The Effects of Fixed-Time Reinforcement Schedules on Functional Response Classes: A Translational Study

by

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Abstract

Research on functional response classes has applied significance because less severe forms of problem behavior have been found to co-occur with other, more severe forms. In addition, the most severe forms are often targeted for intervention without monitoring other less severe forms. Past research has demonstrated that response covariation may occur following treatment in individuals with developmental disabilities. Recently, researchers have used translational research preparations to investigate the covariation of response-class members. The purpose of the present study was to assess covariation in response classes when one class member was targeted for intervention while other members were left untreated using fixed-time schedules of reinforcement, as this treatment is common in both research and practice. Results generally indicated that noncontingent reinforcement was effective in decreasing all response-class members when only one member was targeted. Understanding the behavioral mechanisms responsible for covariation may aid clinicians in developing more effective and efficient treatments.

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List of Abbreviations

BEST	Behavioral Evaluation and Strategy Taxonomy
DRO	Differential Reinforcement of Other Behavior
EXT	Extinction
FR	Fixed-Ratio
FT	Fixed-Time
IRT	Inter-Response Time
MSWO	Multiple Stimulus without Replacement
NCR	Noncontingent Reinforcement
SIB	Self-Injurious Behavior
TI	Treatment Integrity

Introduction

Response Classes and Response Covariation

All response forms that are maintained by the same operant consequence are characterized as a response class (Catania, 1998). Although all members of a response class are functionally similar, class members can include a wide variety of topographies. For example, in a classroom setting, a student may receive attention from his teacher by engaging in appropriate classroom behavior (e.g., raising his hand, answering a question correctly) as well as by engaging in problem behavior (e.g., kicking a classmate, engaging in self-injurious behavior [SIB]). Furthermore, members of a response class may be related beyond their functional similarity such that a change in the probability of one response subsequently changes the probability of other class members. For example, if one problem behavior is placed on extinction (e.g., kicking a classmate) and this response decreases in frequency, another problem behavior belonging to the same response class (e.g., SIB) might subsequently increase in frequency. This interdependent relation between members of a response class is termed response covariation (Parrish, Cataldo, Kolko, Neef, & Engel, 1986).

Early studies investigating the reduction of problem behavior reported observing unexpected covarying effects (both desirable and undesirable) on other untreated behaviors (e.g., Sajwaj, Twardosz, & Burke, 1972). Researchers speculated that such unexpected results might occur because when one behavior was targeted for intervention, the broad system of contingencies changed resulting in other, untargeted behaviors coming into contact with different environmental contingencies (Sajwaj et al.). This speculation subsequently led Willems (1974) to suggest that when targeting an individual's problem behavior for intervention, researchers should simultaneously monitor other problem behaviors exhibited by the individual to assess response covariation as a function of treatment, as the properties of this phenomenon were not well understood.

In subsequent years, a number of researchers have further investigated the variables that effect response covariation. These studies have all demonstrated that the probability of other response-class members may change if the frequency of one or more members has been altered following intervention (e.g., Carr & Durand, 1985; Cataldo, Ward, Russo, Riordan, & Bennett, 1986; Horner & Day, 1991; Parrish et al., 1986; Russo, Cataldo, & Cushing, 1981; Sprague & Horner, 1992). For example, Sprague and Horner compared treatments that targeted only one undesirable member of a response class to treatments aimed to reduce all undesirable responses in a class with two adolescents with severe intellectual disabilities that engaged in multiple problem behaviors. The authors found a generalized decrease in all response-class members when a treatment targeting the entire response class was implemented (i.e., differential reinforcement of alternative behavior, antecedent teaching assistance). However, when a treatment targeting one response-class member was implemented (i.e., blocking, reprimands), an increase in one or more other members of the class was observed.

Shukla and Albin (1996) also provided a demonstration of response covariation with an adolescent male diagnosed with severe to profound developmental disabilities who engaged in multiple topographies of problem behavior maintained by escape from demands. The authors classified these topographies as less severe (e.g., pushing away task materials) and more severe (e.g., self-hitting, kicking others). When escape was available for both less and more severe forms of problem behavior, the participant engaged in markedly higher rates of the more severe forms than the less severe forms. However, when extinction was applied only to the less severe forms, the participant began to engage in higher rates of the more severe topographies. 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.

A more recent study investigated response allocation with children and adolescents with developmental disabilities who engaged in multiple forms of stereotypic behavior (Rapp, Vollmer, St. Peter, Dozier, & Cotnoir, 2004). The authors specifically evaluated the effects of restricting the most probable topography of stereotypy, environmental enrichment, and a combination of environmental enrichment and an additional treatment component (a reinforcement schedule for playing with a toy for one participant and response restriction for another participant). The authors found that restriction resulted in a decrease in the targeted topography as well as a decrease in one other untargeted topography for some participants. In other participants, restriction was also found to decrease the targeted topography as well as increase one or more other topographies. Environmental enrichment resulted in individual effects for each participant. The results from Rapp et al. need to be further considered because no functional analyses were conducted to confirm that the same functional reinforcer maintained all topographies of stereotypy for each participant. Although it may seem logical to assume that stereotypy is maintained by automatic reinforcement as suggested by Rapp et al., there is some evidence that stereotypy may sometimes be maintained by social contingencies as well (Kennedy, Meyer, Knowles, & Shukla, 2000). Furthermore, different stereotypic topographies could plausibly be maintained by different forms of automatic reinforcement (e.g., tactile stimulation, auditory stimulation).

Research on problem behaviors that occur in a response class has significant applied importance for several reasons. First, less severe forms of problem behaviors have been found to co-occur with other, more severe forms problem behaviors (e.g., Lalli, Mace, Wohn, & Livenzey, 1995). Second, when problem behaviors are treated (both in research and practice), the problem behavior that is most severe is typically targeted for intervention first and other less severe topographies are not often simultaneously evaluated (except for research specifically focusing on problem behaviors that occur in a response-class hierarchy) which is at odds with the behavioral ecology perspective recommended by Willems (1974). Third, it seems 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 do not occur (e.g., another topography of problem behavior does not increase; Willems). Understanding response covariation might also lead to more effective and efficient treatments if a treatment is designed to target multiple topographies simultaneously rather than targeting one topography at a time (Parrish et al., 1986). Finally, research on problem behaviors that occur in a response class have remained relatively understudied.

Noncontingent Reinforcement

One highly effective treatment for reducing problem behaviors of individuals with developmental disabilities is "noncontingent reinforcement" (NCR). In this intervention, the behavior's maintaining reinforcer (identified via functional assessment) is delivered on a response-independent basis (e.g., a fixed or variable time schedule; Carr et al., 2000). In addition, during an NCR procedure, the functional reinforcer is often no longer delivered following occurrences of the target behavior (i.e., extinction). This procedure seems desirable because the contingency between the target behavior and the maintaining consequence is eliminated, but the individual receiving intervention still maintains some contact with the reinforcer.

