A Translational Model of Treatment Integrity Failures During Differential Reinforcement Without Extinction

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Abstract

Differential reinforcement of alternative behavior (DRA) has been evaluated as an intervention for problem behavior at optimal and reduced treatment integrity (e.g., St. Peter Pipkin et al., 2010; Vollmer et al., 1999; Worsdell et al., 2000). However, even at reduced treatment integrity, DRA may not always be a feasible intervention due to possible side effects extinction (Athens & Vollmer, 2010). Additionally, problems may arise during reduced treatment integrity if the schedule of reinforcement favors problem behavior rather than appropriate behavior (St. Peter Pipkin et al., 2010; Vollmer et al., 1999). Researchers have demonstrated the efficacy of DRA without extinction by manipulating dimensions of reinforcement on concurrently available schedules (e.g., Athens & Vollmer, 2010; Briggs et al., 2019). The present study extends research on DRA without extinction by evaluating DRA without extinction at reduced levels of treatment integrity. A systematic replication of St. Peter Pipkin et al.'s (2010) human operant procedure was conducted to evaluate errors of omission on the schedule associated with appropriate behavior, problem behavior, and both behaviors. Results thus far suggest treatment integrity errors for appropriate behavior are more detrimental to maintaining optimal treatment effects of DRA without extinction than treatment integrity errors for problem behavior or for both behaviors.

Keywords: differential reinforcement of appropriate behavior, problem behavior, treatment integrity

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Problem behavior is prevalent across cultures (Datta et al., 2018; Murphy et al., 2009; Simó-Pinatella et al., 2017), diagnoses (Goldin et al., 2013; Hardiman & McGill, 2018; Sloneem et al., 2011), and can take on various topographies such as aggression, self-injurious behavior (SIB), and stereotypy (Mazurek et al., 2013; McTiernan et al., 2011; Newman et al., 2015; Ruddick et al., 2015; Steenfeldt-Kristensen et al., 2020). Persistent problem behaviors can limit an individual's participation in educational and vocational or community activities (Carr et al., 2008; Hirn & Scott, 2014), especially as interventions implemented to manage problem behavior become more restrictive (Robertson et al., 2005). The behavior analytic literature has hypothesized (Carr, 1977) and experimentally identified (Iwata et al., 1982/1994; Iwata et al., 1994) several common environmental conditions under which behavior is strengthened and maintained. The conditions include access to attention or tangible items (i.e., social positive reinforcement), escape from aversive stimuli (i.e., social negative reinforcement), and self-stimulation (i.e., automatic reinforcement).

Given the need to reduce problem behavior, much of the behavior analytic research has focused on function-based interventions such as differential reinforcement of alternative behavior (DRA; e.g., Carr & Durand, 1985; Day et al., 1988; Durand & Carr, 1991; Fisher et al., 1998; Fyffe et al., 2004; Piazza et al., 1996; Roane et al., 2004; Vollmer & Iwata, 1992; Zimmerman & Zimmerman, 1962). DRA involves reinforcement of an alternative behavior or a functional communicative response and is typically composed of reinforcement and extinction in which reinforcement is delivered for an alternative behavior and extinction (i.e., discontinuation of contingency between problem behavior and reinforcer) for problem behavior (Grow et al., 2008). For example, Voulgarakis and Forte (2015) demonstrated through a functional analysis that a participant's problem behavior during mealtimes was maintained by escape. An intervention was implemented in which the reinforcer maintaining problem behavior, escaping meals, was delivered contingent on an alternative response of accepting bites of food. Thus, once the participant accepted the pre-determined number of bites, he was allowed to temporarily escape the meal and leave the treatment area. If the participant refused the bites, escape extinction was implemented. Results demonstrated that the participant complied with eating all required bites across sessions.

Often, extinction is a necessary procedure within DRA and varies according to the function, or maintaining environmental variables, of the problem behavior (Vollmer & Iwata, 1992). For problem behavior maintained by social positive reinforcement, the consequence maintaining problem behavior is withheld. For problem behavior maintained by social negative reinforcement, escape from the aversive stimulus is withheld. Finally, for problem behavior maintained by automatic positive reinforcement, the source of the reinforcing sensory stimulus is withheld or attenuated (Vollmer & Iwata, 1992). For example, Shirley et al. (1997) conducted functional analyses that identified problem behavior maintained by social positive reinforcement for two participants (i.e., delivery of preferred shirt for one participant and delivery of a preferred toy for the other) and social negative reinforcement (i.e., delivery of escape) for one participant. Following identification of the function, the experimenters implemented DRA without extinction in which the consequences for the alternative behavior and problem behavior were equated. Subsequently, the experimenters implemented DRA with extinction in which the alternative behavior was reinforced and problem behavior was placed on extinction. Overall, DRA without extinction did not decrease problem behavior for the participants; however, DRA with extinction decreased problem behavior for all participants.

Although extinction is an effective and often necessary component of DRA, there are side effects of extinction that make it difficult to implement. Two of the most common side effects of extinction described and observed in the research literature are extinction bursts and extinction-induced aggression (Goh & Iwata, 1994; Lerman et al., 1999; Lerman & Iwata, 1996). Extinction bursts are immediate increases in response frequency following the withdrawal of reinforcement (Lerman & Iwata, 1996). For example, Goh and Iwata (1994) implemented escape extinction in which escape for SIB was withheld and physical prompts were used to gain compliance with tasks. Escape extinction resulted in immediate increases in the rate of SIB as compared to baseline. Extinction-induced aggression is the immediate increase in aggression following the discontinuation of reinforcement (Lerman & Iwata, 1996). For example, Goh and Iwata did not target aggression for behavior reduction as aggression was exhibited so infrequently by the participant; however, following the implementation of extinction, the participant engaged in aggression in the form of slaps and kicks. In addition, Lerman et al. (1999) evaluated 41 data sets of individuals being treated for SIB using extinction. Results demonstrated that extinction bursts or extinction-induced aggression were observed in 40% of cases. The occurrence of both phenomena were observed in 20% of overall cases.

In addition to extinction bursts and extinction-induced aggression, extinction-induced variability may occur in which novel or different but infrequent topographies of behavior within the same response class occur (Dracobly et al., 2017; Lerman et al., 1999). For example, Lovaas et al. (1965) did not observe SIB in a music setting prior to reinforcing appropriate music behaviors (e.g., clapping, singing); however, following the withdrawal of attention, an increase in SIB was observed. Another side effect of extinction is extinction-induced emotional responses. Extinction-induced emotional responses are an increase in nonaggressive, emotional responses such as crying, pouting, fussing, and screaming (Lerman & Iwata, 1996). For example, Cowdery et al. (1990) reinforced intervals in which scratching did not occur (i.e., differential reinforcement of other behavior) with pennies exchangeable for preferred items. The occurrence of crying was observed when the participant was told he would not be delivered a penny because the contingency was not met.

