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Thinning DRO Schedules of Reinforcement with Progressive Intervals and Constant Unit Price

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Abstract

Children with Autism Spectrum Disorder can present with challenging problem behavior such as vocal stereotypy, property destruction, aggression, and self-injury. A common treatment option is the use of differential reinforcement of other behaviors (DRO) to reduce or eliminate these problem behaviors. This research study explored thinning dense DRO schedules with the use of progressive intervals and adjusted reinforcement to maintain a constant unit price with three students diagnosed with ASD at a non-public school receiving 1:1 instruction. Results indicated that progressive intervals were successful in maintaining low rates of problem behavior while thinning reinforcement schedules. One of the subjects did not increase the interval length past five sessions and future research is proposed to identify a criterion for participant eligibility criterion to be successful with progressive intervals. These findings contribute to the existing field of research regarding thinning schedules of reinforcement for student's problem behavior treated with DRO schedules of reinforcement.

Keywords: differential reinforcement of other behaviors (DRO), unit price, progressive intervals, thinning schedules of reinforcement

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Literature Review

In the field of special education, treating students with autism that engage in severe problem behaviors can be a difficult task. Severe problem behaviors include self-injury, aggression and tantrum behaviors. Tantrum behaviors are further characterized as crying, whining, and yelling that occur with great intensity and for sustained periods of time (Carr, Robinson, Taylor, Carlson, 1990). Students that qualify for special education services under the autism eligibility criteria can present severe problem behaviors. One effective treatment option for students with autism is the use of Applied Behavior Analysis (ABA). ABA is the scientific approach for evaluating environmental factors that influence behavior that is socially significant, and to systematically evaluate variables that may be responsible for changes in behavior (Cooper, Heron & Heward, 2007). ABA can provide students with autism and related developmental disabilities with significant improvements in a wide array of settings and applications (Simpson, 2001).

In the field of ABA, one of the treatment options for severe problem behavior is various schedules of reinforcement. Schedules of reinforcement are defined as the rules that make up the student's environment and the expectations or response requirements of the student to receive reinforcement (Zeiler, 1984). These arrangements help the student and the teacher to understand daily expectations from the student and when reinforcement will be delivered, most often from the teacher or other environmental arrangements.

Differential Reinforcement of Other Behaviors (DRO)

One type of reinforcement schedule is Differential Reinforcement of Other Behaviors (DRO). DRO is a reinforcement based intervention; but, contrary to most, it reinforces in the absence of a specified behavior (Poling & Ryan, 1982). Differential reinforcement procedures provide reinforcement for select behaviors and omit reinforcement for behaviors that the researchers or teachers are trying to eliminate, such as severe problem behavior. For example, if a student engaged in severe problem behavior such as self-injury to gain attention from his teacher, the teacher would not give attention when the student was engaging in self-injurious behavior. Instead, the teacher would give attention when the student appropriately obtained attention, such as saying, "excuse me." The teacher would also be mindful to provide attention with any other appropriate behaviors so that those behaviors would be reinforced consistently. The self-injury would therefore not obtain reinforcement in the form of attention and would theoretically start decreasing in frequency.

The main idea behind differential reinforcement is that the student will gain access to reinforcement differentially, or discriminately, based on what behaviors the researchers want to see increased (e.g., appropriate behaviors) or those behaviors that need to be decreased (e.g., severe problem behaviors). Within the realm of DRO there are many potential variations including ratio or interval based reinforcement. In the Fixed-Interval DRO (FI-DRO) procedure, an initial interval of time is chosen to expect the student to go without engaging in the problem behavior. It is expected that the student will engage in other appropriate behaviors throughout the whole interval and at the end of the interval receive reinforcement for not engaging in the problem

behavior (Cooper et al., 2007). At the end of each interval, after reinforcement is delivered, the time is reset for another interval and continuously done so throughout the entire research or teaching session. If during the interval the problem behavior occurs, no reinforcement is delivered and the interval timer is reset (Cooper et al., 2007). Reuter and Leblanc (1972) found FI-DRO to be more effective than variable-interval DRO, or when intervals were mixed and did not stay consistent.

Another variation of interval based DRO includes whole versus momentary interval DRO. In momentary DRO, the student would receive reinforcement at the end of each interval as long as the problem behavior was not occurring at the specific time that the interval ended (Cooper et al., 2007). In whole interval DRO, the student must maintain appropriate behavior and not engage in the problem behavior throughout the entire, or whole, interval. Whole interval DRO as opposed to momentary interval DRO has been shown to help make DRO a more effective procedure (Repp, Barton, & Brulle, 1983).

Furthermore, when using DRO it is also important to systematically set the initial time interval for reinforcement (Cooper et al., 2007). It is recommended that the rate of behavior during baseline conditions be evaluated for the initial interval. For example, Repp, Felce & Barton (1991) used a formula that was equal to the inverse of the mean response rate during the baseline phase. The inverse was taken because DRO accounts for the absence of behavior (Repp et al., 1991). In other words, instead of looking at the number of times a response occurred the researchers need to look at the amount of time that it did not occur. It is suggested that this formula will help provide a dense schedule of reinforcement making it likely that the subject will easily obtain access

to the reinforcement under this schedule and make it more successful especially during the initial stages of implementation. If an initial interval is set too long, then the subject or student may not get the opportunity to obtain reinforcement due to expectations being set too high (Poling et al., 1982). Although, there is research regarding the initial interval size there is little research on subsequent stages of increasing or differentiating those intervals (Repp & Deitz, 1974; Rozenblat, Brown, Brown, Reeve, & Reeve, 2009).

