Journal of
Applied Behavior Analysis

SEAB
SOCIETY FOR THE EXPERIMENTAL ANALYSIS OF BEHAVIOR

Journal of Applied Behavior Analysis 2021, **54,** 1062–1074 NUMBER 3 (SUMMER)

A preference analysis of reinforcer variation and choice

Laura A. Hanratty and Gregory P. Hanley

Psychology Department, Western New England University

Reinforcement procedures are the cornerstone of behavioral interventions. Previous research has focused on manipulating parameters of reinforcement including quality, magnitude, and rate. In this study, we sought to better understand ways to implement reinforcer choice and variation, and to assess preference for these parameters. Across 10 participants with and without disabilities, we assessed preference for varied reinforcement conditions, as well as choice of reinforcers in a concurrent-chains arrangement. Most participants preferred varied reinforcement conditions and subsequently, choice of reinforcers, over a previously preferred varied reinforcement condition. Implications for reinforcement arrangement in teaching situations are discussed.

Key words: choice, parameters of reinforcement, preference, positive reinforcement, reinforcer variability

Assessing preference for reinforcement parameters in an empirical manner is a means to evaluate the social validity of behavior-change programming (Hanley, 2010), leading to a behavior-change technology that is not only effective but also preferred by its recipients. The use of preferred teaching contexts may lead to a decrease in attempts to escape through problem behavior or may minimize attempts at counter control, as discussed by Carey and Bourbon (2004) and Miller (1991). Parameters such as reinforcer magnitude, delay, rate, and quality have been shown to influence response allocation among concurrently available options in translational research (Neef & Lutz, 2001; Neef et al., 1992, 1993, 1994, 2001) and in the context of socially meaningful behavior including functional communication (Athens & Vollmer, 2010; Vollmer et al., 1999) and play skills (Hoch et al., 2002). Evaluating preference for parameters other than magnitude, delay, rate, and quality of reinforcement may contribute to the implementation of an individualized and preferred reinforcement procedure.

Reinforcer variation and choice are additional reinforcement parameters that should be considered in the use of reinforcement programs, as they may affect efficacy and preferences. Previous research has shown that varied reinforcement was efficacious in maintaining responding (Egel, 1980, 1981) and preferred (Bowman et al., 1997) compared to the same highly preferred items being delivered. Bowman et al. (1997) compared the effects of varied and constant reinforcement using a concurrent-operants arrangement, with edible reinforcers in a ranked order based on preference assessments. In the constant reinforcement condition, responses resulted in delivery of the highest-ranked item from a preference assessment (Fisher et al., 1992). In the varied reinforcement condition, responses resulted in delivery of the items ranked second, third, and fourth from the preference assessment in a random order. Bowman et al. showed that four participants allocated more responses to the varied reinforcement condition, two participants allocated more responses to the constant reinforcement condition, and one participant allocated responses to both conditions,

This study was conducted in partial fulfillment of a Ph. D. in Behavior Analysis from Western New England University by the first author. We thank Rachel Thompson, Jason Bourret, and Chata Dickson for their feedback on earlier versions of this manuscript.

Address correspondence to: Laura Hanratty, 291 Springfield Street, Chicopee, MA 01013. Email: hanrattyl@elms.edu

doi: 10.1002/jaba.835

accessing the high-quality item in the constant condition, and the three less-preferred items in the varied condition. This pattern of responding may not be indicative of indifference. Instead, responding may be a result of the relative preference for all items or the variation of reinforcers across options. A limitation of the Bowman et al. study was that the highly preferred item was only available in the constant condition. Therefore, if there was a relatively large difference in reinforcer quality between conditions, this could have driven preferences more so than variation of reinforcers. Further, reinforcers in the varied condition were only evaluated in a random order; there were no other evaluations included (e.g., a fixed order where the reinforcers were delivered in the same sequence). It is possible that the variation of reinforcers is preferred because satiation to a particular reinforcer (Vollmer & Iwata, 1991) is less likely to occur when multiple types of reinforcers are delivered, similar to previously researched choice arrangements.

