompts and physical guidance according to the same procedures described above.

For the dense schedules, Isaac completed green tasks and Aida and Joshua completed work with the red tasks. The length of the FT schedule component was double the VI schedule component. The procedures were conducted the same as for the lean schedule, with the addition that every 20 s (Isaac), 98 s (Aida), and 158 s (Joshua), a 30-s break was delivered. Therefore, participants could receive both response-contingent and response-independent reinforcement when they worked on colored work activities associated with the dense reinforcement schedule.

Time in reinforcement (i.e., the 30-s break provided contingent on task completion) was excluded from overall session time during this phase. Schedule-manipulation sessions were conducted until (a) the same number of sessions conducted during compliance training was completed, and (b) there was a clear difference between the obtained rates of reinforcement relative to the green and red work activities.

Phase 5: Extinction. Extinction for both destructive behavior and task completion was implemented immediately after the schedule-manipulation phase. Extinction served to evaluate the persistence of task completion following both the lean and dense schedules of reinforcement. The condition (i.e., dense or lean schedule) exposed to extinction first was alternated across participants. The condition associated with the lean schedule for Isaac and Joshua was exposed to extinction first, and the condition associated with the dense schedule was exposed to extinction first for Aida. At the beginning of each session, the participants were given a vocal prompt to complete a work task. Task completion with the vocal prompt produced another work task. If neither task completion nor destructive behavior was exhibited for 5 s, the model prompt and physical guidance procedures were then implemented (i.e., successive prompts followed by another task). Extinction sessions were conducted until (a) task completion decreased to zero or near-zero levels for three consecutive sessions for one condition, (b) there were no differences in task completion following an extended period of extinction, or (c) destructive behavior recovered to rates similar to the baseline condition for three consecutive sessions of both conditions. To be consistent with the schedule-manipulation

phase (Phase 4), sessions lasted 71 s for Isaac, 358 s for Aida, and 558 s for Joshua.

RESULTS

Phase 1: Functional Analysis of Destructive Behavior

Functional analysis results (available from the first author) showed that each participant's destructive behavior was maintained by negative reinforcement in the form of escape from demands. Task completion occurred at an average of 4.4, 2.75, and 0.2 tasks completed for Isaac, Aida, and Joshua, respectively (Figure 1). Destructive behavior occurred at an average of 3.1, 0.4, and 1.8 responses per minute for Isaac, Aida, and Joshua, respectively, during escape sessions of the functional analysis (Figure 2). Additional (positive reinforcement) functions were identified for Isaac (tangible reinforcement) and Joshua (attention and tangible reinforcement).

Phase 2: Baseline

Results for each subsequent phase will be discussed in terms of whether the condition was eventually associated with the lean or dense reinforcement schedules. During baseline sessions, Isaac (Figure 1) completed an average of 0.4 tasks during the lean schedule condition and an average of 0.2 tasks during the dense schedule condition. He displayed the same rates of

