An Analysis of the Effects of Progressive-Ratio Schedules on Client Outcomes

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Abstract

To date, very few published studies have examined the clinical application of progressive-ratio (PR) schedules of reinforcement in applied research. Clinical applications of PR schedules may be effective for treatment of problem behaviors and acquisition of skills. Common applications of PR schedules in applied settings have included simple responses (e.g., pressing a button), of relatively low social significance, rather than complex responses (e.g., academic tasks) during assessment. The purpose of the present study was to evaluate the effectiveness of PR schedules of reinforcement in the identification of highly preferred items and utility in reinforcing correct responding through training in client programming. Unlike previous research, this study used complex responses (e.g., academic tasks) during assessment and examined reinforcer effects on correct responding during client programming. Results showed that PR schedules of reinforcement were effective in identifying reinforcers for all participants, and these reinforcers were effective in increasing correct responding during training and maintenance.

Keywords: progressive-ratio schedules, reinforcer assessment, stimulus preference

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Reinforcement has been cited as the most important and most widely applied principle of behavior and core element of behavior change programs in both basic and applied research (Cooper et al., 2021; Northup et al., 1993). Progressive-ratio (PR) schedules of reinforcement have been examined in basic research for over 60 years (Findley, 1958; Hodos, 1961). This literature has identified that there is a direct relationship between how much effort an organism will make for access to an object or activity (i.e. the breaking point; Hodos, 1961), and reinforcer potency (Jarmolowicz & Lattal, 2010; Poling, 2010; Roane, 2008). The potency of a scheduled reinforcer is especially important when it is arranged to improve a socially significant target behavior (Baer et al., 1968; Poling, 2010). According to Poling (2010), if PR schedules were arranged to improve socially significant target behaviors, applied behavior analysts may be able to predict the clinical utility of a scheduled reinforcer.

PR schedules are designed to examine reinforcer strength, which is the amount of work supported by a reinforcer (DeLeon et al., 2009). PR schedules of reinforcement can increase response requirements in two ways: over successive sessions (DeLeon et al., 1997) or trial-by-trial within a single session (Hodos, 1961; Roane, 2008). For example, when a child emits a predetermined number of responses (e.g., completes five math problems), a reinforcer is delivered (e.g., teacher gives a prize). After the reinforcer is delivered, the subsequent response requirements (i.e., how many response to earn reinforcement) are then increased (Wilson & Gratz, 2016).

Findley (1958) was the first to use PR schedules. He conducted a series of experiments investigating key pecking by pigeons in a concurrent schedule arrangement. More specifically, in some conditions pecking one key (switching key) shifted control from one to another and one

key produced one of two PR 100 schedules. Hodos (1961) investigated a variation of the procedures used by Findley (1958) where PR schedules were studied in isolation and a session continued until a subject failed to make a designated response. The term "breaking point" was first introduced and defined as the last ratio completed before the session ended.

Lattal and colleagues (1998) investigated response persistence under ratio and interval reinforcement schedules. In Experiment 1, three adult hooded rats were either exposed to PR schedules or yoked-interval schedules of food reinforcement. Yoked-interval schedules include both ratio and interval schedules (Catania et al., 1977). The rats were simultaneously exposed to their respective reinforcement schedule (e.g., PR schedule, yoked-interval schedule), which arranged for equivalent interreinforcer intervals. In Experiment 2, pigeons were exposed to alternating sessions of PR schedules and yoked-interval schedules. The results from both experiments showed that responding maintained by interval schedules was more persistent than that maintained by ratio schedules.

Jarmolowicz and Lattal (2010) analyzed the similarities and differences among different scheduling arrangements that have been labeled as progressive-ratio schedules. Under the original PR schedule, the response requirement is increased after each reinforcer. In their review, Jarmolowicz and Lattal found that progressive-ratio schedules have been investigated under three different scheduling arrangements. The first schedule arrangement, the conventional arrangement, included an increase in response requirement with each successive reinforcer (Findley, 1958; Hodos, 1961; Jarmolowicz & Lattal, 2010). Sessions would progress until responding ceased for a predetermined period and the last completed ratio was identified as either the breaking point (Hodos, 1961) or break-point (Lattal et al., 1998). The second arrangement appeared in the 1970s, in which the response requirement increased between

sessions, rather than within sessions (Jarmolowicz & Lattal, 2010). This arrangement was described as the between-sessions arrangement. The fundamental difference between the conventional and between session arrangements is the break-point determination. In the between-sessions arrangement, the break-point is defined as the ratio value (e.g., PR Step Size 10) at which the organism fails to earn reinforcement. The third arrangement, intermittent arrangement, included ratio requirements that remained static for several reinforcers before progressing to the next higher ratio requirement (Ferster & Skinner, 1957).This arrangement has been associated with shorter post reinforcement pauses but low break-points. Jarmolowicz and Lattal determined the term "progressive-ratio" should be consistent with what Hodos (1961) described: where response requirements advance within a session and the break-point is defined as the highest ratio completed prior to cessation in responding.

There have been few published studies using PR schedules in clinical application for treatment development. Reinforcing stimuli identified via PR schedules have been used to reduce or replace problem behaviors (DeLeon et al., 2000; Roane et al., 2001; Wilson & Gratz, 2016). For example, DeLeon and colleagues (2000) used PR schedules to increase response requirements for aberrant behavior (aggression) and taught the participant a functional communicative response using functional communication training (FCT). Initially, researchers implemented a verbal prompting procedure to train the participant to ask for preferred items and aggression was ignored. Following training, rates of aggression and manding were examined under single and concurrent operant arrangements with an FR1 schedule and extinction. Subsequently, PR probes were conducted with manding on an FR 1 schedule and increased schedule requirements for aggression. Results suggested a bias in responding toward the mand response with reduced rates of aggression.

Roane et al. (2001) investigated the utility of PR schedules on reducing automatically reinforced destructive behavior. They first conducted a preference assessment to identify similarly preferred stimuli and then evaluated those stimuli under PR schedules in a single-operant arrangement. This resulted in a single stimulus being associated with more responding under PR schedules relative to the other stimulus, for all participants. These results indicated that two stimuli appearing to be equally effective reinforcers at low response requirements, were associated with differentiated levels of responding under increasing response requirements. In other words, if the schedule had not increased, then the similarly preferred stimuli would be seen as equally reinforcing and/or potent. The reinforcers, as identified via the PR assessment, were then used to successfully reduce automatically reinforced destructive behavior. This study was implemented as a replication of DeLeon et al. (1997) and Tustin (1994) under PR schedules to demonstrate the variation in preference for reinforcers when response requirements increased.

