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# Accumulated and Distributed Response-Reinforcer Arrangements during the Treatment of Escape-Maintained Problem Behavior

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**Abstract**

Contingent positive reinforcement has proven more effective in treating escape-maintained problem behavior than contingent negative reinforcement, particularly when problem behavior continues to produce escape. However, this research has overwhelmingly used distributed-reinforcement arrangements, where tasks and reinforcer access are interspersed throughout the work period. An alternative to interspersal involves allowing the individual to accumulate and then receive a larger quantity of reinforcement once work requirements are completed; this is known as an accumulated-reinforcement arrangement. The current study examined the efficacy of, and preference for positive (food) and negative (break) reinforcement contingencies delivered in accumulated and distributed arrangements in the treatment of escape-maintained problem behavior. In Experiment 1, accumulated break was preferred for 4 of 5 participants and accumulated food was preferred for 3 of 5. In Experiment 2, accumulated break was similarly effective to distributed break for three of five participants and accumulated and distributed food were equally effective for four participants.

*Keywords*: accumulated reinforcement, distributed reinforcement, escape-maintained problem behavior, negative reinforcement, positive reinforcement, schedule thinning

## Accumulated and Distributed Response-Reinforcer Arrangements during the Treatment of Escape-Maintained Problem Behavior

Negative reinforcement has been indicated in the maintenance of approximately one-third of cases of problem behavior exhibited by individuals with intellectual and developmental disabilities (IDD; e.g., Beavers et al., 2013; Hanley et al., 2003; Iwata et al., 1994). Engaging in escape-maintained problem behavior limits an individual's exposure to learning opportunities and other activities that may promote a better quality of life (e.g., Carbone et al., 2007; Carr et al., 1991; Kelly et al., 2015). Researchers have identified a number of efficacious, function-based interventions for escape-maintained problem behavior (see Carbone et al., 2007; Geiger et al., 2010; Rojahn et al., 2012). These interventions are generally designed to disrupt the response-reinforcer relation through extinction, alter the motivation to engage in problem behavior, or both (Geiger et al., 2010; Rojahn et al., 2012).

Many of these treatment approaches involve some version of a differential reinforcement of alternative behavior (DRA) procedure. The treatment may involve delivering a positive (often simply referred to as DRA) or negative reinforcer (differential negative reinforcement; DNRA) following the occurrence of a specific alternative behavior such as compliance, while, ideally, problem behavior is placed on extinction (Lalli et al., 1999; Vollmer & Iwata, 1992). However, it is not always possible to withhold escape (Vollmer et al., 2020) as these procedures typically involve providing physical guidance while the individual engages in problem behavior, which can place therapists and caregivers at risk for injury. Thus, developing procedures to enhance the efficacy of DRA and DNRA without extinction are of significant practical importance (e.g., DeLeon et al., 2001; Lalli et al., 1999; Slocum & Vollmer, 2015; Vollmer et al., 1999).

Lalli et al. (1999) compared DRA procedures with four individuals with escape-maintained problem behavior. Compliance resulted in DRA with a preferred food or DNRA with a break while problem behavior continued to result in escape. In each case, DRA with positive reinforcement proved more effective than DNRA. Several other studies have obtained similar results, suggesting that DNRA without extinction is ineffective in producing clinically meaningful reductions in problem behavior for most individuals (e.g., Carter, 2010; DeLeon et al., 2001; Piazza et al., 1997; Slocum & Vollmer, 2015).

At least in their initial stages, both DRA and DNRA procedures typically arrange for the immediate delivery of a relatively small amount of reinforcement following the alternative response. DeLeon et al. (2014) described this as a distributed reinforcement arrangement. This arrangement may lessen the aversiveness of the instructional context by keeping exposure to instruction brief and by ensuring frequent reinforcement of compliance (e.g., Fulton et al., 2020). The small magnitude of reinforcement may also prevent or delay satiation to the reinforcer for compliance. However, there may be advantages to delivering larger magnitudes of reinforcement following extended work requirements in what DeLeon et al. termed an accumulated reinforcement arrangement.

Research has suggested several practical advantages associated with arranging accumulated reinforcement, such as increased task-completion rates, shorter overall task durations (Bukala et al., 2015; DeLeon et al., 2014), more rapid skill acquisition (e.g., Frank-Crawford et al., 2019; Kocher et al., 2015), and decreased problem behavior (e.g., Fulton et al., 2020; Robinson & St. Peter, 2019). Further, when provided a choice between accumulated and distributed reinforcement contingencies, many individuals have demonstrated a preference for accumulated reinforcement arrangements (e.g., Bukala et al., 2015; DeLeon et al., 2014), including individuals with escape-maintained problem behavior (e.g., Fulton et al., 2020).

Robinson and St. Peter (2019) compared task completion and problem behavior under accumulated and distributed reinforcement arranged using fixed-ratio (FR) 1 schedules. Accumulated reinforcement resulted in higher rates of task completion and lower rates of problem behavior for three individuals diagnosed with attention deficit hyperactivity disorder. However, the function of the participants' problem behavior was never empirically demonstrated. Fulton et al. (2020) extended this research by evaluating these arrangements, using FR 1 schedules of reinforcement, in the treatment of problem behavior identified as maintained by escape through a functional analysis. Similarly, the accumulated reinforcement arrangement was as effective as or more effective than the distributed arrangement for all three participants. Both studies also examined preference for the procedures with only one participant in each study preferring reinforcer accumulation.

Although results from Robinson and St. Peter (2019) and Fulton et al. (2020) suggest that accumulated reinforcement may be more effective in reducing problem behavior than distributed reinforcement arrangements, both studies arranged extinction for problem behavior. Further, both studies combined positive and negative reinforcement contingencies in which compliance resulted in breaks with access to a highly preferred leisure activity. It was not clear if the differential effects of accumulated reinforcement contingencies would hold true when (a) extinction could not be arranged, (b) DRA (positive) contingencies were arranged in isolation, and (c) DRNA contingencies were arranged in isolation. Therefore, the purpose of the current study was to replicate and extend research on the use of positive and negative reinforcement during the treatment of escape-maintained problem behavior by examining preference for

(Experiment 1) and efficacy of (Experiment 2) accumulated and distributed arrangements without the use of extinction. In addition, we examined whether accumulated arrangements differentially affected the efficacy of the functional reinforcer (a break) or a preferred positive reinforcer (food) when the initially dense reinforcement schedule was thinned.

# General Method

## Participants and Setting

Eight individuals participated in this study. Finn, Axel, Arthur, Sadie, Jaxon, Sawyer, and Roland were all patients admitted to an inpatient hospital unit for the assessment and treatment of severe problem behavior. Joel was a student at an educational center serving individuals with ASD and other IDDs. Experiment 1 included Finn, Joel, Axel, Arthur, and Sadie. Finn, Sadie, Jaxon, Sawyer, and Roland participated in Experiment 2. Participant descriptions, diagnoses, verbal abilities and setting locations are summarized in Table 1.

## Functional Analysis

A functional analysis was completed with each participant using procedures similar to those described by Iwata et al. (1982/1994). Each functional analysis included, minimally, (a) an escape condition in which a therapist presented academic or vocational instructions and terminated instruction for 30 s following each instance of problem behavior, and (b) a control condition in which therapists provided the participant with continuous access to highly preferred items, attention, and issued no demands. In some cases, functional analyses included tests for other sources of social positive reinforcement (e.g., attention, tangible conditions) and automatic reinforcement (i.e., ignore). The results from each functional analysis were visually inspected using the structured criteria offered by Hagopian et al. (2015). The functional analysis results are depicted in Figure 1. In each case, the analysis identified behavioral sensitivity to escape as a negative reinforcer for the participant's problem behavior. Finn and Sadie's problem behavior were also sensitive to attention, which was treated outside of this study.

### Preference Assessment

The experimenters conducted a preference assessment with each participant to identify highly preferred foods to deliver as positive reinforcers. Each assessment included six to eight foods presented in a multiple-stimulus-without-replacement (MSWO; DeLeon & Iwata, 1996) format (except for Roland for whom food was omitted due to medical concerns). The experimenter repeated the MSWO assessment three times with each participant, and then rank-ordered items by the mean selection order across the three assessments. Prior to each food session in Experiments 1 and 2, participants selected among the three top ranked foods identified in the MSWO.

