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THE EFFECTS OF FIXED-TIME REINFORCEMENT SCHEDULES ON FUNCTIONAL RESPONSE CLASSES: A TRANSLATIONAL STUDY

MEGAN R. HEINICKE, JAMES E. CARR, AND LINDA A. LEBLANC

AUBURN UNIVERSITY

Research on functional response classes has applied significance because less severe forms of problem behavior have been found to co-occur with more severe forms. In addition, the most severe forms of problem behavior are sometimes targeted for intervention without monitoring other less severe forms. In such cases, it is unknown whether and how untreated forms of problem behavior covary with the targeted behaviors. The present study employed a translational procedure (with button presses as the target behavior) to investigate response covariation under noncontingent reinforcement with typically developing preschoolers. The results indicated that noncontingent reinforcement was generally effective in decreasing all response class members when only one member was targeted.

Key words: fixed-time reinforcement, noncontingent reinforcement, positive reinforcement, response class, response covariation, translational research

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All response forms that are maintained by the same reinforcer are characterized as a response class (Catania, 1998). Response class members can include a wide variety of topographies and also may be related beyond their functional similarity such that a change in the probability of one response occurring subsequently changes the probability of other class members (i.e., response covariation; Parrish, Cataldo, Kolko, Neef, & Egel, 1986). Early studies that investigated the reduction of problem behavior reported observing unexpected covarying effects, both desirable and undesirable, on other untreated behaviors. For example, Sajwaj, Twardosz, and Burke (1972) targeted the excessive conversation initiations of a young boy with an intellectual disability and found that, as the target behavior decreased during extinction, both interactions with his peers (i.e., a desirable behavior) and disruptions (i.e., an undesirable behavior) increased, even though they were not targeted specifically for intervention. To detect findings like these, Willems (1974) suggested that, when targeting an individual's problem behavior for intervention, researchers should monitor other problem behaviors exhibited by the individual to assess response covariation during treatment, because the properties of this phenomenon are not well understood.

In subsequent years, a number of researchers have demonstrated that the probability of other response class members may change if the frequency of one or more members has been altered by intervention (e.g., E. G. Carr & Durand, 1985; Cataldo, Ward, Russo, Riordan, & Bennett, 1986; Horner & Day, 1991; Parrish et al., 1986; Russo, Cataldo, & Cushing, 1981; Shukla & Albin, 1996; Sprague & Horner, 1992). For example, Shukla and Albin (1996) provided a demonstration of response covariation with an adolescent boy with developmental disabilities who engaged in multiple topographies of problem behavior maintained by escape from instructional demands. The authors found that, when escape was concurrently available for less severe (e.g., pushing away task materials) and more severe

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Address correspondence to Megan R. Heinicke, Department of Psychology, 226 Thach Hall, Auburn University, Alabama 36849 (e-mail: mrh0013@tigermail.auburn.edu).

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(e.g., self-hitting, kicking others) topographies, the participant engaged in markedly higher rates of the less severe forms. However, when extinction was applied only to the less severe forms, the participant engaged in high rates of the more severe forms, and the less severe problem behavior was reduced to near-zero levels. Overall, this investigation confirmed that the other members of a response class might increase in frequency when a treatment (e.g., extinction in this case) is applied to some but not all class members.

Research on problem behaviors that occur in a response class has significant applied importance for three related reasons. First, less severe forms of problem behavior have been found to co-occur with other, more severe forms (e.g., Lalli, Mace, Wohn, & Livezey, 1995). Second, we suspect that when problem behaviors are treated typically, the response topography that is most severe is targeted for intervention first and other less severe topographies may not be evaluated simultaneously. Third, it might be necessary to understand the complexities of response classes and response covariation before designing treatments for individuals who engage in multiple topographies of severe problem behavior so that unintended results (i.e., increases in other untreated response class members) do not occur. For these reasons, and the fact that research on problematic response classes has remained relatively understudied, additional research is warranted.

Noncontingent reinforcement (NCR) is one of the most commonly studied and highly effective treatments for reducing the problem behavior of individuals with developmental disabilities (J. E. Carr, Severtson, & Lepper, 2009). In this intervention, the behavior's maintaining reinforcer is delivered on a response-independent basis (e.g., a fixed-time [FT] or variable-time schedule) while the target response is placed on extinction. This procedure is particularly desirable because the contingency between the problem behavior and the maintaining consequence is disrupted, but the individual still maintains some contact with the reinforcer. However, the application of NCR might result in unexpected or undesired treatment effects that require additional treatment if the problem behavior is a member of a response class. If the maintaining reinforcer is still available for other class members, responding might be allocated to such behaviors, especially if they result in immediate reinforcement when the target class member is placed on extinction. For example, if yelling out answers in a classroom is placed on extinction, a teacher might still provide immediate attention to a student who engages in other members of the same attention response class such as swiping task materials off a desk or kicking a classmate. This situation might be likely if the motivating operation (e.g., attention deprivation) for the maintaining reinforcer remains present, such as would be expected to occur under lean FT schedules. Conversely, the response-independent delivery of the maintaining reinforcer might be sufficient to suppress all members of the response class if reinforcer delivery is frequent enough to attenuate the motivating operation.

Researchers have addressed some concerns with the implementation of NCR to reduce problem behavior when the functional reinforcer is concurrently available for engaging in appropriate behavior. For example, Marcus and Vollmer (1996) superimposed differential reinforcement of alternative behavior (DRA) schedules onto FT schedules to treat the problem behavior of three young children with varying diagnoses including Down syndrome, profound intellectual disability, and autism. The authors found that mand acquisition was not disrupted by the time-based delivery of tangible reinforcers for all participants (i.e., a novel alternative behavior was not suppressed). Similarly, Goh, Iwata, and DeLeon (2000) found that mands were acquired when NCR was implemented concurrently with DRA schedules to treat the self-injurious behavior of two adult women who had been diagnosed with profound intellectual disability; however, mands increased only when the FT schedules had been thinned. Collectively, these two studies demonstrated that dense FT schedules that explicitly targeted problem behavior also suppressed another response class member (the mands). However, these mands were new to the response class and had a brief history of reinforcement (i.e., they were taught during the study). Thus, it is unknown whether FT schedules would suppress nontargeted class members with reinforcement histories similar to the target behavior.