In addition to the side effects of extinction, researchers have demonstrated the success of DRA may depend on the treatment integrity with which extinction is implemented following problem behavior (Shirley et al., 1997) and reinforcement following alternative behavior (Mace et al., 2010). Some researchers have suggested low treatment integrity during extinction (i.e., some responses are placed on extinction and some are reinforced) can result in a phenomenon known as the partial reinforcement extinction effect (PREE; Ferster & Skinner, 1957). Under the PREE, partially or intermittently reinforced behaviors are more resistant under extinction conditions following periods of continuous reinforcement. For example, Wertheim and Singer (1964) investigated the effects of the PREE in goldfish by reinforcing swims down an alley on continuous reinforcement (CRF) schedules. After undergoing a 5-day extinction period, the goldfish were exposed to a reconditioning period in which sequences of CRF, variable-interval reinforcement, and extinction were alternated. Results demonstrated that rates of responding during extinction sessions, conducted after the variable-interval reinforcement sessions, resulted in slower reductions as compared to responding after CRF sessions, which decreased rapidly. Therefore, low treatment integrity during extinction may lead to problem behavior that is more resistant to extinction.

Moreover, there is also evidence in the literature that low treatment integrity during reinforcement of the alternative behavior can lead to resurgence of problem behavior. Resurgence is a phenomenon in which previously reinforced behavior increases after an alternative response that was previously reinforced contacts extinction (Ringdahl & St. Peter, 2017). Within DRA, the problem behavior is placed on extinction and an alternative behavior is initially reinforced at high rates. If reinforcement following the alternative behavior reduces or discontinues, responding may be reallocated to the previously reinforced problem behavior, resulting in resurgence (Mace et al., 2010; Ringdahl & St. Peter, 2017). For example, Volkert et al. (2009) replicated a three-component procedure used in basic resurgence studies to evaluate extinction-induced resurgence in the implementation of DRA to intervene on severe problem behavior exhibited by children with developmental disabilities. In Experiment 1, procedural components included reinforcement of problem behavior during functional analysis, DRA, and subsequent extinction of the problem behavior and the newly acquired alternative response (i.e., test for resurgence). Instead of extinction, Experiment 2, tested for resurgence under intermittent schedules of reinforcement for the alternative behavior. Results of Experiment 1 demonstrated that resurgence occurred for two of three participants. Moreover, resurgence occurred for all three participants in Experiment 2. The results of Volkert et al. (2009) suggest failures to implement extinction with high integrity during DRA may lead to reductions in the rate at which problem behavior decreases. Additionally, even when extinction is implemented with high integrity, low integrity during reinforcement of the alternative behavior can lead to increases following its initial attenuation.

Although integrity with both components of DRA is important, high integrity may not be feasible (Allen & Warzak, 2000). First, caregivers likely have a history of negative reinforcement for reinforcing problem behavior (e.g., Miller et al., 2010; Stocco & Thompson, 2015). For example, Miller et al. (2010) evaluated a negative reinforcement contingency for caregiver delivered reprimands. During simulated roleplay with caregivers, researchers stopped engaging in problem behavior contingent on adult reprimands or continued to engage in problem behavior despite reprimands. Results demonstrated that the percentage of trials in which reprimands were delivered increased when contingent reprimands attenuated problem behavior. Reprimands decreased during the extinction conditions when problem behavior persisted despite the caregiver's reprimands. The avoidance or immediate decrease in problem behavior may be negatively reinforcing, increasing the probability that caregivers will engage in similar behavior to avoid or reduce problem behavior in the future (Stocco & Thompson, 2015).

Second, it may not always be feasible for treatment agents (e.g., parents, teachers) to implement DRA interventions with high integrity due to increases in response frequency and extinction-induced aggression that accompany extinction. Mitteer et al. (2018) demonstrated how increases in response frequency during DRA can cause errors in treatment integrity. Initially, caregivers were trained on the implementation of a DRA procedure in which problem behavior was placed on extinction and a functional communication response was reinforced. Following training, caregivers practiced the DRA intervention in a clinical setting with confederates acting as children engaging in problem behavior. During training, rates of problem behavior were gradually decreased, and rates of functional communication responses were gradually increased across sessions. Following training, a treatment adherence condition in which confederates engaged in steadily increasing problem behaviors while caregivers were tasked with implementing the DRA procedure independently was simulated. Results demonstrated all three participants reinforced problem behavior at least once during the treatment adherence condition.

In this example, when faced with increases in problem behavior during DRA, all caregivers engaged in previously reinforced behavior (e.g., reprimands, soothing statements) instead of adhering to extinction. Therefore, during treatment, when presented with extinction-induced increases in response frequency and aggression, caregivers may be unlikely to continue to reliably implement treatments with extinction components (McConnachie & Carr, 1997).

Third, it may be difficult for caregivers to consistently withhold reinforcers within DRA (Codding et al., 2005). There are times when withholding these consequences, or implementing extinction, is counterintuitive to therapeutic outcomes. For example, for severe or dangerous topographies of behavior, withholding reinforcement may cause harm to the individual or others in the environment. In another example, withholding reinforcement for certain topographies of behavior be impossible when individuals are larger than those implementing DRA (Athens & Vollmer, 2010). Inconsistent implementation can lead to intermittent reinforcement, which may make reductions in problem behavior more difficult.

Given the importance of high levels of treatment integrity within DRA, researchers have evaluated the effectiveness of DRA at varying levels of implementation (e.g., 20%, 100%) and across treatment integrity errors (i.e., commission or omission errors; Northrup et al., 1997; St. Peter Pipkin et al., 2010; Vollmer et al., 1999; Worsdell et al., 2000). Errors of commission involve the delivery of a reinforcer following problem behavior, and errors of omission involve the failure to deliver an earned reinforcer. During treatment integrity evaluations, reinforcement for the problem behavior, appropriate behavior, or both is systematically thinned while appropriate and problem behaviors are measured to evaluate the reduced effect of integrity on behavior. For example, Vollmer et al. (1999) evaluated errors of commission and omission during phases in which reinforcers were delivered following some instances of problem behavior and withheld following some instances of appropriate behavior. For example, during one treatment integrity manipulation, the researchers reinforced 25% of appropriate responses and 75% of problem behaviors. Results demonstrated that despite the errors of commission and omission, appropriate behavior remained high across phases and problem behavior remained at stable, low levels. These data suggest that DRA may be an effective intervention at reduced levels of treatment implementation, especially following a history of exposure to DRA full implementation.