### Token Training

All participants had a history of using tokens as part of their educational programming; however, their individual histories with regard to earning, accumulating, and trading tokens varied. Therefore, abbreviated token training was initiated using procedures described in detail in Frank-Crawford et al. (2019). Briefly, token training was conducted with two different sets of tokens, one depicting a break and another depicting the top three preferred foods.

## Experiment 1: Preference for Response-Reinforcer Arrangements

The purposes of Experiment 1 were to (a) replicate prior research that has examined preference for accumulated and distributed access to food, (b) examine preference for accumulated and distributed access to a break, and (c) evaluate the relative preference for accumulated and distributed food and break.

**Response Measurement and Interobserver Agreement**

Experiment 1 included a concurrent-chains arrangement in which participants were presented with several condition cards in the initial link. Selection of each card resulted in the experimenter implementing unique contingencies in the terminal link of the chain. The dependent variable was the percentage of initial-link selections for each condition, which provided an index of relative preference for the experimental conditions in the terminal link. Observers recorded initial-link selections, and then the frequency of problem behavior, prompt delivery, compliance, and token and reinforcer delivery in the terminal links of each trial using pencil-and-paper data sheets. Initial-link selections included touching, pointing to, or vocally indicating one of the initial-link cards. Problem behavior included *aggression* (e.g., hitting, kicking, and scratching), *disruption* (e.g., swiping, ripping, or throwing materials), *self-injurious behavior* (e.g., hitting one's own head, face, or parts of body; self-biting), *resisting* (e.g., physically resisting prompts to complete the instruction, pulling or turning body away from instruction, putting head on desk after an instruction was delivered), and *elopement* (i.e., standing and moving 15 cm or more away from the desk without permission or, if in a standing position, moving more than 1.5 m away from staff without permission). Instructions were delivered using vocal, model, and physical guidance prompts. *Compliance* was defined as a correct response following a vocal or model prompt. Token delivery was scored when the experimenter placed a token on the token board. Reinforcer delivery was scored when the experimenter placed a piece of food on a plate in front of the participant or started the timer for the break.

A second observer collected data during 26%, 37%, 46%, 33%, and 35%, of sessions for Finn, Joel, Axel, Arthur, and Sadie, respectively. Observers' records were compared on a trial-by-trial basis and were scored as either an agreement or disagreement. An agreement was scored if both observers recorded the same participant selection, same level of prompting and compliance, the presence or absence of reinforcer and token delivery, and frequency of problem behavior in a given trial. The total number of trials with an agreement were then divided by the total number of trials; the resulting quotient was converted into a percentage. Across participants, observers agreed on 100% of initial-link selections, problem behavior, token delivery and exchange, and reinforcer delivery. Observers also agreed on 100% of trials for compliance with all participants, except Axel for whom they agreed on a mean of 98.2% (range, 90%-100%) of trials.

**Procedures**

Each participant completed three separate assessments within a concurrent-chains format. In each assessment, the terminal links arranged (a) accumulated reinforcement, (b) distributed reinforcement, or (c) no-reinforcement. In this initial assessment (Positive Reinforcement), the experimenter arranged positive reinforcement (food) in both accumulated and distributed links. In the second assessment (Negative Reinforcement), the experimenter arranged negative reinforcement (break) in both accumulated and distributed links. In the third assessment (Relative Preference), the experimenter arranged both positive and negative reinforcement separately in the accumulated and distributed links.

Each assessment included a minimum of five sessions. One terminal link was identified as most preferred when the participant (a) selected the same initial link across five consecutive sessions; (b) selected the same initial link across 8 of 10 consecutive sessions, or (c) made no differentiated response for 10 consecutive sessions. During the third assessment in which both positive and negative reinforcement were included, the most highly preferred condition was removed from the array after meeting criterion (a) or (b) above, and the assessment was continued with the remaining conditions until the relative preference for each of the experimental conditions was established (i.e., only one initial-link card remained in the array).

The experiment began in this same fashion for Axel but was changed to a paired choice format due to inconsistent responding in the assessment of relative preference. For Axel, thereafter, the relative preference assessment included two of the reinforcement conditions and the control condition. Each condition was paired with every other condition until preference or indifference was determined, after which the next assessment was initiated with a new pair of reinforcement conditions. Each assessment was then conducted for a minimum of 10 sessions, and preference was defined as selection of the same initial link across at least 80% of the sessions.

### ***Guided Exposure and Discrimination Test***

Guided exposure to the relevant conditions occurred prior to beginning each assessment. During guided exposure, the experimenter placed the relevant condition cards on the table in front of the participant in a horizontal line and explained the contingencies associated with each. The experimenter then prompted the participant to select a card and implemented the terminal-link contingencies associated with the selected card. This process was repeated for each card (see below). Next, the experimenter conducted a discrimination test by asking the participant to identify each card based upon the stated contingency for the condition and the instruction to select the card that matched the contingency. This was repeated until each condition had been correctly identified. All participants with the exception of Jaxon, Sawyer, and Roland correctly identified each condition (thus, Jaxon, Sawyer, and Roland only participated in Experiment 2).

### ***Terminal-Link Contingencies***

After the participant selected an initial link card, the associated terminal-link contingencies were implemented, which included the presentation of 10 tasks in accordance with a discrete-trial teaching format (e.g., Lerman et al., 2016). The tasks were those included in the escape condition of the functional analysis or that were reported to be associated with higher rates of problem behavior during educational programming. For each task, the experimenter presented the relevant antecedent and prompted the participant to complete the instruction. Model and physical guidance prompts followed incorrect responses or no response within 5 s of the preceding prompt. A correct response following the vocal or model prompt in the absence of problem behavior resulted in access to the reinforcer noted below. All problem behavior was exposed to extinction.

**Accumulated Food.** Selection of the accumulated food condition resulted in a statement of praise and the delivery of a food token following compliance in the absence of problem behavior. An incorrect response, no response, or the occurrence of problem behavior resulted in the presentation of the next programmed prompt. The participant completed all 10 tasks consecutively. The experimenter also informed participants of the total food they amassed. Following the completion of the 10th task, participants traded the tokens in exchange for accumulated food selected prior to session (e.g., five tokens resulted in five pieces of food).

**Accumulated Break.** The accumulated break condition was identical to the accumulated food condition with two exceptions. First, a break token was delivered immediately contingent upon compliance. Second, each break token was exchanged for 30-s access to a break. To separate the effects of positive and negative reinforcement, participants did not have access to attention or leisure items during the break.

**Distributed Food.** Selection of the distributed food condition resulted in a statement of praise and the immediate delivery of a small piece of the food selected prior to the start of session following compliance. The next task was initiated after 5 s, to allow for consumption of the food.

**Distributed Break.** The distributed break condition was identical to the distributed food condition with the exception that a 30-s break was delivered contingent upon compliance.

**No-Reinforcement Control.** During the control condition, the participant completed all 10 tasks consecutively and compliance resulted in praise.

## Results and Discussion

Figure 2 depicts the cumulative number of trials in which each condition was selected for Finn, Joel, and Axel. In the initial Positive Reinforcement assessment, all three participants preferred accumulated food. Finn, Joel, and Axel continued to prefer the accumulated condition in the Negative Reinforcement assessment. When preference across accumulated and distributed break and food was assessed in the Relative Reinforcer assessment, Finn preferred the accumulated break condition, Joel equally preferred both accumulated conditions to the distributed conditions, and Axel preferred both food conditions to break. This indifference between accumulated and distributed food persisted during a subsequent reversal to the Positive Reinforcement assessment. Axel also demonstrated indifference between the two reinforcement conditions in the reversal to the Negative Reinforcement assessment. It was unclear what caused the shift in preference, and due to the inconsistencies in his choices across replications of the Positive and Negative Reinforcement assessments, the Relative Reinforcement assessment was continued in a paired-choice format. Overall, Axel preferred the accumulated and distributed food conditions most, followed by accumulated break, and then distributed break which was selected least often. For all three participants, accumulation appears to have increased the value of both food and break.

Figure 3 depicts the results for Arthur and Sadie. Arthur initially preferred the accumulated food condition in the Positive Reinforcement assessment. The Negative Reinforcement assessment indicated that Arthur clearly preferred the accumulated break. During the initial Relative Preference assessment, Arthur exhibited exclusive preference for the distributed food condition, which was replicated in a reversal to the assessment of Positive Reinforcement. The Relative Preference assessment was reinitiated, results of which indicated that he preferred food to break and he preferred accumulated break to distributed break. The results of the Positive and Negative Reinforcement assessments and the initial phases of the Relative Preference assessment for Sadie indicated that she clearly preferred distributed reinforcement to accumulated reinforcement regardless of reinforcer type. During the final phase of Relative Preference assessment when both accumulated arrangements were available, her preference was nearly equal across reinforcer type, although Sadie did select accumulated break over accumulated food in the final five sessions.

