Evaluating DRO with Asymmetrical Magnitude of Reinforcement

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Evaluating DRO with Asymmetrical Magnitude of Reinforcement

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ABSTRACT

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Differential reinforcement of other behavior (DRO) is a reinforcement schedule used in behavior analytic procedures aimed at decreasing various forms of challenging behavior. DRO commonly includes a reinforcement component and an extinction component; a reinforcer is delivered on an interval-based schedule dependent on the omission of a target behavior and the reinforcer is withheld following the occurrence of the target behavior (i.e., extinction). Although interventions using DRO can be effective for challenging behavior, procedures that include extinction can at times be impractical or lead to undesirable side effects. A DRO schedule can be implemented without extinction, but previous research has shown limited utility of this tactic when a function-based reinforcer is delivered contingent on challenging behavior and a non-function-based reinforcer is delivered for meeting the omission-interval requirement (e.g., effective suppression of challenging behavior in a small proportion of participants). One potential solution would be to use an asymmetrical DRO arrangement in which meeting the omission requirement results in a greater magnitude reinforcer than the target behavior that continues to produce a lesser magnitude reinforcer. A growing field of literature has shown that another form of differential reinforcement, differential reinforcement of alternative behavior, can result in decreases in challenging behavior in the absence of extinction with asymmetrical reinforcers arranged by manipulating parameters such as magnitude, immediacy, and quality. This experiment examined the effects of whole-interval DRO with and without asymmetrical magnitude of reinforcement for the omission and emission of the target response. First, target responding was reinforced during baseline. In one treatment condition, a higher magnitude of points was delivered contingent on the absence of the target behavior. In another condition, the magnitude of points for engaging in the target behavior and omitting the target behavior was symmetrical (i.e., the same number of points). In the final condition, the delivery of points contingent on engaging in the target behavior was discontinued (i.e., extinction) and the higher magnitude of points was delivered contingent on the absence of the target behavior. The results obtained do not support the use of DRO without extinction using an asymmetrical magnitude of reinforcement to decrease a target response. Extinction may be a necessary component for DRO schedules to be effective. If there are clinical limitations to implementing extinction, DRO may not be a viable intervention.
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Evaluating DRO with Asymmetrical Magnitude of Reinforcement

Differential reinforcement of other behavior (DRO) is a widely recognized reinforcement schedule used in behavior analytic procedures aimed at decreasing various forms of problem behavior including self-injury, aggression, and disruption (Athens & Vollmer, 2010; Mazaleski et al., 1993; Rey et al., 2020). The application of DRO often includes a reinforcement component and an extinction component (Mazaleski et al., 1993). A reinforcer is delivered on an interval-based schedule dependent on the absence of a target behavior, and the extinction procedure consists of withholding the reinforcer contingent on the occurrences of the target behavior (Mazaleski et al., 1993). DRO can be implemented using a whole-interval DRO (wDRO) or momentary-interval DRO (mDRO; Repp et al., 1983). When implementing a wDRO reinforcement schedule, the reinforcer is delivered contingent on the absence of the target behavior for the entire interval (Repp et al., 1983). The mDRO procedure involves delivering the reinforcer if the target behavior is absent at the time that the interval ends (Repp et al., 1983). Two comparison studies demonstrated that wDRO was more effective than mDRO, but the authors suggest that mDRO may be a more viable intervention in cases where the implementer is unable to continuously observe the client (Conyers et al., 2003; Repp et al., 1983). Furthermore, DRO schedules can be arranged as resetting or non-resetting. With a resetting DRO, if the target behavior occurs during an interval, the interval is reset. With a non-resetting DRO, regardless of the occurrence of the target behavior, the interval will continue until its natural end. Both resetting and non-resetting DRO schedules have been used to decrease socially significant challenging behavior (Repp & Deitz, 1974; Shabani et al., 2001).

Interventions employing DRO schedules have been used to decrease challenging behavior with various populations including individuals with intellectual disabilities, autism
spectrum disorder, and typically developing children (Conyers et al., 2003; Daddario et al., 2007). Research has demonstrated that these behavioral decreases achieved with DRO schedules can generalize across applied settings including homes, clinics, classrooms, and inpatient facilities (Conyers et al., 2003; de Zubicaray & Clair, 1998). In addition to the treatment effects obtained when applied to individual participants, DRO has been effectively applied as a group contingency in a class-wide intervention (Daddario et al., 2007).

The use of DRO has led to procedural variations and interest in identifying the behavioral processes responsible for successful outcomes, which are not well understood (Jessel & Ingvarsson, 2016). Jessel and Ingvarsson (2016) propose four main hypotheses that could explain the processes responsible for behavior change when implementing DRO schedules as an intervention component. First, the reinforcer delivered contingent on the absence of a response may function as an abolishing operation and reduce the target behavior through satiation. Second, by withholding the reinforcer contingent upon the target behavior (i.e., extinction), the response-reinforcer contingency is disrupted and therefore leads to a reduction in the target response. Third, the delay in the immediacy of reinforcer delivery following the target behavior may function as negative punishment. Finally, the behavior change could be due to adventitious reinforcement of ‘other’ behavior that displaces the target behavior. Two or more of these processes could be operating simultaneously or could depend on the presence of specific aspects of a DRO arrangement. For example, a non-resetting DRO could increase the temporal distance between an instance of challenging behavior and the delivery of a reinforcer, this increased delay may function as negative punishment and be the mechanism of behavior change in this example. Alternatively, a mDRO would not require a specific temporal distance between the challenging behavior and the reinforcer. The reinforcer will be delivered as long as the target behavior is not
occurring at the end of the interval. In this case, behavior change may be a result of disrupting the response-reinforcer contingency and adventitiously reinforcing another behavior. With four possible mechanisms, the extent to which extinction is a necessary component for behavior change is unclear.

Multiple factors arise in applied settings that can prevent the inclusion of extinction as part of an intervention. Although extinction is an effective component of behavior modification, it is not always possible or safe to implement (Athens & Vollmer, 2010). For example, if an attention-maintained behavior requires blocking to protect the individual or others, the necessary act of blocking could be reinforcing, and extinction would not be possible (Athens & Vollmer, 2010). Similarly, behavior that is maintained by automatic reinforcement is often not a candidate for extinction when the reinforcer cannot be controlled by the implementor (Jessel & Ingvarsson, 2016). Finally, extinction is not viable for behavior maintained by escape when the implementers are physically unable to prevent escape in a safe manner (Athens & Vollmer, 2010).

