Journal of
Applied Behavior Analysis

Accumulated reinforcers increase academic responding and suppress problem behavior for students with Attention-Deficit Hyperactivity Disorder

Nicole Robinson and Claire C. St. Peter

West Virginia University

We compared rates of academic responses and problem behavior during mathematics with distributed and accumulated reinforcer arrangements for 3 students with Attention-Deficit Hyperactivity Disorder who engaged in chronic, severe problem behavior. All 3 students engaged in more academic responding and less problem behavior when reinforcers accumulated throughout the session, relative to conditions in which reinforcers were distributed throughout the session or withheld completely. We then conducted concurrent-chain analyses to evaluate student preference for the reinforcer arrangements. Two students preferred distributed reinforcers, even though this arrangement continued to produce problem behavior. One student preferred accumulated reinforcers. Our data replicate previous findings regarding the efficacy of accumulated-reinforcer arrangements, but suggest that students do not always prefer the most efficacious reinforcer arrangement.

Key words: academic responding, concurrent chain, delay, impulsivity, problem behavior

Delay to reinforcer delivery and duration of reinforcer access affect the reinforcing efficacy of items and activities and children's choices for those items (e.g., DeLeon et al., 2014; Fisher, Thompson, Piazza, Crosland, & Gotjen, 1997; Hoch, McComas, Johnson, Faranda, & Guenther, 2002; Neef, Shade, & Miller, 1994; Steinhilber & Johnson, 2007). Reinforcers may be most effective when delivered immediately (e.g., Sy & Vollmer, 2012). However, immediate reinforcer delivery is not always possible, particularly in school settings. Teachers may require that students complete large amounts or long periods of work before reinforcers are available. Even when immediate reinforcer delivery is possible, it may require relatively brief access to the reinforcer to be practical. A common reinforcer arrangement in applied behavior analysis involves delivery of short durations (e.g., 15 - 30 s) of reinforcer access immediately following each correct response. However, such short access may sometimes limit the reinforcing efficacy of the item or activity. For example, activities that have a natural progression through time, such as playing games or putting together puzzles, may be more reinforcing when the individual has enough continuous access to complete the activity (Steinhilber & Johnson, 2007). To be practical, longer reinforcer durations must sometimes occur at a delay or necessitate a larger work requirement per reinforcer delivery.

Children diagnosed with disorders characterized by impulsive decision making (e.g., Attention-Deficit Hyperactivity Disorder or ADHD) often select immediate, lower-magnitude reinforcers over delayed, higher-magnitude reinforcers (Neef, Bicard, & Endo, 2001; Neef et al., 2005). Relatedly, children with ADHD may prefer immediate access to short-duration reinforcers (a distributed-

The current study was completed in partial fulfillment of the requirements for a Master of Arts degree for the first author, under the supervision of the second author. We would like to thank Brittany Germain and Alexis Laws for their assistance with data collection throughout the study.

Address correspondence to: Claire St. Peter, West Virginia University, Department of Psychology, 53 Campus Drive, Morgantown, WV 26505-6040 Email: claire.stpeter@mail.wvu.edu

doi: 10.1002/jaba.570

reinforcer arrangement) to accumulating longer access periods that occur after a delay (an accumulated-reinforcer arrangement) when the unit price (amount of reinforcer available per response) is equated across arrangements. However, this finding has not yet been demonstrated in the literature, and two recent studies conducted with other populations suggest opposite outcomes. DeLeon et al. (2014) found that individuals with developmental disabilities consistently preferred reinforcer arrangements in which access time accumulated throughout the session and was delivered at the end of the session to arrangements in which shorter durations of reinforcer access occurred more immediately after each response. Each response resulted in 30-s access to the reinforcer, but the distribution of reinforcer deliveries varied across conditions. In the distributed-reinforcement condition, the experimenters provided 30-s access to the participant immediately after each correct response. In the accumulated-reinforcement condition, the participants earned a token for each correct response and exchanged each token at the end of the session for 30-s access to the reinforcer. The participants were exposed to both contingencies repeatedly and then given choices between reinforcer arrangements. For all four participants, the accumulated-reinforcer condition produced higher response rates on a daily living task and was more preferred by the participants than the distributed-reinforcer condition. Similarly, Bukala, Yao Hu, Lee, Ward-Horner, and Fienup (2015) found that teenagers with an autism diagnosis preferred accumulated reinforcer arrangements to distributed ones. Unlike the study by DeLeon et al., Bukala et al. did not include tokens in the accumulated condition. Two of the three teenagers generally completed work more rapidly in the accumulated condition than the distributed condition, and all three teenagers preferred the accumulated condition over the distributed condition.