The majority of applied research has evaluated PR schedules in a single operant arrangement (e.g., Roane, 2008). Glover and colleagues (2008) evaluated methodological considerations in the development of PR schedules. They assessed the extent to which PR schedules presented under single or concurrent arrangements would produce differential outcomes across stimuli. The results showed that similar break-points were obtained during both the single and concurrent arrangements. These results were important because prior research using FR1 schedules in single and concurrent arrangement have generally produced unequal results between arrangements (Roane, 2008). One possible limitation of single-schedule reinforcer assessments is that response rates could be similar between low and high preferred stimuli because of ceiling effects (Roscoe et al., 1999).

PR schedules have been analyzed in basic research and published in the *Journal of the Experimental Analysis of Behavior* since Hodos (1961) first described them and Findley (1958) first employed them. Although PR schedules have been extensively analyzed in basic areas of behavior analysis, it has only been in the last 20 years that PR schedules have been published applied journals such as the *Journal of Applied Behavior Analysis* (Poling, 2010). Although the basic and applied literature use the same term for PR schedules, it should be noted that their measures are not equivalent. The dependent variables that are measured and used to detect the influence of PR schedules in applied and basic research can be different (e.g., response effort, topography of the response). In other words, target responses commonly used in basic research are often simple responses (i.e., less effortful) such as key pecking in pigeons (Findley, 1958) or lever pressing in rats (Hodos, 1961). In contrast, PR schedules in applied research typically include target responses that are complex (e.g., academic tasks) and have been associated with lower levels of responding at high response requirements (Roane, 2008). The specifics of a given procedure, including the independent variables and dependent variables, can influence reinforcer potency (Roane, 2008). For example, a basic study may analyze the effects of drugs on PR responding, whereas an applied study may investigate a child's responding during a block in bucket task in order to analyze the reinforcer potency of a preferred item.

Wilson and Gratz (2016) examined the utility of PRs as an assessment tool to inform a differential reinforcement treatment package. The authors investigated the utility of a treatment package that was aimed to replace the participant's problem behavior with a functionally equivalent alternative response. First, the researchers identified environmental conditions that maintained the problem behavior by completing a functional analysis. Second, they trained the participant to engage in appropriate manding using FCT. Following FCT, a PR assessment was

conducted to determine the breaking point of the functional communicative response that was taught during FCT. During the assessment, problem behavior was put on extinction and the vocal mand that was taught during FCT was placed on a stepwise PR1 schedule of reinforcement. Last, the researchers examined the results of the PR assessment to inform a differential reinforcement of alternative behavior (DRA) treatment package. During DRA, the participant's problem behaviors decreased and the schedule of reinforcement for the functional communicative response surpassed levels of responding observed in the PR assessment. The results replicated and extending previous research supporting breaking points of communicative responses can be used to inform treatment and also can change following treatment (e.g., the participant's increased responding during skill acquisition). One limitation of the study was that there was no follow-up data collected to determine if the communicative response maintained during natural reinforcement schedules in the classroom (Wilson & Gratz, 2016).

Little applied research using PR schedules has used tasks in the individual's repertoire or that was a part of their everyday programming and educational goals during assessment. Instead, previous researchers have incorporated tasks including filing manila folders (Glover et al., 2008), button pressing (Roane et al., 2001), disk tasks (Francisco et al., 2008), and placing blocks in buckets (DeLeon et al., 2009). Some researchers have used previously mastered tasks on which they were currently working (e.g., Call et al., 2012; Kodak et al., 2007; Russell et al., 2018). Roane and colleagues (2005), selected PR tasks within each participant's education plan for the PR assessment. The tasks used in the study included completing math problems for one participant and completing a sorting envelope task. Little to no research using PR schedules have used the items from the PR assessment to improve socially significant behaviors through skill acquisition following the PR assessment. It should be noted that socially significant behaviors

are most often defined or described subjectively and can be rather complex (Wolf, 1978). Such behaviors are often selected on the basis that they will improve a person's quality of life (Lerman et al., 2013). Socially significant behaviors should increase a person's habilitation and can be behaviors such as language, social, motor, and academic skills (e.g., Bannerman et al., 1990; Cooper et al., 2019; Lerman et al., 2013).

Although items have been identified via PR schedules through identifying break-points, these stimuli are rarely evaluated following the assessment to determine their reinforcing potency following assessment. As previously mentioned, reinforcers identified via PR schedules have been used to treat problem behaviors but experimenters have not used the items to reinforce and increase socially significant behaviors. Roane (2008) suggested three important research topics on PR schedules that have relevance to the field of behavioral science. These research topics included: procedural considerations for the arrangement of PR schedules, the use of PR schedules to bridge basic and applied research topics, and the clinical use of PR schedules to develop therapeutic programs. Although PR schedules are suggested to be used in clinical practice with individuals with intellectual and development disabilities (IDD; Wilson & Gratz, 2016), the clinical utility of PR schedules has been questioned by several researchers in regards to the number of unknown variables regarding general procedural arrangements (Poling, 2010; Leon et al., 2021; Reed et al., 2013; Russell et al., 2018). The general procedural arrangements include limited guidelines for optimal step sizes, limited evidence of breakpoint stability for the items assessed, (e.g., food), and some have suggested that the aspects of PR schedules may be aversive (i.e., high ratio values; Poling, 2010). These procedural arrangements have yet to be empirically evaluated (Leon et al., 2021).

Stimulus preference assessments are designed to predict stimuli that will serve as potent reinforcers for reducing problem behavior (DeLeon et al., 2009; Francisco et al., 2008; Roane et al., 2001). However, some assessments may result in identification of false negatives for either high- or low-preference stimuli (Francisco et al., 2008). For example, Roscoe et al. (1999) compared results of two previous studies (Fisher et al., 1992; Pace et al., 1985) on reinforcer identification and combined the methodologies of both studies. They evaluated the selection of low preferred and high-preferred stimuli under single and concurrent schedule arrangements. The results indicated that absolute reinforcement effects associated with a given stimulus may be best evaluated in a single schedule arrangement. Francisco et al. (2008), Glover et al. (2008), and Penrod (2008) attempted to replicate the findings of Roscoe et al. (1999). By evaluating the extent to which low-preferred stimuli functioned as reinforcer under PR schedules. Results of Glover et al. suggested that low-preference stimuli were not as effective as highly preferred stimuli under PR schedules. On the other hand, results of Penrod et al. and Francisco et al. indicated that low-preference stimuli often function as effective reinforcers under PR schedules.