Differential reinforcement strategies are one of the most popular and integrated techniques to help manage problem behaviors (Cowdery, Iwata, & Pace, 1990). For example, Cowdery and colleagues (1990) conducted a research study with a nine-year-old boy, who was hospitalized due to self-injurious scratching. The researchers systematically faded an originally dense schedule of reinforcement based on a three phase intervention. The initial two phases focused on systematically fading a successful token economy for appropriate behavior. In the final and third phase, a generalization component was added and the participant was added to a group setting and later implemented the procedure at home with the parents (Cowdery et al., 1990). The results of this research are significant because within DRO literature it is one of the only studies that focus on generalization or maintenance components. This research team successfully transitioned the DRO procedure to non-professionals and treatment fidelity was maintained, suggesting that although initial implementation need be more systematic, that treatment phase after initial treatment effects are observed can be done effectively.

Thinning Schedules of Reinforcement

Typically, there are two procedures within ABA for thinning a pre-existing schedule of reinforcement (Cooper et al., 2007). As discussed earlier, practitioners should be guided to utilize a gradual increase of the response required to receive reinforcement (Cooper et al., 2007). The other suggestion for thinning schedules is to use explicit instructions so that the student understands the rules involved with gaining access to reinforcement as this may improve the effectiveness of the intervention (Cooper et al., 2007). In regards to interval DRO, it is suggested that the duration of each interval be thinned by a constant duration, both proportionately and based on the learner's performance (Cooper et al., 2007; Poling & Ryan, 1982). Within interval DRO, interventions must pay attention to the potential that if an interval is increased, or thinned and the student's problem behavior worsens it is suggested that the practitioner decrease the interval to an appropriate level based on student behavior improvements (Cooper et al., 2007).

The research across settings verifies that utilizing DRO interval and ratio schedules are successful in reducing problem behavior (Poling & Ryan, 1982). Currently in the research there are suggestions for thinning schedules of reinforcement while using DRO-Interval schedules (Roane, Falcomata & Fisher, 2007). However, there is very little research that tests a diagnostic format to thin reinforcement. Cooper and colleagues (2007) outline guidelines and suggestions, but specifics as to how quickly or when exactly reinforcements should be thinned are not provided. Roane (2008), states that all of the variables within a DRO schedule have been studied in applied settings but each study erratically determines how to manipulate the variables. Rozenblat and colleagues (2009), also extensively review research that explores many options but

conclude that in regard to how or when to increase intervals a majority of them use somewhat arbitrary requirements.

Although previous research has given broad and brief guidelines, another treatment option for thinning reinforcement involves the use of a progressive schedule of reinforcement. Trosclair-Lasserre, Lerman, Call, Addison and Kodak (2008) defined progressive ratio schedules of reinforcement as a schedule in which the number of responses required to obtain a reinforcer increased within a research session based on successful completion of the previous schedule requirement (Trosclair-Lasserre et al., 2008). Results indicated that, for progressive ratios to be successful, the magnitude of the reinforcer had to be adjusted according to the response required to obtain the reinforcer (Trosclair-Lasserre et al., 2008). This indicates that there must be a balance between reinforcer amounts and the amount of work the student had to complete to gain access to the reinforcer. Further, the researcher must be aware of the sensitive relationship between the reinforcer and the student's drive to earn the reinforcer when evaluating schedules of reinforcement and thinning procedures.

Typically, the evaluation of fading procedures using progressive schedules explores the relation to reinforcer potency. Researchers often increase the interval quickly and see a terminal interval where the subject either stops responding or engages in other behavior because the cost of the reinforcer has become too high (Roane, Lerman, & Vorndran, 2001). This research typically uses progressive schedules to evaluate how long or hard the subject is willing to work for different reinforcers and then assign a reinforcer effectiveness based on the amount the subject is willing to work for it. However, in this line of research the balance is not maintained between the price

of the reinforcer (i.e., how much the student has to work for it) and the actual reinforcer amount that the student earns. When applying progressive schedules to DRO and maintaining the unit price it will add to the research by effectively applying two different procedures to effectively and efficiently thin a DRO schedule that must initially start very small or dense.

Applying Behavioral Economics Concepts to Thinning Reinforcement

When a DRO interval is manipulated across time, and reinforcement is thinned systematically, the researcher must think about the balance involved in keeping the reinforcer desirable so that appropriate behavior maintains throughout treatment. Research literature in the field of behavioral economics highlights the use of concepts imbedded within microeconomics and applies them to the concept of behavior analysis and reinforcement schedules (Madden, 2000). Roane and colleagues (2007) and Borrero, Francisco, Haberlin, Ross, and Sran (2007) all look specifically at problematic behaviors such as vocalizations, aggression, self-injurious behavior and disruptive behavior and specify the value of establishing an appropriate unit price for reinforcement throughout treatment procedures. Unit price, is defined as, "the expenditure given for a particular amount of a commodity and is expressed by the equation P = R/A, where P is the price of the reinforcer, R is the response requirement and A is the magnitude of the reinforcer" (Roane et al., 2007, p. 530). In other words, there is a mathematical representation of behavior that indicates that organisms have a price they are willing to pay for certain reinforcers and the amount of the reinforcement they are receiving.