Although research on problem response classes with clinical populations has great clinical importance, there are some barriers to research. To answer empirical questions about problem response classes, researchers must first have access to individuals with multiple response topographies that are functionally related. The prevalence of such cases is unknown. In addition, some class members may not have been emitted recently because other members of the response class have been successful at producing the maintaining reinforcer (i.e., latent class members may exist). Finally, it may not be feasible to delay treatment while conducting multiple functional analyses to ascertain the existence of a functional response class (a necessary prerequisite before treatment could be applied and systematically evaluated). However, translational research that involves either analogue or clinical populations with basic procedures (i.e., arbitrary rather than clinically important responses) may provide a solution for circumventing these challenges.

Shabani, Carr, and Petursdottir (2009) employed a translational model for studying response classes in which preschool-aged children were presented with a response panel of three buttons that each required a different amount of response effort to press. In the first phase of the study, presses on one button resulted in token or edible reinforcement and presses on the other buttons produced no programmed consequences. This concurrent schedule was implemented in subsequent phases, each time with a different button available for reinforcement. After presses on each button had been added systematically to the functional response class, reinforcement was then made concurrently available for all button presses; not surprisingly, responding was almost exclusively allocated to the lowest effort button, even though presses on the other buttons also produced reinforcement. Interestingly, the results of the investigation were consistent across participants with and without developmental disabilities. Mendres and Borrero (2010) recently and systematically replicated the Shabani et al. findings using a computer-based procedure with college students.

Shabani et al. (2009) and Mendres and Borrero (2010) developed novel translational procedures for generating functional response classes in readily available populations. These procedures were developed specifically to answer additional applied questions about response classes more expeditiously than under typical applied circumstances (e.g., obviating the need for pretreatment functional analysis). In addition, to our knowledge, no clinical studies of NCR have evaluated the effects of treatment implementation across a problem response class. Thus, the purpose of the present investigation was to utilize the Shabani et al. procedure to evaluate the covariation of response class members when only one class member was targeted for intervention using NCR. The specific experimental question was whether NCR would reduce both members of a two-response class when reinforcement remained available for one of them. Young children were selected as the participants because their relatively limited language repertoires likely increased the probability that their responding would come under contingency rather than rule control.

METHOD

Participants and Setting

Participants in the study included three typically developing girls (Marie, 5 years old;

Ann, 3 years old; Lynn, 4 years old) and one boy (Keith, 4 years old) who were recruited from a local day-care center. The children were reported to have normal language development by the director of the center and their parents. All participants complied with adult instructions throughout the study.

All sessions took place in a small room located in the participants' day-care center. In all sessions, the experimenter (the first author) sat next to the participant at a table. One other trained, independent observer (an undergraduate research assistant) was also present during a subset of sessions to collect treatment integrity data. All sessions lasted 5 min and were conducted one to three times per day, 3 to 5 days per week. Participants' total time commitment in the study ranged from 10 to 20 weeks and depended on their individual performance and availability.

Response Apparatus

The response apparatus consisted of three differently colored plastic buttons (12.7 cm) that were mounted laterally to a wooden response panel 15.2 cm from each other. The apparatus was placed 25.4 cm in front of the participant to equate the response effort of pressing each button. This distance allowed the participant to respond without requiring him or her to lean on the table and remained consistent over the course of the investigation. An initiation button was centered between the response panel and the participant (i.e., 12.7 cm from the edge of the table to the center of the button). The participant was required to press this button before pressing any of the buttons on the response panel. This initiation button was included to increase the interresponse times (IRTs) of the target behaviors and, in turn, decrease the likelihood that they would enter into response chains (Shabani et al., 2009). The experimenter also held a small button (i.e., the "reinforcer entry" button) that was pressed every time a tangible reinforcer was delivered. All buttons were connected to a USB interface (X-keys USB Switch Interface with a DB25 connector) that converted button presses into keyboard strokes on a laptop computer. The Behavioral Evaluation Strategy and Taxonomy (BEST) software was used to record the keyboard strokes for subsequent data analysis. Prior to each session, the apparatus, converter, and computer software were tested to ensure that the devices were functioning properly; no instances of malfunction were observed during the study.

Response Measurement

The primary dependent measure in this study was individual button presses per minute; these data were collected using the BEST software in real time as the child pressed each button (i.e., computer-automated data collection). Thus, no human interobserver agreement data were collected. In addition, BEST software collected data on the delivery of programmed consequences when the experimenter pressed the reinforcer entry button each time a putative tangible reinforcer was delivered.

Design

Characteristics of both reversal and concurrent-schedule designs were used in this study to demonstrate functional control. Using a reversal design, functional control was demonstrated by reversing experimental contingencies across phases (Kazdin, 2011). In addition, functional control was demonstrated within phases via the concurrent-schedules design by evaluating response allocation for both responses when simultaneous alternative schedules were in place for responding on the buttons (Poling, Methot, & LeSage, 1995).

Procedure

Preliminary procedures. Before experimental sessions, we conducted two multiple-stimulus without replacement (MSWO) preference assessments (DeLeon & Iwata, 1996). One assessment consisted of three arrays of five to eight small food items. The second assessment consisted of three arrays of putative secondary reinforcers (e.g., stickers, jewels, stamps). All stimuli were nominated by participants' parents as preferred and approved.

After preference assessments were completed, participants were given the opportunity to choose one of the three putative secondary reinforcers that were identified by the MSWO assessment as the most preferred prior to each 5-min session. The stimulus that was chosen was then delivered contingent on button pressing during that session (depending on the condition and schedule in place). In addition, participants were given the opportunity to choose one of the three food items that were identified as the most preferred from the food-item preference assessment at the end of sessions as a reward for working with the experimenter.

Experimental procedures. The participant was given an instruction to play with the buttons following an experimenter-delivered model of the response–reinforcer contingency in all but the FT phases of the study. The participant also was given an instruction to press the initiation button if he or she failed to do so before pressing the target buttons whenever that occurred. Sessions were terminated and data were discarded if the participant walked away from the apparatus or did not respond for 2 min. This occurred twice for Keith. If the participant walked away from the apparatus or stopped responding for less than 2 min, the session continued and data were included in data analysis.

Training. Prior to baseline, the participant was taught to press an initiation button that was placed directly in front of him or her immediately before pressing one of the other target buttons. Each time the initiation button was pressed during training, the experimenter prompted the participant to press one of the three other buttons in a quasirandom order. Training was conducted until participants correctly pressed the initiation button before pressing the target button when instructed by the experimenter to press a specific target button (e.g., "Show me how you press blue") for five consecutive trials.