In contrast, St. Peter Pipkin et al. (2010) parametrically evaluated the effects of errors of commission and omission on appropriate and problem behavior during DRA using a translational model. The researchers used a computerized experimental program containing one red and one black circle analogous to appropriate and problem behavior, respectively. During treatment integrity manipulations, clicks to either circle were reinforced via point delivery according to random-ratio (RR) schedules of reinforcement and varied depending on the type and phase of integrity error (i.e., errors of commission, errors of omission, or both errors of commission and omission). Results suggested differential effects on appropriate and problem behavior based on the types of treatment integrity errors that were assessed. During errors of omission, the level of appropriate behavior remained high during 80% and 60% treatment integrity conditions but decreased across participants during 40% treatment integrity conditions. Levels of problem behavior remained low, occurring at near-zero levels across participants. Errors of commission and combined errors yielded similar results. That is, the level of appropriate behavior remained high during 80% and 60% treatment integrity conditions; however, during 40% treatment integrity conditions, the level of appropriate behavior decreased, and the level of problem behavior increased across participants. These results suggest that errors of omission during DRA may not be detrimental to its efficacy; however, errors of commission may responsible for detriments in the efficacy of DRA. Thus, reinforcers delivered following problem behavior (i.e., errors of commission) may have more of a detrimental effect on treatment outcomes during DRA than errors in which reinforcers fail to be delivered for alternative behavior (i.e., errors of omission; St. Peter Pipkin et al., 2010; Worsdell et al., 2000). These data suggest treatment integrity needs to be high during treatments that rely on withholding reinforcers following problem behavior for the best treatment outcomes to be demonstrated.

Given the side effects of extinction and importance of withholding the reinforcer following problem behavior (Lerman & Iwata, 1996; St. Peter Pipkin et al., 2010), there may be times when the use of DRA is contraindicated. DRA may be contraindicated when (a) the reinforcer for problem behavior cannot be identified, (b) the reinforcer cannot be withheld due to the size of the behaving individual, or (c) the intensity or magnitude of the behavior is too intense or severe (Athens & Vollmer, 2010; Kunnavatana et al., 2018; Trump et al., 2020). Therefore, researchers have evaluated the efficacy of DRA without the use of extinction (e.g., Athens & Vollmer, 2010; Borrero et al., 2010; Briggs et al., 2019; Davis et al., 2012; Kunnavatana et al., 2018). In contrast to DRA, DRA without extinction does not withhold reinforcing contingencies, but manipulates parameters (e.g., rate, immediacy, magnitude) of reinforcement to favor appropriate behavior over problem behavior. In DRA without extinction, there are two concurrently available, independent schedules of reinforcement for alternative and problem behavior (Athens & Vollmer, 2010). The matching law (Herrnstein, 1961) states that responding on one of these schedules will match the overall rates of reinforcement provided for that schedule. Thus, with the use of concurrent schedules of reinforcement, reinforcement can be manipulated to favor appropriate responding over problem behavior.

For example, Athens and Vollmer (2010) evaluated the single and combined influence of duration, quality, and immediacy of reinforcement on appropriate and problem behavior. During the quality analysis for one participant, problem behavior resulted in 30 s of escape and access to one low-preferred toy; however, engaging in appropriate behavior resulted in 30 s of escape and three high-preferred toys. Results demonstrated the suppression of problem behavior and increase of appropriate behavior when reinforcers following appropriate behavior were more immediate, of a longer duration, and of higher quality relative to reinforcers following problem behavior. Moreover, Briggs et al. (2019) evaluated the isolated and combined effects of quality and magnitude on escape-maintained behavior. Results suggested delivering a combination of quality and enhanced magnitude of reinforcement for appropriate behavior relative to problem behavior resulted in positive treatment outcomes. Overall, the effectiveness of DRA without extinction for reducing problem behavior and increasing appropriate behavior has been established in the literature, especially when schedules of reinforcement are manipulated such that they favor appropriate rather than problem behavior (MacNaul & Neely, 2018; Trump et al., 2020).

In contrast to DRA, the effectiveness of DRA without extinction at reduced treatment integrity has yet to be evaluated in the literature. Even in the absence of concerns associated with extinction, DRA without extinction is still susceptible, like other interventions, to errors in treatment integrity. Therefore, there exists a need to experimentally evaluate the effects of treatment integrity errors during DRA without extinction to provide information on the least amount of treatment integrity required to achieve the greatest treatment outcomes. Thus, the behavior analytic literature on DRA without extinction may benefit from a parametric evaluation of treatment integrity failures on levels of appropriate and problem behavior during DRA without extinction. Therefore, the purpose of the present experiment was to systematically replicate and extend Experiment 1 of St. Peter Pipkin et al. (2010) by evaluating the effects of errors of omission during DRA without extinction using a computerized translational model.

Method

Participants and Setting

Participants were six undergraduate and graduate students enrolled in behavior analytic programs at a large midwestern university. Participants received extra credit for participating in and completing the experiment; however, extra credit was not dependent upon performance during the experiment. One important criterion for inclusion in the study was that participants showed differentiation in levels of responding during baseline and DRA without extinction (i.e., full-treatment integrity phases). That is, during baseline, levels of problem behavior demonstrated clear increases from levels of appropriate behavior. Conversely, during the full-treatment integrity phase, levels of appropriate behavior demonstrated clear increases from levels of problem behavior. One participant was excluded as behavior was not differentiated during baseline and DRA without extinction phases.

The experimental program was hosted online such that participants were able to access the experiment through a web address provided by the researcher. Access to a computer and internet to connect to the experimental study were required for participation. Participants completed the study in two, 60-min session blocks. Each 60-min session was broken into six, 10-min phases. The researcher attended all experimental sessions with each participant via Zoom to attend to any technical difficulties.

Apparatus

A computer program using Microsoft Blazor was created to deliver all experimental components. Experimental components programmed included the delivery of points earned, the beginning and the ending of experimental sessions, the manipulation of treatment integrity reduction phases, and data collection. From the participant's view, the experimental program contained one black circle, one red circle, a cumulative point box located at the top left of the screen, and a timer located in the top right of the screen. The red and black circles contained on the screen traveled in random directions, independently of each other. Points were earned by clicking the circles for 1 s according to the programmed reinforcement schedules for each circle across different phases of the experiment. To signal the earning of each point, the cumulative point box flashed green for approximately 1 s.

Response Measurement and Interobserver Agreement (IOA)

Similar to St. Peter Pipkin et al. (2010), clicks to the black circle represented problem behavior and clicks to the red circle represented appropriate behavior. Thus, the dependent variables were the frequency of clicks to the black and red circles during each minute across each 10-min phase. Microsoft Blazor was programmed to record the frequencies of mouse clicks to the red and black circles, in addition to point deliveries, for each participant. At the end of each experimental session, the program created a CSV file output containing these data and sent the file to a database the researcher accessed to calculate data.

