The Effects of Fading Schedules of Noncontingent Reinforcement with and without Extinction

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Submitted to the graduate degree program in Applied Behavioral Science and the Graduate Faculty of the University of Kansas in partial fulfillment of the requirements for the degree of Master of Arts.

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Date Defended: 6 May 2022

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Date Approved: 6 May 2022

Abstract

Individuals with intellectual and developmental disabilities are at an increased risk of problem behavior, which can result in various impediments to daily living and injury to themselves and others. Noncontingent reinforcement (NCR) is often used with individuals with IDD. NCR is typically used concurrently with extinction (EXT); however, the effectiveness of NCR without EXT has demonstrated promising, but mixed results. The current translational study replicated and extended Saini et al. (2017) to evaluate (a) the effectiveness of NCR on reducing an analogue to problem behavior with and without EXT while fading schedules of reinforcement, (b) levels of variability in responding during and following NCR schedule fading with and without EXT, and (c) response resurgence following changes in schedules of reinforcement with and without EXT. Application of a reinforcement schedule thinning procedure recommended by LeBlanc et al. (2002) was also evaluated. Results indicated that both NCR with and without EXT decreased the target response rate for all six participants; however, only NCR with EXT decreased the response rate to clinically significant levels. Participants exposed to NCR without EXT engaged in more variable responses than those exposed to NCR with EXT, and resurgence occurred more often for participants exposed to NCR with EXT. The reinforcement schedule thinning method was effective at quickly reaching the terminal thinning criteria while maintaining a low to zero rate of problem behavior for three participants exposed to NCR with EXT. Limitations of the current study, as well as directions for future research are discussed.

Keywords: noncontingent reinforcement, without extinction, schedule thinning, analogue to problem behavior, response variability, resurgence

Acknowledgments

I would like to thank my advisor, Dr. Jessica Juanico, for her guidance and support throughout this process. I have yet to find the words to adequately express how much I appreciate you, other than drastically. Additionally, I would like to thank Dr. Robin Kuhn for her assistance in the creation of this project, as well as the creation of imperative Excel formulas. I would also like to thank Dr. Claudia Dozier and Dr. Tara Fahmie for volunteering their time to serve on my committee. Finally, I would like to thank my family and friends for their noncontingent patience and support.

Table of Contents

List of Figures

The Effects of Fading Schedules of Noncontingent Reinforcement with and without Extinction

Individuals with intellectual and developmental disabilities (IDD) have an increased risk of problem behavior, such as aggression or self-injury (Kurtz et al., 2020). While estimates vary, approximately 50% of individuals with IDD engage in some form of problem behavior (Dekker et al., 2002). Problem behavior can result in a loss of access to reinforcers, educational time, and mainstream environments (Doehring et al., 2014; Kahng et al., 2002). More serious risks include the risk of injury (e.g., bruising, bleeding), loss of function (e.g., blindness), disfigurement, or death (Hyman et al., 1990; Kuhn et al., 2009). Problem behavior, particularly severe problem behavior, can have extreme consequences both for the individuals who engage in it, as well as for those who care for them (e.g., caregivers, teachers; Kurtz et al., 2020).

Noncontingent reinforcement (NCR) is an empirically supported, function-based treatment for problem behavior and is often used with individuals with IDD (Carr et al., 2008; Phillips et al., 2017). Implementing an NCR procedure involves the response-independent delivery of stimuli with known reinforcing properties (Vollmer et al., 1993). NCR can be implemented within a variety of schedule arrangements, including fixed-time (FT), variable-time (VT), or continuous access. For example, Hagopian et al. (2001) implemented NCR by delivering the functional reinforcer (tangibles) on an FT 3-min schedule. Mace and Lalli (1991) delivered the functional reinforcer (attention) on various VT schedules (VT 90 s, VT 60 s, or VT 30 s). Marcus and Vollmer's (1996) initial NCR schedule consisted of continuous access to the functional reinforcer (tangible). Additionally, a delay can be programmed prior to the response-independent delivery of stimuli contingent on the occurrence of problem behavior (e.g., Britton et al., 2000; Vollmer et al. 1997). For example, Britton et al. (2000) implemented a momentary

differential reinforcement of other behavior (mDRO) procedure such that if problem behavior occurred within 10 s prior to the delivery of reinforcement, the reinforcement delivery was delayed in 10-s increments until the problem behavior had not occurred for 10 s. NCR has been shown to be effective at reducing problem behavior maintained by various functions including social negative reinforcement (e.g., escape from instructional demands), social positive reinforcement (e.g., attention, access to tangibles), and automatic reinforcement. NCR has also been shown to be effective across response topographies such as self-injurious behavior (SIB), aggression, stereotypy, pica, elopement, disruption, and bizarre speech (Carr et al., 2000; Carr et al., 2008).

The two primary advantages of NCR include the ease of implementation compared to other reinforcement schedules and decreased extinction (EXT) bursts (Carr et al., 2008; Phillips et al., 2017). Constant, or any, monitoring of behavior is unnecessary during NCR implementation because reinforcement delivery is response-independent; therefore, implementation of NCR may be easier than other schedules that require constant monitoring of an individual's behavior such as differential reinforcement of other behavior (DRO; Vollmer et al., 1993). NCR may also decrease the likelihood of EXT bursts because while the contingent relationship between the response and consequence is disrupted, the functional reinforcer is still frequently available (Vollmer et al., 1993). Most studies reporting the effectiveness of NCR implement EXT concurrently (Carr et al., 2000). That is, the target behavior is typically placed on EXT (i.e., withholding reinforcement following problem behavior) during inter-reinforcement intervals. For example, Kahng et al. (2000) implemented NCR with EXT with three participants whose problem behavior was maintained by social positive reinforcement (i.e., attention or

access to tangibles). The functional reinforcer was delivered on a FT schedule, while all occurrences of the problem behavior were ignored.

However, implementing EXT concurrently with NCR may not be possible in all situations. For example, problem behavior may be too severe to warrant the increased risk and safety concerns associated with EXT bursts (Newman et al., 2021), an individual may be too physically large to prevent access to reinforcement (Fritz et al., 2017), or problem behavior may not be conducive to EXT due to the inability to withhold reinforcement (e.g., automatically reinforced behavior; Rapp & Vollmer, 2005; Vollmer, 1994). While the effectiveness of implementing NCR without EXT has not been widely studied, some researchers have demonstrated promising, but mixed effects (e.g., Fritz et al., 2017; Hagopian et al., 2000; Lalli et al., 1997; Phillips et al., 2017; Saini et al., 2017; Wallace et al., 2012).

Lalli et al. (1997) conducted a study to evaluate the essential components of NCR, specifically whether an initial NCR schedule based on mean latency to the first instance of problem behavior during the functional analysis was effective and whether EXT was necessary to decrease problem behavior. The first phase of the study consisted of conducting a functional analysis for three participants that indicated all participants engaged in problem behavior maintained by social positive reinforcement (i.e., access to preferred objects or activities). The second phase of the study evaluated the effectiveness of an initial FT schedule based on the mean latency to the first instance of problem behavior during the functional analysis for two participants in which the reinforcer was delivered for 30 s. In this phase, NCR was implemented concurrently with EXT (i.e., problem behavior did not result in access to preferred objects or activities). The reinforcement schedule was thinned progressively (i.e., by a fixed amount) contingent on three sessions with a zero level of problem behavior. Results of the second phase

indicated NCR with EXT was effective at decreasing problem behavior to zero for both participants; however, increases in problem behavior were observed for one participant immediately following implementation of NCR with EXT, as well as for both participants as the schedule was thinned. Terminal thinning schedules were FT 600 s (10 min) and FT 720 s (12 min).

The third phase investigated whether NCR without EXT could reduce problem behavior for the third participant. Procedures were identical to the second phase with the exception that 30-s access to the preferred object was given contingent on each occurrence of problem behavior (i.e., fixed ratio [FR] 1) and according to the FT schedule. Results indicated that implementation of NCR without EXT was associated with an immediate increase in problem behavior; however, problem behavior decreased to zero across sessions. Problem behavior remained at zero each time the schedule was thinned to a terminal schedule of FT 300 s (5 min). Results of Lalli et al.'s (1997) study indicated that NCR with and without EXT can be effectively faded to relatively lean schedules of reinforcement (i.e., FT 5 min, FT 10 min, FT 12 min). Because only one participant was exposed to NCR without EXT condition, the generality of the findings is limited.