Baseline. Before all baseline sessions, the participant was seated in front of the apparatus and given the instruction to begin pressing the buttons after a single model from the experimenter. No programmed consequences were delivered for responding. Baseline sessions were conducted until steady-state responding was observed (i.e., a minimum of three sessions with minimal variability between data points and no evidence of trend).

Response class training. Following baseline, all participants entered a response class training condition that included three phases. In the first phase, responding on the left button was immediately followed by the delivery of a programmed consequence (i.e., sticker, stamp) on a fixed-ratio (FR) 1 schedule and all responses on the right button were placed on extinction (conc FR 1 EXT). Similar to baseline, there were no programmed consequences for responding on the middle button, which served as a nonreinforcement control for potential automatic reinforcement properties of button pressing. In the next phase, the schedules of reinforcement for the left and right buttons were reversed (i.e., programmed consequences followed responding on the right button; conc EXT FR 1). In the third and final phase of training, responses on either the right or left button were immediately followed by the programmed consequence (conc FR 1 FR 1). Progression from one phase to the next occurred when steady-state responding was observed as described above.

Treatment evaluation. NCR manipulations began after the response class training phases ended. The first phase consisted of delivering putative secondary reinforcers on an FT schedule while placing the response with the highest rate of responding in the prior phase on extinction; this is the most common clinical form of NCR (FT plus EXT; J. E. Carr et al., 2009). Programmed consequences were delivered on an FR 1 schedule for responding on the other button (e.g., conc FR 1 EXT, FT 9 s). The initial FT schedule value was set at half of the mean IRT calculated from the button with the highest rate of responding in the prior condition. After stable responding was observed, the participant was exposed to the contingencies in the prior phase (i.e., conc FR 1 FR 1). After stable responding was observed in this condition, the experimenter implemented an additional condition in which secondary reinforcers again were delivered on an FT schedule, the response with the highest rate of responding in the prior phase was placed on extinction, and programmed consequences were delivered on an FR 1 schedule for responding on the other button (e.g., conc EXT FR 1, FT 11 s). The FT values were derived for this condition as described above.

Schedule thinning. For Lynn, schedule thinning was conducted during her final treatment evaluation phase. The goal of this procedure was to thin the FT schedule value to a maximum density of 5 min. The first three increases in the FT schedule values were set at a 100% increase from the prior value followed by 50% increases from the prior value (i.e., 10 s, 20 s, 40 s, 60 s, 90 s). If responding on the target button remained at or below 80% of the reduction from the final conc FR 1 FR 1 schedule (i.e., below 1.2 responses per minute) for three consecutive sessions, the FT schedule value increased the following session. If responding on the target button exceeded this value, the prior schedule value was reestablished; however, this never occurred. The schedule-thinning manipulation is analogous to schedule-thinning procedures that have been used in applied settings to further develop the utility of NCR as a manageable treatment for caregiver implementation (e.g., Kahng, Iwata, DeLeon, & Wallace, 2000).

Treatment Integrity

Treatment integrity data were collected on (a) accurate responding on the reinforcer entry button, (b) correct implementation of FR 1 schedules, (c) correct implementation of extinction schedules, and (d) correct implementation of FT schedules. Treatment integrity scores for responding on the reinforcer entry button were calculated by having an independent observer tally the number of programmed consequences that were delivered physically to the participant by the experimenter either during the session or via videotape. This number then was compared to the number of times the experimenter pressed the reinforcer entry button (recorded via BEST software). The lower count was divided by the higher count and converted to a percentage. This measure was conducted to lend credence to the remaining treatment integrity calculations, because an important part of the analysis was handled manually (e.g., the delivery of programmed consequences, implementation of extinction) and was necessary to prepare the data that were collected using BEST for the remaining treatment integrity analyses.

Because multiple contingencies were in place in each condition (e.g., conc FR 1 EXT, FT), treatment integrity was calculated separately for each contingency rather than analyzing each condition as a whole. The integrity scores for FR 1 schedules were calculated as the percentage of times the experimenter delivered the programmed consequence (determined via the reinforcer entry button) within 2 s of the participant pressing a button on an FR 1 schedule. The integrity scores for extinction schedules were calculated as the percentage of times the experimenter did not deliver the programmed consequence (determined by pressing the reinforcer entry button) within 2 s of the participant pressing a button on an extinction schedule. The integrity scores for extinction schedules are reported separately for phases with and without FT schedules. The integrity scores for FT schedules were calculated as the percentage of times the experimenter delivered the programmed consequence (determined by pressing the reinforcer entry button) within a 2-s window (i.e., 2 s before or 2 s after) of the specific FT schedule value (e.g., 10 s) elapsing.

All treatment integrity scores were averaged and reported per participant and were above discipline standards. Integrity of reinforcer entry was calculated for at least 74% of sessions with a minimum score of 96%. For FR 1 schedules, integrity was calculated for at least 63% of sessions with a minimum score of 94%. For extinction schedules, integrity was calculated for at least 33% of sessions when FT schedules were also in place and for at least 16% of sessions when FT schedules were not in place. Minimum scores for these calculations were 88% and 100%, respectively. For FT schedules, integrity was calculated for at least 95% of sessions with a minimum score of 90%.

RESULTS

Keith's data are depicted in Figure 1 (top). Throughout baseline, Keith did not respond on the button apparatus. In the first phase of response class training (conc FR 1 EXT),[1] he initially responded on all three buttons; however, by the third session he displayed high rates of responding on the button under the FR 1 schedule and low rates on both buttons that were placed on extinction. When the contingencies were reversed in the second phase of training (conc EXT FR 1), responding again was allocated to the button under the FR 1 schedule. In the last phase of training (conc FR 1 FR 1), he continued to display high rates of responding on the button that was under the FR 1 schedule in the prior phase even though programmed consequences were delivered immediately following responding on both buttons. In the first phase of the treatment evaluation (conc FR 1 EXT, FT 9 s), the button associated with the highest rates in the previous condition was targeted for intervention. Presses on that button were placed on extinction and an FT 9-s schedule was implemented. Responding on all buttons in this phase immediately decreased to zero and remained stable even though programmed consequences remained available for responding on the other "untreated" button. When both buttons were placed on FR 1 schedules in the next phase (conc FR 1 FR 1), responding again was allocated to the same button that had been targeted previously for intervention. Finally, when the same button was targeted for intervention again in the final phase (conc FR 1 EXT, FT 10 s), there was evidence of a brief period of persistence on the button under extinction before responding decreased to near-zero levels on all buttons.