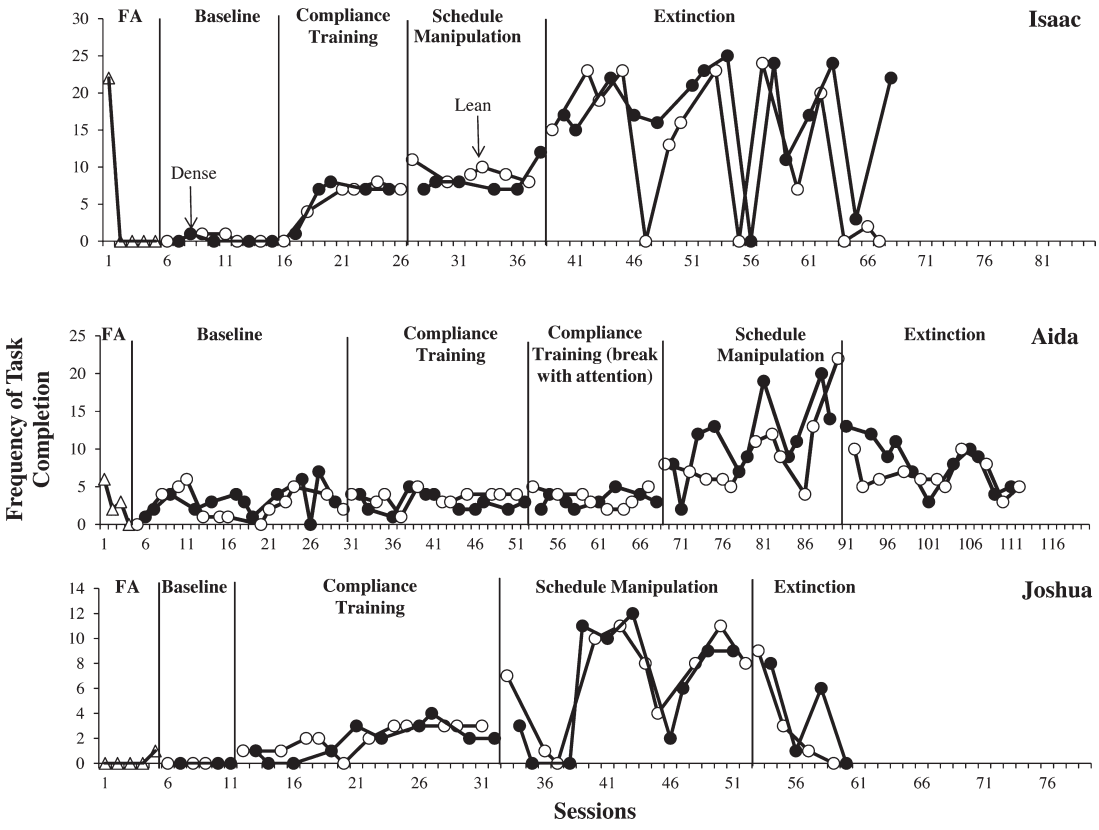

Figure 1. Frequency of task completion for Isaac (top), Aida (middle), and Joshua (bottom). Filled circles represent the dense schedule condition, and open circles represent the lean schedule condition.