Participants in the studies by DeLeon et al. (2014) and Bukala et al. (2015) were diagnosed with autism or developmental disabilities and exhibited limited verbal repertoires. Individuals with more complex verbal repertoires and diagnoses characterized by impulsivity, such as ADHD, may be more sensitive to immediate reinforcer deliveries and, therefore, may be likely to prefer distributed arrangements. However, this effect has not yet been demonstrated. Additionally, neither DeLeon et al. nor Bukala et al. included a direct measure of problem behavior. If accumulated-reinforcer arrangements promote more work completion, it is possible that they also better suppress problem behavior than distributed conditions. The purpose of the current study was to replicate and extend the studies by DeLeon et al. and Bukala et al. in two ways. First, we evaluated the efficacy of, and student preference for, accumulated and distributed reinforcer arrangements with students who had age-typical verbal skills, diagnoses associated with impulsive behavior, and a history of chronic or severe problem behavior. Second, we extended the findings obtained by DeLeon et al. by comparing the efficacy of accumulated and distributed reinforcer-delivery arrangements on both academic responding and rates of problem behavior.

METHOD

Participants and Setting

Three 10-year-old students participated. All students attended a public suburban alternative-education center that served students who engaged in frequent or severe problem behavior. Willis was a Caucasian male with diagnoses of ADHD and Reactive Attachment Disorder. He had a history of engaging in high rates of problem behavior such as high-intensity aggression and property destruction, noncompliance, and elopement. Before attending the alternative-education center, he was placed in an inpatient facility to manage his high rates of problem behavior. Harmony was a Caucasian female with diagnoses or educational labels of Mild Intellectual Disability, ADHD, Anxiety Disorder, Post-Traumatic Stress Disorder, and Phonological Disorder. Harmony had a history of high rates of problem behavior, resulting in a previous placement in an inpatient treatment facility. She sexually assaulted others, bit, pulled hair, destroyed property, and engaged in noncompliance. Miles was a Caucasian male with diagnoses of Conduct Disturbance Not Otherwise Specified, Obsessive Compulsive Disorder, Attention Deficit Disorder (ADD), and Asperger Syndrome. He engaged in high rates of problem behavior that included high-intensity aggression and property destruction, and noncompliance. All three students had complex verbal repertoires and communicated using complete sentences, but had academic deficits including below-grade-level math performance.

We conducted all research sessions at a table in the back of the student's classrooms. Although only the experimenter and student sat at the table, we conducted sessions during ongoing instruction, and there were typically two other adults and four other students present in the classroom. The other adults and students engaged in varying instructional activities. Sessions were conducted 2 or 3 days a week with each student, and a maximum of three sessions were conducted with each student each day. We consulted with the students' teachers to select mathematic tasks for which the student had received instruction but required further practice to be functional skills in the classroom. Willis and Harmony completed addition problems with sums to 10. Miles completed addition and subtraction problems with single digits. Each problem appeared on a 7.6 cm by 12.7 cm flashcard.

Response Measurement

Trained observers collected frequency data on correct and incorrect academic responses in 10-s intervals using a paper–pencil measure. A correct answer consisted of the student saying the entire math problem, including the numbers in the equation (in any order), the operator (plus or minus), the word "equal" or "is," and the correct sum or difference. Observers scored an incorrect answer when the math sentence was incomplete or if any of the numbers or sums were incorrect. When students self-corrected, observers scored the initial response as incorrect but a subsequent correct response to the same flashcard as correct.

Observers also collected data on problem behavior and reinforcer access using 10-s partial-interval recording. Problem behavior included noncompliance, inappropriate vocalizations, property destruction, and aggression. Noncompliance was defined as any pause in responding greater than 15 s, head down for greater than 5 s, or eye rolling. Inappropriate vocalizations or gestures included cursing, threatening, name-calling, giving the middle finger, naming private body parts, pretend shooting using fingers as guns, protesting, screaming, and exaggerated sighing. Property destruction was defined as ripping paper, breaking or biting materials, tipping over furniture, kicking or hitting furniture, throwing materials farther than 0.3 m away from another person, and spitting on materials or furniture. Aggression was defined as any attempted hitting, kicking, biting, pinching, grabbing, scratching, spitting (on or within 0.3 m of another person), and throwing objects within 0.3 m of another person. Reinforcer access was defined as the child having access to the item selected, which continued until the experimenter said, "my turn" and started removing the item.

During the concurrent-chain assessment, we collected paper–pencil data on the students' choices for reinforcer arrangement. After the selection was made, we collected data in 10-s intervals with paper–pencil measures for correct and incorrect responses, problem behavior, and reinforcer access as described above.