Ann's data are depicted in Figure 1 (bottom). No buttons were pressed during her initial baseline sessions. During the first phase in the response class training condition (conc FR 1 EXT), she engaged in high levels of responding on the button under the FR 1 schedule and near-zero levels of responding on the other buttons. During the contingency reversal phase of training (conc EXT FR 1), she began to respond reliably in a rapid chain of pressing the left (EXT), middle (EXT), and right (FR 1) buttons. In an effort to circumvent chaining by slowing down her responding, the experimenter provided Ann with the rule, "Before you press the buttons, you should think about which button you want to press [3-s pause] and then press it. Then you should think about the next one you want to press [brief 3-s pause] and then press it," and also provided a model of responding that corresponded with the rule. However, neither this presession manipulation nor the provision of a model of a nonexemplar of the rule in the subsequent session had an effect on Ann's pattern of behavior. The experimenter then began to verbally prompt five trials of pressing the button under the FR 1 schedule prior to beginning sessions (i.e., the experimenter said "Press the blue button"). This presession manipulation proved to disrupt Ann's pattern of chaining, and she began to

[1] Because presses on the middle (control) button never resulted in reinforcer delivery, its schedule designation (EXT) is omitted from all references to the concurrent schedule in the remainder of the article and figures. The concurrent-schedules designation refers to the schedules for the left and right buttons, respectively. Superimposed FT schedules are also designated in treatment evaluation phases.

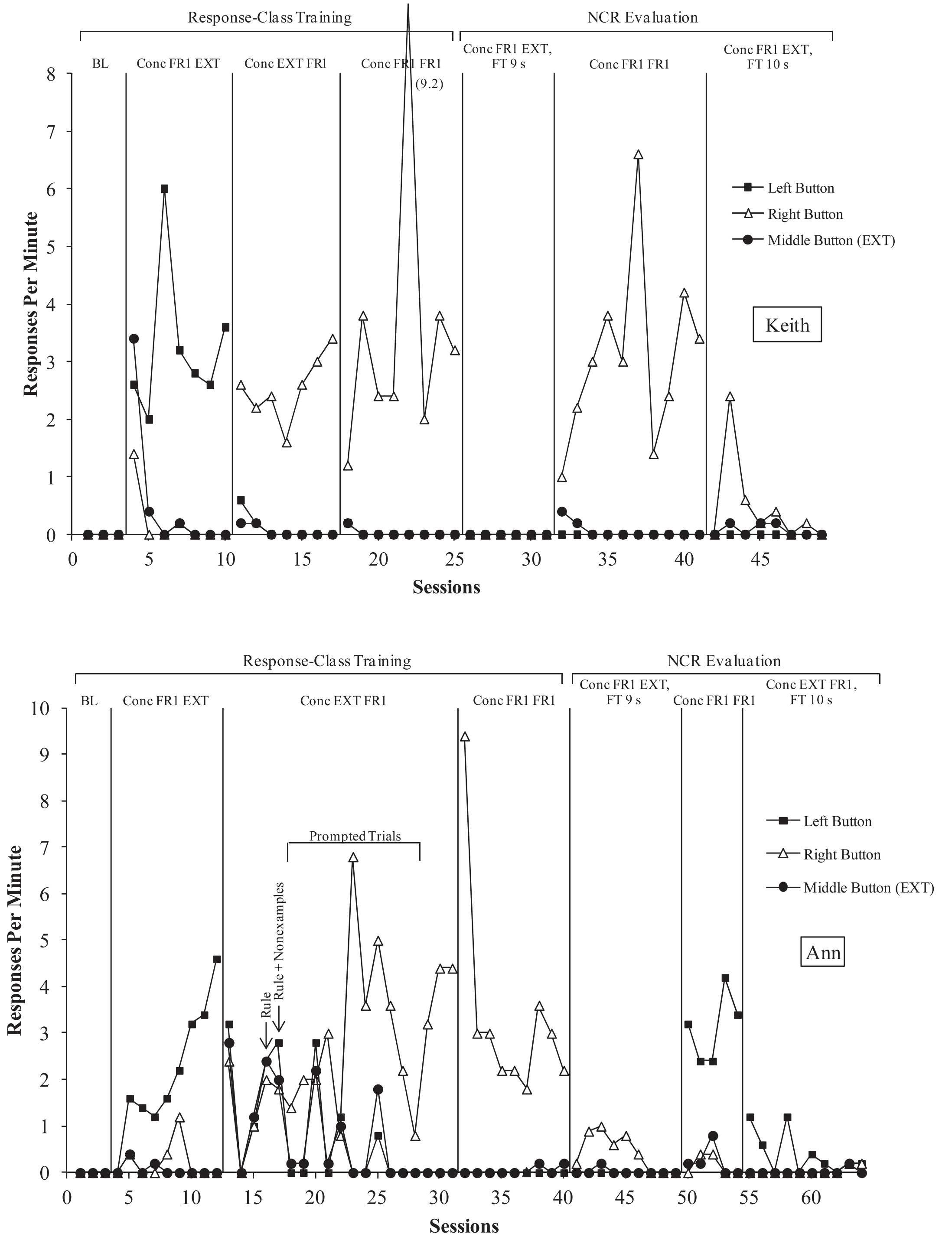

Figure 1. Results for Keith (top panel) and Ann (bottom panel), depicted as responses per minute on the left, right, and middle buttons. Phase labels refer to the concurrent schedule in place for the left and right buttons, respectively. Middle-button presses were placed on extinction throughout the study.

respond at high rates on the button under the FR 1 schedule. The presession prompts were removed for the last three sessions in this phase, and responding remained stable with no evidence of chaining.

In the last phase of the response class training condition (conc FR 1 FR 1), Ann continued to engage in high rates of responding on the button that had been under the FR 1 schedule in the previous phase. During the first treatment phase (conc FR 1 EXT, FT 9 s), there was evidence of a brief period of persistence on the right button before responding decreased to near-zero levels on all buttons. When both buttons were again available for the delivery of programmed consequences (conc FR 1 FR 1), she began to respond at high rates on the button that had been left untreated (FR 1) in the previous treatment evaluation phase. After responding stabilized, responding on this button was targeted in the final phase (conc EXT FR 1, FT 10 s). Similar to her previous treatment phase, there was evidence of a brief period of persistence on the button under extinction; however, all buttons were pressed at near-zero levels near the end of the phase.