Many early basic research studies demonstrated that delivering reinforcers on a response-independent basis resulted in a reduction in behavior (e.g., Edwards, West, & Jackson, 1968; Herrnstein, 1966). This phenomenon soon made its way into the applied literature as a control for reinforcement procedures (Carr et al., 2000; Rescorla, 1967). Later, Vollmer, Zarcone, Smith, and Mazaleski (1993) evaluated NCR as a treatment for reducing attention-maintained SIB of three women with developmental disabilities. The authors compared the effects of fixed-time (FT) reinforcer delivery to another highly effective procedure for reducing aberrant behavior, differential reinforcement of other behavior (DRO). The authors demonstrated that both DRO and NCR were successful in decreasing problem behavior to acceptable levels for all three participants. Interestingly, the authors also demonstrated that, compared to DRO, NCR resulted in fewer extinction-induced side effects, higher rates of reinforcement, and a more manageable procedure to implement. Two additional studies have compared DRO and NCR interventions for reducing problem behavior (Britton, Carr, Kellum, Dozier, & Weil, 2000; Kodak, Miltenberger, & Romaniuk, 2003). Britton et al. found similar results when comparing NCR (with an additional reinforcer delay component to prevent adventitious reinforcement) to DRO with an adult male diagnosed with profound mental retardation who engaged in aggression. The authors found that the participant came into contact with more reinforcers during the NCR condition compared to DRO. Finally, Kodak and colleagues also found both interventions to be effective in reducing multiply controlled problem behavior in a seven-year-old girl with multiple diagnoses.

The generality of NCR as an effective treatment for a variety of response topographies and reinforcement functions has also been demonstrated in the applied literature. Since it has been shown that noncontingent attention can be effective in decreasing attention-maintained SIB (Vollmer et al., 1993), research has also shown that NCR can also be effective in treating problem behavior maintained by escape. For example, Vollmer, Marcus, and Ringdahl (1995) were successful in decreasing the rates of escape-maintained SIB in two young boys with developmental disabilities by delivering short breaks from teaching sessions on an FT schedule. Also, Lalli, Casey, and Kates (1997) compared NCR with extinction to NCR without extinction with three children with developmental disabilities; the authors found that both variations of the procedure were successful in decreasing aggression and SIB maintained by access to tangible items. Lindberg, Iwata, Roscoe, Worsdell, and Hanley (2003) demonstrated the long-term effects of NCR in reducing SIB maintained by automatic reinforcement for adults with developmental disabilities and demonstrated the maintenance of treatment effects for up to one year.

Noncontingent reinforcement is currently one of the most widely researched procedures for reducing problem behavior (Carr & LeBlanc, 2006); however, the effects of NCR applied to one member of a response class on other treated class members are unknown. For example, Baker, Hanley, and Mathews (2006) decreased the severe aggression of an elderly woman diagnosed with dementia to near-zero levels using noncontingent escape from caregiving tasks. While this study clearly demonstrated the effectiveness of noncontingent escape as a treatment, another interesting and important empirical question might have been addressed by determining if there were other topographies that belonged in the same escape response class (e.g., false medical complaints). If other class members existed, it would have been important to measure those topographies to investigate if they increased or if novel topographies emerged during or after treatment implementation when severe aggression no longer produced the maintaining reinforcer.

If a problem behavior being targeted for reduction belongs to a response class, the application of NCR might result in unexpected or undesired treatment effects. 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 response-class member is placed on extinction. This situation might be likely if the motivative 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 motivative operation. Applying NCR to one class member might also require additional treatment implementations. Overall, although NCR is currently a widely researched procedure, its applications to response classes are unknown.

A Translational Model for Studying Response Classes

While research on aberrant response classes with clinical populations has great clinical importance, there are some barriers that exist for researchers interested in investigating the topic. In order to answer empirical questions about aberrant response classes, researchers would need to have access to individuals with multiple response topographies that are functionally related. In addition, some response class-members may be difficult to identify because they may not have had the opportunity to be observed due to a certain member of the response class being highly successful at accessing the maintaining reinforcer. Finally, before treatment can be applied to a response class, each class member must be identified via functional analysis. Conducting multiple functional analyses can be quite time consuming, and if the problem behaviors being targeted are dangerous for the individual (e.g., severe SIB) or for others in the environment (e.g., severe aggression), it may not be feasible to delay treatment while conducting multiple functional analyses to ascertain the existence of a functional response class.

One way to circumvent the above challenges is the use of translational research. Translational research is a style of research that unites concerns for both fundamental principles and everyday problems and outcomes (Mace & Critchfield, 2010). In applied behavior analysis, translational research typically consists of using a clinical population (or a "stand-in" population) with an arbitrary task preparation (Mace & Critchfield). Translational research is well suited for answering questions involving response classes because lengthy pre-treatment functional analyses are no longer necessary. In addition, it is possible to answer research questions with more easily available participants using translational models, therefore allowing actual clients to access more immediate treatment by remaining in active programming.

A translational model for studying response classes was recently published. In this model, Shabani, Carr, and Petursdottir (2009) used a response panel of three buttons that was placed laterally in front of the young children. To press each button, a different amount of response effort was required as each button differed in required activation pressure and distance from the participant. The button that was physically closest to the participants required the least amount of pressure (termed the low-effort button), the button that was located beyond the low-effort button required more pressure (termed the medium-effort button), and the button that was located the farthest from the participants required the most pressure (termed the high-effort button).

In the first experiment of the Shabani et al. (2009) study, the participants were taught to press buttons by including three conditions (one for each button) under which edible or token reinforcement was delivered only for pressing one specified button and no reinforcers were delivered for pressing the other two buttons in a concurrent schedule. A subsequent condition was then conducted where responding on any of the three buttons resulted in reinforcement. During this condition, 3 of the 4 participants' responses were allocated to the low-effort button. The authors then placed the low-effort button on extinction while continuing to deliver the reinforcer following responding on the medium- and high-effort buttons followed by a reversal to the previous condition where all button pressing was reinforced. When the low-effort button was not available for reinforcement, the majority of participants' responses were allocated to the medium-effort button. Then, when reinforcement was again available for the low-effort button, responding on the low-effort button increased once again. The results of the first experiment in the study demonstrated that a response class had been developed for all participants. In addition, the results of this study were consistent across both participants with and without developmental disabilities, validating the use of children without disabilities as a suitable population for additional translational research.

Mendres and Borrero (in press) recently extended the translational model developed by Shabani et al. (2009) to investigate the role of negative reinforcement as well as positive reinforcement in the maintenance of response classes. Eleven college students participated in the study, and the frequency of computer trackpad clicks on a sequence of three moving squares was the primary dependent measure. In Experiment 1, the authors systematically replicated Experiment 1 from the Shabani et al. investigation. Participants were told to earn as much money as they could by clicking on the squares, and all sessions were 3 min in duration. Each of the three squares was a different color that was correlated with a specific fixed-ratio (FR) reinforcement schedule (i.e., FR 5, FR 15, FR 25). When a response requirement was met, a tone sounded and a point was added to a counter that was visible on the computer screen. A changeover penalty was also implemented in which the number of clicks made on previous squares reset each time the participant pressed a different square (i.e., the ratio requirement was met only by engaging in consecutive clicks on the same square). Participants were told that points could be exchanged for money at the conclusion of the study. The authors were able to successfully develop a response class in which participants allocated responding in an optimal manner to earn as many points for the least amount of effort as the contingencies changed across phases (e.g., when one square was placed on extinction).