Table 2 shows the mean percentage of tasks with problem behavior and compliance. Problem behavior was generally low and compliance was generally high in all conditions, with a few exceptions. Finn engaged in problem behavior in a single session in each of the three conditions he selected. Joel engaged in problem behavior across both conditions in the first few sessions in the Positive Reinforcement assessment; problem behavior then quickly decreased across sessions and remained low. Problem behavior was more variable during the Negative Reinforcement assessment, and occurred at low levels across both conditions throughout the assessment. Sadie's problem behavior occurred on a few occasions in the distributed break condition.

Experiment 1 represents a replication and extension of prior research examining preference for accumulated and distributed reinforcement generally (e.g., DeLeon et al., 2014) and specifically for individuals with escape-maintained problem behavior (e.g., Fulton et al., 2020). Fulton et al. (2020) combined positive and negative reinforcement in their evaluation of preference for accumulated and distributed reinforcement, and their results varied across participants. This variability in preference is inconsistent with prior research involving persons with IDD who were *not* reported to engage in escape-maintained problem behavior—in these studies, most participants preferred to accumulated reinforcers (e.g., Bukala et al., 2015; DeLeon et al., 2014; Frank-Crawford et al., 2019). Thus, it is possible that function of problem behavior may be one variable that influences preference for response-reinforcer arrangements.

The current study furthered this line of research by examining preference for these arrangements separately with positive and negative reinforcement. To date, only one study has systematically evaluated these arrangements with food (i.e., DeLeon et al., 2014), and three of those four participants preferred accumulated food. Like Fulton et al. (2020), results of the current study are mixed and only two of the five individuals clearly and consistently preferred accumulated food to distributed (Finn and Joel). Axel's results were mixed, although the Relative Preference assessment suggested accumulated food was more preferred. The remaining two participants demonstrated either a clear (Sadie) or emerging preference (Arthur) for distributed food. Notably, Arthur started taking Aripiprazole when the study began, a side effect of which is increased appetite. It is possible that the medication influenced Arthur's selection for the distributed food condition by functioning as a motivating operation, making immediate access to food relatively more preferred (e.g., Northup et al., 1997). These results differ from those of prior research that has historically suggested a strong preference for reinforcer accumulation (e.g., DeLeon et al., 2014). It is possible that continuity in reinforcer access, hypothesized by DeLeon et al. to drive (at least in part) preference for reinforcer accumulation, may be less important to the value of food than activity-based reinforcers. Alternatively, the mixed outcomes of the current study, and those observed in Fulton et al. could suggest that function of problem behavior may play a role in preference for reinforcer accumulation.

Finn, Joel, Axel, and Arthur preferred the accumulated break to distributed break, and Sadie preferred distributed break (see negative reinforcement assessment). Overall, these results suggest that there may be added value in arranging accumulated access to reinforcers for individuals with escape-maintained problem behavior, and in arranging accumulated access to break, in particular. To the extent that preferences predict reinforcer efficacy, these data further suggest that accumulated break may be an effective arrangement for some individuals, which was tested in Experiment 2.

## Experiment 2: Efficacy of Response-Reinforcer Arrangements

The purposes of Experiment 2 were to (a) determine whether accumulated reinforcement was effective in decreasing escape-maintained problem behavior, (b) compare the efficacy of accumulated positive and negative reinforcement in the treatment of escape-maintained problem behavior, and (c) determine whether reinforcer accumulation improved the durability of interventions during schedule thinning while escape extinction is not implemented.

### Response Measurement, Experimental Design, and Interobserver Agreement

Data collectors used BDataPro (Bullock et al., 2017) to collect data on problem behavior, prompts, compliance, token and reinforcer delivery, and task initiation. The main dependent variable was the percentage of trials in which problem behavior occurred. Secondary variables included compliance and instruction duration. Response definitions were identical to those described in Experiment 1. Instruction duration was calculated by subtracting the time of the final instruction completion from that of the initial verbal prompt (while also removing reinforcer access for the distributed condition).

Experiment 2 involved a combined reversal and multielement design (ABABC). The A phase was baseline. The B phase included a multielement comparison of four treatment conditions: (a) distributed food, (b) distributed break, (c) accumulated food, and (d) accumulated break. The C phase involved reinforcement schedule thinning and again included a multielement comparison of the effects of the four interventions on problem behavior.

A second observer collected data during a mean of 31.4% (range, 25.3% to 45.1%) of sessions across participants. Interobserver agreement data were calculated using the block-by-block agreement method described by Mudford et al. (2009). Mean agreement coefficients for problem behavior, compliance, and task initiation equaled 98.6% (range, 97.7% to 99.3%), 97.4% (range, 94.2% to 99.1%), and 95.5% (range, 90.3% to 99.5%), respectively. Agreement coefficients for experimenter behavior in sessions equaled 94.1% (range, 89.1% to 97.4%) for instructional prompts and 97% (range, 90.7% to 99.5%) for reinforcer and token delivery.

**Procedures**

Each session included 20 instructional trials during which academic or vocational tasks were presented using the same prompting procedure and the same strategy for identifying tasks described in Experiment 1. In addition to emulating how the participant's educational programming was typically implemented (blocks of trials from the same program), trial-based sessions also served several other purposes, including controlling for the maximum units of reinforcement delivered in a given session, and equating the total number of demands issued across conditions, variables that had not been controlled for in other research comparing positive and negative reinforcement in treatment of problem behavior.

During each trial, the experimenter presented an instruction and prompted the participant to complete it. The consequences for participant responding varied across conditions (as described below) but generally consisted of praise for compliance and reinforcer delivery during the reinforcement phase. Incorrect or no response resulted in the implementation of the next prompt in the sequence. Across all phases and conditions, problem behavior that occurred during the instructional sequence resulted in the immediate delivery of 30 s of escape.

### *Baseline*

The baseline condition (A) was identical to the escape condition of the functional analysis with the exception that the session was trial based rather than time based.

### *Reinforcement*

Four treatment conditions were assessed for Finn, Sadie, Jaxon, and Sawyer during the reinforcement phase (Phase B): (a) distributed food, (b) distributed break, (c) accumulated food, and (d) accumulated break. For Roland, only the distributed and accumulated break conditions were included. For Finn, two additional accumulated conditions were evaluated: (a) accumulated variant food, and (b) accumulated variant break. The procedures were identical to those described in Experiment 1 with three exceptions. First, the participant did not select which condition was conducted. Rather, the experimental conditions were quasi-randomly alternated across sessions such that each condition was implemented before any were repeated. Second, problem behavior resulted in 30 s of escape across all conditions. Third, in the accumulated variant conditions, Finn completed 10 trials, then traded his tokens and accessed his accumulated reinforcement (e.g., if he earned 8 break tokens, he received a 4 min break). This cycle of 10 trials followed by reinforcer access was then repeated such that each session continued to consist of 20 total trials broken into two units of 10.

***Schedule Thinning***

During schedule thinning (Phase C), the reinforcement schedule associated with instruction completion increased for each condition to FR 2, FR 4, FR 5, and FR 10 after three (Finn, Sadie, Jaxon, and Sawyer) or six (Roland) sessions were conducted with each condition. Six sessions of each condition were conducted with Roland due to variability in responding during the initial treatment phases. Thus, at FR 2 for example, correct responding (in the absence of problem behavior) following 2 trials resulted in either a token for food (accumulated food) or break (accumulated break), a piece of food (distributed food), or a 30 s break (distributed break). The unit price (i.e., the number of responses per unit of reinforcement), was not held constant during schedule thinning; rather, it increased with each increase in the reinforcement schedule similar to other studies incorporating schedule thinning (e.g., DeLeon et al., 2001; Lalli et al., 1999). Schedule thinning did not exceed FR 10 to ensure that the participant had the potential to accrue at least two reinforcers in accumulated conditions. At FR 4 in the accumulated variant food and break conditions for Finn, the number of trials completed before he accessed his reinforcement was slightly modified to accommodate the FR 4 schedule. Specifically, he first completed 12 trials (instead of 10), followed by reinforcer access, and then completed the final 8 trials, followed by reinforcer access. To allow for accumulation at FR 10, the accumulated variant conditions were reverted back to strictly accumulated such that Finn completed 10 trials, received one token, then completed the remaining 10 trials and received his second token. He was then permitted to trade those two tokens for a 1-min break or two pieces of food.