Furthermore, extinction requires that behavior-change agents are trained to implement the procedure correctly and safely, and even in ideal situations where extinction is implemented with high fidelity, the procedure can have dangerous or otherwise undesirable side effects (Trump et al., 2020). Two common side effects of extinction are extinction bursts and response variability (Lerman & Iwata, 1995; Lerman et al., 1999). An extinction burst is a temporary increase in rate, duration, or intensity of the target behavior following extinction when a response-reinforcer relation has been discontinued (Trump et al., 2020). These types of temporary, unpredictable behavior changes can pose safety concerns for the individual and those involved in the intervention (Trump et al., 2020). Lerman et al. (1999) analyzed 41 datasets of clients who received extinction as a treatment for self-injurious behavior (SIB) and found that extinction
bursts of SIB or an increase in aggression were observed in nearly half of the cases. The prevalence of extinction bursts within interventions that use DRO with extinction is unclear. However, research suggests that the occurrences of extinction bursts are reduced when extinction is combined with other treatment components, which may extend to DRO with extinction (Lerman & Iwata, 1995). The second common side effect of extinction, which can accompany an extinction burst, is response variability. Response variability is the emergence of other behavior topographies in the same response class as the target behavior (Lerman et al., 1999; Trump et al., 2020). Jessel et al., (2015) conducted a human-operant experiment to investigate the effects of DRO on the occurrence of untargeted behavior. They demonstrated that DRO reduced the target response of clicking a computer mouse within a designated boundary, and the participants were observed to engage in topographically similar responses such as tapping on the table or clicking elsewhere (Jessel et al., 2015). Although this laboratory example does not demonstrate a safety concern, response variation in a clinical setting can lead to a situation in which a non-dangerous behavior contacts extinction and other more intense or dangerous behavior results (Trump et al., 2020).

To avoid the negative side effects of extinction and to account for situations in which extinction procedures are not feasible or desirable, researchers have studied differential reinforcement procedures without the extinction component. Many of these investigations have employed differential reinforcement of alternative behavior (DRA) schedules (Athens & Vollmer, 2010; Kunnavatana et al., 2018). According to a literature review on differential reinforcement without extinction conducted by Trump et al. (2020), only 2 publications out of 32 that met their inclusionary criteria evaluated DRO without the extinction component. Both studies used arbitrary reinforcers rather than function-based reinforcers identified as the
maintaining reinforcer through a functional analysis (e.g., using access to preferred items or activities in the DRO procedure for attention-maintained challenging behavior). One of these articles included data for three participants who engaged in SIB maintained by positive reinforcement in the form of attention (Mazaleski et al., 1993). DRO without extinction was implemented by continuing to provide attention for SIB and providing non-function-based reinforcers for the absence of SIB on a DRO schedule. This arrangement, in which the emission and omission of a target behavior result in different reinforcers can be called asymmetrical reinforcement (Baum, 1974; Fisher & Mazur, 1997). Asymmetrical reinforcers can differ in their form or whether they are arbitrary or matched to the function of an undesired behavior, such as in the experiment by Mazaleski et al. (1993) in which attention and preferred items were used. Asymmetrical reinforcers can also be functionally similar but vary in parameters like quality, magnitude, or delay (e.g., providing attention for both response options but providing higher quality attention for one option; Athens & Vollmer, 2010; Kunnavatana et al., 2018). Using the arbitrary, non-function-based reinforcer in the arrangement by Mazaleski et al. (1993) decreased rates of SIB for one participant but was not effective for the other two. When DRO with extinction was implemented (i.e., attention was withheld for instances of SIB), low rates of SIB were observed across all three participants. Cowdery and colleagues (1990) also investigated DRO without extinction using asymmetrical reinforcers for one participant who engaged in severe SIB that was hypothesized to be automatically reinforced. A DRO schedule successfully decreased SIB by delivering tokens that were exchangeable for access to preferred activities contingent on the absence of the behavior. Although not uniformly successful, these limited studies provide some evidence that DRO without extinction may effectively decrease problem behavior under at least some conditions.
Additionally, Call and colleagues (2011) examined the use of asymmetrical reinforcers with a DRO schedule to decrease elopement without the use of blocking (i.e., without extinction). The participant was provided access to a preferred leisure item on a DRO schedule contingent on the absence of elopement. They found that elopement continued to occur in the absence of the blocking component but decreased following the inclusion of blocking. The authors discussed that other manipulations for arranging asymmetrical reinforcement parameters such as increasing response effort for the target behavior or adjusting the quality, quantity, or delay of reinforcement for the concurrently available responses could have been more successful.

Although these types of parameter manipulations have not been investigated in DRO without extinction, previous research has demonstrated the effects of altering the parameters of asymmetrical reinforcement in other differential reinforcement procedures. For example, previous DRA research has demonstrated that behavior is sensitive to differential reinforcement without extinction when aspects like duration, quality, or delay of the reinforcer are manipulated (Athens & Vollmer, 2010; Kunnavatana et al., 2018). Differential reinforcement procedures can be conceptualized as concurrent reinforcement schedules in which two or more responses are available simultaneously (Athens & Vollmer, 2010). For example, the responses available in a DRA procedure would typically include the problem behavior and the alternative behavior. The individual can choose to engage in either concurrently available response and access the consequences associated (e.g., reinforcement or extinction). In DRA without extinction, the same responses would be concurrently available; however, engaging in any of the available responses would be reinforced. A growing area of research has demonstrated that when presented with a DRA schedule without extinction, participants will allocate responding to the alternative behavior when the occurrence or omission of a target behavior results in varying immediacy,
magnitude, duration, or quality of a reinforcer (Athens & Vollmer, 2010; Kunnavatana et al., 2018; Peterson et al., 2009).

Athens and Vollmer (2010) found that they were able to achieve a greater response allocation to the alternative response by manipulating duration, quality, and delay of the reinforcer in conjunction compared to an intervention that included only one of these components. Additionally, Kunnavatana et al. (2018) implemented an intervention using a DRA schedule in which delivering a reinforcer with higher quality, magnitude, and immediacy for the alternative response was successful in decreasing problem behavior. Further, Peterson et al. (2009) conducted an experiment using a DRA schedule where high-quality and longer duration breaks were used to reinforce the alternative response of work mands, medium-quality and duration of breaks were delivered contingent on break mands, and lower-quality and shorter duration of breaks were delivered contingent on problem behavior. They found that the highest response allocation was for the highest quality and longer duration breaks and that the consequence contingent on problem behavior had the lowest response allocation.

No published studies were identified that evaluate whether the same effects can be seen in application to DRO. Although DRA and DRO share some fundamental similarities, the behavioral mechanisms behind their effect may differ. DRO is a type of omission training that delivers a reinforcer contingent on the nonoccurrence of a target response, and with DRA, a reinforcer is delivered contingent on the emission of a replacement, or alternative behavior (Rey et al., 2020). Existing DRO research has demonstrated that DRO without extinction is not uniformly successful; however, it is possible that a DRO in which the absence of the target response is reinforced with a greater magnitude of reinforcers would decrease response allocation to the target behavior.
The purpose of the current experiment was to examine the effects of a resetting whole-interval DRO with random intervals (hereafter, “rDRO”) on a target response in a human operant arrangement. A baseline condition and three treatment phases were implemented. During baseline, instances of the target response were reinforced with the delivery of one point on a random interval (RI) 5-s schedule. During the asymmetrical treatment condition, a higher magnitude of points (five points) was delivered contingent on the absence of the target behavior and the baseline contingency remained in place for the emission of the target response (CONC \(^1\) rDRO 5 s RI 5 s). During the symmetrical condition, the magnitude of points for engaging in the target behavior and omitting the target behavior was symmetrical (i.e., both resulted in one point; CONC rDRO 5 s RI 5 s). In the extinction condition, the delivery of points contingent on engaging in the target behavior was discontinued (i.e., extinction) and the five points were delivered contingent on the absence of the target behavior (rDRO). The researcher hypothesized that rDRO with asymmetrical magnitude of reinforcers would decrease the target behavior compared to response rates during the baseline phase. Some reduction in target responding was expected in both the symmetrical and asymmetrical conditions, but target responding was hypothesized to decrease more in the asymmetrical condition. A comparable reduction in target behavior was expected in the rDRO with extinction and rDRO with asymmetrical magnitude conditions when compared to baseline.