A second, independent observer collected data during 33% (i.e., 40 min) of the experimental session for each participant. Data were collected randomly across four phases for each participant. Interobserver agreement (IOA) was calculated separately for clicks to the red and black circles by (a) comparing data collection records of the primary and secondary observers within each 1-min interval, (b) calculating the proportion of agreement (i.e., smaller number of responses scored divided by larger number of responses scored) during each 1-min interval, and (c) averaging proportion of agreement across each 1-min interval. Mean agreement across participants was 98.8% (range, 96.8%-100%) for clicks to the red circle and 99.3% (range, 96.8%-100%) for the black circle. For Participant 10, mean agreement was 98.8% (range, 96.7%-100%) for clicks to the red circle and 100% for the black circle. For Participant 11, mean agreement was 98.4% (range, 99.3%-100%) for the red circle and 99.9% (range, 96.7%-100%) for the black circle. For Participant 12, mean agreement was 99.7% (range, 99.3%-100%) for the red circle and 100% for the black circle. For Participant 13, mean agreement was 96.9% (range, 90.9%-100%) for the red circle and 96.8% (range, 88.3%-100%) for the black circle. For Participant 15, mean agreement was 100% for the red circle and 100% for the black circle.

Procedures

General Procedure

At the start of the experiment, a dialogue box appeared on the participant's screen with the following message:

> This entire experiment will last for a total of 125 min, including two 60-min session blocks separated by one 5-min break. You will use your mouse to click on either the red or black circles on the screen to earn as many points as possible. For the first part of the experiment, you will undergo six 10-min sessions, take a 5-min break, and then you will undergo the last six 10-min sessions before finishing the experiment. A start button will appear on the screen prior to every 10-min session and a thank you message will appear at the end of every 10-min session. If you have to use the restroom, get water, or if you have any questions to ask, please do so now before starting the first session. Good Luck!

All participants experienced baseline, DRA without extinction, and the treatment integrity evaluation; however, the type of treatment integrity error during the treatment integrity evaluation varied by participant.

Baseline

During baseline, clicks to the black circle resulted in 1 point on a fixed-ratio (FR) 1 schedule of reinforcement while clicks to the red circle resulted in 0 points.

DRA without Extinction

During differential reinforcement without extinction, clicks on the black circle resulted in 1 point on an FR 1 schedule of reinforcement. Clicks on the red circle resulted in 4 points on a FR 1 schedule of reinforcement and a simultaneous message of praise.

Treatment Integrity Evaluation

In the treatment integrity evaluation, clicks to either the black circle or the red circle were reinforced according to random-ratio (RR) schedules. An RR schedule is a type of probability schedule in which there are no maximum ratio values like there are in variable-ratio schedules (DeLeon et al., 2013). Each response had an equal probability of being reinforced at any given time. That is, as treatment integrity levels decreased for clicks on both the red and black circles, fewer reinforcers were available simultaneously.

Participants in Subset 1 were exposed to omission errors for appropriate behavior, or clicks on the red circle, in which systematic reductions in treatment integrity levels resulted in the schedule of reinforcement for appropriate behavior becoming increasingly thinner (first 60-min session) or denser (second 60-min session). Participants in Subset 2 were exposed to omission errors for problem behavior, or clicks on the black circle, in which systematic reductions in treatment integrity levels resulted in the schedule of reinforcement for problem behavior becoming increasingly thinner (first 60-min session) or denser (second 60-min session). Participants in Subset 3 were exposed to omission errors for appropriate and problem behavior, or clicks on the black and red circles, in which systematic reductions in treatment integrity levels resulted in the schedule of reinforcement for problem behavior and appropriate behavior becoming increasingly thinner (first 60-min session) or denser (second 60-min session). All subsets were exposed to four levels (i.e., 20%, 40%, 60%, and 80%) of reduced treatment integrity.

20% Integrity. This level of treatment integrity was associated with a 20% probability of reinforcement for appropriate, problem, or combined behavior. Following clicks to the red, black, or both circles, the experimental program randomly selected a value between 1 and 10 and delivered points if the selected value was 1 or 2 (St. Peter et al., 2016).

Appropriate Behavior. During the treatment integrity evaluation for appropriate behavior, clicks to the red circle resulted in 4 points and a simultaneous message of praise on an RR 5 schedule of reinforcement. Engaging in problem behavior, or clicking on the black circle, resulted in 1 point on an FR 1 schedule of reinforcement.

Problem Behavior. During the treatment integrity evaluation for problem behavior, clicks to the black circle resulted in 1 point on an RR 5 schedule of reinforcement. Engaging in appropriate behavior, or clicking on the red circle, resulted in 4 points and a simultaneous message of praise on an FR 1 schedule of reinforcement.

***Combined Behavior*.** During the combined treatment integrity evaluation, clicks to both the red and black circles, resulted in the delivery of 1 point for clicks on the black circle and 4 points and a simultaneous message of praise for clicks on the red circle on an RR 5 schedule of reinforcement.

40% Integrity. This level of treatment integrity was associated with a 40% probability of reinforcement for appropriate, problem, or combined behavior. Following clicks to the red, black, or both circles, the experimental program randomly selected a value between 1 and 10 and only delivered points if the selected value was less than or equal to 4.

Appropriate Behavior. During the treatment integrity evaluation for appropriate behavior, clicks to the red circle resulted in the earning of 4 points and a simultaneous message of praise on an RR 2.5 schedule of reinforcement. Engaging in problem behavior, or clicking on the black circle, continued to be reinforced with 1 point on an FR 1 schedule of reinforcement.

Problem Behavior. During the treatment integrity evaluation for problem behavior, clicks to the black circle resulted in the earning of 1 point on an RR 2.5 schedule of reinforcement. Engaging in appropriate behavior, or clicking on the red circle, continued to be reinforced with 4 points and a simultaneous message of praise on an FR 1 schedule of reinforcement.

Combined Behavior. During the combined treatment integrity evaluation, clicks to both the red or black circles, resulted in the delivery of 1 point for clicks on the black circle and 4 points and a simultaneous message of praise for clicks on the red circle on an RR 2.5 schedule of reinforcement.

60% Integrity. This level of treatment integrity was associated with a 60% probability of reinforcement for appropriate, problem, or combined behavior. Following clicks to the red, black, or both circles, the experimental program randomly selected a value between 1 and 10 and only delivered points if the selected value was less than or equal to 6.

Appropriate Behavior. During the treatment integrity evaluation for appropriate behavior, clicks to the red circle resulted in the earning of 4 points with a simultaneous message of praise on an RR 1.66 schedule of reinforcement. Engaging in problem behavior, or clicking on the black circle, continued to be reinforced with 1 point on an FR 1 schedule of reinforcement.

Problem Behavior. During the treatment integrity evaluation for problem behavior, clicks to the black circle resulted in the earning of 1 point on an RR 1.66 schedule of reinforcement. Engaging in appropriate behavior, or clicking on the red circle, continued to be reinforced with 4 points and a simultaneous message of praise on an FR 1 schedule of reinforcement.

Combined Behavior. During the combined treatment integrity evaluation, clicks to both the red or black circles, resulted in the delivery of 1 point for clicks on the black circle and 4 points and a simultaneous message of praise for clicks on the red circle on an RR 1.66 schedule of reinforcement.