In recent research on choice of reinforcers, Toussaint et al. (2016) assessed the efficacy of choice and preference for the teaching contexts that were differentially associated with choice-making opportunities in subsequent sessions. Toussaint et al. expanded on previous research by using three high-quality items for the choice array, emulating teaching contexts, as well as demonstrating the efficacy of using choice of reinforcers to teach a new academic skill. Results showed that children mastered the targeted skills in the choice and no-choice conditions in a similar number of sessions, with individual differences in which led to mastery first. However, when preference was assessed, all children showed a preference for the choice-making condition. Toussaint et al. demonstrated that we could expand on the previous research in choice as a reinforcer by using arrays of reinforcers to emulate applied settings. By using arrays of reinforcers from which individuals may choose, it is possible, similar to the varied reinforcement arrangements, to avoid momentary satiation, which may play a role in preference for choice conditions in addition to the act of choosing itself (Schmidt et al., 2009; Tiger et al., 2006).

Thus, the purpose of the current study was to extend previous research on reinforcement parameters by examining preferences for varied reinforcement and choice of reinforcers. We evaluated preference for varied reinforcement in a concurrent-chains arrangement to isolate the response indicative of preference from the responses influenced by the reinforcement schedules that may have been present in Bowman et al. (1997). Unlike Bowman et al., we included the highest preference item in both the constant and varied condition to better control for qualitative differences across conditions. We then evaluated the preference for choice of reinforcers compared to varied reinforcement conditions that were demonstrated to be preferred. Further, we expanded previous research on choice of reinforcers by comparing choice conditions to two arrangements that may be common in applied settings, including (a) a fixed delivery order (i.e., items always delivered in the order of first, second, and third) and (b) a random schedule (i.e., each reinforcer had an equal chance of being delivered for each response) that was counterbalanced (i.e., each reinforcer was programmed to be delivered an equal number of times within a trial block).

Method

Participants, Setting, and Materials

Ten children, ages 5 through 11, participated in the study. Jesse, Jenny, and Alex were enrolled in a special education pullout classroom for children, all three were diagnosed with learning disabilities and performing below grade level. Max was diagnosed with autism and enrolled in a special education classroom

Table 1

Participants, Settings, and Responses

Participants	Settings	Responses
Jesse	Special education classroom	Addition increasing in complexity- accurate responses were defined as completing one math problem by writing an accurate answer under the problem
Jenny & Alex	Special education classroom	Grammar questions increasing in complexity-accurate responses were defined as writing the correct word or punctuation under one question
Max	Autism classroom	Writing the letter "M"- accurate responses were defined as writing all parts of one letter "M" within the lines provided
Alice, Mary, Tara, Zack, Jane & Lisa	General education classroom	Writing the alphabet, both upper and lower case- accurate responses were defined as tracing all parts of one letter, on the outline provided

for children diagnosed with autism. Sessions took place in a separate area of the classroom. Alice, Mary, Tara, Zack, Jane, and Lisa were typically developing children enrolled in a general education kindergarten classroom. Sessions took place in a separate small room in the school. Session areas included a table, chairs, and worksheets containing academic problems or lined/tracing paper, along with spare paper for an alternative activity.

Responses were identified by the researcher and teachers for each student. Responses were chosen that were previously acquired, but for which teachers identified a need for continued practice. For example, Max had previously learned to write the letter "m" but his teacher identified a need for more practice to increase legibility. Jesse, Jenny, and Alex had different academic responses for each of the comparisons. For example, Jesse started by adding a single-integer number to a double-integer number followed by either subtraction or addition of a single-integer from a double-integer number. Max, Alice, Mary, Tara, Zack, Jane, and Lisa all had the same response across conditions. See Table 1 for setting and responses specific to each participant.