Method

Participants and Materials

Fifteen undergraduate college students (13 female and 2 male), ages 18 to 32 were recruited from the West Virginia University psychology department. All participants reported

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\(^1\) Notably, in this arrangement, the concurrently available schedules in the symmetrical and asymmetrical conditions were programmed on a single response object.
their race as white. Participants received extra credit in a psychology course for participating. 

One dataset was excluded due to the target behavior persisting during both extinction phases (see Appendix B & C). One dataset was excluded due to a program error that resulted in a loss of data. Datasets from thirteen participants were included (11 female and 2 male), ages 18 to 32 (Figures 1–5). All sessions occurred in a 3.96 m x 2.13 m laboratory room with a Dell desktop computer on a desk. One participant completed a session at a time. A customized program programmed in Visual Basic © was used to display a light gray background and a 25-mm circle that traveled around the screen at a speed of 25 mm/s. The circle was red, blue, yellow, or black depending on the phase. There was a point counter on the bottom left-hand side of the screen that turned orange momentarily when points were accrued. The program recorded time-stamped data for the target behavior (i.e., clicking on the traveling circle) and mouse clicks made on the background of the screen. A researcher observed the participant throughout the session via a two-way mirror. Participants were not excluded based on colorblindness since the colors were arranged such that they are discriminable for people with color vision deficiencies (Wong, 2011).

Two criteria for exclusion were used to ensure that the points functioned as reinforcers for the participants. Datasets would have been excluded if target responses trended downward in the last five data points in either baseline phase. No participants were excluded based on these criteria. Datasets were also excluded if the target behavior did not decrease during at least one extinction phase to 10% or less of the median response rate during baseline. Percentage of baseline provided a criterion to measure extinction that was relative to the participant’s baseline rates, which was variable across participants. These criteria resulted in the exclusion of one participant (Appendix B & C). Additionally, the data for a second participant (211) were excluded because data from several phases were not recorded due to a computer program error.
Design

A multiple-treatment reversal design was used for all participants, and phases were counterbalanced across participants so potential order effects could be identified. Each participant was assigned to one of three arrangements: ABCDADCB, ACBDADBC, or ADBCACBD. The list used to assign an arrangement to each participant was created prior to the experiment using a random number generator. Participants were recruited until at least three participants were included under each of the arrangements. The dependent variable in this study was defined as clicking the mouse on the traveling circle (i.e., target response) on which reinforcement schedules were arranged. The duration of each phase was 15 min and phases were signaled by a different colored circle; all other features remained the same.

Procedures

The experiment duration was 120 min per participant with an additional 30 min allotted to complete the informed consent process and questionnaire. When participants arrived, they were asked to read and sign the consent form. The researcher answered any questions about the consent form or study. The participant was instructed to stow their belongings in a plastic container in the corner of the room and silence their cell phone. The participants sat in front of the computer screen where the computer mouse was positioned in front of the screen and the keyboard was placed out of reach. They were told that there was a point counter on the bottom left-hand side of the screen, and they were to figure out how to earn points. The researcher told the participant to push the “ok” button on the screen when they were ready. After the participant completed the first four phases of the computer task, the researcher entered the room and notified them of a 10 min break. When the participants returned for the second portion of the computer task, the instructions were repeated. Once the participant completed the final four phases, they
were asked to complete a questionnaire that included demographic and open-ended questions regarding what the participant thought the purpose of the study was and if they used any strategies to earn points (Appendix A). The researcher debriefed the participant by explaining that the study was a laboratory model of an intervention that is used when working with people who engage in challenging behavior and this experiment was examining the best way to deliver rewards to be the most effective.

**Baseline**

The A phase was the baseline condition wherein one point was accrued for emission of the target response on a RI 5-s schedule (see Table 1). For all RI schedules across phases, the lower limit of the schedule was 2 s and the upper limit was 8 s. The circle was blue and traveled on a gray screen.

**Asymmetrical Reinforcement Condition**

The B phase was the DRO with asymmetrical magnitude condition, wherein one point was accrued for the emission of the target response on a RI 5-s schedule and five points were accrued for the omission of the target response on a rDRO 5-s schedule. Across all phases, the rDRO 5-s schedule had a lower limit of 2 s and an upper limit of 8 s. During this condition, point accrual would be maximized by a participant omitting the target response for the duration of the phase. The circle was red and traveled on a gray screen.

**Symmetrical Reinforcement Condition**

The C phase was the DRO with symmetrical magnitude condition2, wherein one point

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2 Differential reinforcement typically refers to arrangements where consequences from some classes or forms of behavior differ from the consequences provided for other classes or forms of behavior. Although DRO with symmetrical magnitude of reinforcement is used to describe the conditions of this phase, both the emission and omission of the target response result in the same consequence (1 point) and may not be considered a differential reinforcement procedure.
was accrued for emission of the target response on a RI 5-s schedule and one point was accrued for the omission of the target response on a rDRO 5-s schedule. During this condition, point accrual could be maximized by allocating responses to either schedule since both schedules delivered the same magnitude of points. The circle was yellow and traveled on a gray screen.

**DRO with Extinction Condition**

The D phase was the DRO with extinction condition, in which points were not accrued for emission of the target response and five points were delivered on a rDRO 5-s schedule. The circle was black and traveled on a gray screen.

**Data Analysis**

Data analysis included visual inspection of the variability, level, and trend of the graphed data across the baseline and treatment phases. The rate (i.e., target responses per min) was calculated for each participant throughout the eight 15-min phases of this study (Figures 1–5). Additionally, the number of reinforcers that were delivered each min for each of the reinforcement schedules were graphed (Figures 6–10). These graphs depict how the reinforcers were distributed to a participant across the phases (e.g., the proportion of reinforcers delivered on the DRO schedule vs. the RI schedule). Other behavior (i.e., mouse clicks off of the circle) were also recorded and graphed (see Appendix D). Additionally, the percentage of baseline was calculated by dividing the median number of responses per min during each treatment phase (i.e., asymmetrical, symmetrical, extinction) by the median number of responses per min of the participant’s corresponding baseline phase and multiplying by 100 (Table 2). This calculation was used to analyze the percentage change in responding from baseline during the treatment phases. The suppression criteria for these data was 10% or less of the median response rate during baseline.
Results

Datasets from fifteen participants were collected; two datasets were excluded and thirteen were included. Order effects were not detected across the different counterbalanced arrangements; therefore, the results are grouped according to phase.