80% Integrity. This level of treatment integrity was associated with an 80% probability of reinforcement for appropriate, problem, or combined behavior. Following clicks to the red, black, or both circles, the experimental program randomly selected a value between 1 and 10 and only delivered points if the selected value was less than or equal to 8.

Appropriate Behavior. During the treatment integrity evaluation for appropriate behavior, clicks to the red circle resulted in the earning of 4 points and a simultaneous message of praise on an RR 1.25 schedule of reinforcement. Engaging in problem behavior, or clicking on the black circle, continued to be reinforced with 1 point on an FR 1 schedule of reinforcement.

Problem Behavior. During the treatment integrity evaluation for problem behavior, clicks to the black circle resulted in the earning of 1 point on an RR 1.25 schedule of reinforcement. Engaging in appropriate behavior, or clicking on the red circle, continued to be reinforced with 4 points and a simultaneous message of praise on an FR 1 schedule of reinforcement.

Combined Behavior. During the combined treatment integrity evaluation, clicks to both the red or black circles, resulted in the delivery of 1 point for clicks on the black circle and 4 points and a simultaneous message of praise for clicks on the red circle on an RR 1.25 schedule of reinforcement.

Experimental Design

To assess the sole and combined effects of errors of omission during DRA without extinction, participants were randomly assigned to one of three subsets: omission errors for appropriate behavior (Subset 1), omission errors for problem behavior (Subset 2), or a combination of omission errors for appropriate and problem behavior (Subset 3). Within each subset, a reversal design was employed such that the frequency of clicks to either response option was measured during two 60-min sessions. The first session consisted of baseline, DRA without extinction, and four phases of reduced treatment integrity in descending order (i.e., 80%, 60%, 40%, and 20%). The second session consisted of reversed phases including baseline, DRA without extinction, and four phases of reduced treatment integrity in ascending order (i.e., 20%, 40%, 60%, and 80%).

Results

The results of the study are depicted in Figures 1-3. Minutes are scaled to the x-axis, and frequency of responding is scaled to the y-axis. Closed circles denote frequency of problem behavior (i.e., black circle clicks), and open circles denote frequency of appropriate behavior (i.e., red circle clicks). Graphing conventions remain the same across all figures.

Figure 1 depicts the results for Subset 1 (i.e., omission errors to appropriate behavior). During baseline, Participant 13 initially engaged in similar levels of appropriate and problem behavior; however, following the first minute, appropriate behavior decreased and maintained at a low level of responses, and problem behavior increased and maintained at a high level. When DRA without extinction was implemented, Participant 13 immediately engaged in a high level of appropriate behavior and a lower level of problem behavior. During 80% treatment integrity, problem behavior initially increased but rapidly decreased to a low level. The level of appropriate behavior remained high, maintaining at a similar level to DRA without extinction. During 60% treatment integrity, appropriate behavior initially decreased followed by an increasing trend to a higher level. Level of problem behavior was higher across 3 min but rapidly decreased, remaining at a low and stable level for the remainder of the phase. During 40% treatment integrity, level of appropriate behavior maintained at a similar albeit slightly lower level as compared to previous phases. The level of problem behavior maintained at a low level. During 20% treatment integrity, appropriate behavior decreased, and problem behavior increased to similar levels. During the second session, overall baseline patterns of responding were replicated. Participant 13 engaged in more variability during the second exposure to DRA without extinction in which the level of appropriate behavior was initially high, followed by a decrease to a low level, and an increase to a high level. An inverse pattern of responding was observed with problem behavior. During 20% treatment integrity, the level of appropriate behavior was low and slightly variable. Level of problem behavior was high with a slight decreasing trend. During 40% treatment integrity, levels of appropriate behavior immediately increased to a high but variable level, and problem behavior immediately decreased and maintained at a low level. During 60% treatment integrity, appropriate behavior decreased to a moderate level, and problem behavior increased with some overlap between responses; however, overall level of problem behavior remained lower than appropriate behavior. During 80% treatment integrity, Participant 13 engaged in a slightly higher level of appropriate behavior. The level of problem behavior initially maintained from 60% treatment integrity for 4 min; however, the level decreased to and maintained at a lower level.

Figure 2 depicts the results for Subset 2 (i.e., omission errors to problem behavior). The data for Participants 11, 12, and 15 are depicted in the top, middle, and bottom panels, respectively. During baseline, Participant 11 initially engaged in similar levels of appropriate and problem behavior; however, appropriate behavior decreased and maintained at a low level of responses, and problem behavior increased and maintained at a higher level. When DRA without extinction was implemented, Participant 11 immediately engaged in a high level of appropriate behavior that decreased across the phase and a lower level of problem behavior. During 80%, 60%, 40%, and 20% treatment integrity, Participant 11 (top panel) engaged in a high and variable level of appropriate behavior and low to zero level of problem behavior. These patterns of responding were replicated during the second session in which Participant 11 engaged in a low level of appropriate behavior and high level of problem behavior during baseline, and a high but variable level of appropriate behavior and low to zero level of problem behavior during DRA without extinction, 20%, 40%, 60%, and 80% treatment integrity. During baseline, Participant 12 (middle panel) engaged in a moderate to low level of appropriate behavior and high level of problem behavior. When DRA without extinction was implemented, Participant 12 immediately engaged in a high, decreasing level of appropriate behavior and a lower level of problem behavior. During 80%, 60%, 40%, and 20% treatment integrity, Participant 12 engaged in a high and variable level of appropriate behavior and low to zero level of problem behavior. These patterns of responding were generally replicated during the second session in which Participant 12 engaged in a low level of appropriate behavior and high level of problem behavior during baseline, and a high level of appropriate behavior and low to zero level of problem behavior during DRA without extinction, 20%, 40%, 60%, and 80% treatment integrity. During baseline, Participant 15 (bottom panel) engaged in a low level of appropriate behavior and high level of problem behavior. When DRA without extinction was implemented, Participant 15 immediately engaged in a high level of appropriate behavior and a low to zero level of problem behavior. This pattern of responding continued during 80%, 60%, 40%, and 20% treatment integrity. These patterns of responding were replicated during the second session in which Participant 15 engaged in a low level of appropriate behavior and high level of problem behavior during baseline, and a high level of appropriate behavior and low to zero level of problem behavior during DRA without extinction, 20%, 40%, 60%, and 80% treatment integrity.