Hagopian et al. (2000) evaluated the role of EXT in NCR and attempted to identify the factors influencing problem behavior maintained by access to social positive reinforcement (i.e., access to tangibles and attention) within schedule thinning. A reversal design was used which included baseline, NCR without EXT, and NCR with EXT. Schedule thinning was conducted in both NCR phases. Initial schedules of reinforcement for the NCR conditions were FT 30 s resulting in 30-s access to preferred items (i.e., continuous access). For all three participants exposed to NCR without EXT in which problem behavior also resulted in 30-s access to preferred tangibles or attention on an FR 1 schedule, problem behavior immediately decreased

and maintained at zero following the initial FT 30-s schedule. Schedules were then systematically thinned by increasing the inter-reinforcer interval (e.g., noncontingent access for 30 s every 30 s thinned to noncontingent access for 30 s every 45 s). Contrary to Lalli et al. (1997), results indicated that NCR without EXT was associated with increases in problem behavior as the schedule was thinned. The increases in problem behavior during schedule thinning necessitated the inclusion of an EXT component to effectively thin the schedule with a low level of problem behavior for all participants. However, following the implementation of EXT, a temporary, sharp increase in problem behavior characteristic of an EXT burst was observed with all participants. The researchers concluded that the bursts in responding following the addition of EXT suggested that the initial decreases in problem behavior during NCR without EXT were not due to EXT. Stimulus engagement also remained high during reinforcer access time for all participants throughout all NCR phases potentially indicating that satiation was not in effect. The researchers concluded that matching theory may be the best conceptual framework through which to view their results. In matching theory, increasing the schedule of alternative reinforcement (e.g., response-independent reinforcement or NCR) reduces responding on the concurrent response-dependent schedule. Therefore, the participants consumed free reinforcement when it was available and engaged in problem behavior to obtain reinforcement when free reinforcement was less frequently available during schedule thinning.

Saini et al. (2017) discussed that implementing NCR without EXT may be problematic due to the increased number of stimulus-reinforcer pairings (i.e., delivery of the reinforcer contingent on problem behavior) compared to NCR with EXT during which problem behavior never accesses reinforcement. An increased number of stimulus-reinforcer pairings may lead to an increase in behavioral resurgence and persistence in the presence of a disruptor. For example,

a disruptor to an NCR without EXT procedure (e.g., EXT) may lead to an increase in behavior (i.e., resurgence). Due to the potential repeated pairings of the problem behavior and reinforcer in NCR without EXT, the likelihood of resurgence may be higher following a disruptor (e.g., EXT) than in NCR with EXT because EXT is already present within the treatment. Treatment integrity failures (e.g., accidentally implementing EXT within an NCR without EXT procedure) may be more common in applied settings and may result in resurgence or treatment relapse. For example, a busy caregiver attending to another child may not be able to implement an NCR without EXT procedure with fidelity, resulting in some instances of problem behavior being placed on EXT. Therefore, it is important to understand how EXT affects NCR without EXT.

Saini et al. (2017) evaluated response persistence and resurgence by including a phase of EXT only (i.e., disruptor) following NCR with and without EXT with three participants using a translational model. The analogues to problem behavior were the complete depression of a button switch (for two participants) and dropping poker chips into a box (for one participant). The researchers used a reversal design with two primary phases: NCR with EXT and NCR without EXT for one participant (Gen). Each primary phase had three sub-phases: baseline, treatment, and EXT. For the other two participants (Gavin and Jakob), a multiple schedule with three phases (i.e., baseline, treatment, and EXT) was used. The two components of treatment were NCR with EXT and NCR without EXT. Each component lasted 1 min and was presented five times in a quasirandom order within a 10-min session. An index card with a different color on each side was used as a discriminative stimulus to indicate which component of the multiple schedule was in effect.

Prior to the start of the study, the target behavior was pre-trained on a variable interval (VI) 30-s schedule of reinforcement using highly preferred toys or edibles, which were

subsequently used through all other phases in the study. Access to toys was given for 15 s, during which the session clock was paused. Reinforcer consumption time for the edibles (i.e., M&Ms) did not require the session clock to be paused as it did not interfere with the participant's ability to engage in the analogue to problem behavior. During baseline, the reinforcer was delivered on the VI 30-s schedule. During NCR with EXT, the reinforcer was delivered on a VT 30-s schedule, which the authors stated was similar to how NCR is typically implemented for problem behavior maintained by social consequences. An mDRO procedure was added to the end of the VT schedule, which delayed reinforcer delivery if the participant engaged in the analogue to problem behavior within 4 s of the reinforcer delivery. During NCR without EXT, reinforcement was delivered for the analogue to problem behavior response-dependently on a VI 30-s schedule, as well as response-independently on a VT 30-s schedule. Reinforcement was equated for problem behavior and the NCR schedule. During EXT only, all programmed reinforcer deliveries were terminated.

Results of the study indicated that for two of the three participants (Gen and Gavin), NCR without EXT was associated with more immediate decreases in the target behavior compared to baseline than in NCR with EXT. However (for Gen), only NCR with EXT decreased responding to a near zero level, whereas neither condition resulted in a near zero level of responding for the other participant (Gavin). For the third participant (Jakob), both NCR with EXT and NCR without EXT immediately decreased responding to a near zero level; however, no significant differences were observed between NCR with EXT and NCR without EXT. Results for all three participants also indicated that NCR without EXT was associated with a higher level of resurgence in the EXT only phase. The researchers concluded that while the delivery of alternative (response-independent) reinforcers weakened the response-reinforcer contingency,

providing response-dependent reinforcers concurrently with response-independent reinforcers (i.e., NCR without EXT) increased resurgence and persistence during the EXT only phase. One potential explanation given by Saini et al. (2017) for these results was that the increased overall rate of reinforcement available during NCR without EXT may result in greater resurgence when EXT is implemented and all reinforcement is terminated.

While Saini et al. (2017) evaluated response persistence and resurgence, the researchers did not fade the schedules of reinforcement throughout the NCR phases. Fading schedules of reinforcement during NCR is an important step in the treatment of problem behavior as most initial schedules are too dense (e.g., continuous access) to be maintained in applied settings. Previous research regarding NCR implemented either with or without EXT has not reliably demonstrated a consistent procedure for the most efficient way to develop an initial schedule or thin the reinforcement schedule. While some initial schedules were implemented with continuous access (e.g., Fritz et al., 2017; Hagopian et al., 2000; Vollmer et al., 1993), others were based on the average inter-response time (IRT) during baseline (e.g., Kahng et al., 2000; Wallace et al., 2012) or the mean latency to the first problem behavior (e.g., Britton et al., 2000; Lalli et al. 1997). Similarly, schedule thinning was implemented either by removing a predetermined number of reinforcers per minute (e.g., Fritz et al., 2017; Hagopian et al., 1994; Wallace et al., 2012; Vollmer et al., 1993), increasing the inter-response interval by a predetermined interval (e.g., Hagopian et al., 2000), increasing the FT schedule by a predetermined amount (e.g., Britton et al., 2000; Carr & Britton, 1999; Lalli et al., 1997), or basing the schedule on the mean IRT of the previous three sessions (e.g., Kahng et al., 2000).

The lack of consistency regarding a standard method for implementing and thinning NCR schedules could result in less effective NCR treatments, especially as the schedule is thinned as it

is not clear which thinning method is most effective. Because NCR without EXT would typically be most beneficial for severe problem behavior (Fritz et al., 2017), having an effective, standardized method of fading could assist practitioners in developing the most effective treatment while decreasing the risk of injury. In 2002, LeBlanc et al. proposed a model for decreasing the intensity of reinforcement-based interventions in clinical practice. The authors recommended using an initial schedule that is the most intense schedule manageable and establishing a series of 8-12 thinning steps prior to the terminal schedule. The authors also recommended allowing sufficient exposure to each new thinning step prior to proceeding. While the authors stated that two consecutive exposures may be sufficient, they acknowledged that it had not been empirically tested. Finally, the authors stated that to facilitate progressing as quickly as possible, periodic probes at leaner thinning steps and the terminal thinning step can be conducted. For example, after three consecutive successful thinning steps, probe three steps leaner. When the progression has reached the halfway point, a terminal probe may be conducted. The authors recommended future research replicate the model.

Additionally, EXT bursts and resurgence have also been the only EXT side effects studied within the implementation of NCR with and without EXT (Britton et al., 2000; Carr & Britton, 1999; Hagopian et al., 2000; Hagopian et al., 1994; Lalli et al., 1997; Vollmer et al., 1993; Wallace et al., 2012). Other side effects of EXT have not been evaluated to determine whether a difference exists between NCR with and without EXT. Other side effects, such as variability in responding, could have important implications on clinical practice and determining whether to use EXT when considering the emergence of other undesirable topographies (e.g., problem behavior) or desirable topographies (e.g., an appropriate, alternative response) of behavior. For example, Goh and Iwata (1994) observed an increase in aggression following the

implementation of an EXT procedure for SIB maintained by social negative reinforcement. However, Grow et al. (2008) demonstrated exposing problem behavior maintained by social negative reinforcement to EXT resulted in response variability in the form of un-trained, appropriate alternative responses that could be subsequently reinforced. It may be important to understand whether variable responding occurs in the context of NCR with and without EXT as this may affect the efficacy of both procedures.

Therefore, the purposes of this study were to replicate and extend Saini et al.'s (2017) study to evaluate (a) the effectiveness of NCR on reducing an analogue to problem behavior with and without EXT while fading schedules of reinforcement, (b) levels of variability in responding during and following NCR schedule fading with and without EXT, and (c) response resurgence following changes in schedules of reinforcement with and without EXT. A secondary purpose of this study was to replicate the model outlined by LeBlanc et al. (2002) to determine whether their recommended method of thinning NCR reinforcement schedules could be adapted to decrease the effort required when determining how to efficiently thin an NCR schedule in an applied setting with severe problem behavior.

Method

Participants and Setting

The participants in this study were six students currently enrolled in undergraduate and graduate programs at the University of Kansas. Participants were at least 18 years old. Participants were screened for color-blindness at the beginning of the experiment and excluded if unable to differentiate among colors (i.e., blue, red, purple, yellow) involved in the experiment. Per instructor approval, participants received extra credit for participating in the study.