Two stimuli can appear to be equally effective reinforcers at low response requirements but have differential levels of responding when those response requirements increase (DeLeon et al., 1997; Roane et al., 2001; Roane, 2008; Tustin, 1994). In other words, a stimulus may appear to be highly preferred at low response requirements (e.g., FR1 schedule), but have low levels of responding under higher response requirements (e.g., PR schedule). Previous studies (DeLeon et al., 1997; Roane et al., 2001; Tustin, 1994) suggested that potential reinforcers should be exposed to increased schedule requirements in order to identify reinforcer efficacy.

Preference assessments are often not representative of contingencies arranged in practical settings (i.e., low response effort, dense schedule of reinforcement; Leon et al., 2021;).

Increasing response requirements could aid in identifying reinforcers that are more durable under real-world modifications like schedule thinning or increased task difficulty (Leon et al., 2021). Reinforcement schedules may alter the relationship with responding and reinforcement, which may limit the generality of data obtained by typical reinforcer assessments (e.g., DeLeon et al., 1997; Tustin, 1994). That is, reinforcement schedules alter the reinforcing efficacy of a given stimulus, so exposing reinforcers to certain schedules (e.g., FR schedules) and changing to another (i.e., variable schedules) may influence responding. Preference for an item at one response requirement may not be predictive of preference under another response requirement (Leon et al., 2021). In other words, increasing schedule requirements for concurrently available reinforcers may help further identify clearer preferences between one item and another (DeLeon et al., 1997).

The goals, procedures, and effects of behavior analytic research should be of social significance (Wolf, 1978). There is no published applied research that discusses the social validity of PR schedules and the overall acceptability of treatments using PR schedules. According to Wolf (1978), behavior-analytic research should focus on the social importance of treatment goals, acceptability of treatments, and social importance of treatment effects. This present study intended to evaluate the social significance of PR schedules and its role in client outcomes and treatment effects. A possible way to measure the social validity of PR schedules is to analyze the effect a putative reinforcer has on behavior of social significance. No previous study to date has analyzed the utility of PR schedules on the acquisition of socially significant behaviors. Long-term treatment effects and applicability of reinforcers identified via PR schedules have yet to be analyzed. Thus, the purpose of the present study was to evaluate the

effectiveness of a PR reinforcement assessment in the identification of highly preferred items and utility in reinforcing correct responding through training during client programming.

Method

Participants

Three children diagnosed with autism spectrum disorder (ASD) served as participants: Bart (12-year-old male), Nala (10-year-old female), and Paris (7-year-old female). Each participant received intervention services in a center-based program based in applied behavior analysis (ABA) and other integrative services (e.g., occupational therapy, speech–language therapy). Participants were selected if they could meet the following criteria: sitting at a table, completing programming tasks without engaging in problematic behaviors that could cause harm to the participant or experimenter, history of training using discrete trial training (DTT), history of participating in preference assessments. Recruitment for participants took place via email to Board Certified Behavior Analysts (BCBAs), who worked at a autism intervention clinic where the participants went to school. Parent and BCBA consent were required and obtained for study participation.

Settings and Materials

Assessment sessions were conducted in an assessment room at an autism intervention clinic where the participants went to school. The room was equipped with a table, chairs, video camera and relevant session stimuli (e.g., pencil and paper, sight word cards, visual stimuli). Participants were permitted to bring leisure items (not a part of the study) to the assessment room along with food and drinks. Training sessions were either conducted at the clinic at each client's individual workspace or in the assessment room. Because of COVID-19 and privacy concerns, most sessions were conducted in the assessment room. Sessions were conducted at least once a

week and no more than 2 total hours per day. Across all PR assessment sessions, high-preferred items, as determined by the preference assessment, and relevant task materials, were present.

Dependent Variables

The primary dependent variables were break-point values and percentage of correct responding. During the PR assessment, break-points were measured for each session. Each break-point was defined by the largest ratio completed under the PR schedule for each session (e.g., Hodos, 1961). In other words, if the response requirement was a PR Step Size 6 and the participant only competed 5 out of 6 responses, then the break-point would be a PR Step Size 5 (i.e., the last completed ratio). Correct responding was defined as the percentage of trials of correct responding on target clinical tasks. These were defined on an individual basis. An example of correct responding during assessment: the participant saying "apple" when presented with the written word "apple".

Experimental Design

A multielement design (Wolery et al., 2014) was used for the PR reinforcer assessment and a multiple baseline across participants design (Gast et al., 2014) was used for the baseline and maintenance probes and training. In the multielement design, participants remained in the baseline condition until stable levels of responding with little variability were reached so that step sizes could be accurately evaluated for the reinforcer assessment. The reinforcer assessment was conducted with two stimuli that were alternated in a quasi-random order until there was a differentiation in levels of responding between the stimuli. In the multiple baseline across participants design, each of the participants started baseline probe sessions at the same time. The researcher tracked client outcome data via percentage of correct responding during client programming. For Paris, once all probes sessions were stable, Paris started training and once

Paris' responding was increasing or stable, Nala began training. Once all participants had stable responding during training, maintenance probes were administered.

Procedure

Preference Assessment

Prior to conducting the PR reinforcer assessment, a paired stimulus preference assessment (PSPA; Fisher et al., 1992) was conducted. The PSPA included up to 8 stimuli. The stimuli used in the preference assessment were chosen based off of parent and clinician report. Every participant had eight items in their assessment and each item had a corresponding visual to be used for every trial to make it as salient as possible. During the preference assessment, each stimulus was paired twice, once on each side (i.e., right or left), with every other stimulus in a predetermined randomized order to allow comparisons of all possible stimulus pairs. There were 56 total trials for each assessment.

For each trial, the experimenter placed two stimuli approximately a foot apart on a table in front of the participant and the participant was prompted to make a choice (e.g., the therapist said, "pick one"). Participants selected a stimulus by either reaching toward the item or touching the item or by naming the item (e.g., saying "baby doll"). When the participant attempted to select both stimuli, the items were removed from the table and a new trial with a new pair of stimuli was presented. Each participant had 5 s to choose an item. If a participant did not make a choice in the five seconds, the experimenter presented a new trial with different stimuli and that trial was taken out of the total number of trials. The results of the preference assessment were analyzed by dividing the number of trials that each item was chosen by the total number of trials, multiplied by 100%. Two highly ranked stimuli that were chosen on a similar percentage of trials

were used in the reinforcer assessment. Stimuli approached 100% of all trials for every participant.

PR Baseline

The reinforcing efficacy of the two similarly ranked HP items from the preference assessment was evaluated. The PR assessment task for each participant was chosen based on clinician recommendation. A task that the participant could readily complete with at least 80% correct responding and could be completed in repetition, was chosen. The PR assessment tasks included reading consonant-vowel-consonant (CVC) words (Bart), answering "which" questions (Paris), and reading consonant blend words (Nala). The same task and materials were used for entire PR assessment (baseline and reinforcement). During baseline sessions, no contingencies were arranged for the emission of the target response (i.e., tacting letters).