Conditions that were deemed ineffective at a given schedule were discontinued while schedule thinning continued with the remaining conditions. Interventions were identified as ineffective when: (a) the mean percentage of trials in which problem behavior occurred at a given schedule value was equal to or exceeded 50% of the mean percentage of trials in which problem behavior occurred during baseline, (b) there was no apparent decreasing trend, and (c) the mean percentage of trials with problem behavior did not exceed 50% of baseline because of elevated rates during a single session. The analysis continued until all interventions were deemed ineffective or low and stable levels of problem behavior were observed at the terminal schedule.

**Results and Discussion**

Finn's data are depicted in Figure 4. He engaged in high levels of problem behavior during baseline. Finn's problem behavior persisted across most of the treatment phases when reinforcement was introduced. Anecdotally, he repeatedly perseverated on completing 10 tasks, which was the number of tasks he experienced in each condition in Experiment 1. The accumulated variant conditions were therefore introduced. Following this modification, problem behavior decreased across all conditions and remained low through schedule thinning and when the strictly accumulated food and break conditions were reintroduced at FR 10.

Figure 5 depicts the outcomes for Sadie (top panel) and Jaxon (bottom panel). Sadie engaged in problem behavior across most trials during baseline. The treatment conditions all resulted in an immediate suppression in problem behavior and these effects were maintained as the schedule of reinforcement was thinned to FR 5. Jaxon engaged in moderate levels of problem behavior during baseline. Jaxon's problem behavior decreased across sessions in both food conditions and in the accumulated break condition while it remained elevated in the distributed break condition. The reintroduction of the treatment conditions was associated with low and stable levels of problem behavior across all conditions. Problem behavior remained low in all conditions as the schedule of reinforcement was thinned to FR 10.

The top panel of Figure 6 depicts the results of Experiment 2 for Sawyer. He engaged in moderate levels of problem behavior during baseline. Problem behavior decreased during the reinforcement phase, although a modest amount of overlap was observed between baseline and the reinforcement conditions. During the reversal to the reinforcement phase, the mean level of problem behavior during the accumulated break condition exceeded the baseline criterion and the trend across was increasing. Therefore, accumulated break was discontinued while the remaining conditions were exposed to schedule thinning. At FR 5, problem behavior began to increase across all three remaining treatment conditions; thus, this phase was extended beyond three series. Eventually, all three conditions became ineffective at FR 5.

Roland's results are depicted in the bottom panel of Figure 6. Like Sawyer's results, a moderate amount of overlap was observed between baseline and reinforcement conditions for Roland. However, the trend differed in that an increasing trend in the percentage of trials with problem behavior was observed in his initial baseline, whereas decreasing trends tended to be observed during the reinforcement phases. At FR 2, the mean level of problem behavior increased in accumulated break. Therefore, accumulated break was discontinued[1] while the schedule was thinned to FR 4 in the distributed break condition. Problem behavior increased at FR 4 and remained elevated during the final three sessions.

Table 3 depicts the mean compliance and instruction duration. Similar to Experiment 1, compliance was roughly equivalent for all participants. Prior research has suggested that accumulated reinforcement conditions may result in more efficient responding, which has been

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[1] One session of accumulated break was conducted at FR 4 due to miscommunication between the individuals conducting the session and the first author.

attributed to increased handling costs (i.e., time it takes to consume the reinforcer and then re-orient to the task materials) associated with distributed arrangements (e.g., DeLeon et al., 2014). In the current study, instruction duration provided a measure of response efficiency. Results of the current study differed from past research in that one of the distributed conditions was generally associated with the shortest instruction durations. Furthermore, accumulated break was associated with the longest instruction durations in four of five cases, whereas distributed break was associated with the most efficient responding in three cases. Thus, these data suggest that arranging a break in an accumulated manner may not increase the efficiency of task completion.

Prior research to suggest that accumulated reinforcement results in more rapid task completion used activity reinforcers (e.g., Bukala et al., 2015; DeLeon et al., 2014; Frank-Crawford et al., 2019). Only DeLeon et al. (2014) evaluated efficiency with food; their results indicated that two of the four participants completed the tasks more rapidly in the distributed condition with food as the reinforcer. In the current study, distributed food was also associated with shorter instruction durations for two of four participants. It is possible that food delivery arranged in distributed reinforcement is not associated with increased handling costs in the same way that accumulated leisure activities may be because the individual can consume the food while maintaining orientation to the task materials.

The results of Experiment 2 partially replicate those of Fulton et al. (2020) by further suggesting that accumulated reinforcement might be effective in decreasing escape-maintained problem behavior. In Fulton et al., the accumulated condition was as effective as or more effective than the distributed condition for all three participants; however, accumulated break was as effective as distributed break in only two of four cases in the current study; for Finn, neither condition was initially effective. In no case was accumulated break *more* effective than distributed reinforcement. Accumulated food, on the other hand, was as effective as the distributed conditions in three of four cases in which food was used; and those effects maintained during schedule thinning. For Finn, only when accumulated variant food was introduced were consistent reductions in problem behavior observed. It is possible that the superiority of accumulated reinforcement observed by Fulton et al. was a result of the *combined* effects of positive and negative reinforcement.

Distributed breaks produced large reductions in problem behavior for Finn, Sadie, and Jaxon even though problem behavior continued to produce escape; however, for Finn distributed break only produced strong treatment effects following the introduction of the accumulated variant conditions. Although the break conditions appeared to produce small to moderate reductions in problem behavior for Sawyer and Roland, there was a high degree of overlap between responding in treatment and baseline. Interestingly, distributed break appears to have been effective in maintaining lower levels of problem behavior for three of the five participants in the current study. This finding differs from prior research comparing positive and negative reinforcement in the treatment of escape-maintained problem behavior where distributed break was rarely as effective as positive reinforcement (e.g., DeLeon et al., 2001; Lalli et al., 1999). Our findings may be an artifact of the experimental design in that rapid alternation of highly preferred, effective conditions with less preferred ones may have lessened the aversiveness of the overall instructional context and therefore decreased the motivation to engage in problem behavior. Similar results were observed by Fulton et al. (2020) with the distributed condition. Specifically, the distributed condition was initially ineffective for two of three participants when it was evaluated in isolation. It was not until it was evaluated in the context of a multielement design, alternated with the accumulated condition, that reductions in the distributed condition were obtained. This possibility is important to acknowledge and further evaluate as treatments are likely to include only a single reinforcement arrangement at any given time. Future research should independently verify the efficacy of treatment conditions by conducting them for an extended number of sessions in isolation of other conditions.

## General Discussion

The current studies evaluated whether accumulated reinforcement arrangements were preferred by individuals with escape-maintained problem behavior and whether they were effective in reducing problem behavior. Accumulated breaks were more preferred than distributed breaks for most participants. In addition, when arranged on an FR 1 reinforcement schedule, accumulated breaks (or the accumulated variant) produced similar outcomes to distributed breaks for four of the five participants. Accumulated food (or the accumulated variant) was as effective as distributed food for all participants. This replicates results of Fulton et al. (2020) in that accumulated reinforcement can be effective for individuals with escape-maintained problem behavior, particularly under dense schedules of reinforcement. These findings extend prior research by examining variations to strict reinforcer accumulation for one participant.

Results were mixed during schedule thinning. Specifically, accumulated break was not effective at FR 1 for Sawyer and less effective than distributed reinforcement at FR 2 for Roland. Falligant et al. (2019) found that although accumulated arrangements may be more preferred under dense reinforcement schedules, preferences may shift away from accumulated and toward distributed arrangements as schedules are thinned, particularly if the unit price is not held constant. This shifting of preference is not unique to accumulated and distributed reinforcement arrangements; similar preference shifts have been observed in examinations of contingent and noncontingent schedules of reinforcement (e.g., Luczynski & Hanley, 2010). Thus, if leaner schedules impact preference, and preference predicts efficacy, then is it perhaps not surprising that in some cases, the accumulated arrangement became less effective over time. However, research also suggests that holding unit price constant may be effective in warding off a shift in preference toward distributed reinforcement (Falligant & Kornman, 2019). It is not clear whether the accumulated arrangement would have remained more effective during schedule thinning for Roland had the unit price been held constant such that increases in the FR schedule were also associated with increases in the unit of reinforcement. This represents an important area for future research.