Experiment 2 of Mendres and Borrero (in press) was an evaluation of the effects of negative reinforcement in the maintenance of a response class. Participants began the first 3-min session with $20.00 in the visible counter on the screen and were told to try to avoid losing as much money as possible by clicking on the squares. The three different colored squares were correlated with the same schedule values as in Experiment 1; however, in this experiment, participants lost $0.01 for a ratio requirement not met within a 10-s window on a given square. Additionally, participants lost $0.01 every 10-s for each square placed on extinction. In general, the authors found that responding was allocated to the square with the least effortful schedule value across conditions. However, when more than one square was required to avoid point loss, the authors found that participants did not behave optimally.

Shabani et al. (2009) and Mendres and Borrero (in press) developed novel translational models to evaluate response classes while eliminating the need to conduct lengthy pretreatment functional analyses with clinical populations. These preparations were developed such that additional experimental questions about environmental conditions and response classes could be answered more expeditiously than under applied circumstances. Thus, the purpose of the present investigation was to utilize the Shabani et al. preparation 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 treatment would reduce both members of a two-response class when reinforcement remained availability for one of them. As with the Shabani et al. study, typically developing preschool children were evaluated as a "stand-in" for individuals with developmental disabilities. This population was chosen because children ages 3 to 5 have limited rule development and Shabani and colleagues demonstrated similar results for participants with and without developmental disabilities.

Method

Participants, Setting, and Materials

Participants in the study included 3 girls (Marie, 5-years old; Ann, 3-years old; Lynn, 4-years old) and 1 boy (Keith, 4-years old) who were recruited from a local daycare center. Only children who were reported to have normal language development from both the director of the daycare center as well as the child's guardian were recruited for the study. All participants complied with adult instructions throughout the study.

All sessions took place in a small room located within the participants' daycare. In all sessions, the experimenter sat next to the participant at a table. One other trained, independent observer was also present during a subset of sessions for interobserver agreement (IOA) and treatment integrity (TI) data collection purposes. All sessions were 5 min in duration and were conducted 1 to 3 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.

The response apparatus consisted of three differently colored 5 in. plastic buttons that were mounted laterally to a wooden response panel 6 in. from each other. The buttons were placed identical distances (i.e., 10 in.) in front of the participants to equate the response effort for pressing each button. This distance allowed participants to respond without requiring them to lean on the table, and this distance remained consistent for all participants over the course of the investigation. An additional button was placed centrally in between the response panel and the participant (i.e., 5 in from the edge of the table to the center of the button). Participants were required to press this button before pressing any of the buttons on the response panel. This additional button was included to increase the inter-response times (IRTs) of the target behaviors and in turn decrease the likelihood that would enter into response chains. 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. See Figure 1 for a depiction of the response apparatus.

Measurement and Data Analysis

The primary dependent measure in this study was button presses per min and was collected using the BEST software. Responses per min on the alternative activity were also collected. Interobserver agreement for the alternative activity was calculated by having both the experimenter and an independent observer tally the number of responses that were made on the activity during the session. These two numbers were then compared, and the lower count was divided by the higher count and multiplied by 100% and was averaged across sessions for each participant. Interobserver agreement was calculated for 90%, 100%, 99%, and 91% of sessions for Keith, Ann, Lynn, and Marie and averaged 100%, 100%, 99%, and 100%, respectively.

In addition, BEST software collected data on the delivery of programmed consequences by having the experimenter hold and press a small button that was connected to a laptop computer each time a programmed consequence was delivered. Participant responses on the apparatus were analyzed using visual inspection of line-graph data.

Experimental Design

Characteristics of both withdrawal and concurrent-schedule designs were used in this study to demonstrate experimental control. Using a withdrawal design, experimental control across phases was demonstrated as the pattern of responding changed only as a result of the independent variable being introduced (Cooper, Heron, & Heward, 2007). Using concurrent schedules, experimental control was demonstrated within phases by measuring response allocation for both responses when simultaneous, alternative schedules were in place for responding on the buttons (Poling, Methot, & LeSage, 1995).

Procedures

Preliminary procedures. Participants' caregivers were asked to list and rank their child's favorite foods and toys, as well as list any food allergies, or foods and toys that they preferred their child not be given during the study (see Appendix A for the assessment). Each participant also had the opportunity to indicate his or her preferred foods or toys by responding to the questions, "What snacks/toys do you like to eat/play with…what else?" and "What snacks/toys would you like me to bring when I come to see you?" Foods and toys that were suggested by children that were not previously identified by caregivers were approved before use in the study.

Using the items from these interviews, participants were each asked to choose from an array of 5 to 8 potential secondary reinforcers (e.g., stickers, jewels, stamps) using a multiple-stimulus (without replacement) (MSWO) preference assessment (DeLeon & Iwata, 1996). Five to eight items were placed in an array in front of the participant who was instructed to pick one. When the participant selected one of the items, he was allowed to place the item onto a piece of paper in front of him, while the remaining items were rearranged in another array. After selection, the item was not returned to the array, but the participant was able to select from the remaining items. This process was repeated until all items were selected or the participant refused to select an item. The MSWO procedure was conducted a total of three times. Preference was determined by the number of selections divided by the number of presentations across the three arrays, multiplied by 100%. Participants were given the opportunity to choose 1 of the 3 stimuli 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).

Two additional MSWO preference assessments, one evaluating activities and the other evaluating food items, were conducted prior to the study using the procedure described above. However, during the activity preference assessment, the participants were given access to their chosen activity for 60 s following selections, and participants were allowed to consume their chosen food item following selections during the food preference assessment. The activity that was identified as being moderately preferred (i.e., the activity that was ranked 3rd out of a total of 5 activities) was placed on a small table directly behind the participant throughout the entire study. These activities included bead sorting for Marie and Ann, placing small differently colored pegs into a peg board for Lynn, and punching holes into a piece of construction paper using a small, star-shaped hole punch for Keith. Finally, participants were given the opportunity to choose 1 of the 3 food items that were identified as the most highly preferred from the food preference assessment at the end of sessions as a reward for working with the experimenter

Experimental procedures. Participants were provided with an instruction - "You can either play with the buttons or play with the [name of the alternative activity]. You can get started" - following an experimenter-delivered model in all phases of this study (with the exception of the FT phases). If participants asked questions about the procedure during any phase of the study, the same instruction was provided. Participants were also provided with an instruction to press the additional button if they failed to do so before pressing the other two buttons. Sessions were terminated and data were discarded if participants walked away from the apparatus or did not respond for 2 min. This occurred twice during the study for Keith. If participants walked away from the apparatus or stopped responding for less than 2 min, the session continued and data from such sessions was included in data analysis.