Roane and colleagues (2007) studied the effects of manipulating a unit price and paid special attention to monitoring the reinforcer earned alongside the thinned schedule or reinforcement. The subject, a 16-year-old boy engaged in different forms of inappropriate verbal behavior (e.g., humming, imitation sounds, repetitive requests). With the use of a radio as a reinforcer the team faded an initial 20 second radio break every 10 seconds without inappropriate vocal behavior up to 180 seconds for a break. In an attempt to analyze the unit price value, the team conducted a second session that maintained a constant unit price. This meant that as they increased the intervals between reinforcement they also increased the time received with the radio. The time spent with the radio was determined by doubling the interval schedule each time and keeping a 2:1 ratio. This condition allowed for the subject to access the reinforcer while still maintaining low rates of behavior. However, in the first condition when the unit price was not adjusted treatment was no longer effective in maintaining the low levels of target behavior (Roane et al., 2007).

Borrero and colleagues (2007) also studied the concept of unit price and applied them to work tasks in a natural setting with both groups and individuals with developmental disabilities. The students in both conditions demonstrated that as the schedule of reinforcement was thinned the students had a decrease in the obtainment and consumption of the reinforcer (Borrero et al., 2007). This can lead one to believe that if the unit price is set too high, it can lead to potential decreasing effort put forth to achieve reinforcement. In other words, the students have the feeling that the reinforcer "costs too much" to even try.

This concept is also evident in the ABA term, ratio strain, which can be the result of reinforcement costing too much and often results from abrupt increases or when transitioning to a thinner schedule of reinforcement (Cooper et al., 2007). It is cautioned that although a reinforcer may help improve behaviors at a rather dense schedule, its true magnitude is tested when those schedules are thinned and the student theoretically has to work harder for the reinforcer. It is assumed that it no longer holds effective to maintain appropriate behavior if the student begins to show an increase in rates of problem behavior or avoidance (Poling, 2010).

Although the effects of DRO interval schedules have been evaluated and extensively researched to be successful in reducing challenging behavior, there is still limited research in the field that applies directly to effective and efficient thinning of these schedules in an effort to generalize the results to more environments for the student to access. It is known when implementing DRO interval schedules to procedurally start with a dense schedule (Repp & Slack, 1977; Topping, Larmi & Johnson, 1972). However, there is little known about how to best fade this dense schedule of reinforcement. If schedules can be thinned effectively using progressive schedules, it will allow them to gain access to more instruction and more skills within each of their living environments. The students with autism that benefit from these reinforcement-based interventions often need maximum assistance throughout all aspects of their lives including daily living skills, socialization, self-help, personal hygiene and academic skills. These skills can be difficult to teach with the interruption of challenging behavior but these treatments also require dense schedules of reinforcement that are also disruptive to learning. If many of the disruptive challenging behaviors as well as the invasiveness

of the procedure used to eliminate them can be effectively and efficiently thinned it will allow the students the opportunity to access so much more.

With more practical interventions, caretakers are able to provide quality treatment consistently. If the schedule is thinned, there is also the potential that the treatment can generalize and that others in the student's life can help maintain the treatment. Without such a dense schedule of reinforcement there is also opportunity for the student to gain access to more natural response and reinforcement contingencies outside of these structure reinforcement procedures. All of this can lead to the student leading a more successful life with the least restrictive interventions and long term maintenance of positive behaviors (Rozenblat et al., 2009). A decrease in disruptive behaviors can help benefit all those involved in the student's community including the teacher, family or caretakers responsible for reinforcement delivery.

Method

Research Question

What are the effects of applying progressive schedules to interval length within DRO schedules of reinforcement used to maintain low rates of severe problem behavior in students diagnosed with Autism?

Hypothesis

Traditional research and treatment guidelines in the field specify that DRO intervals should be faded gradually, proportionately, and by a constant duration based on the student's performance (Cooper et al., 2007). However, there is little research that utilizes progressive ratio schedules. In 2007, Roane and colleagues utilized a thinning schedule with a balanced unit price, meaning that as the time between reinforcement

increased, the time allotted with the reinforcer also increased. When this balance was not maintained results varied and reinforcement was not as effective. It is predicted that with the use of progressive schedules and equal unit price across the thinning procedure, FI-DRO will be faded effectively by maintaining low rates of problem behaviors and obtain thinned schedules efficiently across a four week period. It is also predicted that the intervals will increase more quickly and successfully than by using the traditional method across school days as opposed to within school days. This will be demonstrated by a longer average interval length in baseline than in the treatment phase.

Research Design

The research design is a multiple baseline across participants. This design was chosen to use the treatment across individuals to see the effects of the use of progressive schedules with the use of pre-existing schedules of reinforcement.