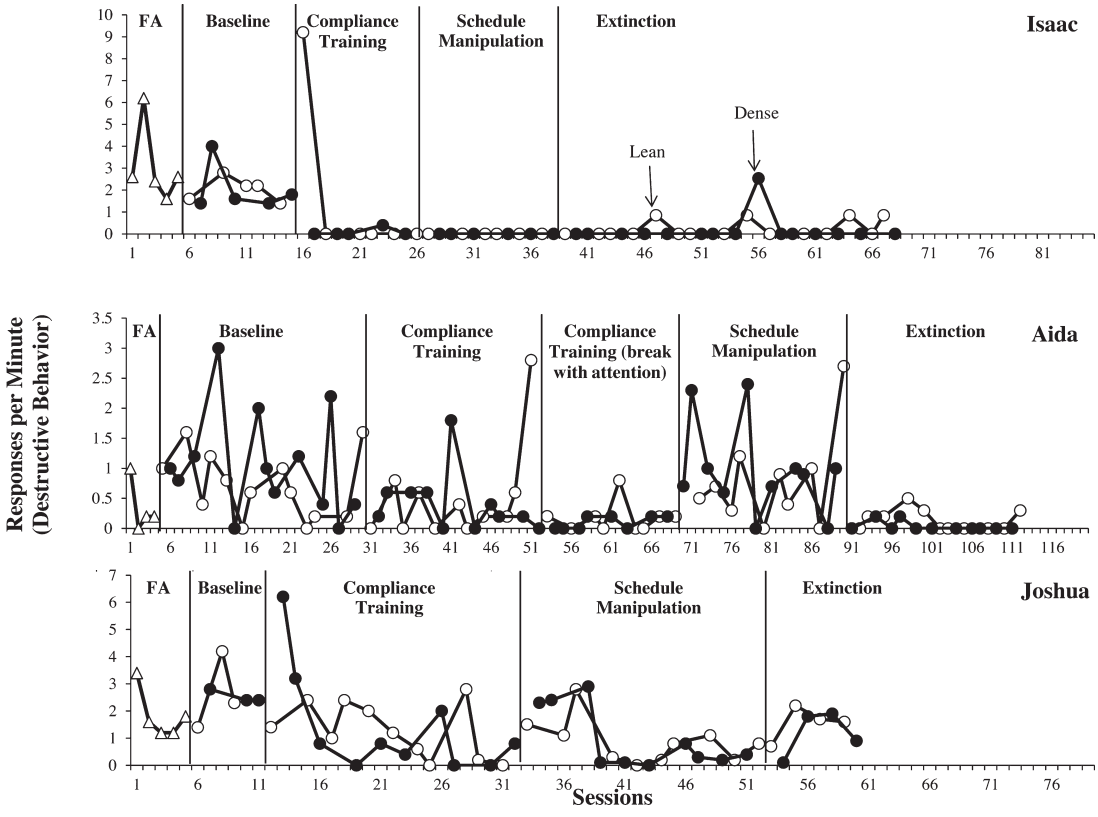

Figure 2. Responses per minute of destructive behavior for Isaac (top), Aida (middle), and Joshua (bottom). Filled circles represent the dense schedule condition, and open circles represent the lean schedule condition.

destructive behavior across the lean ($M = 2.0$ responses per minute) and dense ($M = 2.0$ responses per minute) schedule conditions (Figure 2). The rate of reinforcement for destructive behavior (Figure 3) was similar between the two schedule conditions (lean schedule condition = 1.4 responses per minute; dense schedule condition = 1.5 responses per minute).

During baseline, task completion for Aida (Figure 1) occurred at an average of 2.6 tasks during the lean schedule condition and an average of 3.1 tasks during the dense schedule condition. Aida displayed similar rates of destructive behavior across the lean and dense schedule conditions (Figure 2). Destructive behavior occurred at an average of 0.7 responses per minute during the lean schedule condition and at an average of 1.1 responses per minute during the dense schedule condition. Obtained rate of reinforcement (Figure 3) was slightly lower for the lean schedule condition ($M = 0.2$ responses per minute) than for the dense schedule condition ($M = 0.3$ responses per minute).

Joshua (Figure 1) did not complete any tasks during baseline. He displayed similar rates of destructive behavior during the lean and dense schedule conditions (Figure 2). Destructive behavior occurred at an average of 2.6 responses per minute during the lean schedule condition and at an average of 2.8 responses per minute during the dense schedule condition. The obtained rate of reinforcement (Figure 3) was