Interobserver Agreement

Two observers simultaneously and independently collected data for 41% of reinforcer-efficacy sessions and 48% of concurrent-chains sessions across students. For both reinforcer-efficacy and concurrent-chains sessions, the observers' records of correct and incorrect responses were compared within each 10-s interval by dividing the smaller count by the larger count for each response type, averaging the quotients across all intervals in the session, and multiplying by 100. If neither observer scored a correct or incorrect response within that 10-s interval, the interval was counted as 100% agreement. We then averaged these agreement scores across all sessions for each student. The interobserver agreement (IOA) scores averaged 93% for correct responses (range, 72% - 100%) and 93% for incorrect responses (range, 61% - 100%) during the reinforcer-efficacy sessions, and 98% for correct responses (range, 94% - 100%) and 97% (range, 88% - 100%) for incorrect responses during the concurrent-chains sessions.

For problem behavior, we calculated IOA by dividing the number of intervals during each session for which the two observers agreed on the presence or absence of the event by the total number of intervals in the session, and converting the proportion to a percentage. Observers collected IOA during 41% of sessions. During the reinforcer-efficacy sessions, IOA scores averaged 97% for noncompliance (range = 83% - 100%), 97% for inappropriate vocalizations or gestures (range = 89% - 100%), 99% for property destruction (range = 94% - 100%), and 100% for aggression. During the concurrent-chains sessions, IOA averaged 99% for noncompliance (range, 92% - 100%), 98% for inappropriate language or gestures (range, 92% - 100%), 100% for property destruction, and 100% for aggression.

For 43% of concurrent-chains sessions, the second observer also collected data on student choices. We calculated IOA by comparing the recorded choice across observers (i.e., agreement if they recorded the same choice) and divided the total number of agreements by agreements plus disagreements across the phase, and converted to a percentage. Observers agreed on 100% of recorded choices.

Treatment Integrity

A second independent observer collected data on the extent to which the experimenter implemented the procedures according to the protocol. To collect these data, the observer used a checklist that specified each step of the procedure and measured whether the experimenter implemented each step correctly at each opportunity. We collected treatment-integrity data for 31% of reinforcer-efficacy sessions and 43% of concurrent-chains sessions. Treatment integrity was 100% throughout the study.

Design

We used a multielement design to assess effects of reinforcer distribution.

Students experienced three conditions (i.e., accumulated reinforcers, distributed reinforcers, control), in random order without replacement (i.e., block randomization). In one instance, an error in randomization resulted in an additional distributed session with Willis (session 9). After completing the efficacy analysis, we assessed student preferences using a concurrent-chains procedure.

Procedure

General session procedures. Before starting the experiment, we identified activities that might serve as reinforcers by asking each student to list four items that were available in the classroom and with which he or she liked to play, such as iPads, Legos, building magnets, or Play-Doh. The experimenter asked the child to select one of these four items before each session in the accumulated and distributed conditions. The experimenter delivered that item during reinforcer-access periods during the following session. The experimenter asked the child to choose a reinforcer before presenting any discriminative stimuli associated with a particular condition so that upcoming session type did not influence reinforcer selection. Students did not choose a reinforcer before control sessions.

Each experimental session consisted of a 3-min work period, exclusive of reinforcer-access time. During sessions, students held the stack of flashcards and read math problems aloud as quickly as possible. The experimenter instructed the student to read the entire problem, including the answer, for two reasons. First, reading the entire problem aloud might help students to build intraverbal chains between the number families. Second, having the child read the entire problem out loud might indicate whether errors were due to incorrect statement of the problem (i.e., number identification) or arithmetic errors. The experimenters provided this information to the classroom teachers at the end of the study.

Between sessions, the experimenter delivered tokens as part of a class-wide behavior management system. The experimenter delivered tokens independently of the child's responding during the session so that token delivery did not differentially affect performance within the sessions. We included response-independent token delivery so that students could access class-wide rewards that they would have otherwise missed as a result of their participation in the study during ongoing classroom instructional time. Experimenters ignored all problem behavior during work sessions and implemented reactive procedures from the student's individualized behavior intervention plan following sessions if needed.

Reinforcer-Efficacy Analysis

Accumulated sessions. At the start of each session in the accumulated condition, the experimenter placed a stack of 50 yellow flashcards in front of the student and stated, "You will earn 15 seconds to play for each correct answer and will get to play at the end of the session. Say the problem and answer out loud. If you mess up, go back and say the problem over again." The experimenter started a work timer for 3 min that was not visible to the student. The experimenter did not provide any feedback on student responses during the session and kept the data sheet out of the student's sight to more closely simulate accumulated-reinforcer conditions that would occur in a classroom. After the 3-min work period elapsed, the experimenter multiplied the number of correct responses by 15, told the child the duration of earned reinforcer access, set a timer for this duration, and allowed the student to access the selected item for the earned duration. For example, if the child said 10 correct math problems, he or she received 150-s access to the item. After the reinforcer-access period, the experimenter said "my turn" and removed the item.