Independent variable. The use of progressive intervals on DRO schedules of reinforcement, based on students omitting challenging behavior is the independent variable. Using the same guidelines suggested in research (Poling et al., 1982) the progressive intervals will increase proportionately, based on learner performance and by a constant duration. The guidelines for increasing the interval throughout the day specify, two consecutive intervals without challenging behavior. If the student earns their reinforcer consecutively two times in a row the interval increases. The increments to increase are based on the initial interval time. The intervals increased by at least 10% each time the student met the criteria to increase (Cooper et al., 2007). If the student engages in challenging behavior within one of the intervals the interval will not increase and will remain the same. If the student has challenging behavior that

increases above the mean rate at which the research began for more than three intervals the time between reinforcement will decrease.

Dependent variable. The average length of intervals that the student goes without receiving reinforcement is the dependent variable. Throughout the research session, data was collected on the Daily Progressive-Interval Data Sheet (see Appendix A), and included the length of the interval between reinforcement breaks and whether or not challenging behavior was observed. The average length of interval was calculated from the Daily Progressive-Interval Data Sheet by taking the total duration of intervals and dividing it by the total number of intervals that occurred in the session. This is an appropriate measure because the interval changes are the intervention and will most clearly show a potential experimental effect over monitoring the behavior. However, challenging behaviors were also evaluated alongside the length of the interval to maintain low rates of occurrence based on the implementation of progressive intervals.

Setting & Participants

The experiment took place at a California non-public school with 1:1 instruction for most students. The classrooms typically have eight to eleven students in each classroom. Students access individualized programming as documented in their Individualized Education Program (IEP) throughout the day with assistance from a trained instructional aide. Within each classroom there are eight to ten instructional aides and one classroom teacher. The behavior intervention plans are developed by the classroom teacher and progress is monitored by a team including the instructors, classroom teachers, and are overseen by a Board Certified Behavior Analyst

(BCBA). Each student's target behaviors are measured daily as they occur and the total duration and frequency are charted daily in Microsoft Excel. Pseudonyms were used for all participants. The participants included 1 male and two females with FI-DRO interventions currently in place for treatment of challenging behaviors including aggression, self-injury, vocal stereotypy or destructive behaviors.

Participant 1. Sean is a male age 18, at the non-public school receiving 1:1 instruction throughout the entire school day (6.25 hours). Sean engages in the following target behavior: aggression, self-injury, PICA, spitting, dropping, eloping and destructive behaviors. Aggression includes grabbing, pinching, hitting, hair pulling, biting, stepping on feet and headbutting. Sean receives reinforcement through the use of a DRO schedule every minute. Each minute that passes in the absence of target behavior, he receives a token and every four tokens he receives a half piece of candy. Each morning an informal preference assessment is conducted with a variety of candies (starburst, Swedish fish, jelly beans) and the edible item determined preferred is used throughout the school day.

Participant 2. Kristen is a female age 16 attending a non-public school receiving 1:1 instruction throughout the entire school day (6.25 hours). Kristen engages in aggression and self-injury. Aggression is defined as any time Kristen hits another person with an open palm or closed fist, and or sustained grabbing. Currently, Kristen receives reinforcement every two minutes and thirty seconds in the form of tokens. When she receives five tokens in the absence of target behavior she can choose between a three-minute computer or painting break.

Participant 3. Ashley is a female, age 15, attending the same non-public school and receiving 1:1 instructional time for 4.75 hours of the school day. Across all research

sessions, she had 1:1 instruction. She engages in the following target behaviors: aggression (e.g., biting, hitting, nail digging), self-injury (e.g., self-biting, hitting self) and property destruction (e.g., hitting, biting, kicking objects resulting in the item breaking). Ashley currently receives five tokens every two minutes and thirty seconds. Once she earns all of these tokens she can choose between a two-minute break on the computer or an edible item (e.g., pickles, cookies).

Measures

Data was collected within research sessions on the average length of an interval based on the student behavior. An interval was determined by the set duration of time that the student receives differential reinforcement in the form of a token and a praise statement. The daily behavioral data collected for each individual student was recorded and entered into an Excel database.

Validity. Data collection of defined target behaviors included direct observation of target behaviors with training on each response definition of each behavior as defined above. Reinforcement intervals were evaluated daily to determine the next days starting interval and to determine measurement validity. If the interval throughout the research session remains the same in the intervention phase, it will be determined that the interval did not change due to the occurrence of target behavior. The researcher also determined the number of seconds the interval increased progressively based on 10% of the mean interval from the previous day's intervals. Reinforcement magnitude also increased by 10% to maintain constant unit price. Reinforcement magnitude was also monitored each session to determine the new amount to receive with each schedule of reinforcement.

Reliability. In order to assess for inter-observer agreement (IOA), multiple observers compared data on changing interval lengths throughout each session and the occurrence or nonoccurrence of challenging behavior. IOA was collected for at least 20% of the sessions across all individuals (see Appendix B). Across all students IOA was collected for at least 20% of the sessions and remained at 100% agreement for Sean and Kristen. For Ashley's sessions 95% inter-observer agreement was obtained.

Treatment fidelity was collected on the use of the DRO procedures for each participant. Treatment fidelity will be given a score based on a treatment fidelity form (see Appendix B) that evaluated the implementation of the FI-DRO schedule of reinforcement and overall treatment integrity. Treatment fidelity data was taken across all three participants during at least 20% of the research sessions. Treatments were evaluated based on the correct interval length, observation of target behavior, the timer running continuously, the determination of the next schedule's interval length, the presence of the timer across all school activities, reinforcer magnitude and delivery. Performance feedback was provided during one of Ashley's sessions regarding the initial interval for the session. Across all observations treatment integrity was evaluated. Across all participants treatment integrity remained high and no other intervention was needed.