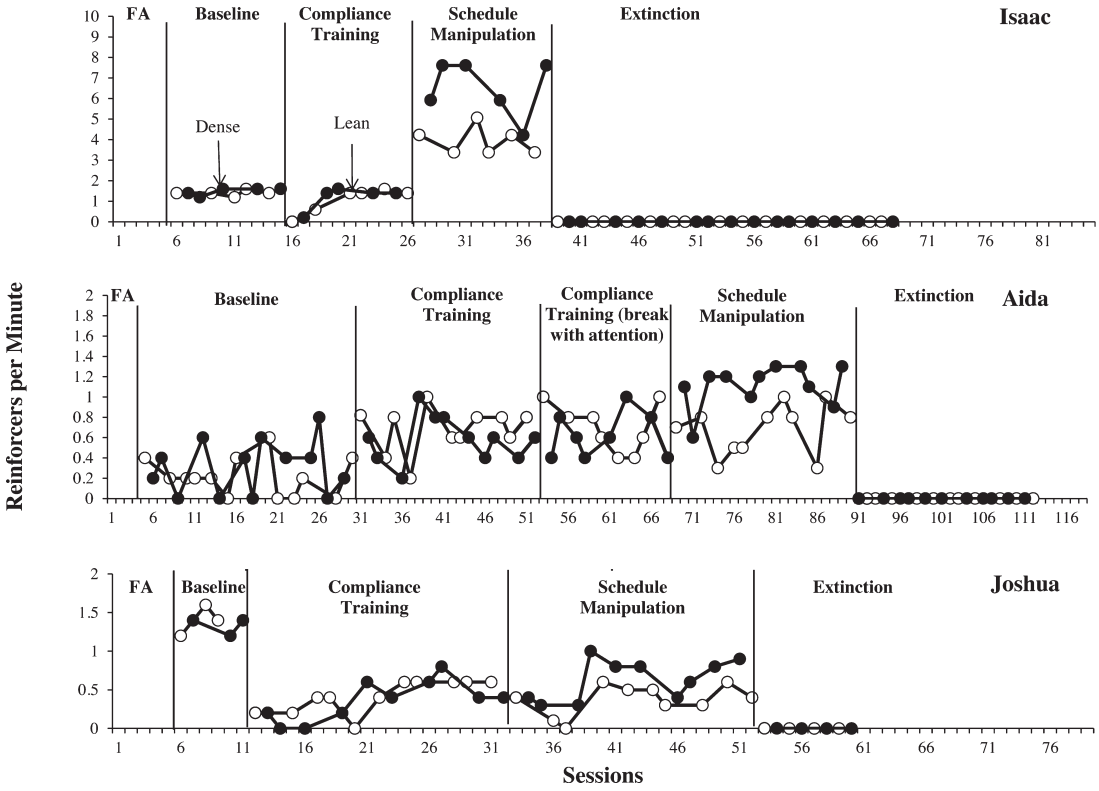

Figure 3. Reinforcer delivery per minute for Isaac (top), Aida (middle), and Joshua (bottom). Filled circles represent the dense schedule condition, and open circles represent the lean schedule condition.

similar for the both stimulus conditions (lean schedule condition = 1.4 responses per minute; dense schedule condition = 1.3 responses per minute).

Phase 3: Compliance Training

During compliance training sessions for Isaac, task completion increased and remained steady (Figure 1). Isaac completed an average of 5.5 tasks during the lean schedule condition and 6.0 tasks during the dense schedule condition. Destructive behavior increased initially but decreased after one session and remained steady at low rates (Figure 2). Destructive behavior occurred at a mean of 1.5 responses per minute during the lean schedule condition and 0.08 responses per minute during the dense schedule condition. No other destructive behavior occurred after the first session in the lean schedule condition. The obtained rate of reinforcement during compliance training was similar for both the lean and dense schedule conditions (Figure 3). The average obtained rate of reinforcement was 1.1 responses per minute for the lean schedule condition and 1.2 responses per minute for the dense schedule condition.

For Aida, task completion with work activities remained stable and similar to that observed during baseline (Figure 1). During compliance training with a break only, Aida completed an average of 3.5 tasks during the lean schedule condition and an average of 2.9 tasks during the dense schedule condition. However, destructive behavior was variable and averaged 0.5 responses per minute during the lean schedule condition and 0.4 responses per minute during

the dense schedule condition (Figure 2). Average task completion increased to 3.5 tasks for the lean schedule condition and 3.3 tasks during the dense schedule condition during compliance training sessions with a break for attention. Destructive behavior decreased and averaged 0.2 responses per minute for the lean schedule condition and 0.1 responses per minute for the dense schedule condition during the modified compliance training phase. The obtained rate of reinforcement during all compliance training was similar for both the lean and dense schedule conditions (Figure 3). Average obtained rate of reinforcement for the entire lean schedule condition was 0.6 responses per minute. Average obtained rate of reinforcement for the entire dense schedule condition was 0.7 responses per minute.