Training. Prior to baseline, participants were taught to press an additional button that was placed directly in front of them. This button was placed centrally in between the response panel and the participant (i.e., 5 in from the edge of the table to the center of the button). Each time the additional button was pressed during training, the experimenter prompted the participant to press 1 of the three other buttons in a quasirandom order.

Baseline. In all baseline sessions, participants were exposed to the apparatus and provided with the instruction to begin pressing the buttons following a model provided by the experimenter. No programmed consequences for responding were delivered. Baseline sessions were conducted until steady state responding was observed (i.e., a minimum of three sessions with minimal variability between data points with 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 an FR-1 schedule while all responses on the right button were placed on extinction (EXT). Similar to the baseline condition, there were no programmed consequences for responding on the middle. The middle button functioned as a nonreinforcement control throughout the study. 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). In the third and final phase of response-class training, responding on both the right and left buttons was immediately followed by the programmed consequence. Progression from one phase to the next occurred when steady state responding was observed as indicated above.

Treatment implementation and manipulation. After a response class had been demonstrated, NCR manipulation conditions began. The first phase in this condition consisted of delivering programmed consequences on an FT schedule while placing the response with the highest rate of responding in the previous phase on extinction, constituting the most common clinical form of NCR (FT + extinction; Carr, Severtson, & Lepper, 2009). Programmed consequences were delivered on a FR-1 schedule for responding on the other button. 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 previous condition. After stable responding was observed, the participant was exposed to the contingencies in the prior phase (i.e., FR 1 for left and right buttons). After stable responding was observed, the experimenter implemented an additional condition in which programmed stimuli were again delivered on an FT schedule while placing the response with the highest rate of responding in the previous phase on extinction while still delivering programmed consequences on a FR-1 schedule for responding on the other button. The FT values were derived for this condition in an identical manner to that described above.

Schedule thinning. For Lynn, a schedule thinning procedure was conducted following her final treatment implementation 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 previous value followed by 50% increases from the previous 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 FR-1 both phase (i.e., below 1.2 responses per min) for three consecutive sessions, the FT schedule value increased the following session. If responding on the target button exceeded this value, the previous 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 that have further developed the utility of NCR as a manageable treatment for caregiver implementation (e.g., Kahng, Iwata, DeLeon, & Wallace, 2000).

Treatment Integrity

Treatment integrity (TI) 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. The TI scores for responding on the reinforce-entry button were calculated by having an independent observer tally the number of programmed consequences that were physically delivered to the participant by the experimenter either during the session or via videotape. This number was then compared to the number of times the experimenter pressed the reinforcer-entry (recorded via BEST software). The lower count was divided by the higher count and multiplied by 100%. The TI scores for FR-1 schedules were calculated as the percentage of times the experimenter delivered the programmed consequence (determined via the reinforce-entry button) within 3 s of the participant pressing a button on a FR-1 schedule. The TI 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) within 3 s of the participant pressing a button on an extinction schedule. The TI scores for extinction schedules are reported separately for phases with and without FT schedules. The TI scores for FT schedules were calculated as the percentage of times the experimenter delivered the programmed consequence (determined by pressing the reinforcer-entry) within a 3-s window (i.e., 3 s before or 3 s after) of the specific FT schedule value (e.g., 10 s) elapsing. All TI scores were averaged and reported per participant and were above discipline standards (see Table 1 for a list of TI scores per participant).

Results

Keith's data are depicted in Figure 2. Throughout baseline, Keith's responding was allocated to the alternative activity, and he did not respond on the button apparatus. In the first phase of response-class training (Conc FR1 EXT)[1], Keith 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 the response-class training condition (Conc EXT FR1), Keith's responding was again allocated to the button under the FR-1 schedule. In the last phase of the response-class training condition (Conc FR1 FR1), Keith continued to display high rates of responding on the button that was under the FR-1 schedule in the previous phase even though programmed consequences were delivered immediately following responding on both buttons. In the first phase of the treatment evaluation condition (Conc FR1 EXT, FT 9 s), the button associated with the highest rates in the prior condition was targeted for intervention. Presses on that button were placed on extinction and an FT 9-s schedule was implemented (the FT value for this phase was calculated to be half of the mean IRT for the button with the highest rate in the previous phase). 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

[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 manuscript.

(Conc FR1 FR1), responding was again allocated to the same button that had been previously targeted for intervention. Finally, when the same button was targeted for intervention again in the final phase (Conc FR1 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. Throughout the treatment evaluation, Keith's responding was allocated to the alternative activity only when programmed consequences were unavailable for responding on the button apparatus.

Ann's data are depicted in Figure 3. Ann's responding was allocated to the alternative activity during the initial baseline sessions and no buttons were pressed. During the first phase in the response-class training condition (Conc FR1 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 the response-class training condition (Conc EXT FR1), Ann began to reliably respond in a rapid chain of pressing the left (EXT), middle (EXT), and right (FR1) 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 (brief 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," as well as a model of what using the rule would look like. However, this pre-session manipulation did not affect the pattern of behavior nor did providing Ann with a model of a nonexemplar of the rule in the subsequent session. The experimenter then began to verbally prompt 5 trials of pressing the button under the FR-1 schedule prior to beginning sessions. This pre-session manipulation proved to disrupt Ann's pattern of chaining, and she began to respond at high rates on the button under the FR-1 schedule. The pre-session prompts were removed for the last three sessions in this phase, and

Ann's responding remained stable with no evidence of chaining. In the last phase of the response-class training condition (Conc FR1 FR1), 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 FR1 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 FR1 FR1), Ann 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 FR1, FT 10 s). Similar to her previous treatment phase, there was 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. As with Keith, Ann's responding was allocated to the alternative activity mainly when programmed consequences were unavailable for responding on the button apparatus.

Lynn's data are depicted in Figure 4. Lynn initially responded at very high rates in baseline; however, responding ceased after 5 sessions for the remainder of the phase (with the exception of session 11). At the beginning of the first response-class training phase (Conc FR1 EXT), Lynn showed evidence of chaining similar to Ann. However, when the pre-session manipulation of 5 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, Lynn's responses were almost exclusively allocated to the button under the FR-1 schedule. During the subsequent phase (Conc EXT FR1), responding was, again, almost exclusively allocated to the button under the FR-1 schedule. However, due to the emergence of a response chain in session 38, pre-session prompted trials were instituted prior to session 39.

These trials appeared to disrupt the chain and were no longer needed again in the phase. In the subsequent Conc FR1 FR1 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 FR1 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 FR1 FR1), Lynn again responded at higher rates on the right button that had been treated in the previous phase, although low levels of responding were observed under the left button (also under FR1). When this button was targeted for a second time in her last treatment phase (Conc FR1 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 Lynn's responding remained at zero. Two final sessions were conducted using the maximum FT value of 5 min, and Lynn's responding remained stable. Similar to the other participants, Lynn responded on the alternative activity during baseline, and her responding shifted away from the activity once reinforcement was available for responding on the button apparatus.