Intervention

The following intervention was used to modify the interval of each DRO schedule of reinforcement.

DRO thinning: FI-DRO (Baseline). Baseline data was collected on the standard rate of interval change based on a classroom teacher and individual behavior plan set

criteria for intervals to increase (see Appendix C). Each of the students have a schedule of reinforcement that allows the teacher to deliver a token, and pair the token with differential reinforcement of other behaviors through praise statements, based on the absence of the target behavior. Each interval is set by hand on a count-down timer. When the timer beeps, the student earns a token within a small handheld binder. The student visually sees the number of tokens needed to earn a break with their designated reinforcer (e.g., computer time, iPad time, edible treats). Once all tokens have been earned on the fixed-interval schedule of reinforcement the student earns the break with a countdown timer signifying the end of the break. At the end of the break, the tokens are reset and the student is informed that they have the opportunity to earn another reinforcer break when they earn all of the tokens on the visual board, the timer is reset and the student returns to their regularly scheduled activities.

If the student at any time engaged in any of the target behaviors, the instructor implements a response cost procedure, by removing all of the tokens that the student had earned up until that point. Once the target behavior procedure outlined in the student's individualized behavior support plan are implemented, the instructor restarts the timer on the visual board and tells the student they have the opportunity to earn the reinforcer break by engaging in appropriate, or "other," behaviors. The interval for each token at baseline was pre-determined based on the classroom teacher and the student's performance. Intervals increased based on student performance across a number of school days. For example, if the student had three school days without engaging in target behavior the reinforcement interval increased.

DRO thinning: Progressive interval DRO. The intervention implements a similar procedure to baseline; however, progressive intervals were used within one hour and a half long session to increase the reinforcement interval. As defined by Cooper and colleagues (2007) a progressive interval changes the schedule requirement based on arithmetic progressions to add time to the interval. The interval increased based on 10% of the initial interval. This 10% increase within sessions will increase the average length of intervals if problem behaviors remain at low rates of occurrence and potentially show an experimental effect on the rate of reinforcement based on the interval length.

Procedures

Lattal and Neef (1996), outlined the common algorithms of progressive interval schedules with two broad categories including arithmetic and geometric. In arithmetic schedules a consistent amount of time is added to each following interval. In geometric schedules, the following interval is increased based on a proportion of the previous interval such as 50% of the interval (Lattal & Neef, 1996). In this research, an arithmetic schedule was used based on the student's initial interval. The same number was not used across each student however it was determined by the student's initial interval in baseline. This research utilized a 10% increase to the total interval time rounded to the nearest tenth. If the 10% increase to the total time, did not allow for a whole number the time was rounded to the nearest whole number. For example, if the total interval time was 60 seconds, 10% of that would be 6 seconds and would be rounded to 10 seconds. For the next session, the student's interval would increase by 10 seconds each progressive schedule.

If the student engaged in target behavior during any part of the daily session, the interval immediately returned to the previous successful interval in which no target behavior occurred (LeBlanc, Hagopian, & Maglieri, 2000). The student would need to complete two schedules in the absence of any additional target behavior in order for the interval to increase again.

At the start of each session, the initial interval was determined on the previous session's intervals. The initial interval in a session was based on the mean interval in the previous session (Thompson et al., 2003). The mean interval length was determined by taking the total duration of intervals and dividing it by the total number of intervals obtained within one session.

In accordance with the concept of unit price, the student's intervals between reinforcer breaks increased but the reinforcer magnitude also increased proportionately (Roane, 2007). The student's reinforcer increased by 10% percent. If the reinforcer was an activity the duration of time allowed to engage in the activity increased 10% with each interval increase. If the reinforcer was an edible, the student received a 10% increase in the amount of the edible the student receives. For example, if the student earned a 10-minute computer break, and the next interval increases, the student will then earn an 11-minute computer break when they have earned the next reinforcer break. If the student earned 10 jelly beans each reinforcement schedule, the student then earned 11 jelly beans the next schedule for maintaining appropriate behavior. If the allotted increase percentage was less than one, the reinforcer increased by one or half when possible. For example, if the student only earned one jelly bean, the next total interval the student earned one and a half jelly beans instead of one and one tenth of a jelly

bean. However, if the reinforcer was something that could not be broken into half, it increased by whole number increments.

Data collection. Daily data was collected for the total duration of each hour and a half long session. Based on student performance and the absence of challenging behavior, the instructional staff modified the interval lengths throughout the session (see Appendix A). An average interval length was determined by taking the total duration of intervals and dividing it by the total number of intervals obtained within one session. This was compared to the baseline average interval length in the same manner.

Fidelity. Staff implementing the progressive ratio schedule attended a training based on the individual student that they assisted in the research study. Training, feedback and observation of implementation of the treatment intervention was provided before data was collected with the student. The progressive interval data sheet was monitored and assessed throughout the implementation period (see Appendix A).

Ethical Considerations

The target behaviors identified for treatment include self-injury, aggression, inappropriate vocalizations, and property destruction and need to be occurring at low rates to maintain the safety of the individual and the staff providing services to the individual. It was critical to assess the target behavior rates while thinning the rate of reinforcement. If the schedule of reinforcement became too thin, there was the potential that the specified target behaviors could increase. If the student engaged in target behavior during the session, the interval immediately returned to the previously

successful interval (i.e., the previous interval in which no target behavior was observed).