The experimental program was hosted online, and participants accessed the experiment through a web address provided by the researcher. Participants were required to have access to a computer and internet. The researcher attended all experimental sessions with each participant via Zoom.

Apparatus

The program software for this study was written in a combination of Java Script and HTML to automate all experimental contingencies. The screen displayed a 480x270 pixel light gray rectangle within which an array of four different colored boxes (i.e., blue, red, purple, and yellow) of identical size (i.e., 30x30 pixels) moved randomly across the screen at 20 pixels/s. A light green square shape was located in each of the four corners of the rectangle (i.e., top right, top left, bottom right, bottom left). A score bank was displayed at the top center of the rectangle (see Appendix A for an image of the screen layout). Dragging the moving blue box to the light green square in the top right corner of the rectangle accrued points to the score bank according to various schedules (described below). When a point was delivered, a new screen flashed over the game which stated, “Congratulations! You got a point!” When the game was resumed, the point(s) were added to the existing total in the score bank, which remained visible throughout the experiment. A “Play/Pause” button was located on the top left of the screen above the game rectangle.

Response Measurement and Program Calibration

The website was programmed to automatically record the frequency and location of drags for each colored box to each corner on the screen. At the end of the experimental session, the program created a CSV file output containing the data which was copied into an Excel file and stored on a HIPAA-compliant server.

The dependent variables in this study were the target response (i.e., laboratory analogue to problem behavior), variability in responding, and resurgence. The target response was defined as dragging the blue box to the light green square in the upper right corner of the screen. Response rate was calculated by counting the total number of target responses in a session and dividing by the number of minutes in a session.

Variability in responding was calculated to determine (a) the number of different response forms and (b) the number of novel responses within each session (Dracobly et al., 2017). A different response form was defined as either the participant dragging one colored box following a different colored box (e.g., red to any corner, then blue to any corner) or the participant dragging the same colored box to a different corner of the screen (e.g., blue to bottom left, then blue to bottom right). Novel responses were defined as the first time a participant drags each box to each corner (e.g., the first time the red box is dragged to the bottom left corner, the first time the red box is dragged to the bottom right corner, the first time the blue box is dragged to the bottom right corner) during a session. Total variable responses was calculated by totaling the number of different response forms, as well as the number of novel responses, within a session.

Resurgence was defined as an increase in the target response rate during the first or second session of a leaner reinforcement schedule that exceeded the level of responding during the immediately preceding session at a denser schedule. Additionally, resurgence was evaluated within the same exposure (i.e., first or second) rather than across exposures. Response rate was expressed as a proportion of the average response rate during baseline by dividing the rate of response in each session from the NCR treatment and EXT only phases by the average rate of response of the last three sessions of the immediately preceding baseline.

Calibration procedures were conducted once prior to the beginning of the study. The researcher engaged in pre-determined responses throughout each phase (i.e., baseline, NCR with EXT, NCR without EXT, schedule thinning, and EXT only) and compared the CSV file output to the pre-determined response script to ensure points were awarded or excluded on the appropriate schedule, as well as to ensure all responses were included in the CSV file output. Additionally, calibration checks were conducted throughout the study for at least one session in each phase for each participant. That is, participant responses and point deliveries were observed by the researcher via Zoom, recorded on paper, and compared to the CSV file output. Each calibration check resulted in 100% accuracy of point delivery, point omission, and recorded responses.

Procedures

General Procedure

Participants were randomly assigned to one of two groups. The first group was exposed to baseline, NCR with EXT, and EXT only. The second group was exposed to baseline, NCR without EXT, and EXT only. The study included up to four, 2-hour session blocks for a maximum of 8 hours. Each 2-hour session block included up to 24, 5-min sessions.

At the beginning of each session block, the researcher read the following instructions:

> During this session block, you will be playing a series of games on the screen. You will play each game for 5 minutes. Your point total will be shown at the top center of the screen. If you need to take a break from the session at any point, press the pause button at the top left of the screen and check-in with me via Zoom. At the end of each game, a data box will appear indicating that the session has ended. I

will then ask if you need a 5-minute break or are ready to begin the next game. Are you ready to begin?

Participants were not instructed on the correct response (i.e., dragging the blue box to the upper right corner) as the instructions may block variable responding (Henley et al., 2017).

Baseline

Participants received 1 point each time they successfully dragged the blue box to the light green square in the upper right corner (i.e., FR 1 schedule). Participants did not receive points for dragging the blue box to any other corner or for dragging any other colored boxes to any outlined square. If participants did not reliably engage in the target behavior following two 5-min sessions, then prior to the third session, the researcher stated, "The goal in this game is to drag the boxes to the corners." The researcher stated this instruction for one participant (Participant 954). If participants did not reliably engage in the target behavior within the next two sessions, then prior to the fifth session, the researcher would have stated, "The goal in this game is to drag the blue box to the upper right-hand corner." No participants needed this second instruction.

NCR without EXT (yoked)

The initial NCR schedule was yoked to the average inter-response interval for each point delivery across the final three baseline sessions. For example, if the participant earned the first point in the first baseline at 0:03 s, the first point in the second baseline at 0:04 s, and the first point in the third baseline at 0:02 s, the first point delivery in the NCR without EXT (yoked) phase would be delivered at 0:03 s. Participants received 5 points per delivery on the yoked FT schedule (Carr et al., 1998). Participants also received 1 point on an FR 1 schedule for the target response. No other dragging responses resulted in points.

NCR with EXT (yoked)

NCR with EXT (yoked) was similar to NCR without EXT (yoked); however, participants only received 5 points per delivery on the yoked FT schedule. Participants did not receive any points for the target response or any other responses (i.e., the target response was placed on EXT).

Schedule Thinning

Reinforcement schedule thinning during NCR with and without EXT was conducted to analyze the effects of schedule thinning on response rate, variability, and resurgence. Schedule thinning began following the yoked NCR schedule and continued through the thinning steps if problem behavior maintained at or below 20% of the average of the last three baseline rates for two consecutive sessions. The NCR schedules were thinned by removing 10% systematically from the average baseline reinforcement rate (i.e., 90%, 80%, 70%, 60%, 50%, 40%, 30%, 20%, 10%, 0%) and rounded to the nearest whole number. For example, if 90% of the average baseline reinforcement rate equated to one delivery every 2.2 s, the NCR schedule would be set to FT 2 s. The terminal thinning schedule for all participants was 0%, which equated to FT 300 s (5 min). That is, participants earned one point at the end of the session.

Following three successful steps of schedule thinning (e.g., 90%, 80%, 70%) with problem behavior maintaining at or below 20% of the baseline rate, a probe was conducted for three steps leaner (e.g., 40%). If the participant was successful at that thinning step, another probe was conducted for the terminal thinning schedule (i.e., 0%). Participants continued to receive 5 points on the FT schedule throughout schedule thinning. The same contingencies were in place for the analogue to problem behavior as the previous yoked phase to which the participant was exposed.

If during any typical schedule thinning or probe a participant responded above 20% of the average baseline rate, the thinning schedule returned to the last successful thinning step and the thinning continued using the same progression. If problem behavior again decreased at or below 20% of the average baseline rate, then schedule thinning continued with the previously outlined progression. If the rate of problem behavior maintained above 20% of the average baseline rate for two consecutive sessions, EXT only was implemented.

EXT Only

Following schedule thinning, EXT only was implemented. During this phase, all schedules of reinforcement were terminated. The purpose of this phase was to evaluate whether resurgence was more likely to occur following NCR schedule fading with or without EXT.

Experimental Design

A reversal design (Birnbrauer et al., 1974) with 5-min sessions was used to demonstrate experimental control. The two primary phases, NCR with EXT and NCR without EXT, each had three sub-phases: baseline, treatment with schedule thinning, and EXT. Ongoing visual analysis was used to make decisions regarding changes in phases, as well as schedule thinning, throughout the study.

Results

Figure 1 depicts the rate of the target response and response variability for the three participants (i.e., 954, 158, 612) exposed to NCR with EXT. Sessions are scaled to the x-axis, rate of target responses (responses per min) is scaled to the left y-axis, and the total number of variable responses is scaled to the right y-axis. Closed circles depict the rate of target responses, gray bars depict total variable responses, and the horizontal black lines depict 20% of the average response rate during the final three baseline sessions of the preceding phase. Participant 954 (top

panel) engaged in a zero rate of the target response for the first two sessions, at which point they were given the rule to "drag the boxes to the green corners." Target response rate immediately increased to a high rate for the final three baseline sessions (*M* = 18 responses/min). Total number of variable responses decreased from 38 in the first baseline session to 2 in the final baseline session (*M* = 22 variable responses/session). Following introduction of NCR with EXT (yoked), the rate of the target response immediately dropped below 20% of the baseline rate to near zero and maintained (*M* = 0.07 responses/min). Total number of variable responses increased to 24 in the first NCR with EXT (yoked) session prior to decreasing to 0 in the third session (*M* = 14 variable responses/session). Rate of the target response remained at a low to zero level as the schedule of reinforcement was thinned to 90%, 80%, 50%, and 0% of the average baseline reinforcement rate (*M* = 0.11 responses/min). Total number of variable responses remained at zero as the schedule of reinforcement was thinned to 90% and 80%, increased slightly during 50%, and significantly increased during 0% to a total of 44 in the first session and subsequently decreased to 15 in the second session (*M* = 9 variable responses/session). Following implementation of EXT only, rate of the target response remained at a near zero level for three sessions (*M* = 0.13 responses/min). Total number of variable responses increased to 32 during the first session, then decreased to 0 by the third session (*M* = 16 variable responses/session). During the reversal to baseline, there was an immediate increase to a high response rate (*M* = 22.2 responses/min) and low number of variable responses (*M* = 2 variable responses responses/session). Previous results (i.e., a near zero rate of responding) were replicated throughout NCR with EXT (yoked; *M* = 0.00 responses/min), schedule thinning (*M* = 0.03 responses/min) and EXT (*M* = 0.00 responses/min) for the target response. Total variable responses decreased to 0 during NCR with EXT (yoked; *M* = 0.00 variable responses/session),

maintaining at a low level throughout schedule thinning (*M* = 3.2 variable responses/session), and occurred less often during EXT (*M* = 10.67 variable responses/session); however, an immediate increase and subsequent decrease to 0 variable responses occurred following exposure to 0% and EXT.