Baseline

Response rates during baseline varied in level across participants. The mean number of responses per min ranged from 11.2–169.87 for the first baseline phase and 10–165.33 responses per min during the second baseline phase. Response rates were less variable within participants, with the largest mean difference between a participant’s first and second baseline phase being 15.9 mean responses per min. Cumulative points earned during the first baseline phase ranged from 104–155 and 76–178 during the second baseline phase. No dataset included a downward trend during the last five min of either baseline phase. One dataset (215) included an upward trend from 26 to 106 responses during the last five min of the first baseline phase (Figure 4). One dataset (208) included a single outlier of 173 responses per min with all other data points ranging from 10 to 49 (Figure 1). Otherwise, variability of response rates during the last five min of baseline remained within steady ranges for all datasets. The mean number of reinforcers delivered on the RI schedule during baseline ranged from 5.6–10.1 per min (Figures 6–10).

DRO with Extinction

Of the participants that were included, target behavior met the suppression criteria of decreasing to at least 10% of the median response rate during both extinction phases for nine datasets and during one of the extinction phases for four datasets (Table 2). During the first DRO with extinction phase, the mean number of responses per min ranged from 0.1–52.6 across participants, and during the second exposure to the phase, there was a mean of 0.1–19.3
responses per min. Cumulative points earned during the first DRO with extinction phase ranged from 555–925 and ranged from 615–930 during the second DRO with extinction phase. All datasets had response rates of zero responses per min during at least three out of the last five min of at least one extinction phase (Figure 1–5). The mean number of reinforcers delivered on the DRO schedule during extinction ranged from 9.7–12.0 per min (Figure 6–10).

**Asymmetrical and Symmetrical DRO**

During the asymmetrical and symmetrical reinforcement conditions, response rates varied across and within participant datasets by either decreasing to meet the suppression criteria (0%–10% of median baseline response rates), remaining close to baseline rates, or increasing up to 433.3% of median baseline response rates. Overall, there were four main categories of results: response rates that decreased during both asymmetrical and symmetrical DRO conditions, response rates that decreased during a single asymmetrical condition, response rates that decreased during a single symmetrical condition, and response rates with insignificant decreases during both asymmetrical or symmetrical DRO condition.

**Decrease During Both the Asymmetrical and Symmetrical DRO Conditions**

Participant (214) met the suppression criteria during both exposures to the asymmetrical reinforcement conditions and both exposures to the symmetrical reinforcement conditions. The median response rate during both asymmetrical phases was 0% of the median response rate during baseline (Figure 3 & Table 2). During their first asymmetrical reinforcement condition, participant 214 earned 835 points with a mean of 10.8 instances of reinforcer deliveries per min on the rDRO schedule (five points per delivery) and a mean of 1.7 instances of reinforcer deliveries per min on the RI schedule (one point per delivery; see Figure 8). Participant 214’s response rates during the first exposure of this phase ranged from 0–90 per min. Responding
occurred during seven min of the phase with three min that consisted of markedly higher rates than the rest but no upward or downward overall trend. During participant 214’s second exposure to the asymmetrical reinforcement condition, they earned 923 points with a mean of 12.1 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 1.2 instances of reinforcer deliveries per min on the RI schedule. Response rates during this phase ranged from 0–69 per min. Responding occurred during four mins of the phase all within the first eight min followed by seven min with no responding.

Participant 214 engaged in reduced responding during both symmetrical phases to median response rates that were comparable to extinction (0%–10% of median baseline response rates). During the first symmetrical reinforcement phase, the median response rate was 0% of the median baseline response rate. Participant 214 earned a total of 188 points with a mean of 11.1 instances of reinforcer deliveries per min on the rDRO schedule (one point per delivery) and a mean of 1.5 instances of reinforcer deliveries per min on the RI schedule (one point per delivery). Response rates ranged from 0–218 per min with the highest response rate occurring in the first min of the phase, followed by a steep decreasing trend. Responding decreased to zero by the fourth min and remained at near-zero rates for the remainder of the phase. During the second symmetrical phase, the median response rate was 8.2% of the median baseline response rate, earning 216 points with a mean of 10.1 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 4.3 instances of reinforcer deliveries per min on the RI schedule. Response rates ranged from 0–135 per min with the highest response rates occurring during the beginning and during the last min of the phase. This participant did not engage in the target response during five min of the phase.
Participant 213 engaged in decreased responding during their second exposure to both the asymmetrical and symmetrical reinforcement conditions, but not during their first exposure to these conditions (Figure 1). During the first asymmetrical condition, participant 213’s median response rate was 170% of the median response rate in baseline, earning 654 points with a mean of 7.3 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 6.9 instances of reinforcer deliveries per min on the RI schedule (Figure 6). Response rates ranged from 0–110 per min with variable response rates that increased to a maximum during min three and four before decreasing to zero and remaining level around 38 responses per min. During the second asymmetrical phase, participant 213’s responding decreased with a median response rate 0% of the median baseline response rate, earning 820 points with a mean of 10.6 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 1.3 instances of reinforcer deliveries per min on the RI schedule. Response rates ranged from 0–79 per min with responding that decreased to zero for the last six minutes of the phase.

During the first symmetrical reinforcement phase, participant 213 engaged in increased responding at a median response rate 175% of the median baseline response rate, earning a total of 208 points with a mean of 3.4 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 10.5 instances of reinforcer deliveries per min on the RI schedule. Response rates ranged from 20–117 per min with a variable and increasing trend. During the second symmetrical phase, participant 213 engaged in decreased responding with a median response rate 0% of the median baseline response rate, earning 188 points with a mean of 12 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 0.5 instances of reinforcer deliveries per min on the RI schedule. Response rates ranged from 0–20 per min with no overall trend.
**Decrease During One Asymmetrical Condition**

Two participants (208 & 221) engaged in near-zero response rates during one asymmetrical phase, but these results did not occur during their other exposure to the asymmetrical condition. Participant 208’s median response rate decreased to 0% of the median baseline response rate during the first asymmetrical phase, earning a total of 936 points with a mean of 12.3 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 1.1 instances of reinforcer deliveries per min on the RI schedule (Figure 1 & 6). Response rates ranged from 0–74 per min. All responses occurred across three min during the first five min of the phase and then suppressed to zero for the remaining 10 min. During the second asymmetrical phase, participant 208 continued responding at a median response rate 82.4% of the median baseline response rate, earning 850 points with a mean of 9.7 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 8.3 instances of reinforcer deliveries per min on the RI schedule. Response rates ranged from 5–57 per min with the highest response rate during the first min of the phase. Following the first min, response rates ranged from 5–19 per min with no trend.

During the first symmetrical reinforcement phase, participant 208 engaged in a decrease in responding with a median response rate 38.7% of the median baseline response rate, earning a total of 242 points with a mean of 8.3 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 7.8 instances of reinforcer deliveries per min on the RI schedule. Response rates ranged from 9–57 per min with steady rates between 9–15 and three min consisting of markedly higher rates. During the second symmetrical reinforcement phase, participant 208 engaged in decreased responding with a median response rate 64.7% of the median baseline response rate, earning 242 points with a mean of 8.7 instances of reinforcer
deliveries per min on the rDRO schedule and a mean of 7.5 instances of reinforcer deliveries per min on the RI schedule. Response rates ranged from 8–28 per min with the highest response rate during the first min of the phase and no overall trend for the remainder of the phase.