During all conditions, participants were only instructed to complete one response at a time. Data were taken over several sessions, with within-session increases in response requirements. Response requirements increased throughout the session (e.g., PR Step Size 1, PR Step Size 2, PR Step Size 3…) until a break-point was determined by meeting termination criterion. Sessions were terminated after 15 minutes or 2 minutes without the emission of the correct target response (Harper et al., 2021. Thus, response requirements reset to the first response requirement (i.e., PR Step Size 1) at the beginning of each session and increased until there was a cessation in responding. These data were used to create schedule requirements for the remaining sessions of the reinforcer assessment.

PR Assessment

During the reinforcement phase of the PR assessment, the reinforcing effects of two highly ranked stimuli were evaluated in a multielement design using a single-operant

arrangement. The response requirement to receive access to HP stimuli, increased connected to the predetermined PR schedule. It should be noted, that researchers (e.g., Poling, 2010; Roane, 2008; Wilson & Gratz, 2016) have emphasized a lack in procedural recommendation regarding appropriate step size and response requirement determinations. For this study, PR schedules were individualized for each participant and were determined based on level of responding in baseline and observation of their responding prior to baseline (i.e., day-to-day programming). Ratio requirements for each participant increased across the session until termination criterion was reached (i.e., 2 minutes of no responding; 15 minute session duration). Ratio requirements increased at an additive of 1 (i.e., PR Step Size 1, PR Step Size 2) for Bart and Paris. Due to high levels of responding during baseline, ratio requirements increased an additive of 2 (i.e., PR Step Size 2, PR Step Size 4,) for Nala. Prior to the onset of a session, the experimenter showed the participant the item he or she would receive after completing the target response requirement and provided brief instructions (e.g., "If you would like your [baby doll], you have to [e.g., sort colors]"), and prompted the participant to complete one response, and provided 30-s access to the item being evaluated in that condition. During that session, the participant was presented with the task (e.g., sorting colors) according to the PR schedule in effect. No additional prompts were delivered; thus, if the participant did not respond, the trial would end after 2 min. If the participant made an incorrect response, a new set of task materials were presented and a new trial began. The high-preferred item was delivered for 30 s to the participant contingent on meeting the schedule requirements (e.g., 2 correct responses for a PR 2 schedule). The high-preferred items used in this assessment included slime and videos (Nala), coloring pages and videos (Bart), and a sensory ball and videos (Paris). Task materials (e.g., CVC flash cards) were removed after the delivery of each reinforcer and were returned as soon as the 30-s reinforcement period had

elapsed. All instances of problem behavior were ignored. Response requirements were reset at the onset of each session (i.e., PR Step Size 1) and were dependent on the current schedule requirement. The assessment continued until clear visual separation in responding occurred for at least three sessions with each stimulus.

Baseline

During all training conditions, the experimenter presented the participants with a training task individualized for each participant that followed clinical recommendations following their education goals. In order to make sure the training tasks were selected were of social significance for the participant, the experimenter met with each participant's parents and BCBA to determine the tasks that would be the most beneficial and align with their educational goals. Paris' training task, reading sight words, was selected from her education plan by her parents and BCBA. Paris' parents had worked on reading with her previously, but she was not making as much progress as desired. Bart's training task, receptively identifying community signs and symbols, was chosen from his education plan as a prerequisite skill. Bart's parents and BCBA emphasized the importance of him learning common signs and symbols as he was often out in the community and could exposed to potentially unsafe situations where he lived (i.e., lived in rural area with limited access to emergency assistance). Nala's training task, handwriting, was selected by her parents and BCBA in order to target a skill that would be most beneficial for when she discharged to be homeschooled by her parents. Parents had reported difficulty with getting her to complete writing tasks and it was considered an important skill for her education.

Prior to conducting baseline, the participants were presented with their training task to determine their percentage of correct responding without the highly-preferred item used as

reinforcement. These data were taken over several sessions with their available tangible reinforcers that were not apart of the previously conducted PSPA or PR assessment.

During baseline, the experimenter presented the participants with a training task to complete. The training task was presented with the corresponding instruction (e.g., "Which one says restroom?") and materials (e.g., visual stimuli in a field of 10). Participants were given 5s to engage in the target response (e.g., receptively identifying the restroom sign). All responses, correct or incorrect, received no consequences. The experimenter did not prompt or correct participants' errors during baseline. Experimenters calculated the percentage of correct responding for the training task under these conditions in order to show the effect of the PR item on responding during training. Baseline sessions started at the same time for all participants and training sessions were then implemented following visual inspection of stable responding across probe sessions.

Training

During training, the high-preferred item determined by the PR assessment (e.g., coloring pages) was used to consequate correct responding during the training task. No other items were used contingently during training. Training sessions occurred daily and across all participants (i.e., all participants in one day). The training task was not taught during any other time and the stimuli identified through the PR assessment were withheld from the rest of their programming. The training tasks included handwriting (Nala), reading sight words (Paris), and receptively identifying community signs and symbols (Bart).

Prior to the onset of a session, the experimenter showed the participant the item he or she would receive after correctly responding to the training task. Each participant had specific prompting and error correction procedures implemented that followed clinical recommendations

(i.e., no physical prompting; prompting until independent response). Vocal (Paris) and gestural (Bart and Nala) prompts were used contingent upon incorrect responding but did not result in access to the preferred item. Following error correction, the trial ended and the next one began. In order to receive the preferred item (e.g., slime), the participant was required to emit a specific a correct response (e.g., read sight word), as determined by the specific task. Only independent correct responses resulted in access to the PR item. Prompted responses did not result in access to the PR item, so that the PR item did not influence prompted or corrected responses. Prompts were used to prevent error patterns so that the participants could come in contact with the PR item as much as possible. The mastery criterion for each participant was three consecutive sessions at or above 80% correct responding. This mastery criterion was identical to the criterion at the autism intervention clinic for which they received services.

Maintenance

Maintenance sessions were identical to training sessions using the high-preferred item to consequate correct responding. The experimenter conducted a minimum of three maintenance sessions. Maintenance began one week after mastery and were conducted once a week (Bart and Paris). Due to her being discharged during the research study, the last two sessions for Nala's maintenance probes were run in one day, a week after the first probe. Participants were presented with their training task and percentage of correct responding was measured for each participant. These sessions were conducted in order to compare responding after training using reinforcers determined by the PR assessment.