Distributed sessions. At the start of each session in the distributed condition, the experimenter placed a stack of 50 green flashcards in front of the student and stated, "You will get to play for 15 seconds each time you say a correct answer. Say the problem and answer out loud. If you mess up, go back and say the problem over again." The experimenter set a work timer for 3 min that was not visible to the student. After stating the rule, the experimenter started the work timer and a count-up stopwatch (to obtain a measure of total session duration) simultaneously. Immediately after each correct response, the experimenter paused the work timer and allowed access to the reinforcer for 15 s. After 15 s, the experimenter removed the reinforcer and started the work timer again. The data sheet was out of the student's sight at all times. The session was completed when the 3-min work timer elapsed.

No-reinforcement sessions. At the start of each no-reinforcement control session, the experimenter placed a set of 50 white flashcards in front of the student and stated, "This time, you are not working for toys. Say the problem and answer aloud. If you mess up, go back and say the problem over again." The experimenter did not provide feedback on student responses during the session and kept the data sheet out of the student's sight. The session ended when 3 min elapsed.

Concurrent-chains analysis. At the start of each concurrent-chains session, the experimenter placed the available sets of flashcards (i.e., yellow, green, and white, at the start of the phase) in a random position and equidistant from each other in front of the student, and stated the rules associated with each of the colored flashcards. While pointing to the control-condition cards, the experimenter said, "During this one, you get no toys." While pointing to the distributed-condition cards, the experimenter stated, "During this one, you get toys after you get the problem right." When pointing to the accumulated-condition cards, the experimenter said, "During this one, you get to play at the end of the session." The experimenter then prompted the student to pick a set of flashcards. After the student selected a set of flashcards, the experimenter followed the procedures associated with that condition. If the student refused to select a set of flashcards, the experimenter prompted the student to select up to two more times. If a selection was still not made, the experimenter terminated the session. Once a student selected the same condition three consecutive times, the experimenter removed that set of flashcards from the array of choices. This procedure resembled a multiple-stimulus-without-replacement preference assessment (e.g., DeLeon & Iwata, 1996), and allowed us to determine a hierarchy of preference among available reinforcer arrangements. The concurrent-chains analysis continued until only one choice would have been available in the array, or until the child refused to choose after repeated prompting across two consecutive sessions.

RESULTS

Figure 1 shows the rate of correct academic responses across the three conditions for each of the students, for both the treatment evaluation and concurrent-chains analysis. The solid phase-change line denotes the start of the concurrent-chains analysis; the dotted phase-change line

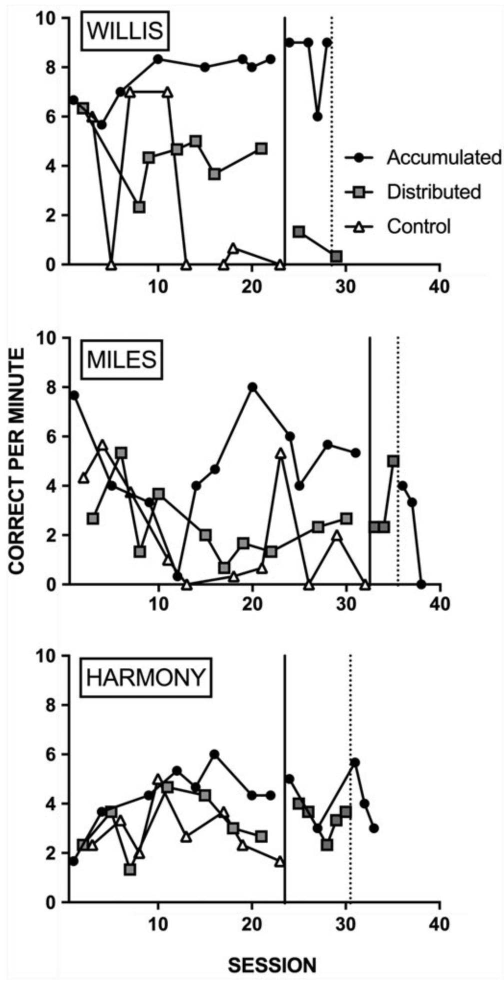

Figure 1. Rate of academic responding across the three conditions for the treatment evaluation and concurrent-chains analysis for Willis (top graph), Miles (middle graph), and Harmony (bottom graph). The solid vertical line corresponds to the start of the concurrent-chain procedure. The dotted vertical line corresponds to the point at which the most-preferred option was removed as a choice.