Participant 158 (middle panel) engaged in a high, increasing rate of the target response during the final three sessions in baseline (*M* = 17.73 responses/min). Total number of variable responses decreased from 94 during the first baseline session to 2 during the final baseline session (*M* = 27.5 variable responses/session). Following the introduction of NCR with EXT (yoked), response rate decreased immediately to a near zero level (*M* = 0.20 responses/min). Total number of variable responses maintained at a low, stable level (*M* = 2 variable responses/session). Response rate remained at a near zero level throughout schedule thinning (*M* = 0.26 responses/min). A slight increase in response rate (1.4 responses/min) was observed during the first session at the terminal thinning schedule (i.e., 0%); however, the response rate was below 20% of the average of the baseline rate and dropped to a near zero level during the second session. Total number of variable responses remained at a low level as the reinforcement schedule was thinned to 90% and 80%, increased slightly during 50% to 12, and significantly increased during 0% to 58 during the first session, decreasing to 37 during the second session (*M* = 15.86 variable responses/session). Following implementation of EXT only, the rate of the target response increased slightly (1.6 responses/min) but remained below 20% of the average baseline rate with minimal variability. Total number of variable responses was variable across EXT sessions (*M* = 26.67 variable responses/session). During the reversal to baseline, the rate of the target response was high with some variability and an increasing trend during the last three sessions (*M* = 14.46 responses/min). Total number of variable responses stabilized at a low level

(*M* = 2.83 variable responses/session). Previous response rate was replicated throughout NCR with EXT (yoked; *M* = 0.13 responses/min), schedule thinning (*M* = 0.14 responses/min), and EXT (*M* = 0.80 responses/min) for the target response. Total number of variable responses occurred at a similar level during NCR with EXT (yoked; *M* = 2 variable responses/session); decreased in schedule thinning during 90%, 80%, and 50% (*M* = 0.00 variable responses/session); increased during the first session of 0% followed by a subsequent decrease (*M* = 15 variable responses/session); and increased during EXT (*M* = 27.67 variable responses/session).

Participant 612 (bottom panel) immediately engaged in a high, increasing rate of the target response during the first three baseline sessions (*M* = 20.33 responses/min). Total number of variable responses decreased from 40 in the first session to 2 in the final two sessions (*M* = 14.67 variable responses/session). Following the implementation of NCR with EXT (yoked), the response rate immediately decreased and remained at a low to zero level (*M* = 0.07 responses/min). Total number of variable responses increased slightly prior to steadily decreasing throughout the phase (*M* = 25.33 variable responses/session). The response rate remained below 20% of the average baseline rate (i.e., 4.07 responses/min) throughout schedule thinning at 90%, 80%, and 50% (*M* = 0.8 responses/min). Increases in responding (2.6 and 2.0 responses/min) occurred during the terminal thinning schedule (i.e., 0%), but the response rate remained at lower than 20% of the average baseline rate for two sessions. Total number of variable responses increased slightly during the second session following thinning to 90%, decreased in 80% and 50%, then increased significantly during 0% to 121 in the first session and 27 in the second session (*M* = 25.33 variable responses/session). Following implementation of EXT only, the response rate maintained and remained below 20% of the average baseline rate for

three sessions (*M* = 2.2 responses/min). Total number of variable responses increased significantly during EXT (*M* = 112.67 variable responses/session). A return to baseline showed an immediate return to a high, increasing rate of the target response for three sessions (*M* = 23 responses/min), as well as a low number of total variable responses (*M* = 8.33 variable responses/session). Previous response rate was replicated for NCR with EXT (yoked; *M* = 0.00 responses/min), and for a majority of schedule thinning (*M* = 0.04 responses/min) with the exception of 0% during which an increase in rate above 20% of the average baseline rate occurred (7.6 responses/min) for the target response. The schedule was returned to the last successful thinning step (i.e., 50%), at which point the response rate decreased immediately to 0. The response rate remained at 0 throughout schedule thinning until the terminal schedule (i.e., 0%), when the response rate again increased (*M* = 2.8 responses/min); however, the response rate remained under 20% of the average baseline rate for three sessions and decreased to near zero during the third session. Total number of variable responses remained at or near zero throughout NCR with EXT (yoked), as well as all schedule thinning steps except 0%, at which point it increased significantly during the first (*M* = 29 variable responses/session) and second exposure (*M* = 34.733 variable responses/session). Following the second implementation of EXT only, the response rate increased above 20% of the average baseline rate for the first session (4.8 responses/min) but decreased to a near zero level for the final three sessions (*M* = 0.13 responses/min) for the target response. Total number of variable responses increased significantly during the first session of EXT prior to decreasing to zero during the final session (*M* = 60 variable responses/session).

Figure 2 depicts the rate of the target response for the three participants (i.e., 507, 249, 473) exposed to NCR without EXT. Graphing conventions are the same as Figure 1. Participant

507 (top panel) immediately engaged in a high, increasing rate of the target response during baseline (*M* = 19.13 responses/min). Total number of variable responses decreased following the first session (*M* = 12.67 variable responses/session). Following implementation of NCR without EXT (yoked), the rate of problem behavior immediately decreased but maintained at a rate greater than 20% of the average baseline rate (*M* = 10.36 responses/min). Total number of variable responses increased then decreased across NCR without EXT (yoked; *M* = 8.4 variable responses/session). During EXT only, the rate of target behavior decreased immediately; however, the rate of the target behavior was variable, vacillating above and below 20% of the average baseline rate for 11 sessions (*M* = 3.65 responses/min; range, 1.4 – 8.6 responses/min). Total number of variable responses immediately increased and remained high throughout the phase (*M* = 64.09 variable responses/session). A return to baseline resulted in an immediate return to a high, slightly increasing rate of the target response for three sessions (*M* = 17 responses/min), as well as a low level of total variable responses (*M* = 10 variable responses/session). Implementation of NCR without EXT (yoked) resulted in an immediate decrease in response rate, maintaining above 20% of the average baseline rate (*M* = 6.2 responses/min), as well as an increase in total variable responses (*M* = 11 variable responses/session). Following implementation of EXT only, the response rate decreased immediately to below 20% of the average baseline rate and decreased to zero by the last session (*M* = 1.45 responses/min). Total number of variable responses immediately increased prior to gradually decreasing throughout the phase (*M* = 34.5 variable responses/session).

Participant 249 (middle panel) engaged in a high rate of the target response following the first baseline session that maintained stability for the final three sessions (*M* = 21.46 responses/min). Total number of variable responses was initially high but quickly decreased to a

low level throughout baseline (*M* = 13.43 variable responses/session). Following the implementation of NCR without EXT (yoked), the rate of the target response immediately decreased to a near zero level for the first two sessions. However, for the next five sessions, the response rate increased and stabilized at above 20% of the average baseline rate with minimal variability (*M* = 8.6 responses/min). Total number of variable responses maintained at a low level throughout NCR without EXT (*M* = 5 variable responses/session). After an initial decrease of responding to near 20% of the average baseline rate in the first session of EXT only (5.6 responses/min), the response rate increased followed by a subsequent decrease to a near zero level (*M* = 4.3 responses/min). Total number of variable responses immediately increased in EXT, followed by a gradual decrease across the phase (*M* = 49.0 variable responses/session). Results were replicated for response rate during baseline (*M* = 21.93 responses/min), NCR without EXT (yoked; *M* = 11.8 responses/min), and EXT (*M* = 0.20 responses/min) for the target response. Total number of variable responses decreased during baseline (*M* = 2.0 variable responses/session) and NCR without EXT (yoked; *M* = 2.0 variable responses/session). Total number of variable responses increased during the first session of EXT followed by a subsequent decrease (*M* = 10.67 variable responses/session).