Participant 221 engaged in decreased responding during their first exposure to the asymmetrical reinforcement condition (Figure 1). Their median response rate was 0% of the median response rate in baseline, earning 900 points with a mean of 12 instances of reinforcer deliveries per min on the rDRO schedule and a mean of zero instances of reinforcer deliveries per min on the RI schedule (Figure 6). Response rates ranged from 0–2 per min; two responses occurred during the first min of the phase and zero responses occurred during the remaining 14 min. During the second asymmetrical phase, participant 221’s responding increase with a median response rate 135.7% of the median baseline response rate, earning 691 points with a mean of 7.4 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 9.1 instances of reinforcer deliveries per min on the RI schedule. Response rates ranged from 18–23 per min with no trend.

During the first symmetrical reinforcement phase, participant 221 engaged in increased responding with a median response rate 113.3% of the median baseline response rate, earning a total of 245 points with a mean of 8.9 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 7.4 instances of reinforcer deliveries per min on the RI schedule. Response rates ranged from 11–24 per min with a variable and increasing trend. During the second symmetrical phase, participant 221 engaged in increased responding with a median response rate 157.1% of the median baseline response rate, earning 262 points with a mean of 7 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 10.5 instances of
reinforcer deliveries per min on the RI schedule. Response rates ranged from 18–23 per min with no overall trend.

**Decrease During One Symmetrical Condition**

Response rates for three participants (209, 210, & 216) decreased during one symmetrical phase with median response rates ranging between 0% and 10% of median baseline response rates; however, these participants engaged in similar rates or increased rates during the other symmetrical condition. Participant 209’s median response rate was 3.3% of the median baseline response rate during their first exposure to the symmetrical condition, earning a total of 200 points with a mean of 9.7 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 3.6 instances of reinforcer deliveries per min on the RI schedule (Figure 2 & 7). Response rates ranged from 0–34 per min with the highest response rates occurring during the beginning and the end of the phase and seven consecutive min with zero responses in the middle of the phase. During the second symmetrical phase, participant 209 engaged in a median response rate 96% of the median baseline response rate, earning 215 points with a mean of 6 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 8.3 instances of reinforcer deliveries per min on the RI schedule. Response rates ranged from 7–36 per min that remained steady with little variability throughout the phase.

During the first asymmetrical reinforcement phase, participant 209 engaged in responding with a median response rate 90% of the median baseline response rate, earning 530 points with a mean of 5.3 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 9 instances of reinforcer deliveries per min on the RI schedule. Response rates ranged from 18–36 per min with no overall trend. During the second asymmetrical phase, participant 209 engaged in increased responding with a median response rate 160.9% of median baseline
response rates, earning 424 points with a mean of 3.5 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 10.9 instances of reinforcer deliveries per min on the RI schedule. Response rates ranged from 30–50 per min with no overall trend.

Participant 210 engaged in a median response rate 8.7% of the median baseline response rate during their first exposure to the symmetrical condition, earning a total of 199 points with a mean of 9.9 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 3.4 instances of reinforcer deliveries per min on the RI schedule (Figure 2 & 7). Response rates ranged from 0–41 per min with the highest response rates occurring during the beginning and the end of the phase and seven consecutive min with zero responses in the middle of the phase.

During the second symmetrical phase, participant 210 engaged in a median response rate 90% of the median baseline response rate, earning 212 points with a mean of 5.6 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 8.5 instances of reinforcer deliveries per min on the RI schedule. Response rates ranged from 15–30 per min that remained steady with little variability throughout the phase.

During the first asymmetrical reinforcement phase, participant 210 engaged in responding with a median response rate 91.3% of the median baseline response rate, earning 717 points with a mean of 7.5 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 10.1 instances of reinforcer deliveries per min on the RI schedule. Response rates ranged from 17–39 per min with a slightly increasing trend. During the second asymmetrical phase, participant 210 engaged in responding with a median response rate 100% of the median baseline response rate, earning 684 points with a mean of 7.1 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 10.3 instances of reinforcer deliveries per min on the RI schedule. Response rates ranged from 14–35 per min with a slightly increasing trend.
Participant 216’s median response rate was 218.5% of the median baseline response rate during the first symmetrical reinforcement phase, earning a total of 194 points with a mean of 5.3 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 7.6 instances of reinforcer deliveries per min on the RI schedule (Figure 2 & 7). Response rates ranged from 7–157 per min with consistent variability throughout the phase and no trend. During the second symmetrical reinforcement phase, participant 216 engaged in decreased responding with a median response rate 0% of the median baseline response rate, earning a total of 194 points with a mean of 11.3 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 1.6 instances of reinforcer deliveries per min on the RI schedule. Response rates ranged from 0–31 per min with the majority of responses occurring in the first 5 min before decreasing to zero.

During the first asymmetrical reinforcement phase, participant 216 engaged in increased responding with a median response rate 159.3% of the median baseline response rate, earning a total of 574 points with a mean of 6.3 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 6.9 instances of reinforcer deliveries per min on the RI schedule. Response rates ranged from 3–149 per min with higher response rates during min 7–12 with the remaining response rates ranging from 3–50. During the second asymmetrical reinforcement phase, participant 216 engaged in increased responding with a median response rate 433.3% of the median baseline response rate, earning a total of 566 points with a mean of 6.2 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 6.7 instances of reinforcer deliveries per min on the RI schedule. Response rates ranged from 6–123 per min with an overall increasing trend that increases in variability during the last 7 min of the phase.

*Insignificant Change During DRO Conditions*
The remaining six participants had insignificant changes in response rate during either of the asymmetrical or symmetrical reinforcement conditions. Participant 212 engaged in a median response rate that decreased to 63.7% of the median baseline response rate during their first exposure to the asymmetrical reinforcement condition, earning 866 points with a mean of 10.2 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 6.7 instances of reinforcer deliveries per min on the RI schedule (Figure 4 & 9). Response rates ranged from 5–17 per min with the highest response rates occurring during the first four min of the phase before decreasing to a steady range of 5–8 responses per min. During the second asymmetrical phase, participant 212 engaged in decreased responding with a median response rate 45.4% of the median baseline response rate, earning 801 points with a mean of 9.8 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 4.4 instances of reinforcer deliveries per min on the RI schedule. Response rates ranged from 0–16 per min beginning with a steady rate of five responses per min for the first six min of the phase. This steady responding was followed by a relative increase in variability as responding increased before decreasing to zero responses per min for the last two min of the phase.

During the first symmetrical reinforcement phase, participant 212 engaged in reduced responding with a median response rate 63.6% of the median baseline response rates earning a total of 234 points with a mean of 9.8 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 5.8 instances of reinforcer deliveries per min on the RI schedule. Response rates ranged from 0–15 per min with the highest response rates occurring in the first two min of the phase. Response rates had no overall trend but decreased to a range of 0–3 during min nine through eleven. During the second symmetrical phase, participant 212 engaged in decreased responding with a median response rate 63.6% of the median baseline response rate,
earning 255 points with a mean of 11.1 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 5.9 instances of reinforcer deliveries per min on the RI schedule. Response rates ranged from 3–10 per min with the lowest response rate during the first min of the phase. Responses remained steady with little variability throughout the remainder of the phase.