denotes the point at which the initially preferred option was removed. We calculated response rate by dividing the total number of correct responses in the session by 3 min (i.e., the duration of work time). During the multielement evaluation, Willis (top panel) engaged in the highest rate of correct responses in the accumulated condition (*M* = 7.6 rpm, range = 5.6-9.0 rpm). Response rates were lower in the distributed (*M* = 4.4 rpm, range = 0.3-6.3 rpm) and control (*M* = 2.0 rpm, range = 0-7.0 rpm) conditions. During the concurrent-chains analysis, Willis continued to engage in high rates of correct responses in the accumulated condition (*M* = 8.3 rpm, range = 6.0-9.0 rpm). When Willis chose the distributed condition, his response rate decreased (*M* = 0.8 rpm, range = 0.3-1.3 rpm) relative to the accumulated condition, and relative to the distributed condition in the multielement evaluation. When the accumulated condition was removed from the array (beyond the dotted line), Willis selected the distributed condition on one session then refused to select for two consecutive initial links, resulting in the termination of sessions without Willis experiencing the terminal link in the chain. Therefore, we collected data on the rate of correct math problem completion for only the single session during which Willis made a selection after the change in available options.

Results for Miles (middle panel) were similar to those for Willis; his correct academic response rates were higher during the accumulated condition (*M* = 4.8 rpm, range = 0.3-8.0 rpm) than during distributed (*M* = 2.4 rpm, range = 0.7-5.3 rpm) or control (*M* = 2.1 rpm, range = 0-5.7 rpm) conditions. When allowed to select the reinforcer arrangement, Miles' academic response rates during distributed sessions remained moderate (*M* = 3.2 rpm, range = 2.3-5.0 rpm). However, after the distributed condition was eliminated as an option, Miles chose the accumulated condition, but engaged in lower rates of academic responding (*M* = 2.4 rpm, range, 0-4 rpm) relative to his performance during those sessions in the multielement evaluation, and rates decreased across time.

Like Willis and Miles, Harmony (bottom panel) engaged in the highest rates of correct academic responding during the accumulated condition in the multielement comparison (*M* = 4.3 rpm, range = 1.7-6.0 rpm), relative to the distributed (*M* = 3.1 rpm, range = 1.3-4.7 rpm) and control (*M* = 2.9 rpm, range = 1.7-5.0 rpm) conditions. Harmony's rate of academic responding did not change substantially when she chose the reinforcer arrangement during the concurrent-chains analysis (accumulated *M* = 4.1 rpm, range = 3.0-5.7 rpm; distributed *M* = 3.1, range = 2.3-4.0 rpm).

Table 1 shows the mean accuracy for each participant across the three conditions in the multielement assessment. For all three participants, accuracy was lower in the control condition than in the accumulated or distributed conditions. Accuracy was generally undifferentiated between accumulated and distributed conditions. Insofar as response rates were higher in the accumulated condition, these findings suggest that accumulated reinforcer arrangements resulted in students trying more problems, and therefore completing more problems correctly, rather than improving overall accuracy.

Figure 2 shows the percentage of intervals with problem behavior. For Willis (top panel) during the multielement phase, problem behavior occurred least frequently in the accumulated condition (*M* = 1%, range = 0%-4%), at higher levels in the distributed condition (*M* = 28%, range = 0%-85%), and most often in the control condition (*M* = 65%, range = 0%-100%). For Willis, problem behavior was more likely in the distributed condition during the concurrent-chains assessment (*M* = 84%,

Table 1
Mean Accuracy Scores across Participants and Conditions

	Accumulated	**Distributed**	**Control**
Willis	80.2%	82.1%	47.6%
Miles	62.6%	68.9%	47.4%
Harmony	71.0%	68.9%	49.7%

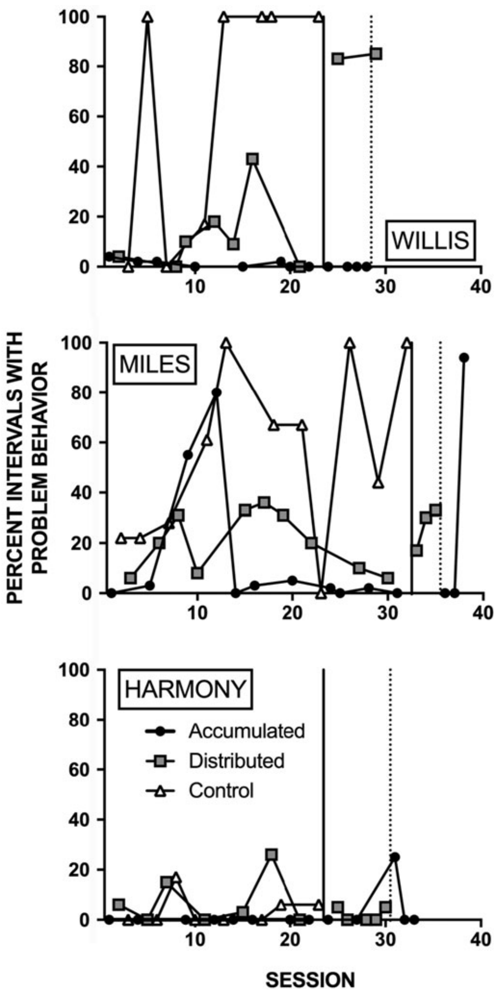

Figure 2. Percent of problem behavior across the three conditions for the treatment evaluation and concurrent-chains analysis for Willis (top graph), Miles (middle graph), and Harmony (bottom graph). The solid vertical line corresponds to the start of the concurrent-chain procedure. The dotted vertical line corresponds to the point at which the most-preferred option was removed as a choice.

range = 83%-85%) than during the same condition in the multielement analysis, but no increases were observed when he chose the accumulated condition (*M* = 0%).