The number of tasks was increased from 10 in Experiment 1 to 20 in Experiment 2 to more closely mimic the number of tasks presented in the typical escape condition of the functional analysis. Finn immediately perseverated on competing 10 tasks in Experiment 2. It is possible that although accumulated arrangements may have been more preferred when the number of tasks required was relatively small and the delay to reinforcement was relatively short, increases in the response effort and reinforcer delay in Experiment 2 may have shifted Finn's preference toward distribution. The accumulated variant condition, on the other hand, still allowed for reinforcer accumulation, but with relatively shorter delays to reinforcement. Additional research on preferences for and efficacy of these arrangements under various effort manipulations and delays to reinforcement is warranted.

Escape-maintained problem behavior can limit both the quantity and quality of access to learning opportunities for individuals with IDD (e.g., Carr et al., 1991), which has important implications for habilitation and overall quality of life. Instruction is synonymous with educational programming and practically ubiquitous to behavioral interventions designed for individuals with IDD. Thus, the success of these interventions relies heavily on individual participation. DNRA with extinction may be difficult or even impractical to implement with perfect fidelity and research has indicated that without extinction, DNRA rarely produces clinically meaningful reductions in problem behavior (e.g., Briggs et al., 2019; Lalli et al., 1999). DRA using a positive reinforcer, such as food, has proven more effective (e.g., DeLeon et al., 2001; Lalli et al., 1999). However, other reinforcers, such as a break, are reportedly used more often by practitioners (Graff & Karsten, 2012) and there are a number of potential negative effects associated with the use of food (e.g., Frank-Crawford et al., 2012). Methods to increase the efficacy of the functional reinforcer, a break, in the treatment of escape-maintained problem behavior could have important clinical implications. Specifically, the use of a break would better align with current practice, may be less disruptive to the classroom environment, and be less likely to evoke interfering behavior that can slow or otherwise hinder skill acquisition. In short, methods to improve the efficacy of DNRA have the potential to provide practitioners with better tools with which to treat escape-maintained problem behavior and may steer practitioners away from reliance on food.

In the current study, allowing accumulated access to a break did not increase the efficacy of DNRA for two participants. Unlike the studies conducted by Fulton et al. (2020) and Robinson and St. Peter (2019), break in the current study was used in isolation of other reinforcers and extinction was not implemented. One method of enhancing accumulated break, while still being sensitive to the possible negative effects of food, would be to combine break with activities and/or to implement extinction when possible. Results of studies conducted by Fulton et al. and Robinson and St. Peter suggest that the combined effects may produce positive treatment outcomes; however, it is unknown whether these results would maintain in the absence of extinction or during schedule thinning. More research is warranted.

The current study is not without limitations. The condition cards depicted a relatively complex series of events and several individuals were unable to participate in Experiment 1 because they failed the discrimination test. Future research could explore different methods to aid in discrimination to allow for an evaluation of preference for individuals that span the continuum of cognitive abilities. In addition, due to time constraints (Joel, Axel, and Arthur) or participants failing the discrimination test (Jaxon, Sawyer, and Roland), only Finn and Sadie participated in both Experiment 1 and 2. Finn preferred the accumulated conditions in Experiment 1, but neither was initially effective in Experiment 2. For Sadie, the distributed food condition was the most highly preferred. She did not engage in problem behavior in that condition, her compliance was the highest in distributed food, and instruction duration was shortest in this condition. These data offer some, albeit limited, support for the notion that preference may correspond to efficacy for some individuals; however, preference and efficacy should continue to be evaluated with the same participants in future research to address this question more fully.

Finally, treatment effects were maintained for at least one condition only through FR 4 for Sawyer and FR 2 for Roland. Although responding continued to be reinforced on a relatively dense schedule for these participants, overall levels of problem behavior were lower, instruction durations were decreased, and compliance was higher than in baseline, suggesting greater opportunities for learning. In addition, these data offer important information regarding effectively arranging reinforcement during thinning. Specifically, the results of this study, like those of Robinson and St. Peter (2019) and Fulton et al. (2020), indicate that under FR 1 schedules of reinforcement, accumulated arrangements are often as effective as distributed arrangements, which may lead to clinicians electing to arrange accumulated reinforcement for clients with escape-maintained problem behavior. However, neither Robinson and St. Peter nor Fulton et al. evaluated how well the treatments held up under leaner schedules of reinforcement. The preliminary results of the current study suggest that, for some individuals, distributed arrangements may be more effective as reinforcement schedules are thinned. To our knowledge, this is the only study to date that has demonstrated this shift in efficacy amongst these arrangements during schedule thinning for this population. These data point to important avenues for future research, such as examining whether larger and more sustained reductions are obtained under leaner schedules with extinction or when combining positive and negative reinforcement.

Differential reinforcement is typically arranged using distributed response-reinforcer arrangements. However, results of an emerging line of research, this study included, suggest that accumulated reinforcement may provide an alternative method for arranging reinforcers for treating escape-maintained problem behavior. It is not yet clear whether the inclusion of positive reinforcement in the break is always necessary; however, the combination of break with access to preferred items is likely to more closely mimic typical educational programming. Importantly, accumulated response-reinforcer arrangements have the potential to put into balance treatment efficacy and practicality with client-directed intervention in which the individual receiving care has the opportunity to participate in the selection of their own intervention, an important goal of habilitation (Bannerman et al., 1990; Hanley, 2010; Van Houten et al., 1988).

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**Table 1**

*Participant Description and Setting Locations*

| Partic-ipant | Gen-der | CA | Diagnoses | Verbal Abilities | Setting Locations |
|---|---|---|---|---|---|
| Finn | M | 11 | ASD, ID-Moderate, ADHD, SMD w/ SIB | Three- to six-word sentences; mands, tacts, IV | Bedroom |
| Joel | M | 13 | ASD | Full vocal sentences; mands, tacts, IV | Classroom |
| Axel | M | 15 | ASD, ID-Moderate, ADHD, SMD w/ SIB | One- to three-word phrases; mands, tacts, IV | Bedroom |
| Arthur | M | 8 | ID-Mild, ADHD, SMD w/ SIB, anxiety and mood disorder (NOS), FAS | Full vocal sentences; mands, tacts, IV | Activity Area |
| Sadie | F | 7 | ASD, ID-Moderate, ADHD, SMD w/ SIB, FAS, developmental disorder of speech and language (NOS) | Full vocal sentences; mands, tacts, IV | Bedroom |
| Jaxon | M | 18 | ASD, SMD w/ SIB, ID-Profound | Vocal approximations, gestures; mands | Bedroom |
| Sawyer | M | 9 | ASD, ID (NOS), ADHD, SMD w/ SIB, intermittent explosive disorder | Vocal approximations, one word phrases with AAC; mands, tacts | Activity Area |
| Roland | M | 15 | ASD, ID-Severe, SMD w/ SIB, anxiety disorder (NOS) | One- to two-word phrases; mands, tacts, IV | Shared Common Area |

*Note.* M = male, F = female, CA = chronological age, ASD = autism spectrum disorder, ID = intellectual disability, ADHD = attention deficit hyperactivity disorder, SMD w/ SIB = stereotypic movement disorder with self-injurious behavior, IV = Intraverbals, NOS = not otherwise specified, FAS = fetal alcohol syndrome, AAC = augmentative or alternative communication.

**Table 2**

*Mean Percentage of Tasks with Problem Behavior and Compliance in Experiment 1*

| | Problem Behavior | | | | | Compliance | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Partic-ipant | DIS Food | DIS Break | ACC Food | ACC Break | CNT | DIS Food | DIS Break | ACC Food | ACC Break | CNT |
| Finn | N/A | 8.3% | 1.7% | 9.2% | N/A | N/A | 22% | 89.6% | 91% | N/A |
| Joel | 4.5% | 2.3% | 7.8% | 3.6% | 1% | 96.7% | 96.7% | 98.6% | 97.1% | 100% |
| Axel | 0% | 0% | 0% | 0% | 0% | 93.2% | 86.7% | 95.8% | 91.6% | 93.3% |
| Arthur | 0% | N/A | 0% | 0% | N/A | 96.3% | N/A | 95% | 96.3% | N/A |
| Sadie | 0% | 12% | 0% | 0% | 0% | 100% | 93% | 98.9% | 96.3% | 100% |

*Note.* DIS = distributed, ACC = accumulated, CNT = Control, N/A = not applicable because the condition was never selected.