Marie's data are depicted in Figure 5. Marie engaged in low levels of responding during baseline, and in general, her responding was allocated to the button under the FR-1 schedule in the first two response-class training phases (Conc FR1 EXT, Conc EXT FR1). When programmed consequences were available for responding on both buttons in the last phase of the response-class training condition (Conc FR1 FR1), 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 (Conc EXT FR1, 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 once again available for responding on both buttons (Conc FR1 FR1), Marie began exclusively responding on the button that had been reinforced in the previous phase. During the final treatment implementation (Conc FR1 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 (FR1) during session 43; however, that single contact did not result in increased response rates. Similar to the other participants, Marie responded on the alternative activity during baseline and generally did not do so again after programmed consequences were available on the button apparatus

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 In general, the results suggest that NCR is effective in 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 response-class member (see Table 2 for a summary of the results). However, there was one NCR treatment implementation for Marie in which the rate of the untreated response-class member increased. In addition, the FT value for Lynn was systematically thinned from 5 s to 5 min following her final treatment implementation condition, and Lynn's responding remained at near-zero levels throughout this procedural manipulation.

In order to explain the results of this investigation, two behavioral mechanisms proposed for the effects of NCR (i.e., extinction and the motivating operation hypothesis) should be considered (Kahng, Iwata, Thompson, and Hanley, 2000). Kahng and colleagues (2000) discuss that the reductive effects of extinction occur because the response-reinforcer contingency is disrupted. On the other hand, 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 parsimoniously explained using the motivating operation hypothesis rather than by appealing to the effects of extinction. While extinction was applied to a targeted response in each treatment implementation, extinction was not applied to the untreated response. Therefore, some participants (e.g., Lynn) did come into contact with the maintaining reinforcer for engaging in the untreated response during treatment implementations, yet the overall rate of all response-class members decreased (except for the first implementation for Marie).

The behavioral mechanisms proposed by Kahng and colleagues (2000) may also be used to account for the one case in this study in which an increase was observed in the untreated response (i.e., the first implementation of NCR with Marie). In this case, Marie may have initially responded on the untreated button due to the extinction-induced variability to access the maintaining reinforcer. Her continued responding on the untreated button may also 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 have an effect on the motivating operation (i.e., the value of the reinforcer may not have been weakened). The FT schedule value in Marie's second treatment implementation (i.e., FT 6 s), where a global effect of NCR was demonstrated, was almost twice as dense as the value in her first treatment implementation.

Conversely, the one case of an increase on the untreated button for Marie may also be explained in light of the probability of programmed consequence deliveries. One method that can be used to evaluate this speculation is to conduct a conditional and background probability analysis to identify a potential response–stimulus contingency for responding on the untreated button (Hammond, 1980). 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 were followed by an environmental event given a certain consequence window (e.g., 5 s) by the number of occurrences of that same behavior in a specified observation window (e.g., 10 min). The background (or response-independent) probability refers to how much of a certain environmental event is available for free (i.e., is not contingent on the occurrence of a behavior) in the environment. This 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 background probability, support exists for a potential positive contingency, meaning there are existing conditions for the certain environmental event to be the maintaining consequence of the behavior (Hammond).

For the current study, a conditional and background probability analysis was conducted for 6 sessions in Marie's first treatment implementation using a consequence window set at 3 s (see Table 3 for a list of conditional and background probabilities per session). 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 background probabilities were calculated to be close to the same value, 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 background probabilities for the remaining 5 sessions in the treatment phase, indicating that there was a potential positive contingency for 5 of the 7 sessions in the treatment phase. That is, the conditional and background probability analysis lend 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 background probability for accessing reinforcers via the FT schedule.

Therefore, a positive contingency would suggest that problem behavior was more likely to result in attention as a consequence.

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 where responding on both buttons was immediately followed by the delivery of a programmed consequence. 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. In reviewing the results of the study, this potential transition effect may have occurred in 5 of the 8 treatment evaluations. However, participants did come into contact with reinforcement for the untreated response in 2 of these 5 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 being delivered for button pressing (e.g., stickers, stamps). Lastly, the schedule thinning manipulation for the FT schedules was only conducted for one of the treatment implementations with 1 of the 4 participants.

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 (in press), it might prove valuable to replicate the current investigation using response classes 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 as problem-behavior response classes are sometimes hierarchically related based on response effort (e.g., Lalli et al., 1995). Also, it seems beneficial to extend the present study to evaluate NCR without incorporating an extinction component. Although NCR has been implemented concurrently with extinction in the majority of empirical investigations in the area of developmental disabilities (Carr et al., 2000), gaining a greater understanding of the importance of extinction in NCR procedures might benefit clinicians. 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., DRO, functional communication training) may be evaluated using translational models.

There may be one preliminary clinical implication worth noting from the current investigation. 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 directly targeted for intervention. This implication has significance for practitioners as the most frequently occurring or most intensive problem behavior is often 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 be understand the finding’s reliability and generality.

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Table 1.

Treatment integrity scores across conditions for each participant

					EXT Schedules					
	Reinforcer Entry		FR-1 Schedules		With FT Schedules		Without FT Schedules		FT Schedules	
Participant	% of Sessions	Score	% of Sessions	Score	% of Sessions	Score	% of Sessions	Score	% of Sessions	Score
Marie	88	96%	69	94%	74	88%	39	100%	95	90%
Ann	95	98%	63	98%	33	100%	38	100%	100	96%
Lynn	74	98%	75	98%	54	100%	56	100%	100	96%
Keith	86	98%	88	99%	50	100%	16	100%	100	94%

Table 2.

Summary of Results per Participant for Both Targeted and Untreated Responses During Each FT-Schedule Implementation

Participant	Treatment Implementation	Target Response	Untreated Response
Marie	1	Decrease	Increase
	2	Decrease	Decrease
Ann	1	Decrease	Decrease
	2	Decrease	Decrease
Lynn	1	Decrease	Decrease
	2	Decrease	Decrease
Keith	1	Decrease	Decrease
	2	Decrease	Decrease

Table 3.

Conditional Probability (CP) and Background Probability (BP) Analysis Results for Each Session in Marie's First Treatment Evaluation

Session	CP	BP	Contingency Relation
29	1	.95	Neutral
30	1	.59	Positive
31	1	.33	Positive
32	1	.43	Positive
33	1	.44	Positive
34	.89	.55	Positive

Figure 1. Pictorial depiction of the response apparatus.