Reliability and Treatment Integrity

Interobserver agreement (IOA) data were collected during 88% of PSPA, 48% of PR assessment, and 44% of training sessions. A research assistant watched a video recording of the

session and collected data on condition-specific child behaviors (e.g., break- points for PR, selection in PSPA) simultaneously while the child responded to each condition's contingencies (e.g., PSPA, PR assessment). IOA was calculated on a trial-by-trial basis. An agreement for a break point value was scored if both observers (the research assistant and experimenter) marked the same break point value for the session. An agreement for a correct response nonoccurrence was scored if both observers marked that the participant emitted a correct response. IOA was calculated by dividing the number of trials of agreements by the number of trials per session and multiplying the quotient by 100 to convert to a percentage. Mean agreement for item selection during the PSPA was as follows: Bart, 100%; Nala, 100%; and Paris, 100%. Mean agreement for break-point value during the PR assessment was as follows: Bart, 75%; Nala, 100%; and Paris, 100%. Mean agreement for correct responding during training was as follows: Bart, 95%; Nala, 93%; and Paris, 100%.

Treatment integrity data were collected for 88% of PSPA, 48% of PR assessment, and 41% of training sessions. A research assistant collected data via video recording on condition-specific experimenter behaviors (e.g., reinforcer delivery for PR, prompting incorrect responses in training) simultaneously while the experimenter employed the procedures for each condition. Treatment integrity data were calculated by dividing the total number of occurrences scored by the total number of opportunities, then multiplying the quotient by 100 to convert the number into a percentage. Treatment integrity was 96% (range, 90%-98%) for the PSPA, 95% (range, 94%-95%) for the PR assessment, and 97% (range, 92%-100%) for training.

Results

Preference Assessment

Figure 1 shows the outcomes of each participant's preference assessment. All stimuli are arranged in Figure 1 from left to right in order of decreasing preference as determined by the PSPA. Items involved in each assessment are listed along the "X" axis; percentage of trials in which the item was selected out of total trials (i.e., 56 trials) is along the "Y" axis. Instances in which multiple stimuli were selected on the same number of presentations occurred of all participants in the PSPA. In other words, each participant had at least two items that were chosen the same number of times.

The upper panel in Figure 1 shows the percentage of trials chosen across stimuli for Bart. Bart chose coloring pages for 25% of all trials and videos for 15% of all trials. Bart also chose coloring on blank paper 15% of trials but chose videos over coloring with blank paper when paired together, which determined videos to be the 2nd HP item. Although not graphically represented, when available as a choice, Bart chose coloring pages for 100% of opportunities and chose videos for 57% of opportunities. Bart never chose activity books.

The middle panel in Figure 1 shows the percentage of trials chosen across stimuli for Nala. Nala chose videos for 24% of all trials and slime for 20% of all trials. When available as a choice, Nala chose videos for 100% of opportunities and slime 79% of opportunities. Nala chose making jewelry once.

The bottom panel in Figure 1 shows the percentage of trials chosen across stimuli for Paris. Paris chose both the ball and videos for 20% of all trials, each. When available as a choice, Paris chose videos for 79% of opportunities and the ball 86% of opportunities. Paris never chose shaving cream.

PR Assessment

Figure 2 shows the result of the PR assessments for all participants. The upper panel of Figure 2 shows the break-point for each item across sessions with the PR schedule for Bart. During baseline, low levels of responding occurred. During the Reinforcement phase, more responding occurred when behavior produced access to the coloring pages than when behavior produced access to videos. The average breaking point for coloring pages was PR Step Size 5 (range, PR Step Size 4 to PR Step Size 7) and average breaking point for videos was PR Step Size 4 (range, PR Step Size 4 to PR Step Size 5), showing clear differentiated pattern of responding over the last 3 sessions of each condition.

The middle panel of Figure 2 shows the results of the PR assessment with the break-point for each item (ball and video) across sessions for Paris. During the first session of baseline, high break-points occurred (e.g., PR Step Size 5) but then decreased and stabilized. During the Reinforcement phase, both stimuli were associated with low break-points (i.e., PR Step Size 0, PR Step Size 1) and low levels of responding (i.e., less than 2 total responses). However, slightly more responding was associated with the videos than the ball. The average breaking point was a PR Step Size 1 for the ball (range, no responding to PR Step Size 4) and a PR Step Size 3 (range, no responding to PR Step Size 6) for the videos. Across increasing schedule requirements, higher break-points were associated with the videos rather than the ball, visually showing differentiated responding over the last 3 sessions.

The bottom panel of Figure 2 shows the results for Nala. During baseline, high levels of responding occurred (i.e., PR Step Size 12). During the Reinforcement phase, high levels of responding also occurred across both items (slime and videos). Both items had high responding but with slightly higher break-points for videos. The average break-point for videos was a PR

Step Size 14 (range, PR Step Size 12 to PR Step Size 16) and average break-point for slime was a PR Step Size 12 (range, PR Step Size 12 or PR Step Size 12). Nala's PR Step Size schedule was an additive of 2 Step Sizes, rather than an additive of 1 Step Sizes for Bart and Paris. Across increasing schedule requirements, higher break-points were associated with the videos rather than slime, visually showing differentiated responding over the last 3 sessions.

Training

The upper panel in Figure 3 shows the results of training for Paris. During training (and maintenance) the reinforcer associated with the highest break-points during the PR assessment was given contingent on correct responding during a task. During baseline, Paris had low levels of correct responding with an average of 33% correct responding for reading sight words. During training, higher levels of responding were associated with videos being contingent on correct responding. Paris had an average of 59% correct responding during training with meeting mastery criterion (80% correct responding across three consecutive sessions) within 10 sessions. During maintenance, Paris maintained high levels of correct responding with an average of 82% correct responding.

The middle panel of Figure 3 shows the results of training for Nala. During baseline, Nala had low levels of correct responding for her handwriting with an average of 16% correct responding. During training, much higher levels of responding were associated with videos being presented contingent on correct responding with an average of 87% correct responding across only three sessions before meeting mastery criterion. During maintenance, Nala remained at high levels of correct responding with an average of 91% correct responding.

The bottom panel of Figure 3 shows the results for Bart during training. During baseline, Bart had low levels of correct responding for receptively identifying community signs and

symbols with an average of 31% correct responding. During training, higher levels of responding were associated with coloring pages being given contingent on correct responding. He had an average of 75% correct responding during training, meeting mastery criterion within four sessions. During maintenance, Bart remained at high levels of correct responding with an average of 80% correct responding.