Participant 215 engaged in a slight increase in responding with a median response rate 107.7% of the median baseline response rate during their first exposure to the asymmetrical condition earning 606 points with a mean of 6.3 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 9.1 instances of reinforcer deliveries per min on the RI schedule (Figure 4 & 9). Response rates ranged from 4–50 per min with no overall trend but lower response rates occurred toward the beginning and end of the phase. During the second asymmetrical phase, participant 215 engaged in decreased responding with a median response rate 56.5% of the median baseline response rate, earning 799 points with a mean of 9.1 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 7.9 instances of reinforcer deliveries per min on the RI schedule. Response rates ranged from 13–44 per min with no overall trend but lower response rates during min two through min five.

During the first symmetrical condition, participant 215 engaged in reduced responding with a median response rate 57.7% of the median baseline response rate, earning a total of 242 points with a mean of 8.2 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 8.2 instances of reinforcer deliveries per min on the RI schedule. Response rates ranged from 11–31 per min with no overall trend with slightly higher response rates during the first min and during the middle of the phase. During the second symmetrical phase, participant 215 engaged in increased responding with a median response rate 115.2% of the median baseline
response rate, earning 215 points with a mean of 3 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 11.3 instances of reinforcer deliveries per min on the RI schedule. Response rates ranged from 25–68 per min with overall steady responding with a slightly increasing trend.

Participant 217’s median response rate decreased to 86.8% of the median baseline response rate during their first exposure to the asymmetrical reinforcement condition earning 696 points with a mean of 7.6 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 8.4 instances of reinforcer deliveries per min on the RI schedule (Figure 4 & 9). Response rates ranged from 17–46 per min with no trend and consistent variability across the phase. During the second asymmetrical phase, participant 217 engaged in a median response rate 95% of the median baseline response rate, earning 711 points with a mean of 7.7 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 8.7 instances of reinforcer deliveries per min on the RI schedule. Response rates ranged from 23–45 per min with no overall trend but lower response rates during min five through min eight.

Participant 217 engaged in a median response rate 118.4% of the median baseline response rate during the first symmetrical phase, earning a total of 244 points with a mean of 6 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 10.3 instances of reinforcer deliveries per min on the RI schedule. Response rates ranged from 38–70 per min. The highest response rate occurs at min four and is outside of the overall range of the remainder of the response rates (38–56) which remain steady but variable across the phase. During the second symmetrical phase, participant 217 continued responding at similar rates with a median response rate 95% of the median baseline response rate, earning 236 points with a mean of 7 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 8.7 instances of reinforcer
deliveries per min on the RI schedule. Response rates ranged from 29–65 per min with the highest response rate occurring during the first min of the phase. The overall variability and trend are similar to the baseline phase.

Participant 218’s median response rate was 100% of the median baseline response rate during the first asymmetrical reinforcement phase, earning a total of 664 points with a mean of 7.3 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 7.9 instances of reinforcer deliveries per min on the RI schedule. Response rates ranged from 9–13 per min with no trend. During the second asymmetrical reinforcement phase, participant 218 had a median response rate 130% of the median baseline response rate, earning a total of 593 points with a mean of 6.1 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 9.2 instances of reinforcer deliveries per min on the RI schedule. Response rates ranged from 8–21 per min with no trend.

During the first symmetrical reinforcement phase, participant 218’s median response rate was 100% of the median baseline response rate, earning a total of 266 points with a mean of 9.2 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 8.5 instances of reinforcer deliveries per min on the RI schedule. Response rates ranged from 8–15 per min with no trend. During the second symmetrical reinforcement phase, participant 218’s median response rate was 110% of the median baseline response rate, earning a total of 221 points with a mean of 6.7 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 8.1 instances of reinforcer deliveries per min on the RI schedule. Response rates ranged from 6–14 per min with no trend.

Participant 219’s responding decreased with a median response rate 15.4% of the median baseline response rate during their first exposure to the asymmetrical reinforcement condition
earning 801 points with a mean of 10.1 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 3.1 instances of reinforcer deliveries per min on the RI schedule (Figure 5 & 10). Response ranged from 0–19 per min and responses persisted at variable rates for the first ten min of the phase before responding began to trend downward. No responding occurred during the last two min of the phase. During the second asymmetrical phase, participant 219’s median response rate increased to 110% of the median baseline response rate, earning 881 points with a mean of 10.1 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 8.1 instances of reinforcer deliveries per min on the RI schedule. Response rates ranged from 8–15 per min with no upward or downward trend across the phase.

Participant 219 engaged in decreased responding with a median response rate 69.2% of the median baseline response rate during the first symmetrical phase, earning a total of 203 points with a mean of 8.3 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 5.3 instances of reinforcer deliveries per min on the RI schedule. Response rates ranged from 0–16 per min with an overall decreasing trend. During the second symmetrical phase, participant 219 responded at similar rates of responding as during baseline with a median response rate 100% of median baseline response rate, earning 260 points with a mean of 9.2 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 8.1 instances of reinforcer deliveries per min on the RI schedule. Response rates ranged from 7–13 per min with no overall trend across the phase.

Similarly, participant 227 engaged in a decrease in responding with a median response rate 68.4% of the median baseline response rate during their first exposure to the asymmetrical reinforcement earning 731 points with a mean of 8.1 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 8.4 instances of reinforcer deliveries per min on the RI
schedule (Figure 10). Response rates ranged from 8–24 per min decreasing in variability but maintaining no trend throughout the phase. During the second asymmetrical phase, participant 227 engaged in decreased responding with a median response rate 55% of the median baseline response rate, earning 980 points with a mean of 12 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 5.3 instances of reinforcer deliveries per min on the RI schedule. Response rates ranged from 0–17 per min with markedly lower response rates during five of the last six min of the phase.

During the first symmetrical phase, participant 227 engaged in a slight increase in responding with a median response rate 105.3% of the median baseline response rate, earning a total of 241 points with a mean of 5.7 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 10.2 instances of reinforcer deliveries per min on the RI schedule. Response rates ranged from 13–27 per min with an increasing trend. During the second symmetrical phase, participant 227 engaged in responding at a median response rate 65% of the median baseline response rate, earning 267 points with a mean of 10 instances of reinforcer deliveries per min on the rDRO schedule and a mean of 7.8 instances of reinforcer deliveries per min on the RI schedule. Response rates ranged from 9–21 per min with steady, but variable responding across the phase.