Validity threats. The main threat to validity in this study was the duration of implementation. The data within the study was collected across a full hour and a half within a classroom environment. There was the potential for timers to be accidentally stopped and not run continuously due to student or staff error or distraction. Validity measures are then threatened by treatment fidelity, staff fatigue or error. Other extraneous variables included individual student medication administration changes in dosages. Other threats to validity included the researcher and direct care staff bias. These biases were addressed in the intervention training provided and direct care staff teams were informed that they should not allow their personal bias effect the research intervention.

Social Validity. At the completion of the study, the researcher completed a four-point Likert scale (i.e., 1 = strongly disagree to 4 = strongly agree) social validity questionnaire (see Appendix D). The questionnaire, adapted from Berger, Manston, and Ingersoll (2016), consists of nine questions designed to understand the perceived usefulness, significance and satisfaction with the implemented intervention (Kennedy, 2005). Participant responses were kept confidential and descriptive statistics were conducted to gain insights regarding the intervention.

Results of the Social Validity questionnaire suggested that staff felt the treatment was effective. They also expressed that it would be functional outside of the research setting for the student to continue to thin schedules of reinforcement throughout the student's school day. It was also noted that teachers would recommend this treatment

design to other individuals. However, this research did not immediately affect other environments outside of school such as community or home settings. This research is the first step in getting these students more access to those environments but does not within the specific scope of the research directly address those environments.

Data Analysis

During treatment, analysis of the average interval length across sessions were monitored. The analysis consisted of evaluating the average interval length increasing, decreasing or remaining the same. If interval means are increasing at a quicker rate than baseline and appropriate behaviors are maintaining than intervention was determined successful for that subject. If interval means were not increasing steadily, it was due to the occurrence of a problem behavior and criterion not met to increase the interval length.

Results

The results for all three participants are depicted in Figure 1. The x-axis is the number of sessions and the y-axis is the mean interval length in seconds. The change between baseline and intervention is depicted by a dotted line.

Participant 1

Sean's results, shown in the Figure 1, indicate that as the progressive ratio schedules were faded, the intervals increased in time from the baseline condition. In baseline, Sean's fixed schedule of reinforcement was consistent at a mean of 60 second intervals. After 20 intervention sessions, the mean of intervals within a session reached 383 seconds. From the beginning of the intervention (session 1) to the last interval mean recorded (session 23) there was a difference of 323 seconds. The mean intervals across

all intervention sessions was 234.5 seconds, which is a 174 second difference from the baseline interval mean.

Participant 2

Ashley, results shown in Figure 1, had intervals increase from a baseline mean of 90 seconds to an overall mean of 98 seconds across all 14 intervention sessions. A difference of eight seconds between baseline to intervention interval means was observed. Ashley was absent on the 18th day of research.

Participant 3

Kristen's results, shown in Figure 1, showed increases in mean interval length across all intervention sessions. Her baseline average was 150 seconds. Her terminal interval was 200 seconds. The mean interval across the seven intervention sessions was 176.4 seconds. The difference between mean treatment intervals and baseline intervals was 26.4 seconds.