Miles (middle panel) engaged in problem behavior less frequently in the accumulated condition (*M* = 14%, range = 0%-80%) and distributed condition (*M* = 20%, range = 6%-36%), relative to the control condition (*M* = 56%, range = 0%-100%) during the multielement evaluation. Miles engaged in more problem behavior, on average, in the accumulated condition of the concurrent-chain assessment (*M* = 31%, range = 0%-94%) than the multielement assessment, but this mean effect is largely due to a very high percentage of session with problem behavior during the last accumulated session. Miles engaged in slightly higher levels of problem behavior during the distributed sessions of the concurrent-chains assessment (*M* = 27%, range = 17%-33%) than in the multielement assessment.

Harmony (bottom panel) never engaged in problem behavior during accumulated-reinforcer sessions (*M* = 0%) in the multielement phase, but engaged in low and variable amounts of problem behavior across the distributed (*M* = 5%, range = 0%-26%) and control conditions (*M* = 2%, range = 0%-17%). The likelihood of problem behavior during the concurrent-chains assessment was equivalent to the multielement evaluation, with the exception of one accumulated-reinforcer session, during which Harmony engaged in moderate levels of problem behavior (accumulated phase *M* = 8%, range = 0%-25%).

Figure 3 shows selection among the conditions during the concurrent-chains assessment. The accumulated condition, which was the most efficacious condition for all three students, was not necessarily the most preferred. Miles (middle panel) and Harmony (bottom panel) consistently selected the distributed condition before the accumulated condition when all three options were available. Although Willis' choices (top panel) aligned with the results of the reinforcer-efficacy analysis, he engaged in a high rate and severity of problem behavior when the accumulated condition was removed from the choice array. His behavior during session 29 (i.e., the first session after removal of accumulated reinforcers as an

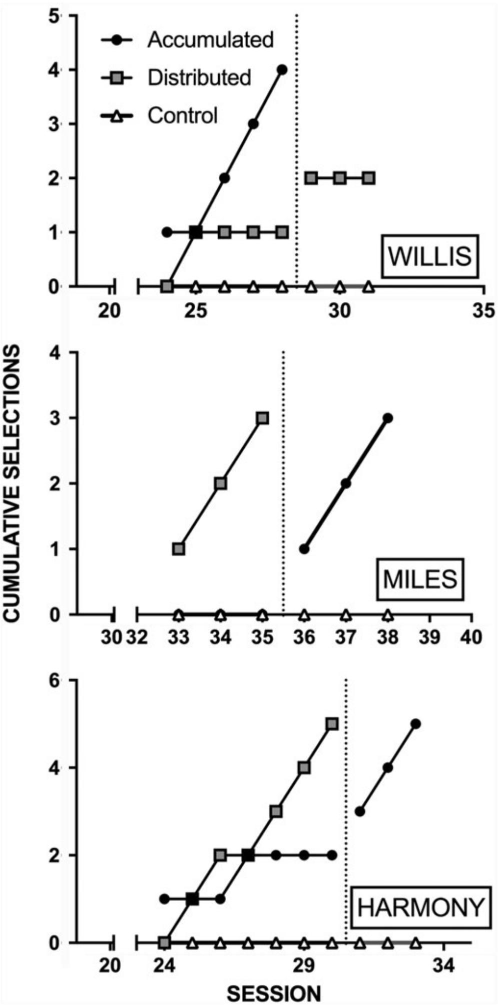

Figure 3. Concurrent-chains analysis cumulative selections for Willis (top graph), Miles (middle graph), and Harmony (bottom graph). Note the x-axis values, which correspond to the session numbers in Figures 1 and 2. Dotted vertical lines indicate the point at which the most frequently chosen selection was removed from the array.

option) necessitated involvement of the school crisis team. After this session, Willis refused to choose between the two conditions across the next two sessions, repeatedly vocalizing that the distributed and control conditions were "too hard" (despite all three sets containing identical problems) and swiping the cards from the table. For this reason, none of the data paths increase across the last two sessions of Willis' concurrent-chain evaluation, and no data are included from these sessions in Figures 1 or 2 because Willis never made it to the terminal link in the chain.