Lynn's data are depicted in Figure 2 (top). She initially responded at very high rates in baseline; however, responding ceased after five sessions for the remainder of the phase (with the exception of Session 11). At the beginning of the first response class training phase (conc FR 1 EXT), she showed evidence of chaining, similar to Ann. However, when the presession manipulation of five prompted trials was implemented, this pattern of behavior was no longer evident and remained so even when the manipulation was removed for three sessions. Toward the end of the phase, responses were allocated almost exclusively to the button under the FR 1 schedule. During the subsequent phase (conc EXT FR 1), responding was, again, allocated almost exclusively to the button under the FR 1 schedule. However, due to the emergence of a response chain in Session 38, presession prompted trials were instituted before Session 39. These trials appeared to disrupt the chain and were no longer needed again in the phase.

In the subsequent conc FR 1 FR 1 condition, Lynn responded at high rates on the button that had been under the FR 1 schedule in the previous phase. When this button was targeted for intervention in the first treatment phase (conc FR 1 EXT, FT 4 s), her responding quickly decreased to near-zero levels on all buttons even though programmed consequences were available for responding on the other, untreated button. When programmed consequences were again available for responding on both buttons (conc FR 1 FR 1), she once more responded at higher rates on the right button that had been treated in the previous phase, although low levels of responding were observed on the left button (also under FR 1). When this button was targeted for a second time in her final treatment phase (conc FR 1 EXT, FT 5 s), Lynn's responding quickly decreased to near-zero levels on all buttons and remained low as the FT schedule was thinned from 5 s to 90 s. When the FT value reached 90 s, an FT value of 5 min was probed (i.e., only one programmed consequence was delivered at the end of the session), and responding remained at zero. Two final sessions were conducted using the maximum FT value of 5 min, and responding remained stable.

Marie's data are depicted in Figure 2 (bottom). She engaged in low levels of responding during baseline, and responding generally was allocated to the button under the FR 1 schedule in the first two response class training phases (conc FR 1 EXT, conc EXT FR 1). When programmed consequences were available for responding on both buttons in the last phase of training (conc FR 1 FR 1), she responded on both buttons, although her responding was higher for one button than the other. Unlike the other implementations of NCR in the study, Marie's responding was allocated to the button under the FR 1 schedule during her first treatment implementation

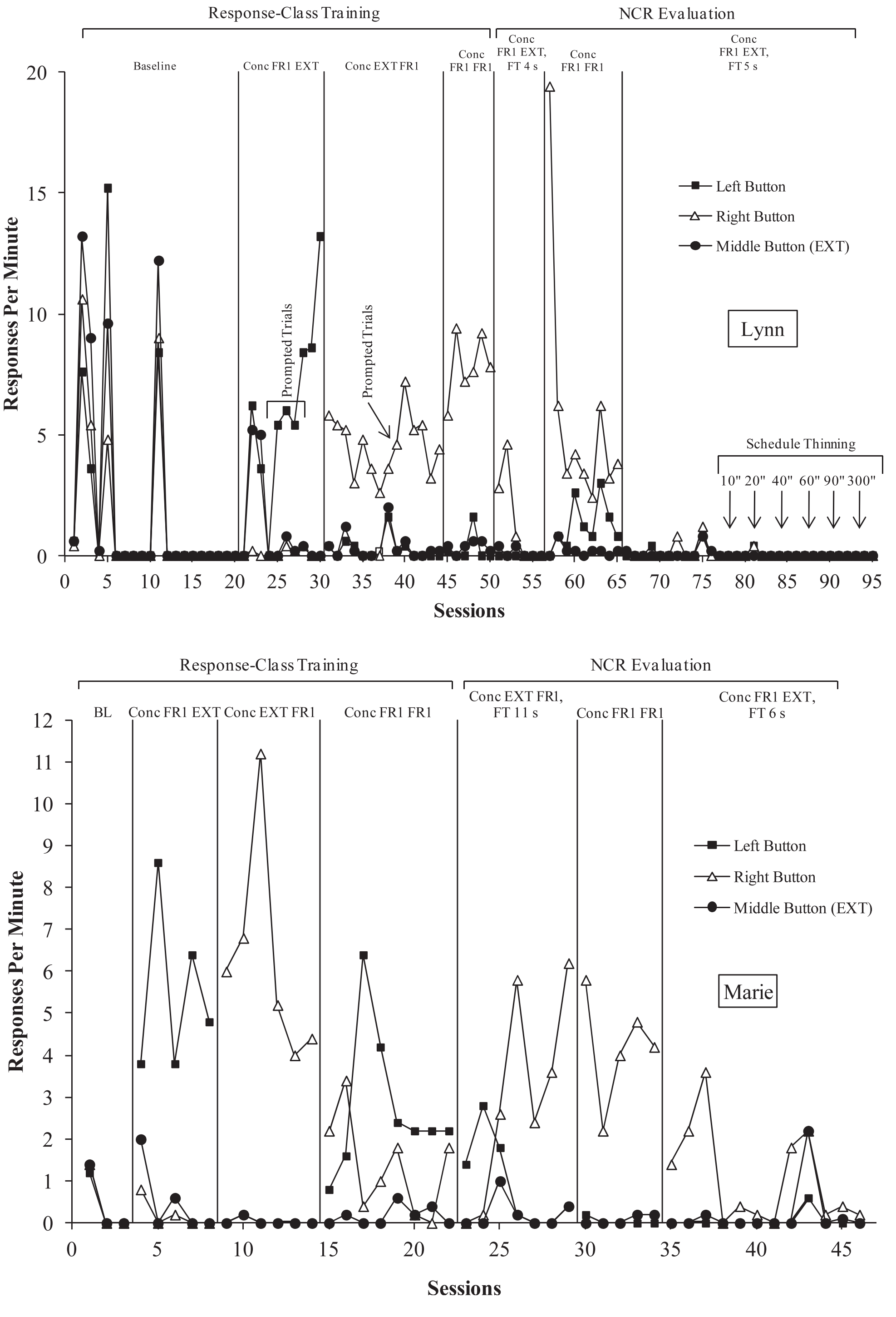

Figure 2. Results for Lynn (top panel) and Marie (bottom panel), depicted as responses per minute on the left, right, and middle buttons. Phase labels refer to the concurrent schedule in place for the left and right buttons, respectively. Middle-button presses were placed on extinction throughout the study.