Figure 3 depicts the results for Subset 3 (i.e., omission errors to appropriate behavior and problem behavior). During baseline, Participant 10 initially engaged in similar levels of appropriate and problem behavior; however, following the first minute, appropriate behavior decreased and maintained at a low level of responses, and problem behavior increased and maintained at a high level. When DRA without extinction was implemented, Participant 10 immediately engaged in a higher level of appropriate behavior and a lower level of problem behavior. Across this phase, appropriate behavior decreased, and level of problem behavior remained stable but lower than appropriate behavior. During 80% treatment integrity, Participant 10 engaged in a moderate level of appropriate behavior. Levels of problem behavior remained similar to the previous phase. During 60%, 40%, and 20% treatment integrity, appropriate behavior maintained at a moderate level with some variability, decreasing towards the end of 20% treatment integrity. Problem behavior decreased to a low level during 60% treatment integrity and increased to a similar level to 80% treatment integrity. This level of responding maintained during 40% treatment integrity and decreased during 20% treatment integrity. During the second session, a low level of appropriate behavior and higher, more variable pattern of problem behavior was obtained during baseline. During DRA without extinction the level of appropriate behavior was high and variable with a decreasing trend towards the end of the phase. Problem behavior immediately decreased and maintained at a low level. A moderate level of appropriate behavior with some variability occurred during 20%, 40%, and 60% treatment integrity, similar to the first session. A slightly lower level of appropriate behavior occurred during 80% treatment integrity. The level of problem behavior maintained at a low, stable pattern of responding during 20%, 40%, 60%, and 80% treatment integrity.

Discussion

The present experiment examined the effects of failures to reinforce (i.e., errors of omission) appropriate behavior (Subset 1), problem behavior (Subset 2), and both behaviors (Subset 3) on responding during DRA without extinction. The effects of these treatment integrity failures were investigated using a human operant procedure that systematically replicated that of St. Peter Pipkin et al. (2010). We manipulated the magnitude and quality of reinforcement for appropriate behavior relative to reinforcement for problem behavior. There were two main overall findings. First, omission errors during the schedule of reinforcement associated with appropriate behavior resulted in response allocation switches from appropriate behavior to problem behavior during 20% treatment integrity. Second, the efficacy of DRA without extinction maintained despite errors of omission during the schedule associated with problem behavior and during the schedule associated with both behaviors. Under these conditions, the level of appropriate behavior remained higher than problem behavior. Thus, the manipulation of multiple dimensions of reinforcement in favor of appropriate behavior rather than problem behavior may mitigate treatment integrity failures, resulting in a high level of appropriate behavior and low level of problem behavior.

Results for Participant 13 in Subset 1 (i.e., omission errors for appropriate behavior) demonstrated problem behavior increased during errors of omission to appropriate behavior when the level of treatment integrity decreased to 20%. Moreover, the level of appropriate behavior steadily decreased during the initial 20% treatment integrity phase and maintained at a low level during the second 20% treatment integrity phase. This pattern of responding in which appropriate behavior decreased and problem behavior increased was demonstrated during both the descending and ascending treatment integrity evaluations, suggesting omission errors for appropriate behavior at 20% treatment integrity are detrimental when reinforcement continues for problem behavior on an FR 1 schedule within DRA without extinction. This finding implies that individuals implementing DRA without extinction should be trained to implement DRA without extinction with at least 40% integrity such that all problem behavior and at least 40% of appropriate responses are reinforced for the best treatment outcomes.

Interestingly, the level of appropriate behavior during the 40% treatment integrity phase was higher and the level of problem behavior was lower than levels in the 60% and 80% treatment integrity phases during the ascending treatment integrity evaluation for Participant 13. Further study is needed as to why this pattern of responding was demonstrated; however, session fatigue might be one reason for decreases in responding during 60% and 80% treatment integrity. Prior to these phases, Participant 13 engaged in overall high rates of behavior during three relatively long consecutive phases (i.e., DRA without extinction, 20% treatment integrity, and 40% treatment integrity). Thus, repeatedly engaging in the clicking response might have caused the participant’s overall rate of clicking to decrease towards the end of the second session.

Another interesting finding is the level of problem behavior was consistently higher across all phases for Participant 13 in Subset 1 than any other participant. Although the level of appropriate behavior remained higher than problem behavior when treatment integrity was 40% or above, moderately high levels of problem behavior during these phases may represent resurgence of problem behavior. Briggs et al. (2019) demonstrated resurgence of problem behavior during DRA without extinction during schedule thinning of appropriate behavior following reinforcing appropriate behavior on denser schedules of reinforcement. It is possible the same pattern of responding was obtained when density of reinforcement for appropriate behavior was thinned during the treatment integrity evaluations. It may be possible to mitigate resurgence by further increasing the magnitude or other parameters of reinforcement to favor appropriate behavior. Although these results are interesting, they should be interpreted with caution as only one participant was included in Subset 1. Therefore, additional participants should experience the contingencies within Subset 1 for firmer conclusions to be drawn about errors of omission for appropriate behavior.

Participants 11, 12, and 15 in Subset 2 (i.e., omission errors for problem behavior) maintained a moderate to high level of appropriate behavior and low to zero level of problem behavior regardless of treatment integrity level. Moreover, problem behavior remained lower in this subset of participants compared to other subsets. This finding was replicated within and across participants. The results of Subset 2 may suggest errors of omission to the schedule associated with problem behavior may not be detrimental to the efficacy of DRA without extinction at any level of treatment integrity. Although interesting, findings from participants in this subset should not be surprising as they are consistent with the matching law (Herrnstein, 1961). That is, on concurrent schedules of reinforcement, an individual will allocate the majority of responding to the denser schedule of reinforcement. These findings suggest that the level of appropriate behavior will maintain if every occurrence of appropriate behavior is reinforced at enhanced dimensions regardless of the schedule in place for problem behavior. Therefore, these results may suggest that individuals with a history of implementing extinction with low integrity may have success with implementing DRA without extinction if they can reinforce every instance of appropriate behavior at increased dimensions.

However, it is also interesting as this type of omission error (i.e., non-delivery of reinforcement for problem behavior) could be conceptualized as extinction and would result in an intermittent schedule of reinforcement for problem behavior. In fact, following each change in treatment integrity, a slight increase in problem behavior was observed. It is unclear whether this pattern would persist if the behavior had not been exposed to DRA without extinction in which both appropriate and problem behavior were reinforced on an FR 1 schedule. Thus, evaluations of this type of integrity error should occur following no history with 100% treatment integrity to determine whether similar patterns would be obtained. Future evaluations should also vary manipulations of reinforcement parameters during treatment integrity phases to determine which types of manipulations (i.e., single or combined) might attenuate the slight increases in problem behavior observed during the start of treatment integrity phases. Moreover, adding a stimulus (e.g., color, message) at the start of phases may help participants to discriminate that engaging in appropriate behavior is more adventitious which may also attenuate problem behavior observed at the start of treatment integrity phases.