**Table 3**

*Mean Percentage of Tasks with Compliance and Mean Instruction Duration in s in Experiment 2*

| Participant | Condition | Compliance | Instruction Duration |
|---|---|---|---|
| Finn | BL | 7.5% | 578.1 |
| | DIS Food | 92.9% | 403.4 |
| | DIS Break | 78.4% | 290.2 |
| | ACC Food | 77.5% | 311.2 |
| | ACC Break | 70.0% | 352.2 |
| | ACC Variant Food | 83.8% | 278.7 |
| | ACC Variant Break | 95.0% | 291.0 |
| Sadie | BL | 23.3% | 750.2 |
| | DIS Food | 99.1% | 325.1 |
| | DIS Break | 97.3% | 398.3 |
| | ACC Food | 98.4% | 352.4 |
| | ACC Break | 84.3% | 475.8 |
| Jaxon | BL | 47.7% | 435.6 |
| | DIS Food | 91.1% | 316.3 |
| | DIS Break | 85.0% | 242.6 |
| | ACC Food | 87.8% | 295.3 |
| | ACC Break | 86.3% | 327.2 |
| Sawyer | BL | 11.3% | 1158.3 |
| | DIS Food | 16.6% | 655.2 |
| | DIS Break | 19.5% | 620.4 |
| | ACC Food | 14.2% | 677.7 |
| | ACC Break | 15.9% | 832.8 |
| Roland | BL | 23.6% | 595.6 |
| | DIS Break | 35.4% | 528.2 |
| | ACC Break | 33.4% | 549.1 |

*Note.* BL = baseline, DIS = distributed, ACC = accumulated.

**Figure 1**

*Responses per Minute during the Functional Analysis*

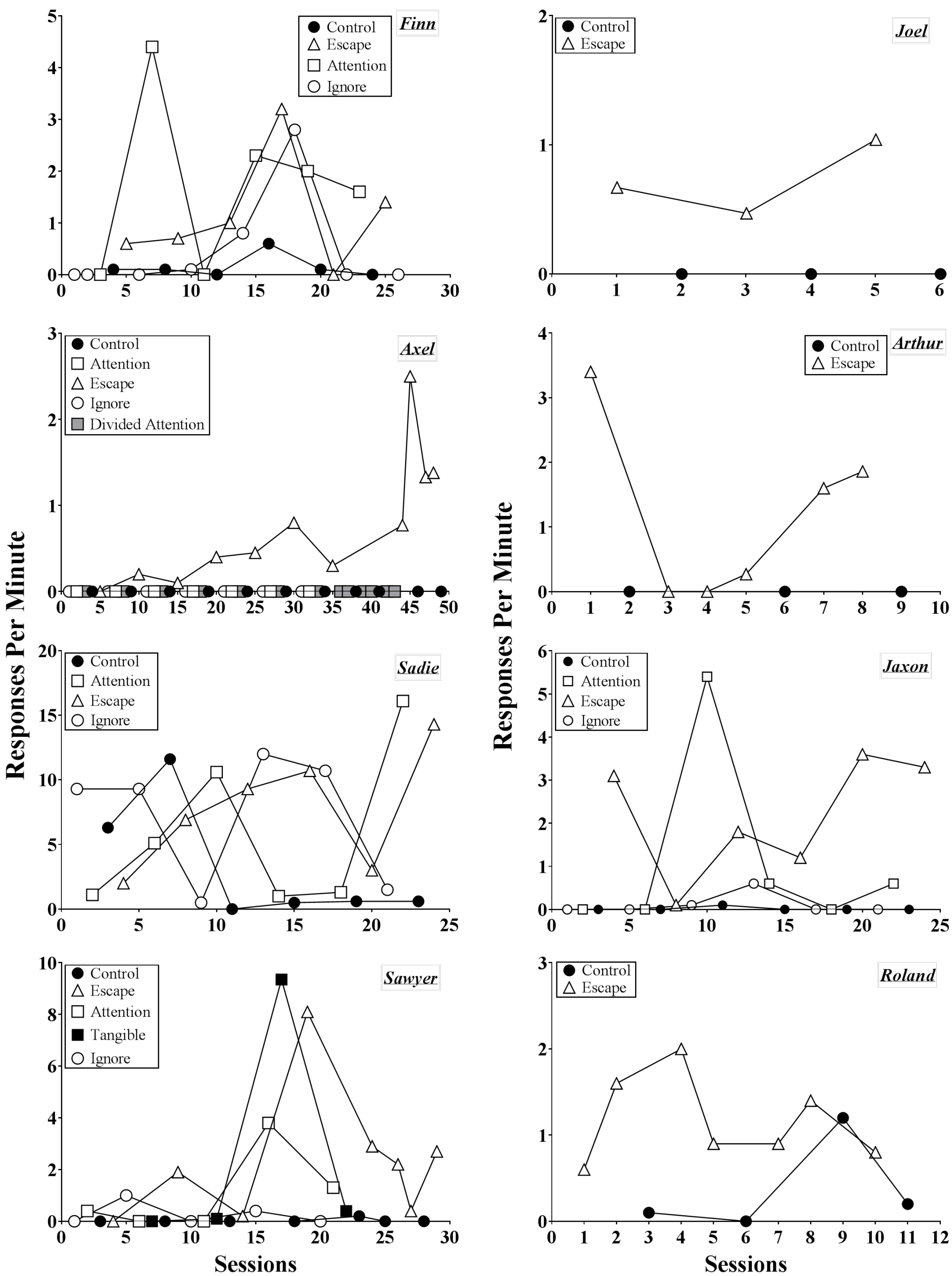
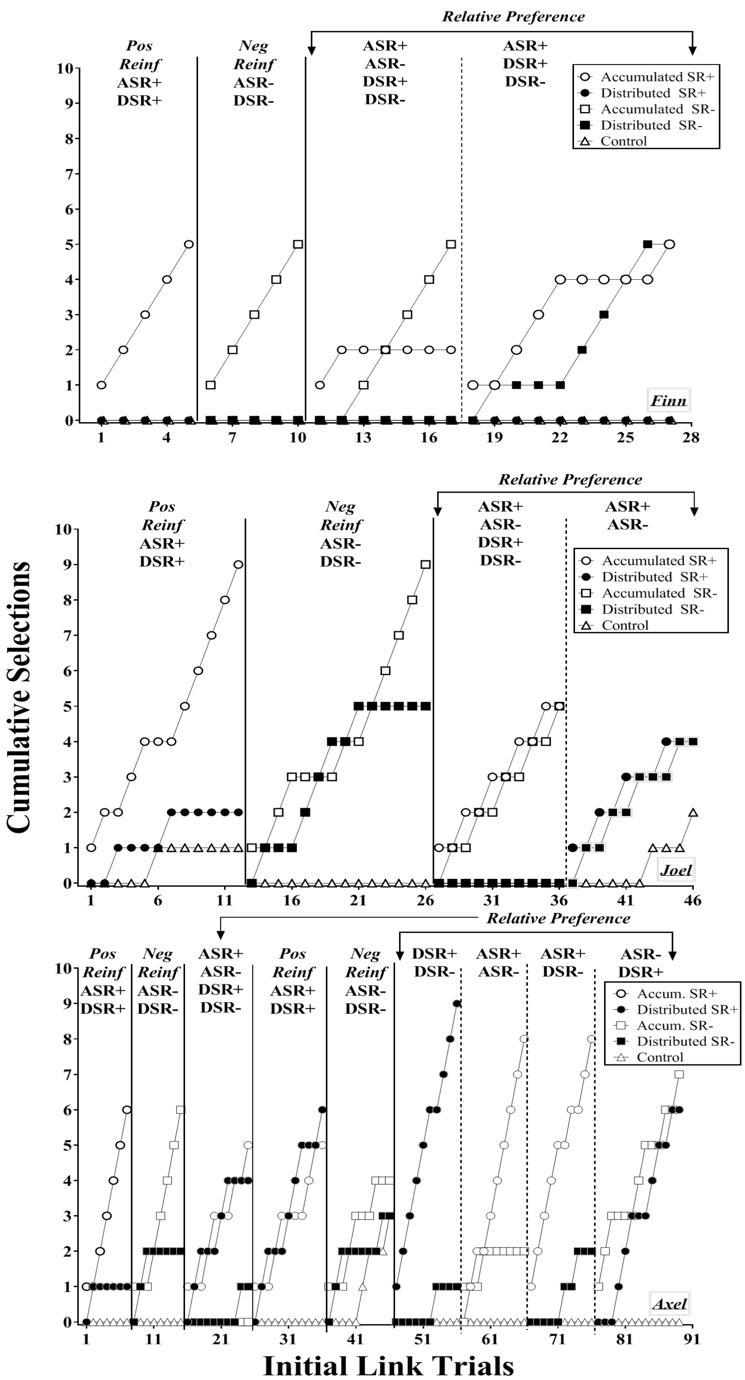