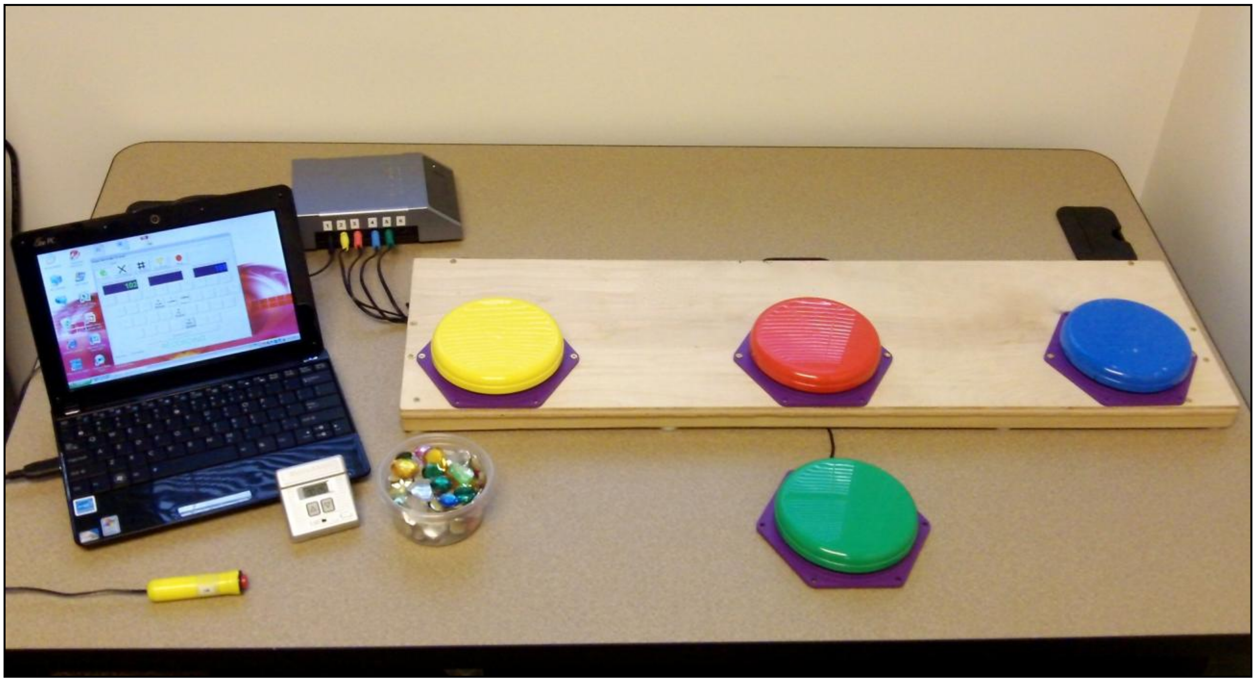


Figure 2. Results for Keith, depicted as responses per min on the left, right, control buttons in the top panel and on the alternative activity (star-shaped hole punch) in the bottom panel.

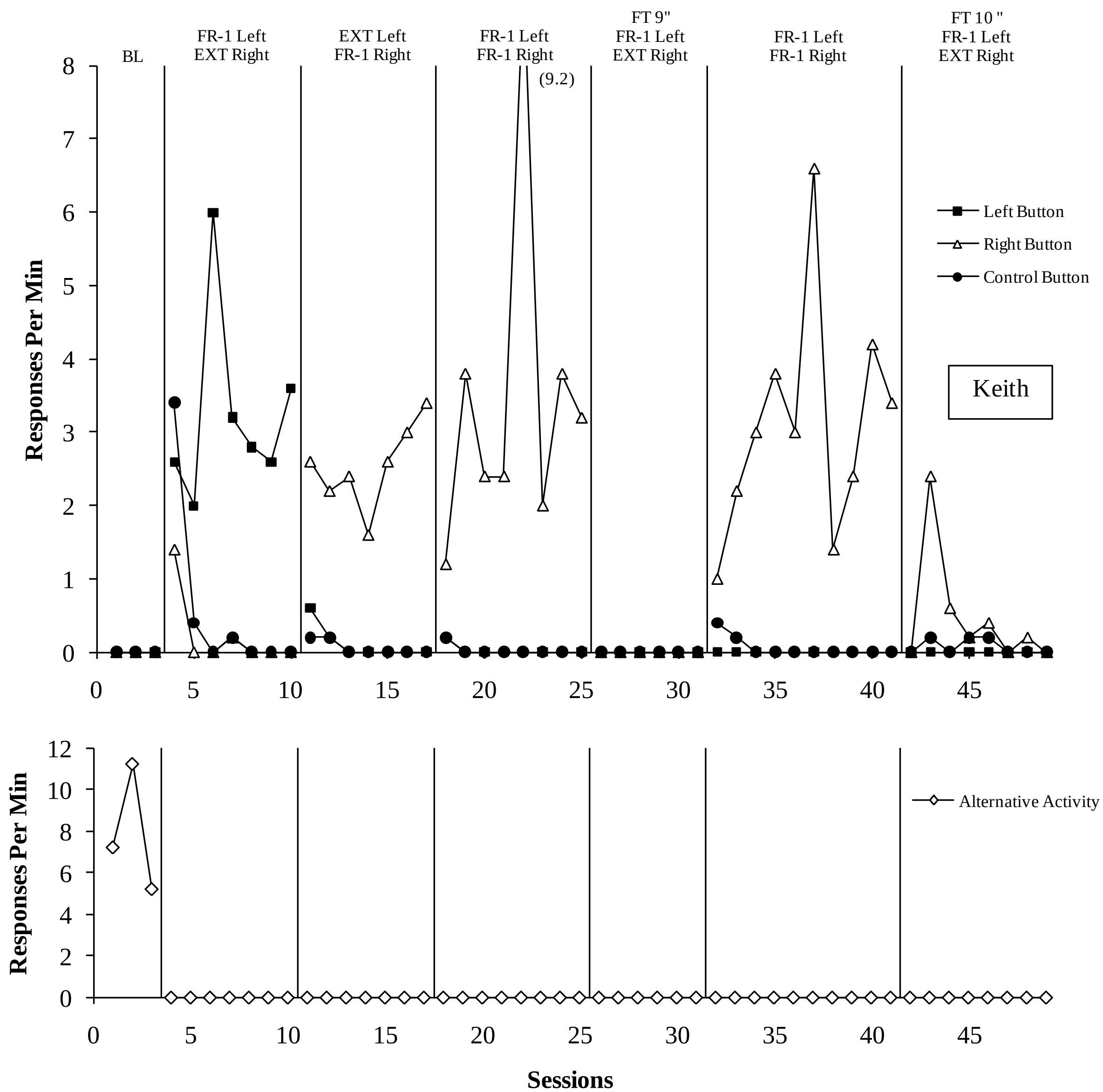


Figure 3. Results for Ann, depicted as responses per min on the left, right, control buttons in the top panel and on the alternative activity (bead sorting) in the bottom panel.