Joshua's task completion increased and remained steady for both schedule conditions (Figure 1). Task completion occurred at an average of 2.1 tasks during the lean schedule condition and at an average of 1.8 tasks during the dense schedule condition. Destructive behavior was on a decreasing trend during this phase (Figure 2). Destructive behavior in the lean schedule condition occurred at a mean of 1.3 responses per minute and at a mean of 1.4 responses per minute during the dense schedule condition. These data showed little difference in destructive behavior relative to one of the schedule conditions. The average obtained rate of reinforcement (Figure 3) for the lean schedule condition was 0.4 responses per minute and was 0.4 responses per minute for the dense schedule condition.

Phase 4: Schedule Manipulation

Isaac's task completion (Figure 1) was slightly higher in the lean schedule condition ($M = 9.2$ tasks completed) than in the dense schedule condition ($M = 8.2$ tasks completed). He did not display destructive behavior during the schedule manipulation condition (Figure 2). Obtained rate of reinforcement (Figure 3) was lower for the lean schedule condition ($M = 3.9$ responses per minute) than for the dense schedule condition ($M = 6.5$ responses per minute), as expected given the added response-independent reinforcement during the dense schedule condition.

Aida's task completion (Figure 1) increased during this phase. Task completion occurred at an average of 9.4 tasks during the lean schedule condition and at an average of 11.3 tasks during the dense schedule condition. Destructive behavior was variable and occurred at a mean rate of 0.7 responses per minute for the lean schedule condition and 1.0 responses per minute for the dense schedule condition (Figure 2). The obtained rate of reinforcement (Figure 3) was lower for the lean schedule condition ($M = 0.7$ responses per minute) than for the dense schedule condition ($M = 1.1$ responses per minute).

Joshua's task completion (Figure 1) increased and occurred at an average of 6.8 tasks for the lean schedule condition and 6.2 tasks for the dense schedule condition. Destructive behavior (Figure 2) occurred at an average of 0.9 responses per minute for the lean schedule condition and 1.0 responses per minute for the dense schedule condition. Rate of reinforcement (Figure 3) was higher for the dense schedule condition ($M = 0.6$ responses per minute) than for the lean schedule condition ($M = 0.4$ responses per minute).

Phase 5: Extinction

During the implementation of extinction, Isaac's task completion (Figure 1) occurred at an average of 12.3 tasks for the lean schedule condition and 17.1 tasks during the dense schedule condition. Task completion decreased to near zero at the end of extinction in the lean schedule condition but continued to persist during the dense schedule condition. Destructive behavior remained low across both schedule conditions (Figure 2) for Isaac. Destructive behavior occurred during only

one session and averaged 0.2 responses per minute in the dense schedule condition and averaged 0.2 responses per minute during the lean schedule condition.

For Aida, task completion (Figure 1) with the dense schedule condition during extinction occurred at an average of 8.3 tasks. Task completion with the lean schedule condition occurred at average of 6.5 tasks. Overall, task completion was initially more persistent in the dense schedule condition before becoming similar to the lean schedule condition towards the end of extinction. Average rate of destructive behavior remained low across both schedule conditions (Figure 2). Destructive behavior in the lean schedule condition occurred at an average rate of 0.1 responses per minute. Destructive behavior in the dense schedule condition averaged 0.04 responses per minute.

For Joshua, task completion (Figure 1) occurred at an average of 3.3 tasks for the lean schedule condition and 3.8 tasks for the dense schedule condition. Task completion was on a decreasing trend during both conditions. Destructive behavior increased in both schedule conditions (Figure 2). Destructive behavior occurred at an average of 1.6 responses per minute during the lean schedule condition and 1.2 responses per minute during the dense schedule condition.

Due to the relatively high degree of variability during the extinction phase for each participant, we calculated cumulative frequency of task completion to further evaluate the relative persistence of task completion during the lean and dense conditions (Figure 4). Isaac showed greater cumulative task completion under the dense condition compared to the lean condition (Figure 4). Task completion increased throughout extinction for the dense condition, whereas smaller increases occurred at the end of the lean condition, indicating lower levels of task completion. Task completion increased throughout extinction for both the dense and lean conditions for Aida (Figure 4). However, cumulative task completion was greater in the dense condition than in the lean stimulus condition. Finally, Joshua showed greater levels of task completion during the dense condition than in the lean condition (Figure 4). However, cumulative task completion increased more slowly toward the end of extinction in both contexts, suggesting low levels of task completion in both conditions.