**Figure 2**

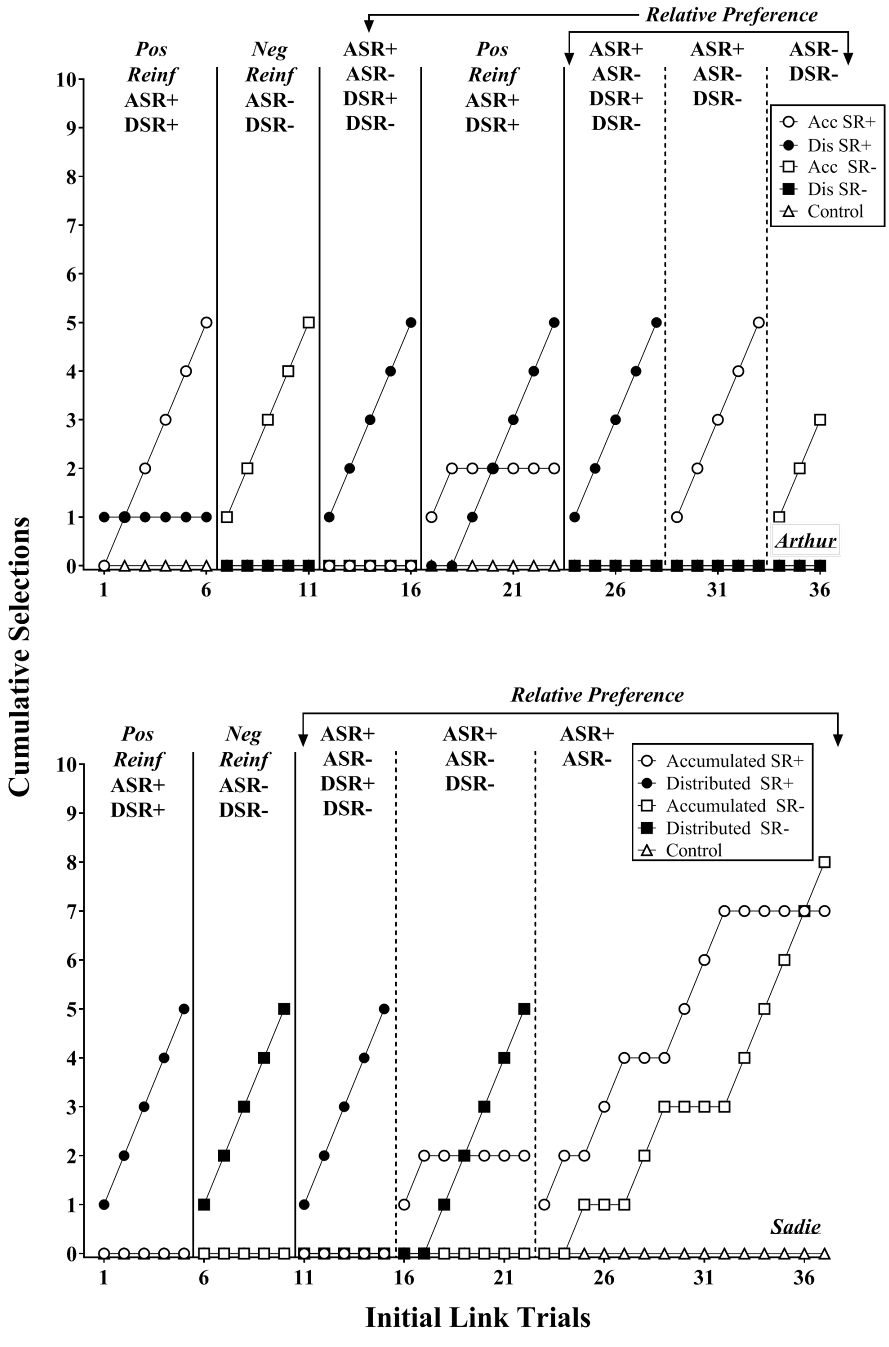
*Cumulative Selections across Each Assessment of Experiment 1*




*Note*. Pos Reinf = positive reinforcement, ASR+ = accumulated food, DSR+ = distributed food, Neg Rein = negative reinforcement, ASR- = accumulated break, DSR- = distributed break. Italics denote the assessment.

**Figure 3**

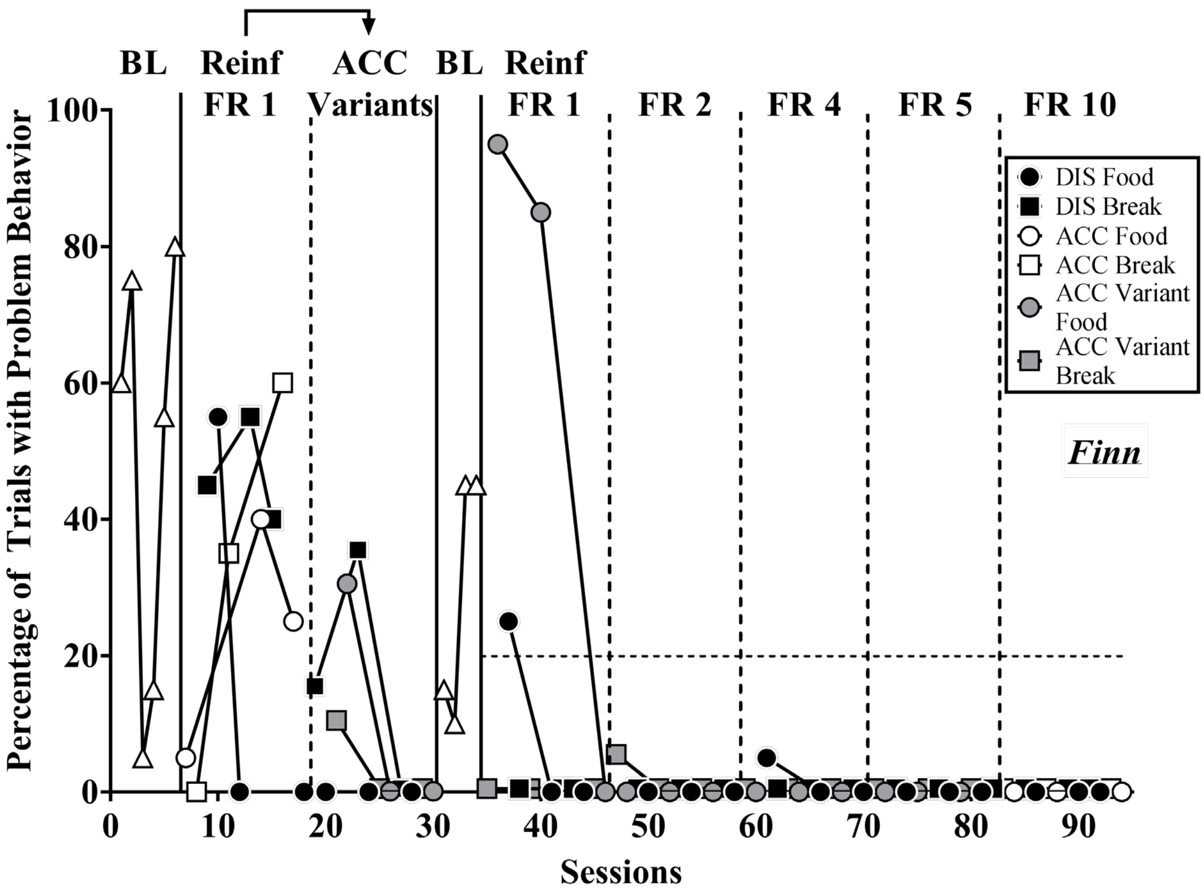
*Cumulative Selections across Each Assessment of Experiment 1*




*Note*. Pos Reinf = positive reinforcement, ASR+ = accumulated food, DSR+ = distributed food, Neg Rein = negative reinforcement, ASR- = accumulated break, DSR- = distributed break. Italics denote the assessment.