(conc EXT FR 1, FT 11 s). That is, when responding on the left button was placed on extinction and an FT 11-s schedule was in place, she accessed additional reinforcers by responding on the untreated right button. When programmed consequences were available once again for responding on both buttons (conc FR 1 FR 1), she began to respond exclusively on the button that had been reinforced in the previous phase. During the final treatment implementation (conc FR 1 EXT, FT 6 s), there was evidence of a brief period of persistence on the button under extinction before responding decreased on the right button and generally remained low on all buttons for the remainder of the phase. Interestingly, during this phase, Marie came into contact with reinforcement by responding on the left button (FR 1) during Session 43; however, that single contact did not result in increased response rates.

Figure 3 depicts summary data for both evaluations completed by all four participants. Specifically, the top panel depicts the mean change in response rate for the target response during each NCR evaluation from the preceding (conc FR 1 FR 1) phase, and the bottom panel depicts the mean change in response rate for the untreated responses (with error bars set at one standard deviation). Both panels suggest that NCR was effective in suppressing the response class member that was targeted for intervention as well as the class member that remained untreated (i.e., when reinforcement was still available). However, the rate of the untreated class member did increase in the first treatment evaluation for Marie (Figure 3, bottom).

DISCUSSION

The main purpose of this investigation was to extend a small but growing line of translational research on operant response classes by evaluating the effects of NCR (via FT schedules) on a response class member for which reinforcement was still available. The results suggest that NCR may be a generally effective procedure for suppressing a response class when it is used to treat its most frequently occurring member, even when the maintaining reinforcer is still available for engaging in another class member. In addition, the FT value for Lynn was thinned systematically from 5 s to 5 min following her final treatment implementation, and responding remained at near-zero levels throughout this procedural manipulation. However, one NCR treatment implementation for Marie was associated with an increase in the rate of the untreated response class member.

Two behavioral mechanisms proposed for the effects of NCR should be considered to explain the results of this investigation. Kahng, Iwata, Thompson, and Hanley (2000) proposed that NCR sometimes operates via extinction because the response–reinforcer contingency is disrupted under NCR. Alternatively, the motivating operation hypothesis states that the reductive effects of NCR occur because the FT delivery of many reinforcers weakens the reinforcer's overall value. In the present evaluation, it seems that the global effects of NCR (i.e., the decreases in both the targeted and untreated response class members) can be explained parsimoniously using the motivating operation hypothesis rather than by appealing to the effects of extinction. Extinction was applied to a targeted response in each treatment implementation, but it was not applied to the untreated response. Therefore, some participants' behavior (e.g., Lynn) did come into contact with the maintaining reinforcer for engaging in the untreated response during treatment implementation, yet the overall rate of all response class members decreased (except during Marie's first implementation).

The behavioral mechanisms proposed by Kahng, Iwata, Thompson, et al. (2000) also may account for the one case in this study in which an increase was observed in the untreated response. In this case, Marie may have responded

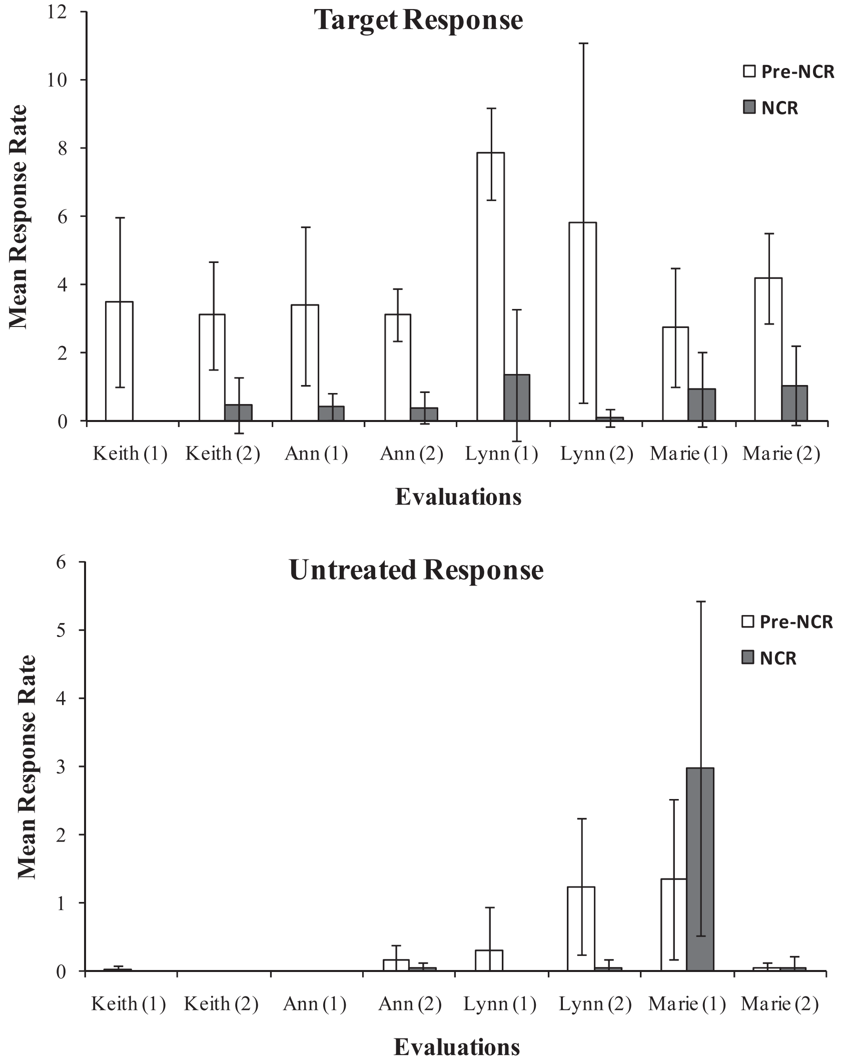

Figure 3. Mean changes in response rate (responses per minute) for both the target (top panel) and untreated (bottom panel) response during each NCR evaluation. Error bars are set at one standard deviation.

initially on the untreated button due to extinction-induced variability. Her continued responding on the untreated button also may be explained in light of the motivating operation hypothesis, in that the FT schedule (i.e., FT 11 s) may not have been dense enough to weaken the value of the reinforcer. The FT schedule value in Marie's second treatment implementation (i.e., FT 6 s), in which a global effect of NCR was demonstrated, was almost twice as dense as the value in her first treatment implementation.