Discussion

The purpose of this study was to examine the effects of DRO without extinction with asymmetrical magnitude of reinforcement, DRO without extinction with symmetrical magnitude of reinforcement, and DRO with extinction. Responding during these phases was compared to baseline during which target responding was reinforced. Response rates decreased during both the asymmetrical and symmetrical conditions for two participants (213 & 214) to levels similar
to response rates obtained during the DRO with extinction phase. Notably, these results with 
similar response rates during the asymmetrical and symmetrical conditions do not align with the 
hypothesis that DRO with asymmetrical reinforcers would have a greater decreasing effect than 
with symmetrical reinforcers. Response rates for two participants (208 & 221) decreased below 
10% of median baseline response rates during one of their exposures to the asymmetrical 
condition but the same level of decrease did not occur during any other DRO condition. Three 
participants (209, 210, & 216) engaged in decreased responding below 10% of median baseline 
response rates during one of their exposures to the symmetrical condition but the same level of 
decrease did not occur during any other DRO condition. The remaining six participants (212, 
215, 217, 218, 219 & 227) continued to engage in the target response during both asymmetrical 
and symmetrical conditions at rates that were not notably reduced from baseline rates of 
responding or were increased from baseline response rates. These results suggest that the use of 
asymmetrical magnitudes of reinforcement during DRO without extinction, as arranged in this 
study, did not effectively reduce the target behavior for most participants.

Overall, participants did not respond in a way that maximized their cumulative points 
during the asymmetrical phase. Because five points were available contingent on the DRO 
schedule, and only one point was available for contingent responding on the RI schedule, 
participants would maximize their cumulative points by engaging in zero target responses. Most 
of the participants failed to maximize their cumulative points because they alternated responding, 
earning from both the DRO and the RI schedules. Engaging in the target response re-sets the 
DRO interval and reduces the number of opportunities a participant has to earn on the DRO 
throughout the phase.
The results of this study are somewhat consistent with the existing literature on the use of DRO without extinction, in that it may work under some conditions, but the necessary conditions are unclear. Although in this experiment the implementation of a DRO schedule with asymmetrical reinforcers was not consistently effective in decreasing the target behavior, this experiment extends the existing literature on using a DRO schedule of reinforcement without extinction in several ways. First, this study did not deliver functionally different reinforcers for omitting and emitting the target behavior (i.e., the reinforcer delivered on the DRO schedule was the same reinforcer used to establish and reinforce target responding). Previous research conducted on DRO without extinction has delivered non-function-based reinforcers contingent on the absence of the target behavior while target behavior continued to contact the maintaining reinforcer (i.e., delivering an arbitrary reinforcer rather than a reinforcer that has been identified as the maintaining variable in the natural environment; Call et al., 2011; Cowdery et al., 1990; Mazaleski et al., 1993). Mazaleski et al., (1993) discussed that using arbitrary, or non-function-based, reinforcers contingent on the omission of a target behavior may not be effective in decreasing a target behavior when a function-based reinforcer is maintaining the target behavior. The results of the current experiment provide preliminary evidence that using function-based reinforcers for both the emission and omission of the target behavior may also not be effective in decreasing a target behavior using DRO without extinction. However, the target response in this study was established in a laboratory setting, with points as reinforcers, and short reinforcement histories which could limit the translational value of the results.

Another factor that distinguishes this study from the existing literature is the use of a translational laboratory model as opposed to a clinical application. A translational laboratory model allows for a more controlled analysis of the behavior and manipulated variables while
limiting potential confounds that experimenters have less control over in applied settings. Since this highly controlled application of DRO without extinction failed to demonstrate a systematic decrease in the target behavior, these results further support that DRO without extinction may not be a viable intervention. However, this translational arrangement also contributes to the limitations of this study. In this laboratory model, the target response of mouse clicks on a circle is an analog for challenging behavior. If the participant responded in a way that maximized their cumulative points, it would have required them to omit the target response (clicking on the moving circle) for the two asymmetrical conditions and the two extinction conditions, which would account for 60 min of the 120 min session. Although disengaging with the task was an available option, there was likely a lack of other behavior options as they were restricted to the laboratory room with no access to other materials or personal belongings (e.g., cell phones). It is possible that clicking on the circle, even in the absence of point deliveries, provided some automatic reinforcement for some participants. Another possible explanation is that participants were responding to self-generated rules about how they were earning points or needed to continue engaging with the computer task. Moreover, there may have been adventitious reinforcement of alternating between points earned on the DRO schedule and the RI schedule.

**Future Directions**

Future research should further investigate the conditions under which behavior is suppressed through asymmetrical reinforcement in DRO arrangements without extinction. Although the arrangement of the current study did not demonstrate a DRO schedule with asymmetrical reinforcement to be effective in decreasing a target behavior consistently across participants, some transient suppression suggests that a decreasing effect may be seen under some conditions. Future research should further investigate the potential mechanisms responsible
for behavior change seen with DRO to better understand the extent to which extinction may contribute to more consistent decreases in the target behavior.

Increasing the point magnitude in the asymmetrical condition (e.g., to 10 or 20 points) for the DRO schedule may be effective in decreasing behavior from baseline response rates by increasing the benefit of omitting the target response. Similarly, the density of reinforcers that are earned contingent on the DRO schedule could be increased by decreasing the duration of the DRO interval. Like increasing the point magnitude, this would increase the cumulative number of points that a participant could potentially earn for omitting the target response during the asymmetrical phase. In clinical applications, once a decrease in behaviors has been achieved, DRO schedules are often faded (Niemeyer & Fox, 1990; Repp et al., 1983). The goal of fading the frequency of reinforcer delivery is to maintain the decreased levels of the target behavior with more naturalistic levels of reinforcement that can be maintained long-term. Although increasing the density of the DRO may make this DRO arrangement more effective, it would be important to also experimentally examine that behavioral decreases could be maintained as the DRO schedule was faded. A parametric evaluation with these reinforcer parameter changes during the asymmetrical condition could determine whether there are sufficient conditions for suppressing target responding in the absence of extinction.

Another potential avenue for future research includes increasing the salience of the point accrual. In the current experiment, the point counter remained on the lower left-hand side of the screen and turned orange upon each increase in points. The number of points increased throughout the first half of the experiment (four consecutive phases) and reset before the second half. Including a sound or additional action to accrue the points (i.e., a consummatory response) may function to increase the salience of the point magnitudes. By increasing the salience, the
differential reinforcement conditions may better control the allocation of responses. However, questionnaire data collected from each participant informed us that some participants were able to label the point amount differences and the conditions of the reinforcement schedules. The participants that labeled the magnitude differences still did not behave in a way that maximized their points. This suggests that even when the point magnitude was salient to a participant, their behavior was not sensitive to the magnitude difference. Additionally, the immediacy of the single point delivered on the RI schedule may have had a greater reinforcing value than a greater magnitude of points at a delay.

To decrease the likelihood that participants will switch between emitting and omitting the target behavior, a change-over delay could be added. It is possible that the reinforcer delivered contingent on the DRO schedule became a discriminative stimulus for the participant to engage in the target response. Engaging in the target response could have been adventitiously reinforced by a reinforcer delivered contingent on the RI schedule. This could account for continued responding throughout a phase. After a point is accrued from the DRO schedule, a change-over delay would increase the duration during which a participant would be unable to earn points contingent on responding according to the RI schedule. This would make it so changeover responses are no longer immediately followed by the accrual of a point and participants would earn fewer reinforcers contingent on the emission of the target response overall. This could decrease the overall response rate during phases in which both schedules are concurrently available. However, as an analog to clinical applications, adding a change-over delay may have limitations. For instance, this would only be a viable option if the reinforcer was able to be controlled by the implementor. Additionally, a change-over delay may function as a local period of extinction and could be accompanied by side effects.
The potential changes discussed here are only worthwhile options if the points accrued in this study are functioning as reinforcers. Although this study took steps to ensure that points functioned as reinforcers for the included participants (e.g., requiring included datasets to have steady rates of responding during baseline and decreased responding during extinction) points may have limitations as a reinforcer. To increase the potential that points are functioning as reinforcers, accrued points could be exchanged for money. Money can be an effective generalized reinforcer that most people have extensive behavioral histories with (Kangas & Hackenberg, 2009). This approach could decrease differences in behavior across participants that could be attributed to variability in reinforcer efficacy (Kangas & Hackenberg, 2009).