**Figure 4**

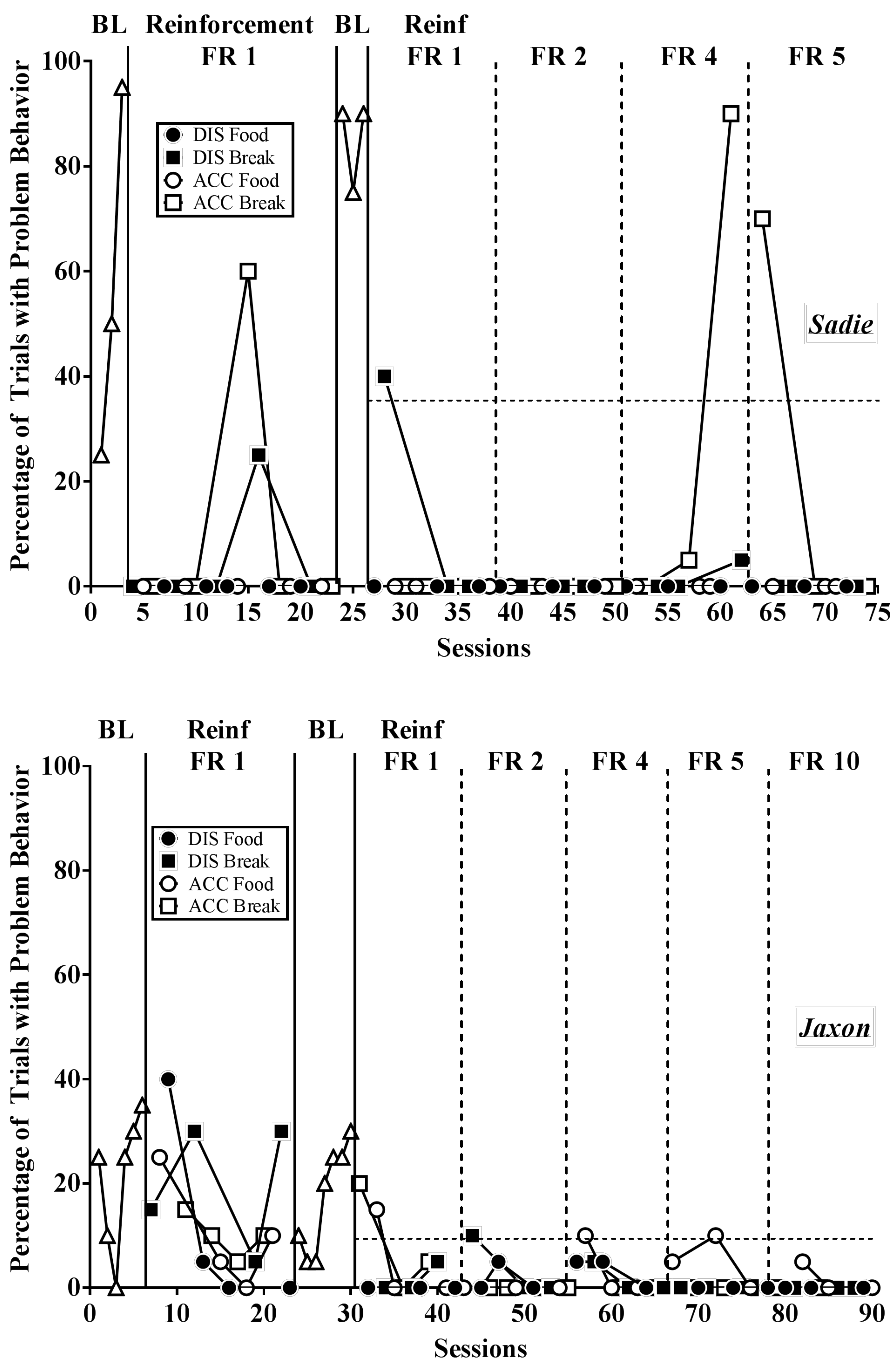
*Percentage of Trials with Problem Behavior in Experiment 2*




*Note*. Reinf = Reinforcement, FR = fixed ratio, DIS = distributed, ACC = accumulated. The dashed horizontal line denotes a 50% reduction in the percentage of trials with problem behavior, relative to baseline.

**Figure 5**

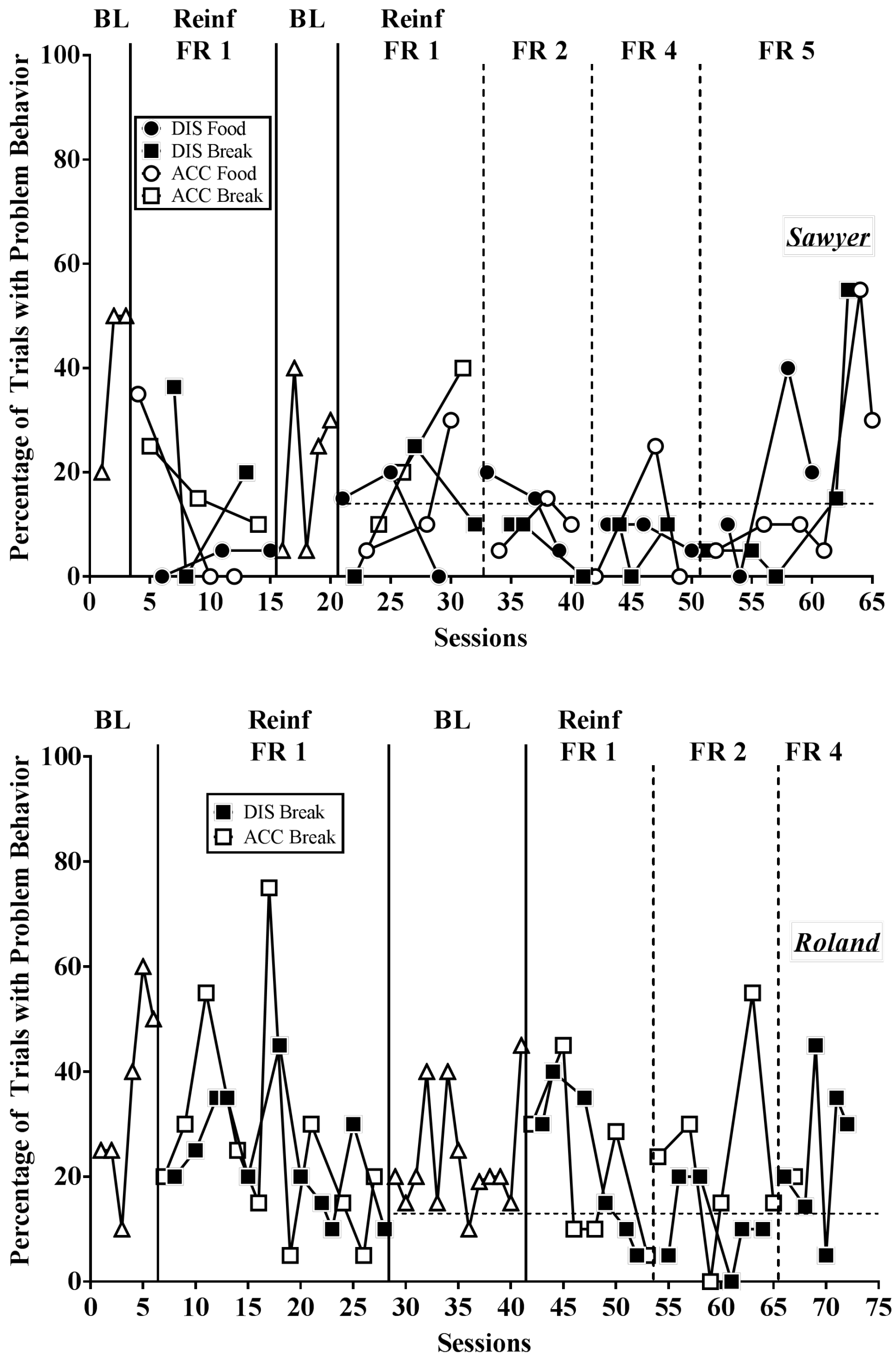
*Percentage of Trials with Problem Behavior in Experiment 2*




*Note*. Reinf = Reinforcement, FR = fixed ratio, DIS = distributed, ACC = accumulated. The dashed horizontal line denotes a 50% reduction in the percentage of trials with problem behavior, relative to baseline.

**Figure 6**

*Percentage of Trials with Problem Behavior in Experiment 2*




*Note*. Reinf = Reinforcement, FR = fixed ratio, DIS = distributed, ACC = accumulated. The dashed horizontal line denotes a 50% reduction in the percentage of trials with problem behavior, relative to baseline.