DISCUSSION

We replicated and extended DeLeon et al. (2014) and Bukala et al. (2015) by evaluating effects of accumulated and distributed reinforcer arrangements on both academic responding and problem behavior with students with complex verbal behavior and diagnoses of ADD or ADHD. We also evaluated the extent to which the students preferred the reinforcer arrangements. Overall, students performed best during the accumulated condition. Rates of academic responding were highest when students worked for accumulated reinforcers, in comparison to distributed reinforcers or no reinforcers (control). This finding replicates the outcomes obtained by DeLeon et al. and Bukala et al., who found that individuals with intellectual or developmental disabilities completed academic and daily living skills tasks most rapidly when earning accumulated reinforcers and extends those findings to a new population. We also extended the findings by showing that the accumulated condition was least likely to result in problem behavior. Taken together, these results suggest that accumulated-reinforcer arrangements may be preferable in academic environments for students with a history of chronic or severe problem behavior.

In our study, student preference did not always align with the most efficacious reinforcer arrangement. Two of the three students preferred the distributed condition to the accumulated condition, even though the distributed condition resulted in continued problem behavior and overall decreased durations of reinforcer access. Previous studies examining reinforcer efficacy and preference, within accumulated and distributed reinforcement, have typically found that preference and efficacy align; that is, students are likely to choose the more efficacious arrangement (e.g., Bukala et al., 2015; DeLeon et al., 2014). The reasons for the discrepancy in the current study are unclear. All three of our students were diagnosed with ADD or ADHD, which is characterized by impulsive decision-making. It is possible that the factors contributing to their diagnoses also led two of the three students to select the condition that resulted in more immediate, but overall shorter duration access (i.e., an "impulsive choice") during the concurrent-chains analysis. However, previous studies have included participants with diagnoses also associated with impulsivity (e.g., autism; Bukala et al.), but have not obtained similar outcomes regarding preference. It is possible that the complex verbal repertoires of our participants as compared to participants in previous studies contributed to the differences in outcomes. Future studies could assess the extent to which participants self-generate rules about the conditions and whether those self-generated statements predict their preferences for conditions. Given that all of our participants used complex language, one potential variable may have been the specific content of our instructions during the concurrent-chain phase. Although all participants had exposure to the contingencies associated with each color of card before the concurrent-chain evaluation began, participants may have selected the accumulated condition because our instructions for that condition did not specifically state that participants needed to engage in correct responses to gain access to toys at the end of the session. Evaluating the role of instructions when assessing preference of highly verbal students may be an interesting avenue for future studies. Alternatively, other uncontrolled differences between conditions (e.g., a preference for card color) may have contributed to our results.

Our data were more variable than those obtained by DeLeon et al. (2014) or Bukala et al. (2015), and our students required substantial exposure to the contingencies before consistent response patterns emerged. There are several possible reasons for this increased variability. First, sessions were conducted in a classroom environment during ongoing instruction. It was not possible for us to control multiple aspects of the environment. At times, there were engaging activities occurring in the classroom behind the participants, which seemed to decrease response rates during our sessions. Response rates also seemed to decrease when other children in the classroom engaged in problem behavior. Unfortunately, we did not collect data on these aspects of the classroom environment, so we are unable to analyze their effects systematically.

The reinforcers available during any given session may have also contributed to response variability. We gave the students a choice between four items before each session and used the selected item as a reinforcer. Although all items were designed to be play-based activities (i.e., iPad, blocks, Legos, letter magnets, building magnets, Play-Doh, toy cars), it is possible that the reinforcing efficacy of some items decreased more than other items when the item was only available for 15 s. Thus, performance may have varied in distributed sessions as a function of the particular item selected before each session. For example, participants could roll a toy car immediately, but it may have taken more time to continue a game on the iPad. Also, reinforcers used within the study were not controlled or restricted outside of sessions. Participants could access these reinforcers by exchanging their tokens each day as part of the class-wide token system. We did not collect data on the item selected, so we cannot correlate item selection and performance. We also do not have data on the number of tokens earned in the classroom, or the items students selected during regularly occurring token exchange. However, our study contributes to the literature by demonstrating positive effects of accumulated reinforcers even in noisy, uncontrolled environments with varied reinforcers, suggesting that this kind of reinforcer arrangement may have powerful influences over behavior.

The particulars of students' diagnoses may have also contributed to some of the variability across participants. Unfortunately, we did not have access to detailed diagnostic records for any of our participants. Although documentation of diagnosis with ADD or ADHD was in each child's educational file, it is possible (and perhaps likely) that participants had been diagnosed with different subtypes of the disorder. Such differences may account for variations in preferences for accumulated or distributed reinforcers across participants. Future research should replicate our findings with a larger sample of participants diagnosed with different subtypes of ADD/ADHD and different disorders associated with impulse control to determine if there are predictive factors associated with particular diagnoses. Similarly, future research should examine the role of medication on efficacy of, and student preference for, accumulated and distributed arrangements. Commonly prescribed medication for ADHD, like methylphenidate, decreases impulsive choice during delay-discounting tasks (Shiels et al., 2009). Methylphenidate and related medications may also shift preference from distributed reinforcer deliveries to accumulated reinforcers, which may in turn improve student performance. Future studies should evaluate the potential role of medication on reinforcer arrangements like those in the present study.