The one case of an increase on the untreated button also may be explained in light of the probability of programmed consequence deliveries. One method that can be used to evaluate this possibility is to conduct a comparative probability analysis to identify the contingency strength for responding on the untreated button (Vollmer, Borrero, Wright, Van Camp, & Lalli, 2001). In this analysis, the conditional probability refers to how likely a certain environmental event is to follow the occurrence of a behavior. This is calculated by dividing the number of occurrences of a certain behavior that was followed by an environmental event given a certain consequence window (e.g., 3 s) by the number of occurrences of that same behavior in a specified observation window (e.g., 5 min). The response-independent probability refers to how frequently a certain environmental event is delivered independent of responding (i.e., not contingent on the occurrence of a behavior). This probability is calculated by dividing the number of environmental events that did not follow occurrences of a certain behavior given a specified consequence window by the overall number of environmental events that occurred during a specified observation window. If, by comparison, the conditional probability is greater than the response-independent probability, support would exist for a potential positive contingency (i.e., the conditions exist for reinforcement to occur).

For the current study, conditional and response-independent probability analyses were conducted for six sessions in Marie's first treatment implementation using a 3-s consequence window. Although selecting the value of consequence windows for this type of probability analysis is always somewhat arbitrary (e.g., Hammond, 1980), a 3-s window was selected due to the density of the FT schedules (e.g., FT 5 s). The analysis was not conducted for the first session in this phase because no responding occurred on the untreated button. For the second session (Session 29) in Marie's treatment implementation, the conditional and response-independent probabilities were calculated to be close to the same value (i.e., 1 and .95, respectively), indicating that there was a potential neutral contingency for this session (i.e., it is unlikely that conditions were present for the delivery of a programmed consequence to maintain responding on the untreated button). However, conditional probabilities were higher than response-independent probabilities for the remaining five sessions in the treatment phase (e.g., calculations of .89 and .55, respectively, for the final session in the phase), indicating that there was a potential positive contingency for five of the seven sessions. That is, the comparative probability analysis lends support to the speculation that Marie may have continued to respond on the untreated button because the conditional probability for doing so was higher than the response-independent probability for accessing reinforcers via the FT schedule.

A few limitations should be considered when evaluating the results of the current investigation. First, some potential transition effects may have occurred when participants entered treatment implementation phases from the immediately preceding phase. Specifically, presses on the button that was available for reinforcement in treatment phases (i.e., the untreated response) might not have been occurring in the previous phase (i.e., under the conc FR 1 FR 1 schedule) in which responding on both buttons was followed immediately by the delivery of a programmed consequence. This pattern of responding may have emerged due to the extinction schedule that was in place for one of the buttons in the previous response class training phase (e.g., conc EXT FR 1 schedule). Alternatively, this pattern of responding under a conc FR 1 FR 1 schedule may have emerged due to the maximization phenomenon that has been observed both in basic (e.g., Herrnstein, 1970) and applied (e.g., Fisher et al., 1992) research when concurrent responses are reinforced on ratio schedules. Therefore, it is possible that the low rate of responding on the untreated button in the treatment evaluation phase may have carried over from the previous phase, making it difficult to determine if the reductive effects of NCR or potential carryover effects were responsible for the low rates of responding observed in the treatment evaluation phases. In reviewing the results of the study, this potential transition effect may have occurred in five of the eight treatment evaluations. However, participants did come into contact with reinforcement for the untreated response in two of these five cases, and their contact with reinforcement did not have differential effects on the outcome of NCR compared to other participants.

Another limitation of the current investigation is that the durability of behavior change over time in each phase is unknown. The phases in this study were kept relatively brief due both to the participants' ages and to aid in maintaining the value of the secondary reinforcers delivered for button pressing (e.g., stickers, stamps). Lastly, the schedule-thinning manipulation for the FT schedules was conducted only for one of the treatment implementations with one of the four participants (Lynn). During this manipulation, Lynn's responding on the untreated button remained at near-zero levels. However, Goh et al. (2000) found that all three participants in their investigation acquired mands during schedule thinning (i.e., the rate of another response class member increased). Therefore, it may be the case that the untreated class member did not reappear during schedule thinning for Lynn due to the relatively similar reinforcement histories for all class members. Alternatively, Lynn may not have responded on the untreated button during the schedule-thinning manipulation due to use of a covert rule to wait for the time-based delivery of the reinforcer. Anecdotally, Lynn said "I am waiting" to the experimenter during two of the sessions in which the FT schedule was set at 300 s.

There seems to be utility in developing future investigations using translational models in this area to aid both researchers and clinicians in understanding the complexities of response classes and response covariation. Similar to the study conducted by Mendres and Borrero (2010), it might prove valuable to replicate the current investigation using response classes that are maintained by negative reinforcement, because the most prevalent reinforcement function of problem behavior of individuals with developmental disabilities is social negative reinforcement (e.g., Iwata et al., 1994). In addition, applying NCR to an apparatus with differentially effortful responses (similar to Shabani et al., 2009) would be ecologically valid because problem-behavior response classes are sometimes hierarchically related based on response effort (e.g., Lalli et al., 1995). It also may prove valuable to replicate the current study using intermittent reinforcement schedules, because the patterns in response class training in the current investigation may have been an artifact of using FR 1 schedules, and the observed patterns may have affected responding in subsequent treatment evaluation phases.

It also seems beneficial to extend the present study to evaluate NCR without extinction. Although NCR has been implemented concurrently with extinction in the majority of empirical investigations in the area of developmental disabilities (J. E. Carr et al., 2009), gaining a greater understanding of the necessity of extinction in NCR procedures might benefit clinicians who sometimes are faced with problem behavior that cannot be placed on extinction. Finally, the effects of additional treatments on response classes that have been shown to be highly effective in reducing problem behavior in applied settings (e.g., differential reinforcement of other behavior, functional communication training [FCT]) may be evaluated using translational models. Specifically, for FCT, it may be valuable to evaluate whether different reinforcement histories of response class members have an effect on the acquisition of mands when NCR is implemented concurrently. This may provide clinicians with better knowledge of the necessity of schedule-thinning procedures when using NCR in conjunction with FCT. That is, it may not be necessary to thin the FT schedule before strengthening an appropriate behavior if the mand was previously in a client's repertoire, whereas schedule thinning may be necessary if the mand required in FCT is novel (as demonstrated by Goh et al., 2000).