Participant 473 (bottom panel) engaged in a high, increasing response rate during three sessions of baseline (*M* = 20.6 responses/min). Total number of variable responses was high during the first baseline session followed by an immediate decrease (*M* = 14.33 variable responses/session). Following implementation of NCR without EXT (yoked), the response rate immediately decreased to zero and remained at zero throughout schedule thinning until the terminal thinning schedule probe (i.e., 0%), at which point the response rate increased to 20.8 responses/min, which was greater than 20% of the average baseline rate. The schedule was

returned to the previous successful thinning step (i.e., 50%), and the response rate again decreased to zero. An attempt to thin the schedule to 40% resulted in an increase in the response rate to greater than 20% of the average baseline rate (*M* = 15.1 responses/min). Total number of response variability decreased to a low level during NCR without EXT (yoked; *M* = 2.0 variable responses/session) and remained at a low level throughout all thinning steps, except for the first session at 50%, both sessions during 0%, and the first session at 40% (*M* = 6.73 variable responses/min). EXT only was then implemented which resulted in an immediate decrease to a near zero level of responding for the first two sessions, followed by an increase in responding greater than 20% of the average baseline rate (*M* = 12.66 responses/min; range, 0.8 – 36.2 responses/min). Total number of variable responses increased significantly in EXT with a decreasing trend across the phase (*M* = 58.14 variable responses/session). Baseline response rate was replicated (*M* = 24.4 responses/min) for target responses, as well as total number of variable responses (*M* = 12.33 variable responses/session). However, during NCR without EXT (yoked), the participant engaged in a response rate greater than 20% of the average baseline rate for 5 consecutive sessions for the target response (M = 14.44 responses per min). Total number of variable responses decreased to a low level (*M* = 2.0 variable responses/session). Following the implementation of EXT only, the participant began engaging in a response rate nearly doubling those during baseline (M = 46.52 responses/min). The participant met the criteria for ending EXT only following 5 consecutive sessions at greater than 20% of the average baseline rate. Total number of variable responses maintained at a low level (*M* = 2 variable responses/session).

Figure 3 depicts the level of the target response expressed as a proportion of baseline for all three participants exposed to NCR with EXT schedule thinning and EXT only. Sessions are scaled to the x-axis. Response rate expressed as a proportion of baseline is scaled to the y-axis.

The first exposure to the phase is denoted by the closed circles, and the second exposure is denoted by the open circles. For all participants, NCR with EXT led to significant reductions in response rate relative to baseline that maintained during schedule thinning. The data for Participant 954 are depicted in the top panel. During the first exposure, resurgence occurred during schedule thinning following the introduction of 50% and 0%. During the second exposure, resurgence occurred during schedule thinning following the introduction of 0%, as well as EXT only. Overall, resurgence during the first exposure occurred at a higher proportion of the average baseline rate compared to the second exposure. The data for Participant 158 are depicted in the middle panel. During the first exposure, resurgence occurred during schedule following the introduction of 80%, 50%, as well as EXT only. During the second exposure, resurgence occurred during schedule thinning following the introduction of 0%, as well as EXT only. Overall, the level of resurgence was relatively similar between the first and second exposures. The data for Participant 612 are depicted in the bottom panel. During the first exposure, resurgence occurred during schedule thinning following the introduction of 0%, as well as EXT only. During the second exposure, resurgence occurred during schedule thinning following the introduction of 0%, as well as during EXT only. Overall, resurgence during the second exposure occurred at a higher proportion of the average baseline rate compared to the first exposure.

Figure 4 depicts the level of the target response expressed as a proportion of baseline for all three participants exposed to NCR without EXT schedule thinning and EXT only phases. Graphing conventions are the same as Figure 3. With the exception of the first exposure for Participant 473, NCR without EXT led to moderate reductions in response rate relative to baseline. The data for Participant 507 are depicted in the top panel. Resurgence did not occur

following the first or second exposure to EXT only. The data for Participant 249 are depicted by the middle panel. During the first exposure, resurgence occurred at a very small level during the second session of EXT only. Resurgence did not occur during any other session in either the first or second exposure to EXT only. The data for Participant 473 are depicted in the bottom panel. During the first exposure, resurgence occurred during schedule thinning following the implementation of 0% and 40%. During the second exposure, resurgence occurred following the implementation of EXT only. Overall, little to no resurgence occurred during NCR without EXT.

Discussion

The primary purposes of this study were to replicate and extend Saini et al.'s (2017) study to evaluate (a) the effectiveness of fading schedules of NCR with and without EXT on reducing an analogue to problem behavior, (b) levels of response variability during and following NCR schedule fading with and without EXT, and (c) response resurgence across all schedules of reinforcement, including EXT. Results of the current study indicate that both NCR with and without EXT decreased the rate of the analogue to problem behavior relative to baseline for all six participants. However, only NCR with EXT decreased the response rate below 20% of the average baseline rate. Additionally, NCR with EXT maintained a low to zero rate of problem behavior throughout reinforcement schedule thinning for all three participants with whom it was evaluated. Levels of response variability were higher during the first exposure to EXT only for all three participants exposed to NCR without EXT than those participants exposed to NCR with EXT. Response resurgence also occurred more often during schedule thinning and EXT only for all three participants exposed to NCR with EXT compared to participants exposed to NCR without EXT.

NCR with EXT was effective at immediately decreasing the analogue to problem behavior to a low or zero rate for all three participants for whom it was evaluated. The mechanism responsible for the effects observed in the NCR with EXT (yoked) condition for Participant 158 appears to be satiation, as evidenced by the low response rate and low number of total variable responses. However, for Participants 954 and 612, the moderate level of total variable responses during NCR with EXT (yoked) and the initial dense schedule thinning phase (i.e., 90%) indicate that the effects of EXT may have been responsible for their initial decrease in response rate.

Schedule thinning to the terminal thinning schedule of FT 300 s (5 min) was also effective with all three participants who experienced NCR with EXT. Slight increases in response rate were observed for two of the three participants (Participants 158 and 612) as the schedule was thinned to 50% and 0%, but response rate remained under 20% of the average baseline rate for both participants. These results replicate other studies demonstrating the ability to effectively thin schedules of reinforcement within NCR with EXT while maintaining a low rate of problem behavior (e.g., Britton et al., 2000; Kahng et al., 2000). The initial increase and subsequent decrease in response rate at leaner schedules of reinforcement (i.e., 50% and 0%) indicate that while satiation may have been in effect for the denser schedules of reinforcement (specifically for Participant 954), EXT may have been the critical component for all participants in maintaining a low response rate throughout schedule thinning.

With the exception of one session for Participant 612, minimal disruption to response rate (i.e., response rate remained under 20% of the average baseline rate) occurred for all three participants who experienced NCR with EXT following the implementation of EXT only. These results extend the evidence that NCR with EXT can be an effective procedure to decrease an

analogue to problem behavior, as well as extend the literature by demonstrating an effective reinforcement thinning procedure. The results of this study indicate that the inclusion of an EXT component within NCR with EXT decreased the ability of the EXT only phase to act as a disruptor to response rate. These results are promising for instances in which NCR with EXT is implemented with perfect fidelity, as was the case in this study. However, fidelity issues may arise more frequently in clinical applications of an NCR with EXT procedure. A more likely disruptor to an NCR with EXT procedure may be accidental reinforcement (i.e., the absence of EXT). Future research could address the extent to which treatment fidelity failures result in disruptions to response rate within NCR with EXT.

NCR without EXT immediately decreased responding for all participants. For one participant (Participant 473), NCR without EXT decreased responding to zero during the first exposure. This same level of decrease in responding (i.e., a zero rate) was not replicated during the second exposure, but the response rate did decrease below the average response rate from the immediately preceding baseline phase. Although there were reductions in response rate for all participants, the reductions did not meet the level of clinical significance defined in this study as an 80% decrease of the average response rate in baseline. These results may be best explained through the theory of the matching law (Herrnstein, 1970), replicating the results of Hagopian et al. (2000). That is, when free points were awarded, the participants did not engage in the analogue to problem behavior to receive reinforcement. However, when free points were not being delivered, the participants engaged in the analogue to problem behavior to obtain reinforcement.

The decrease in the analogue to problem behavior observed for participants exposed to NCR without EXT may replicate some of the findings from Saini et al. (2017). Although Saini et

al. did not analyze their participants' rate of responding in relation to a percentage of baseline, NCR without EXT only decreased one of their participant's (Jakob) responding to near zero levels. The other two participants (Gen and Gavin) continued to respond at a low to moderate rate of the target behavior. Length of exposure may attribute to differences in our findings to those from Saini et al.'s. Specifically, the participants in Saini et al.'s study were exposed to approximately 20 sessions of NCR without EXT. Because the criteria in the current study for terminating NCR without EXT and moving to EXT only was 5 sessions at or above 20% of the average baseline rate, it is unknown whether response rate would have decreased in the current study following repeated exposure to the NCR without EXT (yoked) condition. Future research could assess whether extended exposure to NCR without EXT results in an eventual decrease in responding to clinically significant levels (i.e., 80% reduction of the average baseline rate, as defined in the current study) or if responding stabilizes and maintains at a higher rate. Results regarding an eventual, gradual decrease in response rate following NCR without EXT must be analyzed critically, however, as it may not be appropriate to implement a treatment that does not result in an immediate decrease in severe problem behavior.