DISCUSSION

A common traditional definition of *maintenance* is steady-state treatment effects under the prevailing conditions of treatment (Nevin & Wacker, 2013). Although this type of demonstration is clearly important for studies conducted in treatment contexts, steady-state treatment effects may be a necessary but not sufficient means to achieve maintenance in natural contexts. Changes to antecedent and consequent stimuli occur unexpectedly in applied situations. In fact, many parents report that treatments do not maintain in the natural environment when challenges, such as distracting stimuli (e.g., siblings), are introduced (Kelley, Liddon, Ribeiro, Greif, & Podlesnik, 2015). The maintenance, or persistence, of treatment effects despite these changes to the prevailing treatment conditions is critically important. Measuring a behavior's resistance to antecedent or consequent changes may be a more appropriate way to measure persistence, and behavioral momentum theory may provide a theoretical framework to study persistence of treatment effects.

The initial translations of behavioral momentum theory (Ahearn et al., 2003; Mace et al., 2010; Wacker et al., 2011) have all replicated previous experimental analyses of behavioral persistence. Specifically, these studies have shown that the rate of reinforcement introduced in a stimulus condition, or the time in treatment, positively influenced the persistence of behavior. The current study replicated these findings by

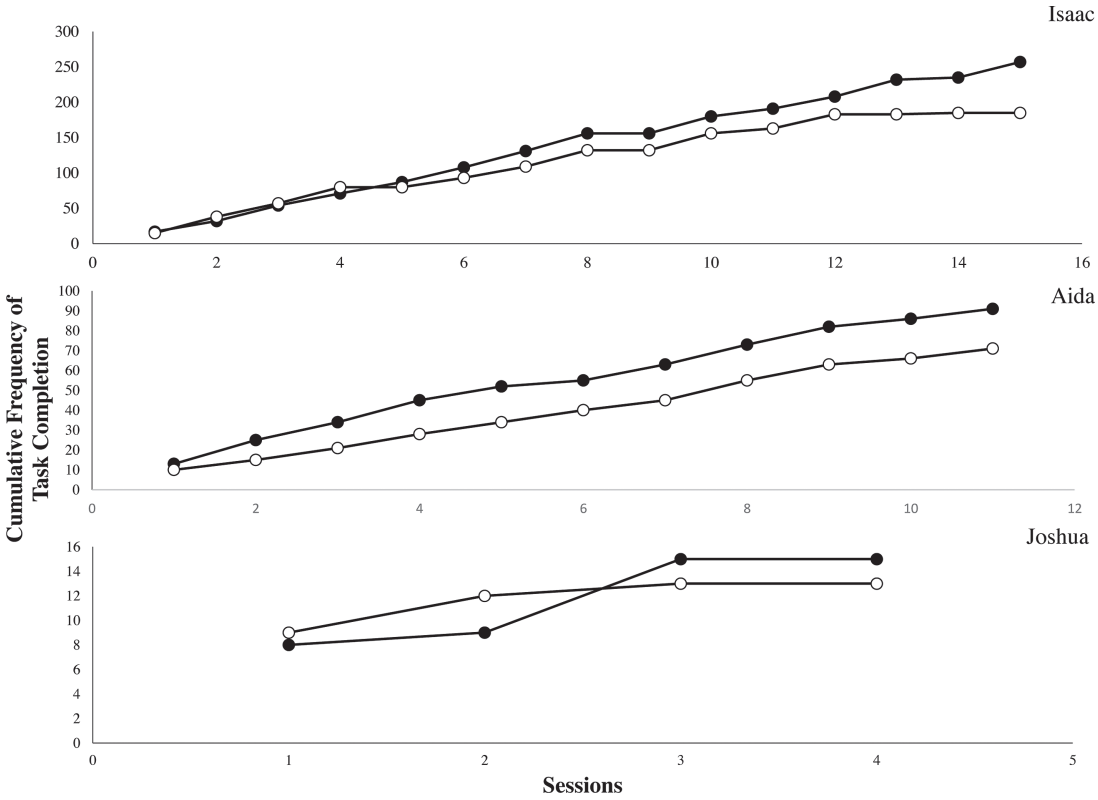

Figure 4. Cumulative frequency of task completion during extinction for Isaac (top), Aida (middle), and Joshua (bottom). Filled circles represent the dense schedule condition, and open circles represent the lean schedule condition.