Of course, the most valuable extension of the present investigation might be a systematic replication with individuals (with or without developmental disabilities) who engage in actual problem behavior. Unlike the current investigation, members of a true problem response class may have different histories of reinforcement, may require varying amounts of effort, and may be maintained by other sources of reinforcement. The current procedure also used a continuous reinforcement schedule; however, in real-world settings, problem behaviors likely are reinforced on an intermittent basis.

A preliminary clinical implication from the current investigation is worth noting. It may be that under similar parameters (i.e., response classes maintained by positive reinforcement, NCR with similarly derived FT schedules), NCR may act as a global treatment for response class members that are not targeted directly for intervention. This implication may have significance for practitioners, because the most frequently occurring or most intensive problem behavior may often be targeted for intervention without identifying and targeting all other potential class members. In other words, the results appear to support current practice. Although this clinical implication does seem viable, systematic replications of this investigation are warranted to evaluate the finding's reliability and generality.

REFERENCES

Carr, E. G., & Durand, V. M. (1985). Reducing behavior problems through functional communication training. *Journal of Applied Behavior Analysis*, *18*, 111–126.

Carr, J. E., Severtson, J. M., & Lepper, T. L. (2009). Noncontingent reinforcement is an empirically supported treatment for problem behavior exhibited by individuals with developmental disabilities. *Research in Developmental Disabilities*, *30*, 44–57.

Cataldo, M. F., Ward, E. M., Russo, D. C., Riordan, M., & Bennett, D. (1986). Compliance and correlated problem behavior in children: Effects of contingent and non-contingent reinforcement. *Analysis and Intervention in Developmental Disabilities*, *6*, 265–282.

Catania, A. C. (1998). *Learning* (4th ed.). Upper Saddle River, NJ: Prentice Hall.

DeLeon, I. G., & Iwata, B. A. (1996). Evaluation of a multiple-stimulus presentation format for assessing reinforcer preference. *Journal of Applied Behavior Analysis*, *29*, 519–532.

Fisher, W., Piazza, C. C., Bowman, L. G., Hagopian, L. P., Owens, J. C., & Slevin, I. (1992). A comparison of two approaches for identifying reinforcers for persons with severe and profound disabilities. *Journal of Applied Behavior Analysis*, *25*, 491–498.

Goh, H., Iwata, B. A., & DeLeon, I. G. (2000). Competition between noncontingent and contingent reinforcement schedules during response acquisition. *Journal of Applied Behavior Analysis*, *33*, 195–205.

Hammond, L. J. (1980). The effect of contingency upon the appetitive conditioning of free-operant behavior. *Journal of the Experimental Analysis of Behavior*, *34*, 297–304.

Herrnstein, R. J. (1970). On the law of effect. *Journal of the Experimental Analysis of Behavior*, *13*, 243–266.

Horner, R. H., & Day, H. M. (1991). The effects of response efficiency on functionally equivalent competing behaviors. *Journal of Applied Behavior Analysis*, *24*, 719–732.

Iwata, B. A., Pace, G. M., Dorsey, M. F., Zarcone, J. R., Vollmer, T. R., Smith, R. G., et al. (1994). The functions of self-injurious behavior: An experimental-epidemiological analysis. *Journal of Applied Behavior Analysis, 27,* 215–240.

Kahng, S., Iwata, B. A., DeLeon, I. G., & Wallace, M. D. (2000). A comparison of procedures for programming noncontingent reinforcement schedules. *Journal of Applied Behavior Analysis*, *33*, 223–231.

Kahng, S., Iwata, B. A., Thompson, R. H., & Hanley, G. P. (2000). A method for identifying satiation versus extinction effects under noncontingent reinforcement schedules. *Journal of Applied Behavior Analysis*, *33*, 419–432.

Kazdin, A. E. (2011). *Single-case research designs: Methods for clinical and applied settings* (2nd ed.). New York, NY: Oxford University Press.

Lalli, J. S., Mace, F. C., Wohn, T., & Livezey, K. (1995). Identification and modification of a response-class hierarchy. *Journal of Applied Behavior Analysis*, *28*, 551–559.

Marcus, B. A., & Vollmer, T. R. (1996). Combining noncontingent reinforcement and differential reinforcement schedules as treatment for aberrant behavior. *Journal of Applied Behavior Analysis*, *29*, 43–51.

Mendres, A. E., & Borrero, J. C. (2010). Development and modification of a response class via positive and negative reinforcement: A translational approach. *Journal of Applied Behavior Analysis*, *43*, 653–672.

Parrish, J. M., Cataldo, M. F., Kolko, D. J., Neef, N. A., & Egel, A. L. (1986). Experimental analysis of response covariation among compliant and inappropriate behaviors. *Journal of Applied Behavior Analysis*, *19*, 241–254.

Poling, A., Methot, L. L., & LeSage, M. G. (1995). *Fundamentals of behavior analytic research*. New York, NY: Plenum.

Russo, D. C., Cataldo, M. F., & Cushing, P. J. (1981). Compliance training and behavioral covariation in the treatment of multiple behavior problems. *Journal of Applied Behavior Analysis*, *14*, 209–222.

Sajwaj, T., Twardosz, S., & Burke, M. (1972). Side effects of extinction procedures in a remedial preschool. *Journal of Applied Behavior Analysis*, *5*, 163–175.

Shabani, D. B., Carr, J. E., & Petursdottir, A. I. (2009). A laboratory model for studying response-class hierarchies. *Journal of Applied Behavior Analysis*, *42*, 105–121.

Shukla, S., & Albin, R. W. (1996). Effects of extinction alone and extinction plus functional communication training on covariation of problem behaviors. *Journal of Applied Behavior Analysis*, *29*, 565–568.

Sprague, J. R., & Horner, R. H. (1992). Covariation within functional response classes: Implications for treatment of severe problem behavior. *Journal of Applied Behavior Analysis*, *25*, 735–745.

Vollmer, T. R., Borrero, J. C., Wright, C. S., Van Camp, C., & Lalli, J. S. (2001). Identifying possible contingencies during descriptive analyses of severe behavior disorders. *Journal of Applied Behavior Analysis*, *34*, 269–287.

Willems, E. P. (1974). Behavioral technology and behavioral ecology. *Journal of Applied Behavior Analysis*, *7*, 151–165.

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