Given NCR without EXT was ineffective in reducing the target response rate to the study's threshold, schedule thinning was only evaluated with the first exposure to NCR without EXT (yoked) for Participant 473. During schedule thinning, the rate of the target response maintained at a low to zero level during 90%, 80%, and 50%. There were increases in responding at 0%. Following a reduction of the target response at 50%, there were again increases in responding at 40%. We were unable to replicate the effects of schedule thinning given maintained high levels of responding in the second exposure to NCR without EXT (yoked). NCR without EXT was not effective at decreasing the analogue to problem behavior

below 20% of the average baseline rate for the other two participants (Participants 507 and 249). Therefore, subsequently thinning the reinforcement schedule was not evaluated. The low total variable responses for all three participants during NCR without EXT (yoked) also suggests that the inability to decrease problem behavior to clinically significant levels may have been due to the continued reinforcement of the analogue to problem behavior. Participants attempted to engage in very few alternative responses, allocating almost all opportunities for responding to the analogue to problem behavior. One attempt to address this could be to increase the density of the initial NCR schedule. However, additional research is needed to determine whether potential decrements in responding under an initial denser schedule of reinforcement result in the ability to subsequently fade the schedule of reinforcement.

During schedule thinning, total number of variable responses for all three participants exposed to NCR with EXT were low until the terminal thinning schedule (i.e., FT 300 s). Total number of variable responses again increased following the implementation of EXT only but decreased to zero within four sessions for two participants (Participants 954 and 612). Similarly, all three participants who were exposed to NCR without EXT (yoked) also engaged in very few instances of response variability during the NCR treatment phase. However, the first exposure to EXT only following NCR without EXT resulted in an increase in the total number of variable responses for all three participants. Overall, results of the current study indicate that dense schedules of NCR implemented either with or without EXT may result in a low number of variable responses. Results also indicate that leaner schedules of NCR with EXT may result in an initial increase in variable responses followed by a subsequent decrease. The implementation of EXT only following NCR without EXT may also result in an increase in variable responses that persists across multiple sessions.

The difference in types of variable responding between NCR with EXT and NCR without EXT could have important implications for clinical application. Due to the low number of variable (or any) responses for participants exposed to NCR with EXT, NCR with EXT may be more applicable for individuals for whom undesirable topographies of response variability may be more likely to occur (e.g., individuals who engage in more than one topography of severe problem behavior). The high number of total variable responses for participants exposed to NCR without EXT following the implementation of EXT only suggests that adding an EXT component to NCR without EXT following a decrease in response rate may be an effective treatment for individuals who are more likely to engage in desirable topographies of response variability, which may be beneficial for shaping and reinforcing appropriate replacement behaviors for problem behavior. Researchers might examine variables related to desirable and undesirable topographies of response variability and whether any individual characteristics may indicate a greater or lesser likelihood of engaging in one topography versus the other.

Interestingly, participants exposed to NCR without EXT allocated nearly all responses during the NCR without EXT (yoked) phase to the analogue to problem behavior, whereas participants exposed to NCR with EXT were typically not engaging in any game-related response. For example, Participant 954 engaged in 0 variable responses during the second exposure to NCR with EXT (yoked), 90%, 80%, and 50%. However, this participant was noted to engage in other responses that were not captured by the computer program. Due to the study being conducted via Zoom, alternative responses could not be observed, but the participant's mouse did not move on the screen indicating no game-play responses occurred throughout the duration of the sessions. Participants exposed to NCR without EXT likely continued to engage in the analogue to problem behavior due to the increased number of pairings between the response

and reinforcement. In contrast, participants exposed to NCR with EXT experienced an increased number of pairings between the response and EXT. NCR is typically combined with other reinforcement-based procedures for appropriate, alternative behaviors (Carr et al., 2008). The lack of an appropriate, alternative response in the current study may also account for the differences in responding for participants in NCR with and without EXT. That is, the participants exposed to NCR with EXT did not receive reinforcement for any game-related responses in which they engaged, whereas the participants exposed to NCR without EXT continued to receive reinforcement for the analogue to problem behavior.

One of the limitations of this study related to response variability was the online nature of the study. The program only collected data on participants' responses (i.e., dragging boxes to the various corners). Anecdotally, participants were observed engaging in other responses, such as clicking on the moving boxes and the green boxes in the corners, clicking on other areas of the display screen, and dragging the moving boxes on top of each other. Therefore, the data for variable responses in the current study does not completely encompass all types of responses in which participants were engaging. Future research should ensure all possible topographies of response variability are accounted for in the data to better examine the effects of NCR with and without EXT on response variability.

Response resurgence occurred for all three participants exposed to NCR with EXT (Participants 954, 158 and 612) and for two of the three participants (Participants 507 and 473) exposed to NCR without EXT. These results are consistent with predictions of behavior momentum theory (Nevin & Shahn, 2011), as noted by Saini et al. (2017). That is, the delivery of alternative reinforcers (i.e., NCR) decreased the rate of responding by weakening the contingency between the response and the reinforcer. However, providing response-independent

reinforcers concurrently with response-dependent reinforcers may sometimes increase response resurgence or persistence. Providing response-dependent reinforcement concurrently with response-independent reinforcement (i.e., NCR without EXT) increased response resurgence slightly for one participant (Participant 507) and more significantly for a second participant (Participant 473). Response persistence, however, was observed for all three participants. That is, the response rate did not decrease to clinically significant levels following the first exposure to EXT only for two participants (Participants 507 and 473) and required six sessions prior to a clinically significant decrease for the third participant (Participant 249). No conclusions can be drawn regarding resurgence following NCR without EXT schedule thinning due to the inability to achieve (Participants 507 and 249) or replicate (Participant 473) schedule thinning with the participants exposed to NCR without EXT. Further research is needed to determine how and when resurgence may occur within NCR without EXT, particularly following an effective reinforcement schedule thinning procedure.

The model proposed by LeBlanc et al. (2002) allowed for schedule thinning to progress quickly to the terminal schedule (i.e., 7 sessions [i.e., 35 min] for two participants [Participants 954 and 158], 7 and 15 sessions [i.e., 35 and 75 min] for the third participant [Participant 612]). Compared to other reinforcement thinning schedules published in the literature, the current thinning method resulted in the ability to thin to an FT 5-min schedule in significantly less time and across fewer sessions. Fritz et al. (2017) used an initial continuous access NCR schedule which was thinned by removing a predetermined number of reinforcers per min. The three participants in their study required between approximately 15 and 40, 10-min sessions (i.e., an average of approximately 4 hours) to meet terminal criteria of FT 5 min. Hagopian et al. (1994) also used an initial continuous access NCR schedule which was thinned by removing a

predetermined number of reinforcers per min. The four participants in their study required between approximately 15 and 30, 20-min sessions (i.e., an average of approximately 8 hours) to meet terminal criteria of FT 5 min. Lalli et al. (1997) used an initial NCR schedule based on the mean latency to the first instance of problem behavior during the FA and thinned the reinforcement schedule by progressively increasing the FT schedule by a fixed amount. While the terminal thinning criteria differed from the current study, one participant required 25, 15-min sessions (i.e., 6.25 hours) to reach FT 300 s, while the other participant required 4, 15-min sessions (i.e., 1 hour) in one environment and 6, 15-min sessions (i.e., 1.5 hours) in another environment to reach FT 360 s. It is also noteworthy that the initial NCR schedule for the second participant in Lalli et al. was FT 120 s, and the initial schedule for the first participant was FT 90 s. Kahng et al. (2000) used an initial NCR schedule based on the mean IRT of problem behavior during baseline and thinned the schedule based on the mean IRT of problem behavior during the previous three sessions. The three participants in their study required between 10 and 30, 10-min sessions (i.e., an average of approximately 6.5 hours) prior to meeting the terminal thinning criteria (FT 5 min).

The ability to fade from an initially dense schedule of reinforcement to a relatively lean schedule in under 75 mins for all participants is a strength of the thinning method used in the current study. Each step of the thinning schedule was based on a percentage of the average response rate for the last three sessions of baseline. In a clinical setting, this would be a quick way to determine the FT schedule for each step of the thinning sequence while ensuring that it was based upon the client's response rate during baseline rather than by an arbitrary, predetermined amount. Additionally, the model proposed by LeBlanc et al. (2002) was also conducive to using visual analysis to quickly guide decision making regarding phase changes.

However, it should be noted that this is a translational model that may not directly translate to clinical applications.

Several limitations to the current study should be addressed. The first limitation is due to the translational nature of the study. The study was not programmed to save participant data after the website had been closed; therefore, any accidental browser closures by the participant during a session resulted in an inability to abide by phase terminating criteria in multiple instances. For example, Participant 249 closed the web browser following the first four baseline sessions, resulting in an extended baseline. Extended exposure to baseline contingencies may have impacted persistence and resurgence in responding during the NCR without EXT and EXT only phases. Participant 507 also closed the web browser during the second exposure to NCR without EXT (yoked) after the third session requiring a premature phase change to EXT only. Because Participant 507's responding during NCR without EXT (yoked) was occurring at a lower and slightly decreasing level, it is impossible to know whether responding would have stabilized at a lower rate or continued to gradually decrease during that phase. Due to time and programming constraints, Participant 507's first exposure to EXT only also had to be ended prior to meeting criteria. Researchers could address this issue by ensuring that the programmed study saves all participant data so accidental web browser closures do not impact results.