Discussion

This present study intended to evaluate the effectiveness of PR schedules of reinforcement in the identification of highly preferred items and the utility of those items in reinforcing correct responses through training. Results of the PSPA illustrated that the assessment was effective in finding two highly preferred items for each participant. Those highly preferred items were then used as reinforcers for task completion under PR schedules of reinforcement. Similar to previous research (DeLeon et al., 1997; Roane et al., 2001; Tustin, 1994), results indicated that although two stimuli appeared to be equally effective at low response requirements, they were associated with differentiated levels of responding during increasing response requirements. In other words, although two stimuli may have appeared to be under equal preference during the preference assessment, results of the PR assessment showed differentiated levels of responding between stimuli for each participant. Thus, this study has replicated previous research (e.g., DeLeon et al., 1997; Roane et al., 2001; Tustin, 1994) in reinforcer identification under PR schedules of reinforcement and suggests stimuli may have differential effectiveness under increasing response requirements.

Furthermore, results suggested that reinforcers identified via assessment were effective in increasing correct responding during training for all participants. These results maintained during with equal or higher levels of correct responding during maintenance for all participants. During

training, participants worked on skills that were either novel (Bart and Paris) or needed improvement (Nala), according to their caregivers. In order to have confidence that the PR-identified putative reinforcing stimulus was the variable responsible for the increased skills acquisition, it was imperative that only the experimenter worked on that skill in the experimental sessions, and no other interventionist worked on it at other times. However, prompts were used in response to errors, which could have potentially influenced correct responding.

It should be noted that reinforcer potency is a hypothetical construct and is not measured directly, but instead inferred based on how the scheduled event interacts with ongoing behavior (Poling, 2010). Reinforcer potency has been defined as the ability of a reinforcer to maintain behavior (Roane, 2008). Prominent behavior analysts have argued that hypothetical constructs play no useful role in a science of behavior (e.g., Skinner, 1953). Although reinforcer potency cannot be measured directly, it can be determined by PR breaking strength (e.g., breaking point), rate of responding, or total number of responses.

It is possible that participants were exposed to learning stimuli similar to those used in research outside of session. For example, Paris' training task included reading sight words in order to watch videos. There is a possibility that Paris not only was able to watch videos outside of session (e.g., at home, in the community), she was also exposed to sight words in books or on signs. There is also a possibility that Bart was exposed to community signs in the community and Nala used a pencil to work on drawing instead of handwriting. Registered Behavior Technicians (RBTs) whom worked with participants were aware of the contingencies and only allowed access to those stimuli during research, but it is still possible they had exposure in some way. In order to receive clinically important changes in behavior, previous research (Kodak et al., 2007; Roane et al., 2001) suggested further examination of post session reinforcement in order to

evaluate whether reinforcers used as part of instructional programs (i.e., training) might need to be restricted outside of session. All participants met mastery criterion (80% correct responding across three consecutive sessions) during training. Results of training indicated that reinforcers identified during PR schedules were effective in increasing correct responding during programming.

To date, no previous research has included a training component (i.e., skill acquisition) following reinforcer identification via PR schedules. Consequently, researchers had limited guidelines for general procedures (i.e., reinforcement schedules, response requirements) for this component. The general procedural arrangements included reinforcement schedules including response requirements and mastery criterion(s). The procedural arrangements for training were based on studies that have used PR schedules to improve or develop treatment (DeLeon et al., 2000; Roane et al., 2001; Wilson & Gratz, 2016).

DeLeon and colleagues (2000) determined reinforcement schedules by the results of PR probe sessions and implemented treatment using FR schedules as well. Roane and colleagues (2001) implemented NCR, DRO, and DRA during treatment following PR schedules and based their reinforcement schedules on results of a multielement FA. Wilson and Gratz (2016) implemented treatment using a FR schedule, where the first ratio of treatment was determined by the last response requirement achieved during the PR assessment.

One limitation of this study was the transition from a lean schedule of reinforcement (i.e., PR schedule) to a dense schedule (i.e., FR1) during training. According to previous research, schedule thinning has been commonly incorporated in reinforcement-based programs for increasing adaptive behaviors (Roane et al., 2001) and is important to incorporate in reinforcement schedules in order to simulate the natural environment. It is not recommended to

transition from to a lean schedule of reinforcement to dense schedule of reinforcement, as lean schedules are most often found in the natural environment (Francisco et al., 2008) and lead to rapid identification of reinforcing effects (Roane et al., 2001).

However, it has been cited that the rapidly thinning reinforcement schedules (e.g., PR schedules) can result in potentially aversive conditions (Russell et al., 2018). In this study, the experimenter determined a FR1 schedule of reinforcement was appropriate for the participants based on responding during the PR assessment and during baseline. It has been cited that schedule-thinning procedures may be difficult to replicate in clinical settings (Roane et al., 2005). All participants had been previously exposed to FR schedules of reinforcement and FR1 schedules were most often used during initial skill acquisition. Therefore, a FR1 scheduled seemed to be the most replicable in a clinical setting. It was important that the procedures used during this study could be replicated and used in clinical application by behavior technicians without having to extensively train technicians how to employ leaner schedules of reinforcement (i.e., intermittent schedules).

Progressive schedules of reinforcement have also been cited as time consuming (Roane et al., 2001) and potentially hard to train individuals how to implement without previous exposure to basic behavior analytic principles. For instance, Nala's parents were interested in using the strategies from the training condition when working on skills during homeschooling. Since she was discharging from services, it was important that her parents could be trained in a timely manner.

According to Piazza et al. (1996), dense reinforcement schedules (e.g., a continuous schedule) have not only been used in order to promote rapid reinforcement effects, but could potentially minimize the confounding effects of other variables (e.g., response difficulty,

response effort). This was especially important, as the skills being taught during training were those of complex responses (e.g., academic tasks). Complex responses have been reported to be associated with decreased levels of responding when response requirements increase (Friman & Poling, 1995).

Another procedural guideline, mastery criterion for each skill during training were developed based on previous research (Call et al., 2012; Wilson & Gratz, 2016) and the criterion in place at the intervention clinic. For Call et al. (2012), mastery criterion for teaching a target response was independent emission of the target response on at least 80% of trials. Wilson and Gratz (2016) implemented FCT following a PR assessment and included a mastery criterion of 100% accuracy for three consecutive trials. Since researchers were aiming to increase a functional communicative response in replacement of problem behavior, it was important that the mastery criterion to be at 100% before further treatment. The experimenter in this present study also based mastery criterion on the criterion in place at the intervention clinic, in order to align with their treatment goals. The mastery criterion for this present study (80% independent correct responding across 3 consecutive sessions) was determined in alignment with the criterion at the intervention clinic, previous research, and treatment goals of each participant. How to determine mastery criterion for skill acquisition following PR assessment should be investigated further.