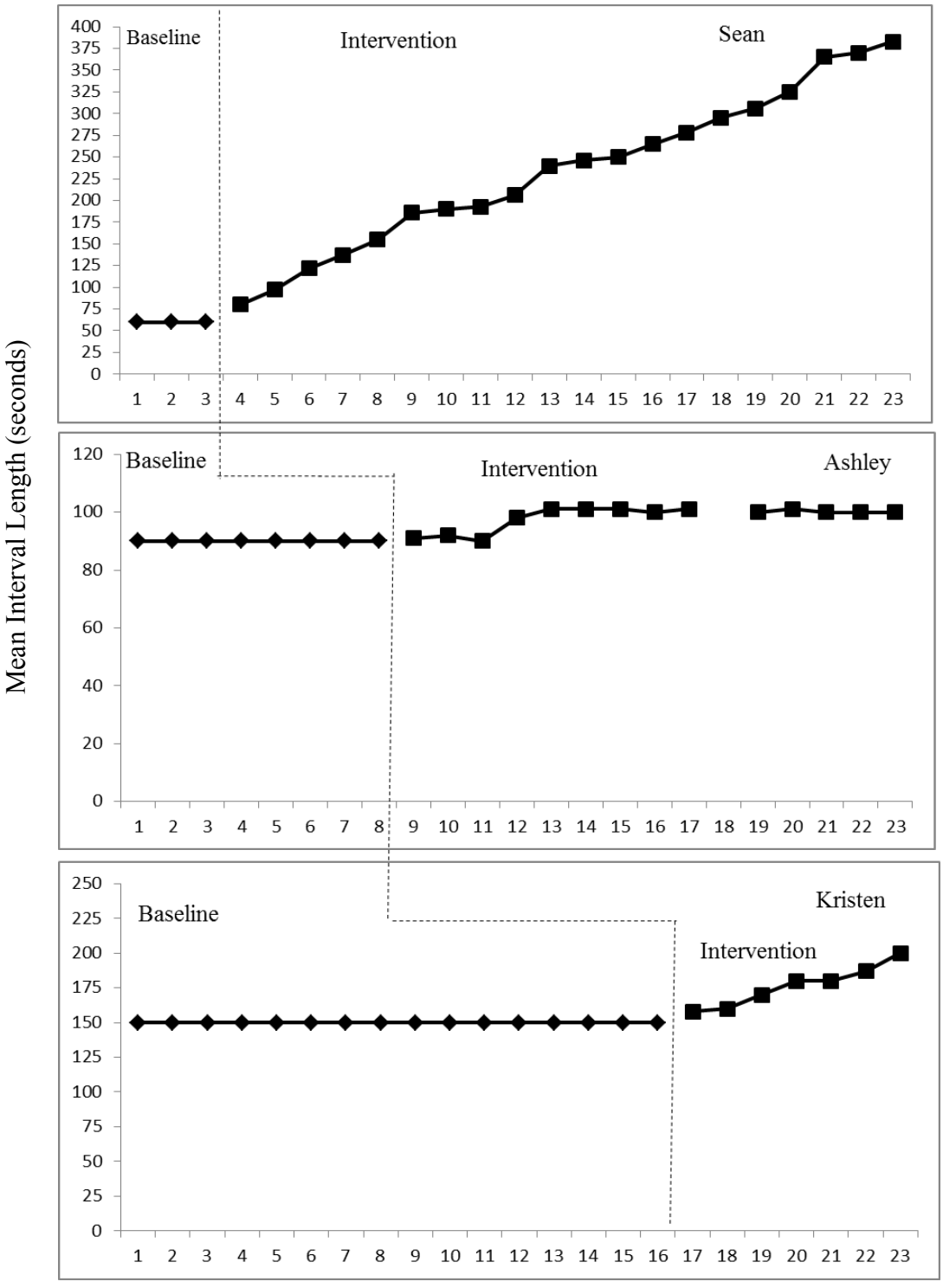

Figure 1. Sean, Ashley and Kristen's response to progressive intervals applied to DRO schedules of reinforcement while maintaining constant unit price.

Discussion

In the field of ABA, great importance is placed on researching and developing successful interventions that can be applied in a student's daily life (Cooper et al., 2007). One of the most common interventions is DRO (Poling et al., 1982). When these schedules are initially implemented intervals are short to ensure effectiveness (Repp, 1974). It is suggested that the intervals be thinned once the behavior is said to be under schedule control. However, the research has little support on how frequent or the ratio that which a schedule should be thinned effectively and efficiently. In regards to response effort to obtain a reinforcer, unit price is examined to develop a theory for successful thinning of initial dense schedules, or short intervals of DRO (Poling et al., 1982). In order to examine the most efficient thinning procedure progressive intervals were explored in relation to reinforcer effectiveness throughout the thinning procedure. The purpose of this research was to examine the effects of progressive intervals to successfully thin FI-DRO schedules of reinforcement while still maintaining low rates of challenging behavior.

All three participants' mean interval increased from baseline with the use of progressive schedules of reinforcement. However, in Ashley's case the intervals increased each session up until session five, after which she remained at an average of 100 to 101 second mean intervals. Sean's interval increased across all intervention sessions. Kristen's mean intervals increased in six out of the seven sessions but did not decrease across any sessions. Her mean interval was the same between sessions four and five. Results support the research hypotheses that interval means would increase over baseline interval means. They are also consistent with Roane and colleagues

(2007), and Trosclair-Lasserre and colleagues (2008), that include a consistent unit price throughout procedures designed to thin schedules of reinforcement.

In looking more closely at Sean's data, one can see that intervals initially increased steadily in sessions four through eight. This was followed by a steep increase between session eight and nine after which the following three sessions increased more gradually. Then from session 12 to 13 another steep increase occurs. The data continues in this fashion as it appears he would adjust to the larger interval increases. On the days in which reinforcement was thinned more dramatically he would occasionally have an episode of challenging behavior in the form of high pitched vocalizations (generally lasting one to three seconds in length), these could have been pre-cursor behaviors, but never they led to more challenging behaviors. However, Sean recovered from the thinner reinforcement schedule quickly and intervals continued to increase across all sessions.

During intervention Sean and Kristen had 0% overlapping data points to baseline. Ashley had the highest percentage of overlapping data at 7%. The other two participants had 0% of overlapping data. Overall, Sean and Kristen's intervention data had a consistent upward trend, indicating intervals increasing and reinforcement thinning successful. Ashley's data was less conclusive and showed a flat trend indicating that intervals were not consistently increasing due to the presence of a target behavior occurring during intervention. Further research may explore students who have similar trends in data, suggesting a period of adjustment to the new, longer interval.

Limitations

The main limitations of this study involve the individual differences in challenging targeted behaviors. Ashley, whose intervals did not increase across all

sessions, had been exposed to the treatment for less than a year and had recently had an increase in one of her targeted behaviors (vocal stereotypy) prior to treatment. Therefore, once treatment was begun, it was not as successful as the others. Future research could explore students that are exposed to DRO as treatment and look at their recent behavioral history before starting treatment. Ashley provided an example in which progressive schedules were not effective when target behavior continued to occur throughout sessions.