The noncontingent delivery of classroom tokens after sessions may have inadvertently suppressed overall rates of problem behavior. We chose to deliver the tokens used as part of the class-wide behavior management system after sessions so that students would not be penalized for being removed from the class-wide system to participate in research. Although these tokens were delivered independently of responding, students had a history of earning tokens in the classroom for refraining from problem behavior. Because we conducted sessions within the classroom environment, and delivered tokens typically used to suppress problem behavior in that environment, student behavior may have been suppressed because of their extraexperimental history with token deliveries. Nonetheless, we obtained orderly relations between the reinforcer arrangement and the likelihood of problem behavior for two of the students.

Unlike the study by DeLeon et al. (2014), we did not use tokens as signals when the students accumulated reinforcer access. Thus, students did not receive immediate feedback about their performance, or reinforcer earnings, during the accumulated sessions. However, students received immediate feedback about their performance in the distributed condition because we provided reinforcer access following each correct response. Although delivering tokens during the accumulated condition may make the feedback provided to the student more equitable across conditions, we chose not to do this to control for exposure to conditioned reinforcers (as this was noted as a limitation in accounting for preferences by DeLeon et al.) and to make our accumulated condition more similar to how the procedures may occur in a classroom. However, this procedural variation may account for the differences in child preference obtained by DeLeon et al. and those obtained in the current study. Additionally, two of our participants (Miles and Willis) were marginally more accurate in the distributed condition relative to the accumulated condition. The provision of feedback may account for those differences. Future research should use tokens in a similar procedure with children diagnosed with ADD or ADHD to isolate whether tokens, behavioral features associated with the diagnosis, or both, influence preference for accumulated reinforcer arrangements.

Although we did not incorporate response-dependent tokens in an attempt to reproduce a more classroom-like environment, we elected to use short work periods (i.e., 3 min). In typical classrooms, students would often be expected to work for longer than 3 min before accessing a reinforcer. Previous studies have used similarly short work periods (i.e., 5 min or 10 tasks in DeLeon et al., 2014; worksheets with three or four problems or 15 beads to string in Bukala et al., 2015). We selected 3 min because it was the longest duration with which students in the classroom were expected to engage in fluency-based instruction. However, the extent to which our findings, or those of previous studies, would replicate with longer work periods is currently unknown. Future research should attempt to replicate our findings using work durations typical in classrooms.

The increased rates of academic responding during the accumulated-reinforcer condition seemed to be due, at least in part, to elimination of pauses and problem behavior that occurred after the removal of the reinforcer during the distributed condition. We conducted one-tailed Pearson correlations between rates of problem behavior and academic responding by condition, which resulted in statistically significant negative correlations for both Miles and Willis during the accumulated and control conditions (detailed correlational data available from corresponding author). During the accumulated-reinforcer condition, the students seemed to respond more rapidly when academics were not paused to reinforce correct responding. Even though the distributed-reinforcer condition provided more immediate feedback to students, students seemed to pause for a lengthy time and engage in more problem behavior following the reinforcer access, although response rates and problem behavior in this condition were not significantly correlated for any of our participants. These findings mirror those of Bukala et al. (2015), who found that accumulated-reinforcer arrangements reduced transition times for some participants. However, because we collected data in 10-s intervals, it was not possible for us to determine the sequence of events within each interval to fully assess the extent to which problem behavior followed removal of the reinforcer. Future researchers should use computerized real-time recording to evaluate the extent to which removal of the reinforcer evokes problem behavior in distributed and accumulated arrangements.

Future research could also examine the role of behavioral function on the efficacy of accumulated and distributed reinforcers for children who engage in problem behavior. In our study, problem behavior typically occurred during and after the removal of the preferred item during the distributed condition. It is possible that problem behavior for the students was maintained by access to tangible items and was therefore evoked when the items were removed. All of our students had previous functional behavior assessments conducted by the school system, which suggested that behavior was maintained by escape for Miles and Willis, and attention, escape, and tangibles for Harmony. However, the methods for those assessments varied, and access to tangibles was not always included as a possible function. Further investigation of the role of behavioral function on the provision of tangible items as reinforcers may foster the development of school-based behavior interventions that are effective and easy for teachers to implement. Accumulated-reinforcer strategies seem to hold much promise in this regard.

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Received November 11, 2016
Final acceptance January 21, 2019
Action Editor, Iser DeLeon