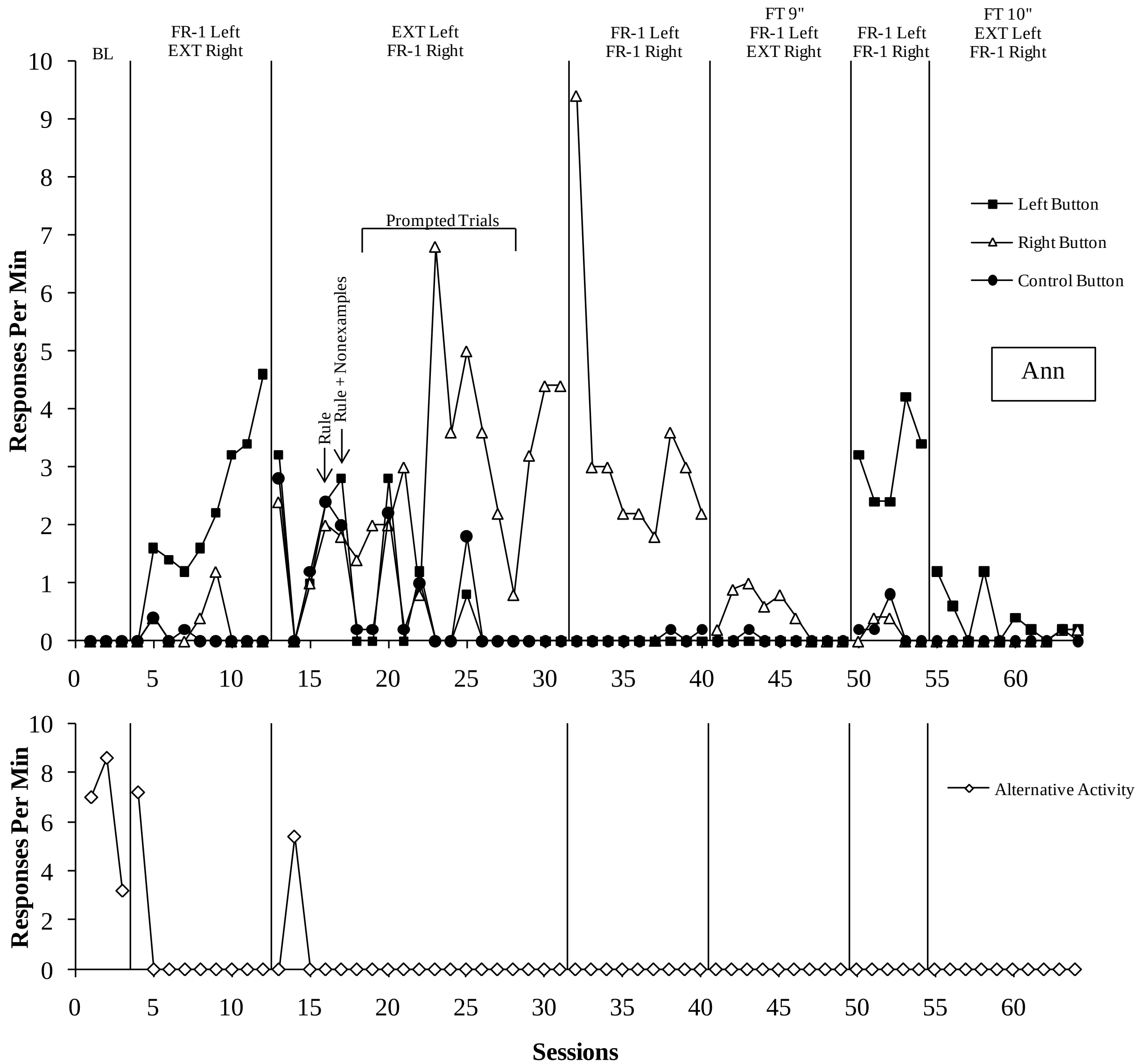


Figure 4. Results for Lynn, depicted as responses per min on the left, right, control buttons in the top panel and on the alternative activity (peg board) in the bottom panel.