Participant 10 in Subset 3 (i.e., omission errors for appropriate and problem behavior) maintained appropriate behavior at a moderate, albeit slightly variable level throughout both sessions despite errors of omission to appropriate and problem behavior. Additionally, Participant 10 engaged in a slightly lower level of problem behavior than appropriate behavior during the first session and a low level of problem behavior during the second session. Thus, on similar schedules of reinforcement, the participant allocated the majority of responding to appropriate behavior. Although the schedules of reinforcement were similar, the magnitude and quality of reinforcement for appropriate behavior was greater. These data may suggest that magnitude and quality offset decrements in responding when these parameters of reinforcement favor appropriate behavior. Although the participant allocated the majority of responding to appropriate behavior, the level of appropriate behavior was lower than all other participants in the current study and the level of problem behavior was slightly lower than appropriate behavior during the first session. The increase in appropriate behavior and reduction in problem behavior may not be clinically significant in that problem behavior continued to occur at a moderate, yet slightly lower level than problem behavior. These results may suggest that errors of omission to both appropriate and problem behavior may need to be minimized such that reinforcement continues to favor appropriate behavior. Similar to the results of Subset 1, these results should be interpreted with caution as only one participant was included in Subset 3. Additional replications of patterns of responding need to occur to draw firmer conclusions regarding combined errors of omission for appropriate and problem behavior.

St. Peter Pipkin et al. (2010) found 40% and 20% treatment integrity resulted in a switch of response allocation from the schedule of reinforcement associated with appropriate behavior to the schedule of reinforcement associated with problem behavior during errors of commission and combined errors of omission and commission within DRA. Thus, the authors concluded errors of commission during DRA were detrimental at 20% and 40% treatment integrity. In Subset 1 of the present study, switches in response allocation were replicated during both exposures to treatment integrity failures during 20% treatment integrity. Thus, errors of omission to appropriate behavior during DRA without extinction were detrimental to its efficacy at only 20% treatment integrity. The comparison of these findings suggests that a cost-benefit analysis of interventions requiring the least treatment integrity to yield the best treatment outcomes may result in the selection of DRA without extinction over DRA, especially in situations in which therapists are limited on the time available to train caregivers or when caregivers have histories of low treatment integrity across interventions implemented.

There are several limitations of the current study. First, although participants were required to engage in fairly simple responses, phases were relatively long (i.e., 10 min). The effects of clicking for relatively long time periods were demonstrated in the variability of responding. Across participants, there were several 1-min intervals in which no responses occurred to either response option. This lack of responding may be evidence of session fatigue and could have contributed to some of the variability in the data. For example, across phases appropriate behavior decreased during the final several minutes of each phase for Participant 11. This may be evidence of within-session fatigue. Researchers could consider decreasing the duration of phases or collecting in the moment data to obtain more consistent, stable patterns of responding, reducing the need for extended phases. Alternatively, researchers could evaluate whether different incentives for participation would have an effect on session fatigue. Benefits offered for participation in the present study may not have been sufficient to sustain motivation throughout phases. Second, conclusions made regarding the effects of errors of omission during DRA without extinction across the different subsets are limited because of the small number of participants included in Subset 1 and Subset 3. Thus, effects could not be replicated across participants within these subsets. Third, it is unclear the extent to which magnitude and quality affected responding as we combined these parameters of reinforcement. It is possible that one or both parameters influenced responding. An additive component analysis could be conducted to identify the isolated effects of these parameters. Fourth, for some participants, there was a lack of replication of levels of appropriate and problem behavior after the first exposure to treatment integrity failures. Although the researcher did not have this ability, researchers should design controls of computerized experiments such that they are able to manually control the switching of phases to allow for real-time data collection for steady state responding. This would allow researchers to switch phases when steady state responding is observed. Finally, similar to St. Peter et al. (2010), our arbitrary response was low effort and may not equate to effort of problem behavior and appropriate behavior. Researchers might consider modifying the response to increase the effort associated with the response to determine whether this affects responding. Additionally, results related to a higher effort response may translate more readily to clinical applications.

Researchers should continue to evaluate the effects that other dimensions of reinforcement, in isolation or combination, have on the effects of treatment integrity failures during DRA without extinction. The present study investigated the combined effects of quality and magnitude; however, in some applied situations, it may not be possible to manipulate those dimensions of reinforcement. For example, it may only be possible to manipulate the immediacy and magnitude of a reinforcer in which a larger quantity of points is delivered immediately for appropriate behavior and a smaller quantity of points delivered after a delay for problem behavior. Additionally, it is unclear the extent to which other magnitudes would affect responding. It is possible that differences in responding would be obtained based on the magnitude programmed. Researchers should consider conducting a parametric analysis of magnitude manipulations to determine whether the amount affects responding within DRA without extinction. Second, researchers should evaluate the extent to which human operant procedures, such as the one implemented in the present study, can be used to identify the types of parameters of reinforcement to which an individual's behavior is most sensitive. Each phase could include a different dimension of reinforcement, and the phase with the highest levels of appropriate responding and lowest levels of problem behavior may be the parameter most likely to evoke appropriate responding. This type of assessment could be conducted clinically as well. For example, Kunnavatana et al. (2018) piloted a parameter sensitivity assessment using arbitrary responses (i.e., selecting between concurrently available buttons associated with specific parameters) that resulted in reinforcers that maintained actual problem behavior (i.e., social positive reinforcement). For example, during the quality sensitivity assessment, selecting either button resulted in a low-quality or high-quality item while magnitude and immediacy were held constant. Finally, researchers should determine how these results translate clinically. Researchers may be able to use these results to identify the schedules of reinforcement during DRA without extinction that evoke the highest levels of appropriate behavior and lowest levels of problem behavior for an individual. Outside of schedules of reinforcement, researchers may also be able to use these results to identify if DRA without extinction is feasible as the best option for intervention. For example, these results suggest that DRA without extinction might be a feasible choice for intervention when caregivers have a history of low treatment integrity with extinction. Moreover, DRA without extinction may not be the best intervention for caregivers who struggle with providing reinforcement for appropriate behavior.

In conclusion, the results of the current study demonstrate that treatment integrity failures (i.e., omission errors) following problem behavior during DRA without extinction in which magnitude and quality are enhanced may not be detrimental to its efficacy, whereas treatment integrity failures falling below 40% following appropriate behavior may be detrimental. Thus, individuals implementing DRA without extinction may take caution to ensure high levels of treatment integrity associated with the schedule of reinforcement for appropriate behavior. These results may be encouraging for those training caregivers to implement DRA as DRA without extinction may be a feasible and effective intervention for problem behavior at reduced treatment integrity, reducing the need to implement extinction, thus avoiding the side effects of extinction. Although results from the present study can be considered promising, they represent the infancy of research on the effects of treatment integrity failures during DRA without extinction.