A second limitation of the study was the manipulation of reinforcer magnitude. The analogue to problem behavior was reinforced on an FR 1 schedule with one point during baseline for all six participants. During NCR without EXT, the analogue to problem behavior continued to be reinforced on an FR 1 schedule with one point. However, response-independent reinforcement delivery in both NCR with and without EXT was five points. Carr et al. (1998) demonstrated that high magnitude reinforcers were more effective in immediately decreasing an

analogue to problem behavior than medium or low magnitudes. However, because reinforcer magnitude was not consistent across phases, it is impossible to determine whether reductions in responding were due solely to the schedule of NCR delivery or due to the magnitude manipulation. In their study, Carr et al. evaluated reinforcer magnitude within an NCR with EXT framework. Interestingly, none of the previous studies evaluating the effects of NCR without EXT attempted to manipulate reinforcement parameters but, instead, equated the response-independent reinforcement to the response-dependent reinforcement. Researchers could further evaluate the effect of manipulating various reinforcement parameters (e.g., magnitude, quality, delay) within NCR without EXT.

Third, while the current study attempted to yoke reinforcement schedules between baseline and NCR with and without EXT phases, it was impossible to equate the amount of reinforcement delivery in NCR without EXT due to the possibility for continued reinforcement for the analogue to problem behavior. Therefore, because all three participants exposed to NCR without EXT continued to engage in the analogue to problem behavior, reinforcement density was higher in the NCR without EXT phase than in baseline. An attempt to address this limitation might be to design a program that can account for response rate in NCR without EXT and automatically adjust the rate of NCR deliveries.

A final limitation to the current study was the lack of an mDRO procedure to prevent potential adventitious reinforcement. While adventitious reinforcement has been demonstrated to occur within an NCR with EXT procedure (i.e., Britton et al., 2000; Vollmer et al., 1997), none of the researchers evaluating NCR without EXT discussed observing adventitious reinforcement. This is not particularly surprising as it seems counter-intuitive for a behavior that is being reinforced response-dependently to simultaneously be adventitiously reinforced. However, as

previously discussed, reinforcer magnitude was manipulated in the current study, in contrast to previous studies that equated reinforcer magnitude. Because the current study did not include an mDRO procedure, it is possible that the reinforcer magnitude manipulation could have resulted in adventitious reinforcement. That is, if the analogue to problem behavior resulting in one point occurred in temporal proximity to the NCR delivery of five points, adventitious reinforcement of the analogue to problem behavior may have been more likely than had the magnitudes been equated. Future research could address this limitation by adding an mDRO procedure, either by postponing reinforcement delivery similar to Britton et al. (2000) or removing reinforcement delivery similar to Vollmer et al. (1997), to prevent the possibility of adventitious reinforcement.

Overall results of the current study suggest that NCR with EXT is an effective method for decreasing an analogue to problem behavior, as well as conducive to maintaining low levels of responding during reinforcement schedule thinning. The model proposed by LeBlanc et al. (2002) was effective at quickly thinning the schedule of reinforcement for all participants exposed to NCR with EXT. NCR without EXT was not effective at decreasing the analogue to problem behavior to clinically significant levels; however, total response variability was higher for all participants in comparison to those exposed to NCR without EXT. Depending on the topographies of the variable responses, the increase in response variability may be advantageous or disadvantageous. Due to the previously discussed limitations, results of the current study should be considered preliminary. Additional research is necessary to determine the extent of generality of these results within clinical applications of NCR with and without EXT.

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Figure 1:

NCR with EXT

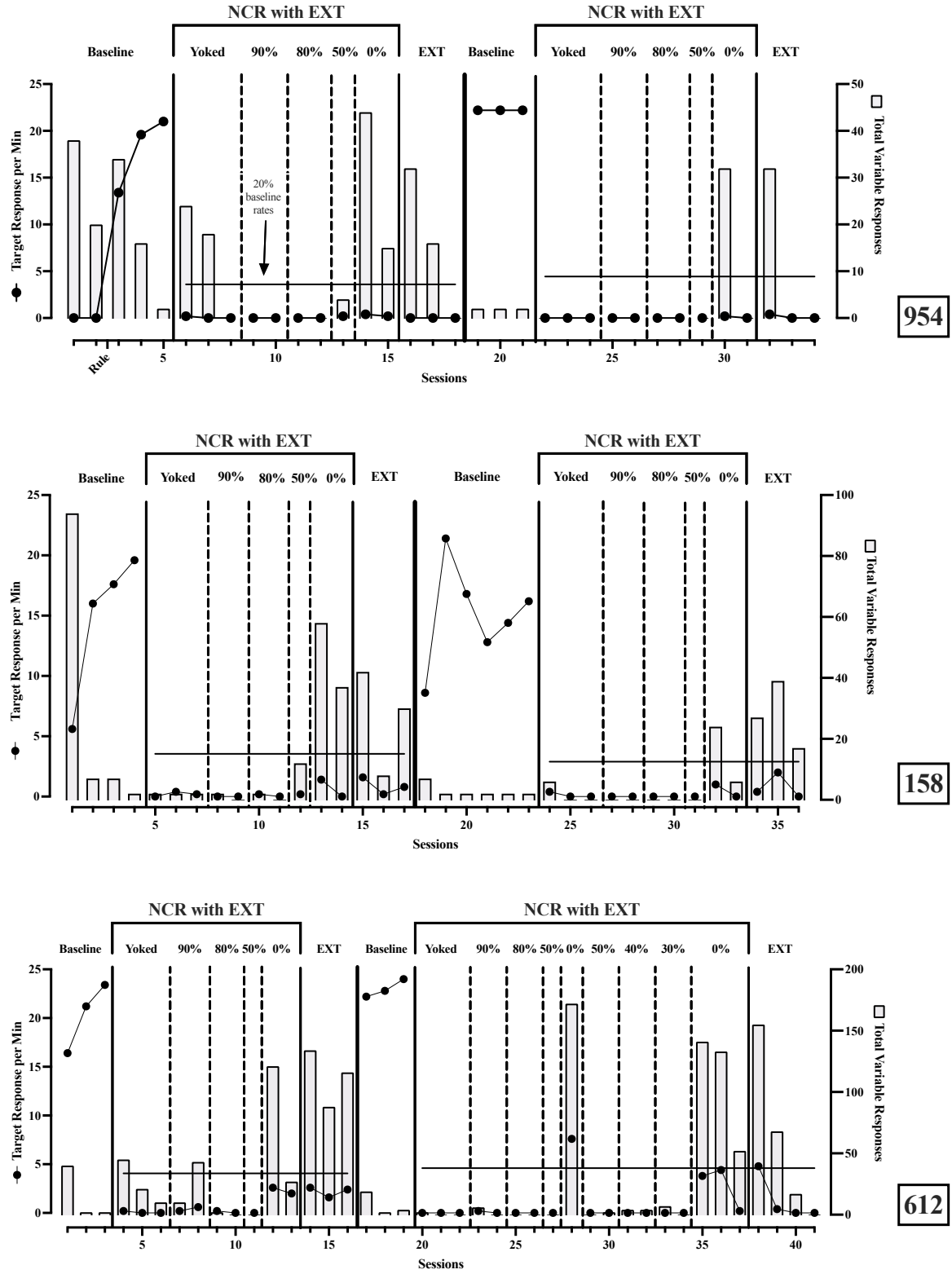


Figure 2:

NCR without EXT

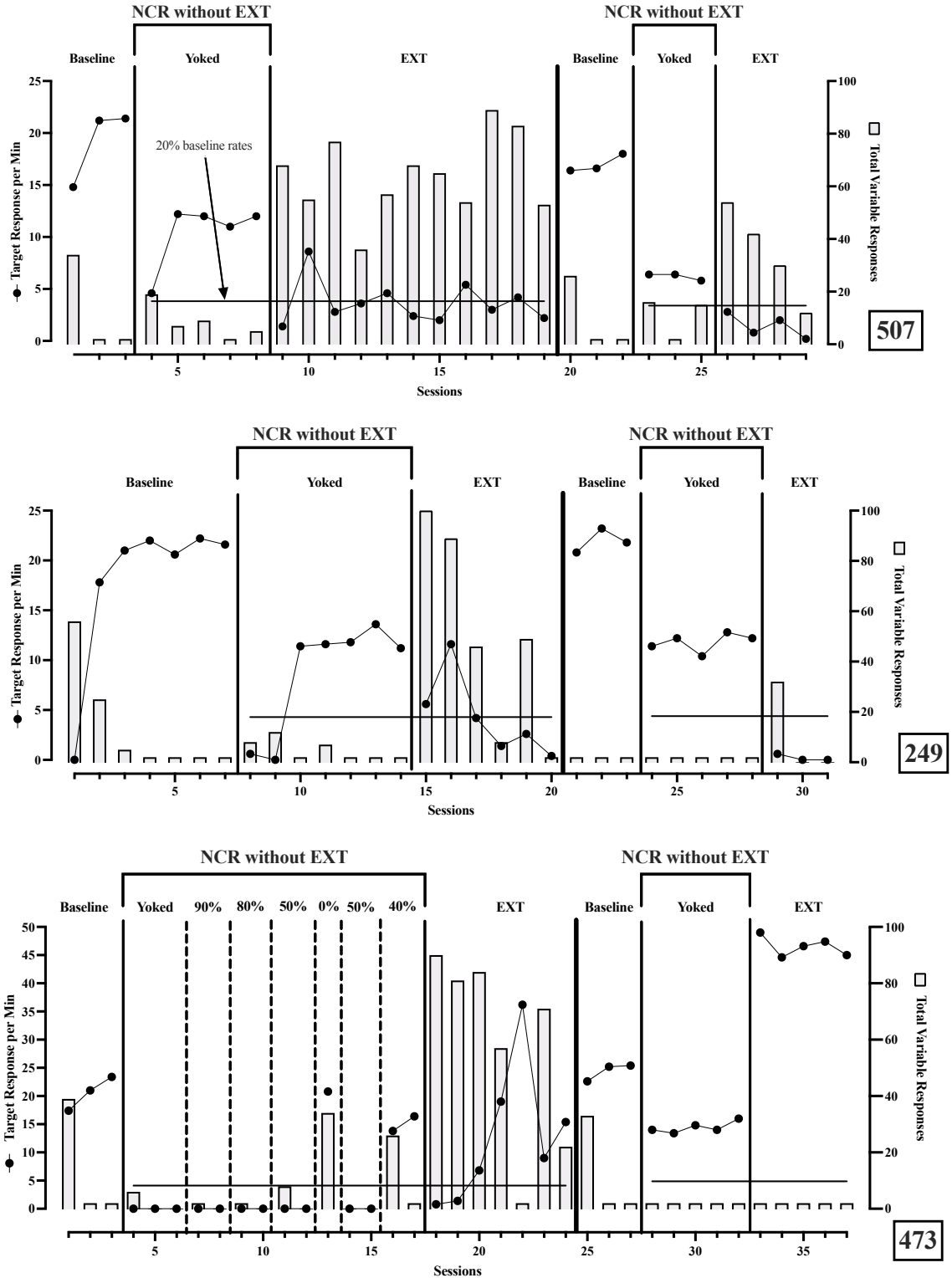


Figure 3:

Response Resurgence with EXT

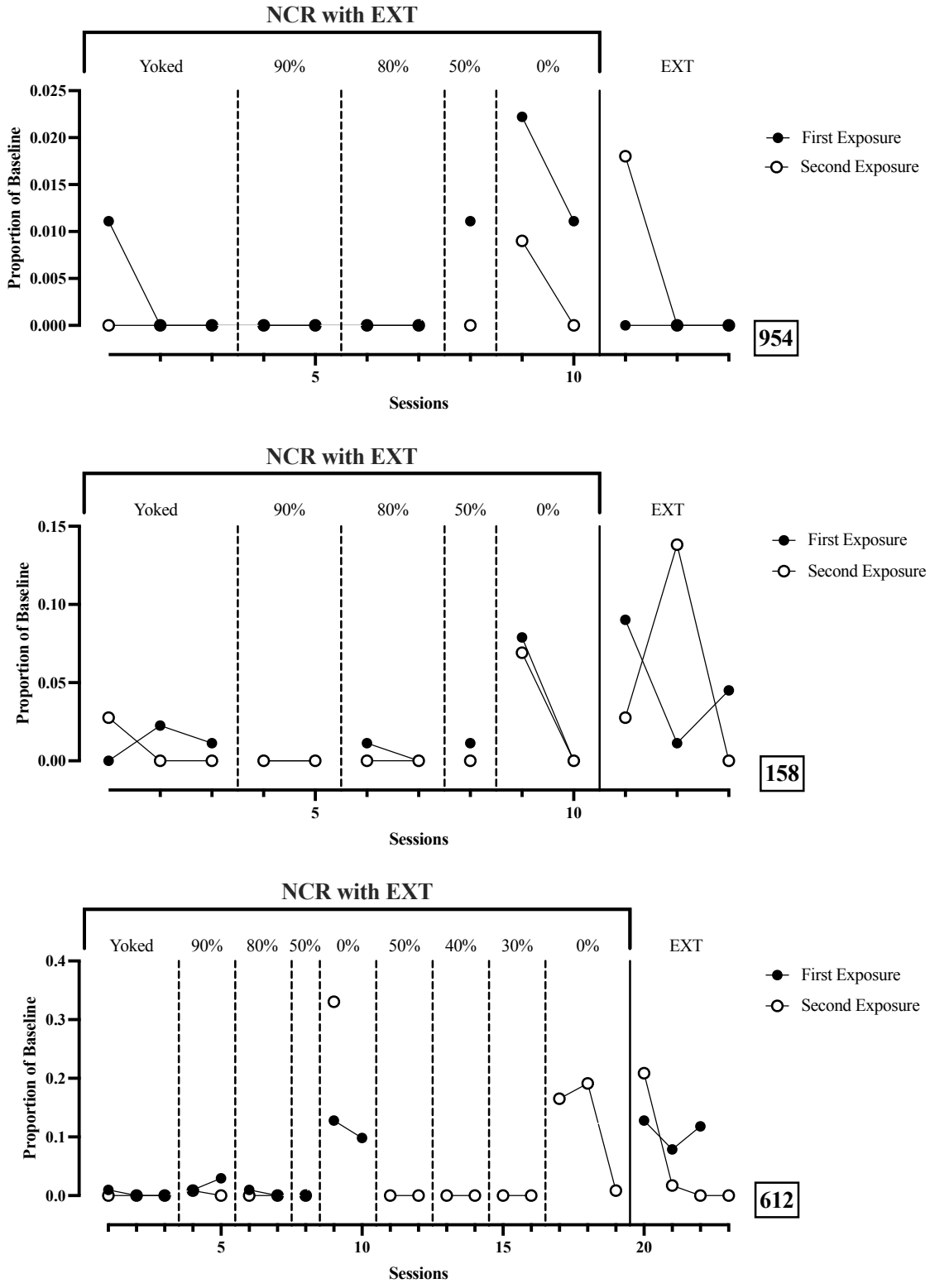
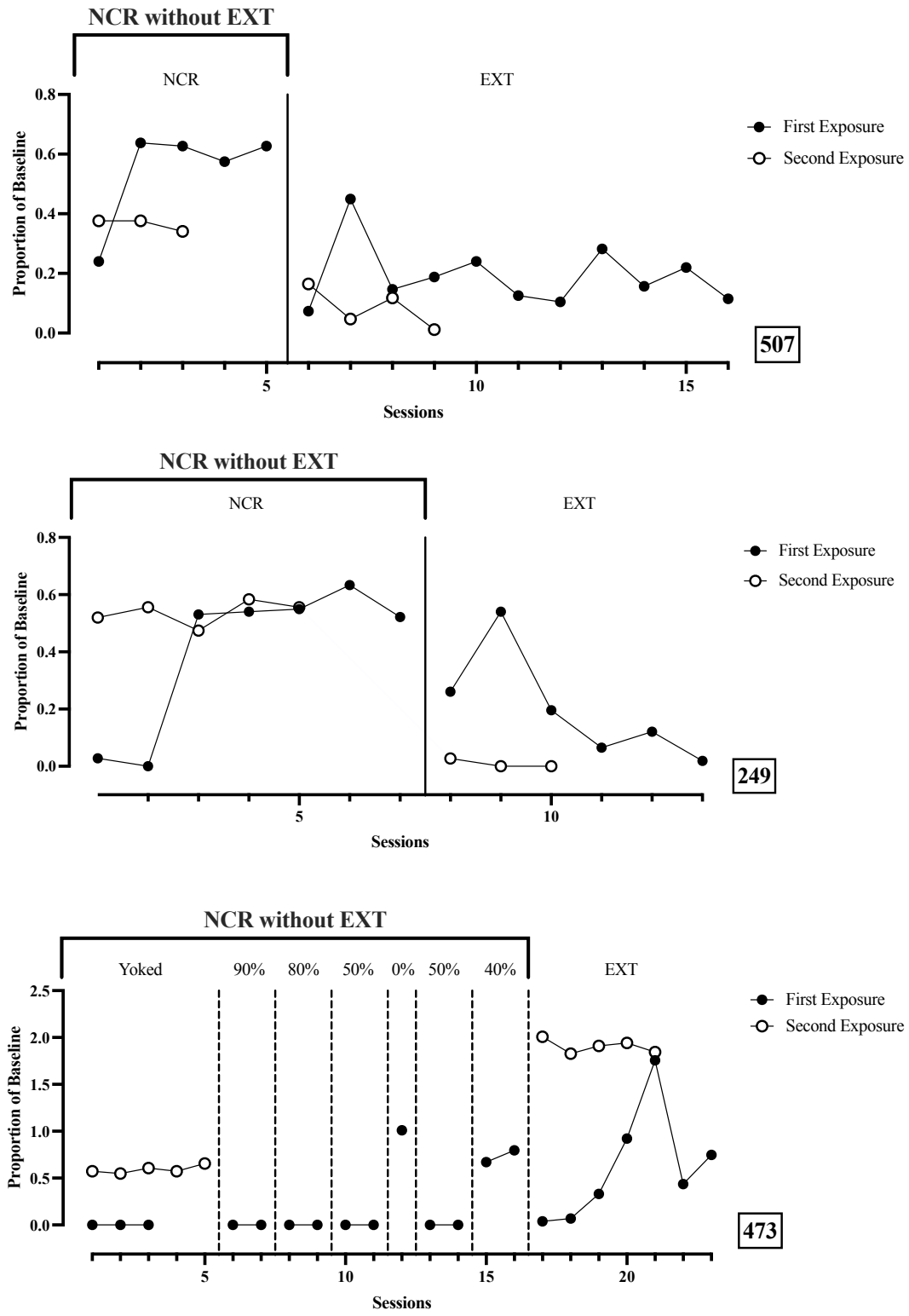


Figure 4:

Response Resurgence without EXT



Appendix A: Screen Layout