Additionally, researchers have suggested further investigation in to the procedural arrangements of PR schedules of reinforcement in order to determine the assessment's clinical utility (Poling, 2010; Leon et al., 2021; Roane, 2008). Unknown variables regarding procedural arrangements (e.g., step sizes, PR schedule, breakpoint stability) could possibly impeded on clinical application of these schedules. As previously mentioned, Jarmolowicz and Lattal (2010) examined the various procedural arrangements that have been used for PR schedules. Since the

term *progressive-ratio* has been associated with several different procedural arrangements, Jarmolowicz and Lattal could not conclude that the different arrangements affect behavior similarly to warrant a no discriminative label. Future analysis in the differential effectiveness between procedural arrangements is warranted.

Although PR schedules were effective in identifying reinforcers during this study, high ratio values (i.e., high PR step sizes) have been suggested as potentially aversive (Leon et al., 2021; Poling, 2010). Although never empirically investigated, previous studies (DeLeon et al., 2000; Leon et al., 2021; Roane et al., 2001) have reported instances of problem behaviors occurring during PR schedules. Problem behavior could be determined and interpreted as evidence of aversion or aversive properties (Leon et al., 2021). Researchers have suggested that future research using PR schedules should include an "opt-out" response for participants to engage in order to terminate sessions without problem behavior (Russell et al., 2018). In the present study, problem behavior did not result in any programmed consequences. Two out of three participants (Bart and Paris) engaged in problem behaviors during the PR assessment. Rather than terminating session contingent on problem behavior, a termination criterion was developed. Termination criterion (2 minutes of no response) was based on the procedures developed by Harper et al. (2021). One participant, Paris, met termination criterion for every session in the PR assessment. Paris often engaged in vocal stereotypy, which often competed with her ability to respond appropriately. Future investigation is needed in the procedural modifications needed for clients who engage in competing behaviors during PR schedules of reinforcement.

There are several limitations of this study that lower the confidence in the causal relationship between the putative reinforcer identified by the PR assessment and the mastery of clinical goals.

Due to the COVID-19 pandemic, participants were required to wear a facemask for all sessions. Most clients that received services at the early intervention clinic did not tolerate mask wearing and consequently, not able to participate in the study. In addition, the mask requirement altered the menu of potential clinical goals on which to work, as facemasks could be a barrier for several skills (i.e., speech and language, social, dental compliance) that would have been potentially influential on client outcomes.

The early intervention clinic in which the study was conducted had strict safety precautions that exerted a strong influence on the study, with an emphasis on social distancing and limited physical interaction between staff and clients. This influenced the study in several ways. First, no outside guests were allowed in the clinic during the study. Due to this constraint, live recording of IOA was not an option. This may have influenced the accuracy of data collection due of technical difficulties (e.g., lack of sound, unclear picture). Most sessions were also run in the assessment room, and not in a client's programming space due to strict social distancing requirements (i.e., only one client per room). Overall, socially significant skills (e.g., verbal behavior, social interaction, dental compliance) could not be worked on during this study due precautions related to the COVID-19 pandemic. Second, the delays between sessions due to COVID-19 quarantines could have had an influence on responding. All participants were required to quarantine at one point in the study, which caused delays in between sessions.

Another possible limitation of the study is that no other reinforcer assessment was conducted to identify potential reinforcers. Due to this, it cannot be determined that PR schedules were more efficient at reinforcer identification than other reinforcer assessments. The present study only investigated the utility of PR schedules and their role on client outcomes. Although the present study analyzed efficacy of PR schedules using percentage of correct responding,

another form of calculation could be used, such as calculating trials-to-criterion. This type of analysis is yet to occur.

One potential limitation is the use of prompting and error correction during training. Due to this, it cannot be determined that it was only the PR item influencing correct responding during training. Prompts were used in this study to prevent error patterns and to teach the participant to the correct response in order to come in contact with the PR item. However, the participants never received the PR item contingent to prompted responses, only independent correct responses resulted in access to the PR item. The use of prompts and error correction could have increased correct responding. Therefore, it cannot be determined that the PR item alone influenced responding. Future research could investigate the differences in responding between dense and lean schedules during skill acquisition following a PR assessment.

Based on the finding from this study, there are several suggestions for future research. Investigators should continue to evaluate the effectiveness of PR schedules in reinforcer identification. It may be important to compare the efficacy of reinforcers identified via PR schedules versus other reinforcer assessments. Researchers should consider comparing skill acquisition with reinforcers acquired via PR schedules to other reinforcer assessments. This present study cannot prove that PR schedules work better in identifying reinforcers, rather that PR schedules were successful in identifying reinforcers for participants in this study. It is possible that other reinforcer assessments could have been effective in identifying reinforcers that increase correct responding for skill acquisition. Another possible replication could include comparing the skill acquisition rates for reinforcers not tested under PR schedules and only exposed to a preference assessment.

Although it cannot be concluded that the reinforcers identified via PR schedules are more effective in influencing correct responding, all participants met mastery criterion for a skill that was either novel or needed improvement. The skills that were targeted during training were those of social significance to the participants and their caregivers. The results of this study further support the use of PR schedules in clinical application, emphasizing the importance of improving skills, rather than reducing or replacing problem behaviors. Although a potential limitation, the transition from a PR schedule of reinforcement to a FR1 schedule of reinforcement during training was beneficial for the participants of this study, as they all met mastery criterion in a short amount of time (i.e., less than 10 sessions). Further investigation is needed for schedule arrangements to be used during training following a PR assessment.

This present study intended to evaluate the social significance of PR schedules and its role in client outcomes and treatment effects. Applied behavior analysts aim to improve socially significant behaviors that provide immediate and long-lasting effects for that person and increase a person's habilitation (e.g., Bannerman et al., 1990; Cooper et al., 2019; Lerman et al., 2013). Target behaviors should be selected because they will a) improve a person's quality of life and, b) allow them to access new reinforcers and new reinforcing contexts (Lerman et al., 2013). An applied science of human behavior should be dedicated to helping people become better able to achieve their reinforcers (Wolf, 1978). All people have the right to eat too many doughnuts and take a nap (Bannerman et al., 1990), but it is the duty of behavior analysts to be vigilant in teaching ways to access those doughnuts and take those much needed naps.

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Figure 1:

PSPA results for Bart, Nala, and Paris.