Overall, the results of this experiment do not support the use of DRO without extinction and asymmetrical magnitude of reinforcement to decrease a target response. A decrease in the target behavior was achieved with the inclusion of extinction for the nine included participants. A decrease in target behavior from baseline rates was not consistently achieved across participants during the asymmetrical or symmetrical conditions. Extinction may be a necessary component for DRO schedules to be effective. If there are clinical limitations to implementing extinction, DRO may not be a viable intervention.
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Figure 1

*Frequency of Target Responses*

*Note.* These datasets include one asymmetrical phase that decreased to at least 10% of median baseline response rates.
Figure 2

*Frequency of Target Responses*

Note. These datasets include one symmetrical phase that decreased to at least 10% of median baseline response rates.
Figure 3

*Frequency of Target Responses*

*Note.* This dataset includes target response decreases below 10% of median baseline response rates for both asymmetrical and symmetrical phases.
Figure 4

Frequency of Target Responses

Note. These datasets did not include decreases in responding during either asymmetrical reinforcement phase to at least 10% of median baseline response rates.
Note. These datasets did not include decreases in responding during either asymmetrical reinforcement phase to at least 10% of median baseline response rates.
Figure 6

Frequency of Reinforcer Deliveries

Note. These graphs depict the frequency of reinforcer deliveries for the three datasets that included one asymmetrical phase that decreased to at least 10% of median baseline response rates. Each occurrence of a reinforcer delivery, regardless of the magnitude of points (i.e., 5 or 1 point), is counted as a single “delivery.”
Figure 7

Frequency of Reinforcer Deliveries

Note. These graphs depict the frequency of reinforcer deliveries for the three datasets that included one symmetrical phase that decreased to at least 10% of median baseline response rates. Each occurrence of a reinforcer delivery, regardless of the magnitude of points (i.e., 5 or 1 point), is counted as a single “delivery.”
Figure 8

*Frequency of Reinforcer Deliveries*

*Note.* This graph depicts the frequency of reinforcer deliveries for the dataset during which target responses decreased below 10% of median baseline response rates for both asymmetrical and symmetrical phases. Each occurrence of a reinforcer delivery, regardless of the magnitude of points (i.e., 5 or 1 point), is counted as a single “delivery.”
Figure 9

Frequency of Reinforcer Deliveries

Note. These graphs depict the frequency of reinforcer deliveries for the datasets that did not include decreases in responding during either asymmetrical reinforcement phase to at least 10% of median baseline response rates. Each occurrence of a reinforcer delivery, regardless of the magnitude of points (i.e., 5 or 1 point), is counted as a single “delivery.”
Figure 10

Frequency of Reinforcer Deliveries

Note. These graphs depict the frequency of reinforcer deliveries for the datasets that did not include decreases in responding during either asymmetrical reinforcement phase to at least 10% of median baseline response rates. Each occurrence of a reinforcer delivery, regardless of the magnitude of points (i.e., 5 or 1 point), is counted as a single “delivery.”
Table 1

Experiment Schedules

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<th>Schedule of Reinforcement</th>
<th>Target Response</th>
<th>Omission of Target Response</th>
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Table 2

Percentage of Median Baseline Response Rate for Included Datasets

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<th>Extinction First D (%)</th>
<th>Asymmetrical Second B (%)</th>
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<td>105.3</td>
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<td>55</td>
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Note. The percentages filled in gray depict the phases during which responding decreased to 10% or less of median baseline responding.
Appendix A

Questionnaire

For research staff:
Participant ID: __________  Date: __________  Time: __________
RA name: ____________________________

Instructions: The purpose of the following questions is to collect information about your demographic variables and your impressions of the study. Please skip any questions that do not feel comfortable answering.

What is your age in years? __________
  • I prefer to not answer

How do you currently describe your gender identity?
  ______________________________________
  • I prefer to not answer

How do you identify your racial and ethnic background? Please select all that apply to you:
  • American Indian or Alaska Native
  • Asian
  • Black or African American
  • Hispanic, Latinx/Latine, or Spanish Origin
  • Middle Eastern or North African
  • Native Hawaiian or Other Pacific Islander
  • White
  • Other/prefere to self-describe: ____________________________
  • Unknown
  • I prefer to not answer

Do you have (or suspect that you have) a color vision deficiency? If yes, what form?

Please describe what happened and what you did during the sessions(s).

Please describe any strategies that you may have used to earn points. Did any of your strategies change across the experiment?

What do you think we are trying to learn from this study?
Appendix B

*Frequency of Target Responses for Excluded Datasets*

![Graph showing frequency of target responses for excluded datasets.](image-url)
Appendix C

Percentage of Median Baseline Response Rate for Excluded Datasets

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<th>Participant</th>
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<th>Second</th>
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<tr>
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<td>Asymmetrical B (%)</td>
<td>Asymmetrical B (%)</td>
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<td>-</td>
<td>100</td>
</tr>
<tr>
<td>220</td>
<td>72.7</td>
<td>54.5</td>
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*Note. Participant 220 was excluded because the target behavior did not decrease during either extinction phase to at least 10% of the median baseline response rate (denoted by the asterisk). Additionally, the data for participant 211 were excluded because data from several phases were not recorded due to a computer program error.*
Appendix D

*Frequency of Other Behavior for Included Datasets*

![Graph showing frequency of other behaviors for included datasets.](image-url)
Frequency of Other Behavior for Included Datasets Continued
Frequency of Other Behavior for Included Datasets Continued
Frequency of Other Behavior for Included Datasets Continued

(A) Baseline  (B) Asymmetrical  (C) Symmetrical  (D) Extinction  (A) Baseline  (D) Extinction  (C) Symmetrical  (B) Asymmetrical

Minute

Other Behaviors

0  1  2  3  4  5

15  30  45  60  75  90  105  120

(A) Baseline  (B) Asymmetrical  (C) Symmetrical  (D) Extinction  (A) Baseline  (D) Extinction  (C) Symmetrical  (B) Asymmetrical

Minute

Other Behaviors

0  2  4  6  8  10  12  14

15  30  45  60  75  90  105  120

(A) Baseline  (B) Asymmetrical  (C) Symmetrical  (D) Extinction  (A) Baseline  (D) Extinction  (C) Symmetrical  (B) Asymmetrical

Minute

Other Behaviors

0  2  4  6

15  30  45  60  75  90  105  120
Frequency of Other Behavior for Included Datasets Continued