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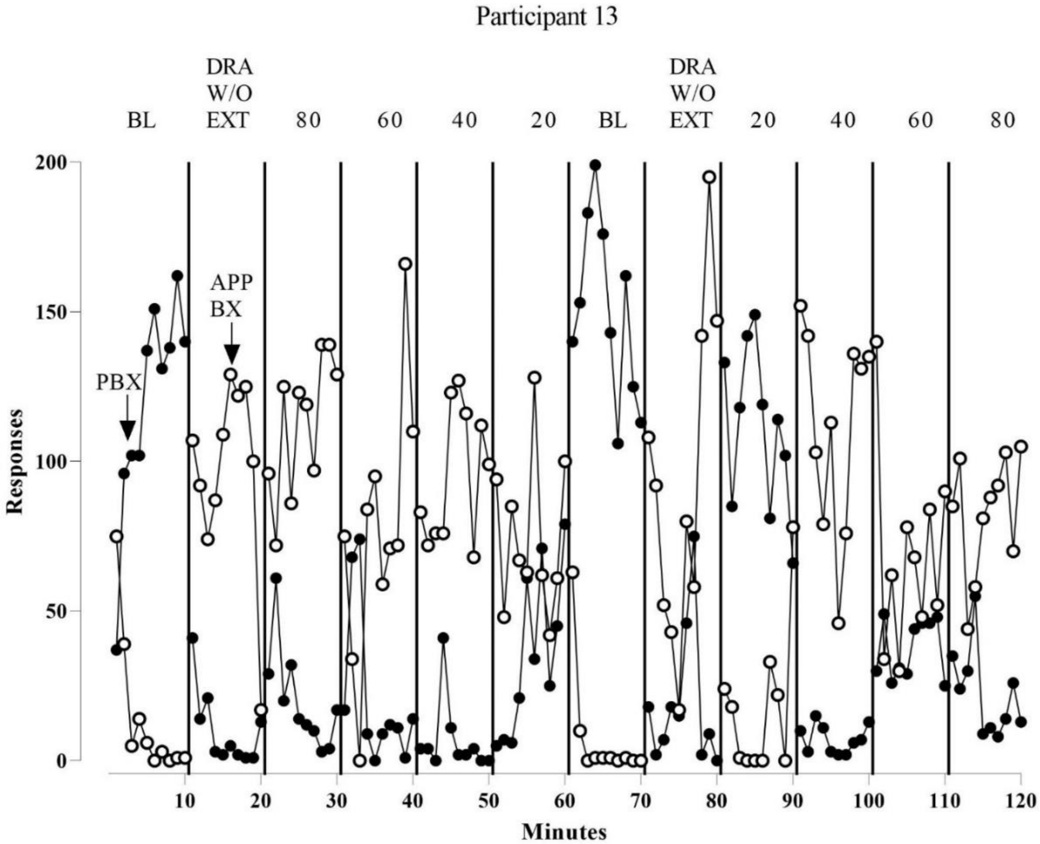
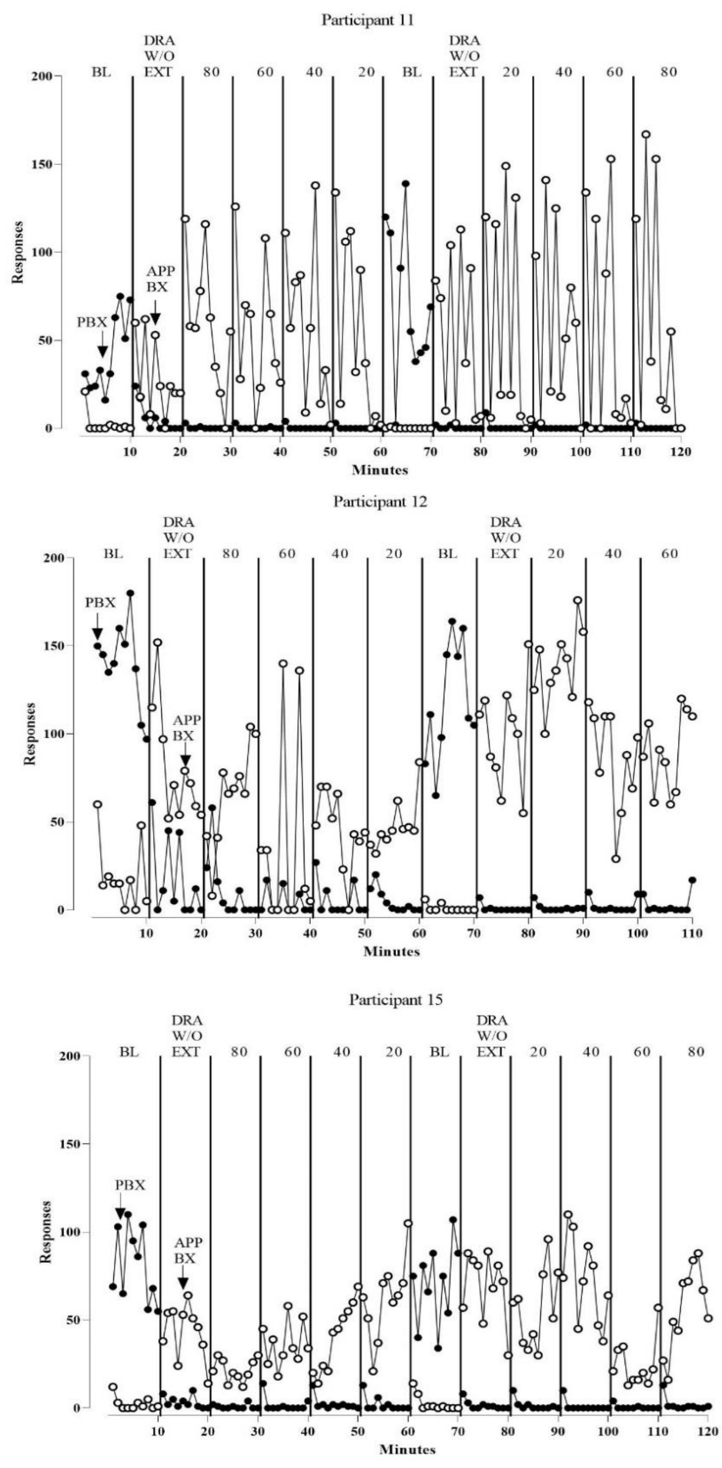
Results for Participant 13 in Subset 1. Closed circles denote rates of problem behavior (PBX), and open circles denote rates of appropriate behavior (APP BX) across baseline (BL), DRA without extinction (DRA W/O EXT), and treatment integrity failure phases.

Figure 1



Results for Participants 11 (top), 12 (middle), and 15 (bottom) in Subset 2. Closed circles denote rates of problem behavior (PBX), and open circles denote rates of appropriate behavior (APP BX) across baseline (BL), DRA without extinction (DRA W/O EXT), and treatment integrity failure phases.

Figure 2



Results for Participant 10 in Subset 3. Closed circles denote rates of problem behavior (PBX), and open circles denote rates of appropriate behavior (APP BX) across baseline (BL), DRA without extinction (DRA W/O EXT), and treatment integrity failure phases.

Figure 3