showing a positive relation between rate of negative reinforcement and persistence of task completion. For all three participants, task completion was slightly more persistent during the dense schedule condition. Because this study specifically evaluated the rate of negative reinforcement on behavioral persistence, the findings show that the same mechanisms responsible for behavioral persistence maintained by positive (Mace et al., 2010) and automatic (Ahearn et al., 2003) reinforcement also apply to behavior maintained by negative reinforcement. Although Wacker et al. (2011) showed strong persistence in target behavior maintained by negative reinforcement, they did not specifically manipulate reinforcement rate as was done in the current study.

The overall differences between the lean and dense conditions in the current study were relatively small compared to previous investigations of behavioral persistence. These differences might be attributed to the overall obtained rates of reinforcement during the dense condition relative to the lean condition. Previous experimental studies of persistence have programmed for highly discrepant rates of reinforcement between the dense and lean schedule conditions. For example, Nevin et al. (1983) programmed for approximately three times the rate of reinforcement in the dense schedule condition than in the lean schedule condition. Although relatively discrepant rates of reinforcement were programmed for the current study, obtained rates were variable for each participant and

occasionally overlapped. It could be that the overall differences between rates of reinforcement were not discrepant enough to observe consistent persistence effects. Future research might program for more disparate rates of negative reinforcement between the schedule conditions to magnify potential differences in persistence of responding.

Stimulus control has often been shown to be an important consideration for studying behavioral persistence (Nevin & Wacker, 2013). Several previous translational investigations of behavioral persistence have occurred, at least partially, in relatively controlled clinical settings (Ahearn et al., 2003; Mace et al., 2010). In the current study, two of the three analyses (Aida and Joshua) were conducted in the participants' homes, whereas the third was conducted in a clinical setting (Isaac). An uncontrolled history of negative reinforcement that occurs outside experimental visits, but still within the same general stimulus context, may have contributed to the overall persistence of task completion in both the dense and lean conditions. It is not clear to what extent this potentially uncontrolled history of negative reinforcement affected these data. However, future researchers may attempt to quantify this uncontrolled history and study its potential effect during persistence analyses.

Visual analysis of the frequency of task completion during the extinction phase for all three participants showed variability in task completion. Periods of variability like this often are associated with increases in destructive behavior (i.e., resurgence). Resurgence was most likely to occur under the lean schedule condition for Isaac and Aida and was equally likely to occur during both schedule conditions for Joshua. Interestingly, previous research has shown that greater resurgence should occur under the dense schedule condition (Mace et al., 2010; Shahan & Sweeney, 2011). These counterintuitive data may also be supported by the relative obtained rates of reinforcement delivered during the lean and dense conditions and also the potentially uncontrolled histories of negative reinforcement in the participant's home environment.

In conclusion, the current study demonstrated the persistence of behavior maintained by negative reinforcement in a socially meaningful context. As hypothesized, rate of negative reinforcement emerged as a critical variable related to the persistence of behavior. The relative response strength of task completion and destructive behavior may have been affected by manipulation of the rate of negative reinforcement for task completion. Translational investigations of behavioral persistence have shown promise for eventually informing clinical practice. Each participant's destructive behavior decreased over the course of the current study, and the relative rate of reinforcement delivered for the socially meaningful alternative behavior reinforced during treatment was shown to affect its occurrence during extinction. It is hoped that continued translational research in the area of behavioral persistence will lead to clinical innovation to address socially meaningful behaviors.

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