One additional limitation of the study is that sessions were conducted in hour and half long sessions, often from 10:00 am to 11:30 am. Therefor the student would come in and start their day with the same baseline dense schedule of reinforcement and then when treatment began jump to the new calculated interval for the day. For Sean, this was a very large jump toward the end of the intervention because he would start the day at 60 second reinforcement intervals, and in treatment be exposed to over 300 second intervals. Future research could investigate keeping intervals consistently progressive across the entire school day. This would also give the student the potential to increase more steadily within the duration of one school day. One of the limitations of a time based study is time itself. Although this research took the mean of all intervals, it did limit how many schedules the student was able to access. For example, Sean only had to earn 4 tokens before another schedule began while Ashely had to earn 6 and Kristen had to earn 5 causing each schedule of reinforcement to last longer and provided fewer opportunities to increase interval length.

Future Research

Future research design could specify a number of schedules the student experience as opposed to a constant duration of research sessions. This research used the hour and a half long session time because it was a long enough period for all students to experience a change in their schedule of reinforcement but did not explore longer durations of treatment due to threats to procedural fidelity with longer session times.

Future research could also be conducted with Ashley; it would be beneficial to see if "booster sessions" would be beneficial for her treatment (Vollmer, Roane, Ringdahl, & Marcuss, 1999). If these "booster sessions" were conducted, interval sizes would be cut to smaller intervals far below the initial interval size. The student would then gain access to the reinforcer more readily and the intervals could potentially be built back up using progressive intervals and may reach higher intervals than with the original intervals obtained in this research project.

It would be beneficial to also look at what students are prime candidates with specifications on when to start applying progressive intervals to a DRO schedule or potentially using progressive intervals from the start of DRO treatment. This research could examine the rate of target behaviors occurring throughout the day and also the thinning history of the student. The students that were most successful in this study had a long history of treatment at the same successful interval (i.e., the schedule maintained low or zero rates of target behavior). Sean's DRO treatment was begun in March of 2015 and the team had maintained his interval for 60 seconds until this research project. His problem behavior dramatically decreased and the team did not evaluate for thinning for fear of losing the treatment effects. However, Sean was one of the most successful students in this thinning procedure. Kristen had begun DRO treatment in May of 2016

with an initial interval of 90 seconds. However, Ashley's DRO treatment was begun in September of 2016 at 120 second intervals. There is the potential that all of her target behaviors were not under schedule control, and led to less dramatic results, such as those observed with Sean and Kristen. Further research would need to be conducted to establish a relationship between treatment history and schedule control variables in relation to the effects of progressive interval schedules applied to DRO treatment.

Conclusion

Ultimately, results demonstrated a treatment effect on DRO schedules with the use of progressive intervals and adjusted reinforcement to maintain a constant unit price. The data show upward trends in 2 out of 3 students and increased interval length across all 3 participants. This research is powerful in assessing treatment design for those affected with ASD whose positive behavior has been maintained through DRO schedules of reinforcement. These results can impact a variety of treatment choices for practitioners choosing DRO as a treatment and provide an effective thinning procedure. This is a crucial area needed for research because it is an integral treatment piece for students that engage in wide range of challenging behaviors including aggression, self-injury and destructive behaviors to start to establish and maintain appropriate behaviors that will help them access the world around them. As well, it will help address the issues involved with this procedure that include the intensive continuous observation and monitoring of problem behavior, treatment design and effective and efficient procedures designed to be thinned and generalized to all environments.

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Appendix A

Daily Progressive Interval Data Sheet

#	Time	Timer Duration to earn 1 token	Target Behavior? (Y/N) *If TB, write # of tokens earned at reduced interval	Should interval change? (Y/N)	Reinforcer Earned? (Y/N)	Reinforcer Magnitude (# of edibles, duration of break)
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						

Appendix B

Treatment Integrity and Inter-Observer Agreement Data Collection Sheet

Timer Duration to earn 1 token								
Was timer set for the correct duration? Did it travel w/ and stay in clear view for student?								
Target Behavior (TB)? (Y/N)								
Timer stopped & reset when TB occurred? Did the timer run continuously if no TB?								
Should interval change? (Y/N)								
Correct duration of the next interval?								
Reinforcer Earned? (Y/N)								
Reinforcer delivered w/in 5 seconds of timer beeping?								
Reinforcer Magnitude (# of items/ duration of break)								
Was the correct magnitude of reinforcer delivered?								

Appendix C

Baseline Interval Data Collection Sheet

#	Time	Timer Duration to earn 1 token	Target Behavior? (Y/N)	Token interval change? (Y/N)	Reinforcer Earned? (Y/N)	Reinforcer Magnitude (# of edibles, duration of break)
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						

Appendix D

Social Validity Questionnaire

Questions:		1 Strongly disagree	2 Disagree	3 Agree	4 Strongly Agree
1	This treatment was effective				
2	I found this treatment acceptable for increasing the student's skills				
3	Using the treatment improved skills across multiple contexts (home, classroom, community)				
4	I think the student's skills would remain at an improved level even after the treatment ends				
5	This treatment improved family functioning				
6	This treatment quickly improved the student's skills				
7	I would be willing to carry out this treatment myself if I wanted to increase the student's skills				
8	I would suggest the use of this treatment to other individuals				
9	This treatment decreased the level of stress experienced by the student's family				