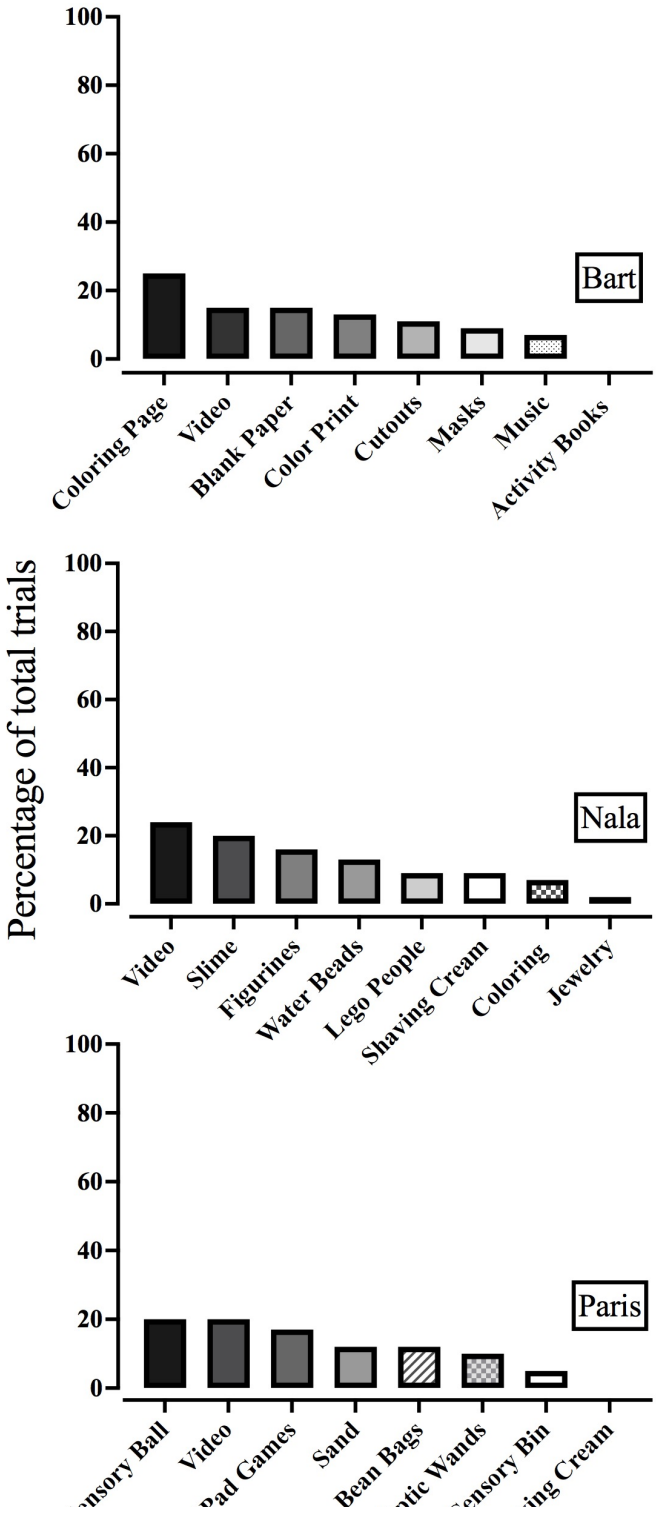

Figure 2:

PR assessment results for Bart, Paris, and Nala.

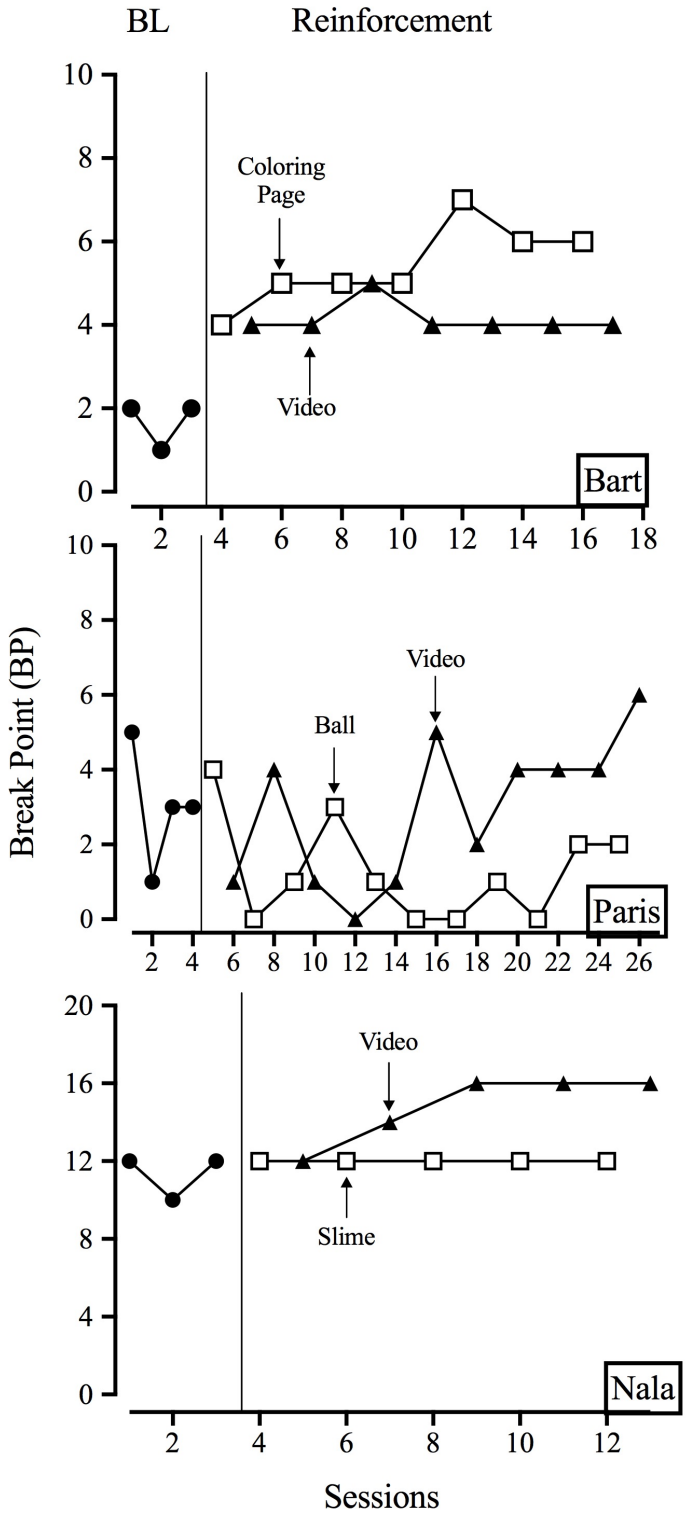

Figure 3:

Training results for Bart, Paris, and Nala.