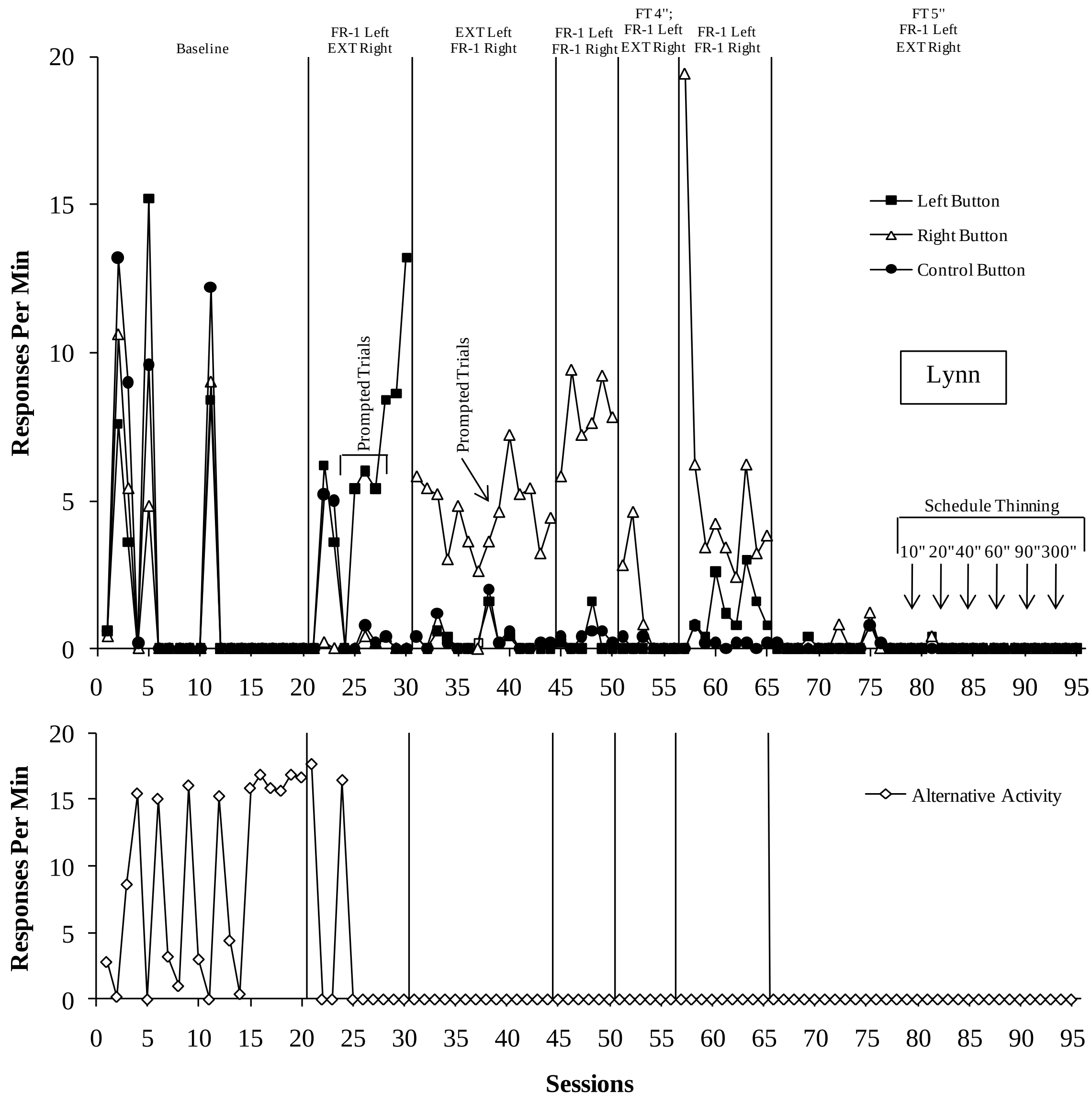
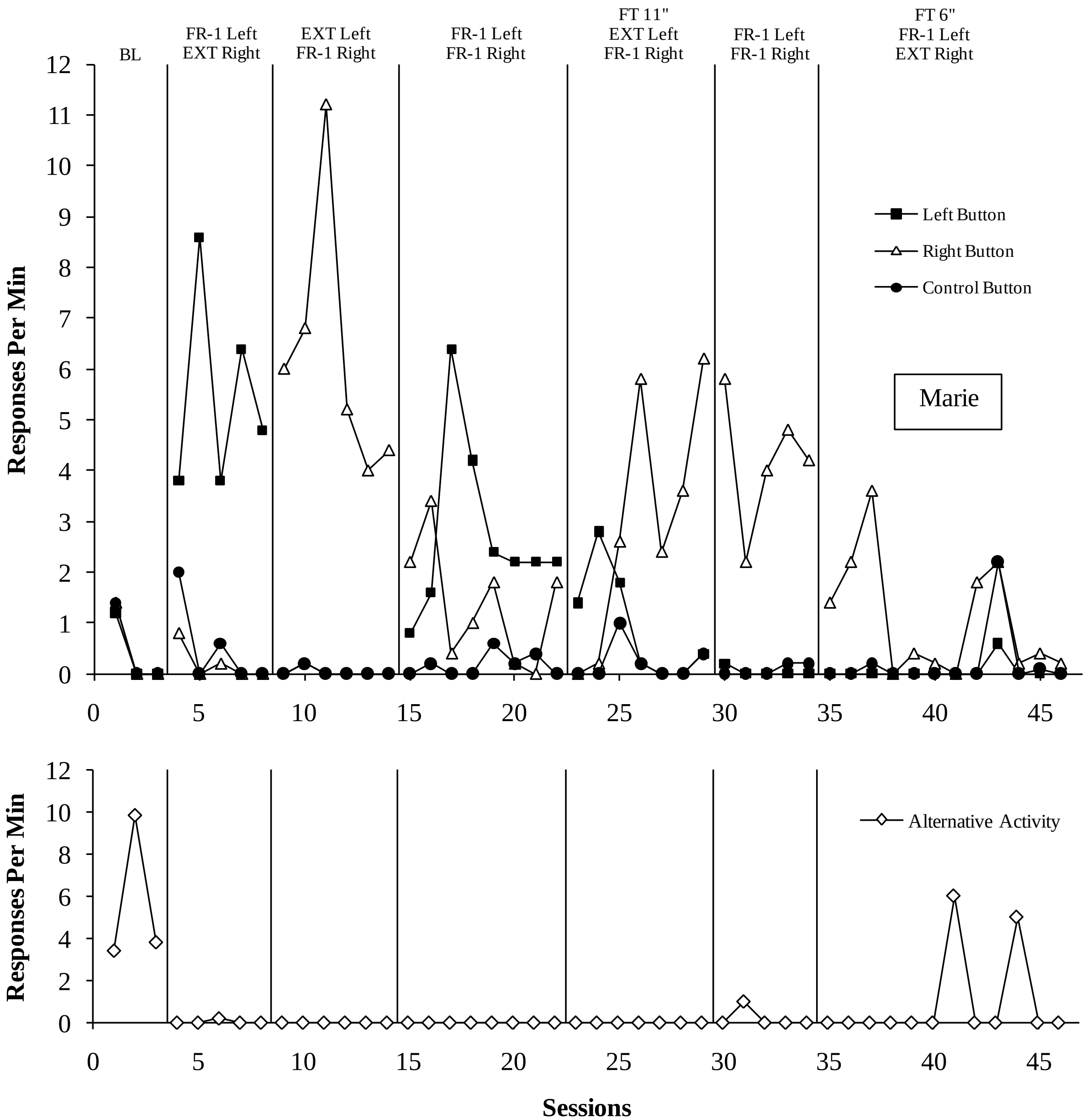


Figure 5. Results for Marie, depicted as responses per min on the left, right, control buttons in the top panel and on the alternative activity (bead sorting) in the bottom panel.



Appendix

Preference Assessment Questions for Caregivers

Child's name: ___________________ Relation to Child: ________________
Date: _______________

We would like to ask you a few questions about what your child enjoys to eat and play with. Given your permission, we will be using these items throughout the study. We will begin by discussing foods. Please be as specific as possible (e.g., reporting that your child enjoys salt and vinegar Pringles instead of reporting your child likes chips).

Section I: Edibles

1. What are some sweet foods that your child enjoys? Some examples would be cookies, fruit candy, and candy bars.

2. What are some salty foods that your child enjoys? Some examples would be potato chips, popcorn and pretzels.

3. What are some sour foods that your child enjoys? Some examples would be sweet tarts, grape fruit and pickles.

4. What are some spicy foods that your child enjoys? Some examples would be barbeque chips, nacho chips and Slim Jims.

5. Are there any foods that your child is allergic to or you prefer that we not give your child during the course of the study?

We will now ask some questions about your child's favorite toys.

Section 2: Tangibles

6. What are some toys that your child has at home that he/she really seems to enjoy?
____
____
____

7. Does your child enjoy playing with certain toys that make sounds? An example of this would be toy steering wheel that makes a honking noise when the horn is pressed. Do you know of any specific toys like this that your child likes?
____
____
____

8. Does your child enjoy playing with certain toys that light up, have mirrors, or have pictures on them? Do you know of any specific toys like this that your child likes?
____
____
____

9. Does your child enjoy playing with things that have different textures? An example would be play-doh. Do you know of any specific toys like this that your child likes?
____
____
____

10. Are there any toys that your child specifically dislikes or you prefer we not give your child during the course of the study?
____
____
____

Having provided the above information, please decide whether or not you wish to allow your child to receive edible items (e.g., small amounts of food) as rewards in this research study. If you decide in favor of your child receiving edible items, he/she will not receive any items that you have listed as allergies or items you have listed you prefer we not give your child. If you decide against your child receiving edible items, he/she will only receive non-food items as rewards (e.g., stickers, stamps).

I give permission for my child to receive edible items as rewards.

Please check one of the following options: [ ] Yes [ ] No

______________________ ___________
Parent/Guardian Signature Date

____
Print name