Data Collection and Interobserver Agreement

Two trained observers independently recorded the number of completed academic responses during sessions, which was defined as the participant independently and correctly completing the specified response (see Table 1 for specific response definitions for each participant). All sessions were videotaped. Rate of correct academic responses was calculated by dividing the number of responses by the session duration (either 3 min or the time in which the participant completed 20 responses, whichever occurred first). Consumption of reinforcers (the reinforcement time) was not deducted from the overall session time because it was very brief (i.e., it did not affect rates of academic responding) and because participants could and often did engage in the academic responses while either eating or placing a sticker on their sheet. During the concurrent-chains arrangements to determine preference for conditions, participants were shown the correlated Wingdings font symbol for each condition. A selection was defined as the participant touching the laminated symbol with their hand or picking up the laminated symbol from the table and handing it to the researcher.

Interobserver agreement data were calculated by dividing the number of agreements during each session by the agreements plus disagreements for the entire session and multiplying by 100%. An agreement for academic responses during the exposure sessions was defined as both observers recording the completion of the academic response, while a disagreement was

defined as one observer recording the completion of an academic response while the other observer did not. An agreement for selections in the concurrent-chains arrangement was defined as both observers recording the selection of a stimulus by the participant reaching out and either touching or picking up the laminated stimulus. A disagreement would have been measured if the two observers noted different selections, but this did not occur. Agreement data were collected on an average of 48% of exposure sessions across participants (range, 37%-60%) and averaged 99% (range, 98%-100%). Agreement was collected for an average of 45% of preference evaluation sessions across participants (range, 33%-55%) and was 100%.

Paired-Item Preference Assessment

Preferences were assessed for 10 items using a paired-item preference assessment consistent with Fisher et al. (1992) prior to the start of each comparison. The 10 items were identified from teacher reports of the reinforcer types they would be willing and able to incorporate in their classrooms. Jesse, Jenny, Alex, and Max all chose from an array of edible items. Alice, Mary, Tara, Zack, Jane, and Lisa all chose from an array of stickers to place on colorful paper. See Table 2 for the specific participant reinforcers used across conditions as well as the percentage of approach responses in paired-item preference assessments.

Reinforcement Sensitivity Test

In order to assess if the chosen stickers or edible items functioned as reinforcers, we completed a reinforcer sensitivity test. In this brief analysis, all potential participants were exposed to a reinforcement and extinction condition. The reinforcement condition was designed to incorporate favorable parameters of reinforcement. The item ranked first in the paired-item preference assessment was delivered immediately on a fixed-ratio (FR) 1 schedule following accurate responses to maximize reinforcement effects. In the control condition (extinction), completing the response did not result in the presentation of a reinforcer. Across reinforcement and extinction conditions, attention was delivered on a fixed-time (FT) 1-min schedule in which a generic statement was delivered, such as "I really like your dress today." In the reinforcement and extinction conditions, items for an academic response (e.g., a math problem or writing) were present, as were materials for an alternative activity (e.g., drawing on a scrap piece of paper). Materials were present for an alternative activity to emulate ecologically valid teaching conditions in which there would be alternative sources of reinforcement or activities (e.g., a break from math problems to doodle on a piece of paper) available. Reinforcement and extinction sessions were evaluated in a multielement design. All sessions continued for 3 min, or until a participant exhibited 20 responses.

Fourteen potential participants were exposed to these conditions. Ten continued in the study following both a demonstration that the edible items or stickers served as reinforcers for the chosen academic responses in the context of an alternative activity (doodling with pencil and paper) and the condition in which reinforcers were delivered was preferred in a concurrent-chains arrangement (data available upon request).

Constant versus Varied Reinforcement Exposure Sessions

The purpose of the exposure sessions, and the choice versus no-choice exposure sessions described below, was twofold. First, these sessions allowed the experimenter to assess if the reinforcement arrangements functioned as reinforcement given changes to the parameters. Second, these sessions were completed to correlate arbitrary stimuli—laminated Wingdings symbols—with reinforcement contexts so

Table 2

Participant Reinforcers across Conditions with Percentage of Trials in Which Each Reinforcer was Delivered

Participant	Constant versus Varied			Choice versus No-Choice		
	Items	Constant	Varied	Items	Choice	No-Choice
Jesse	Starbursts (100)	100	28	Fruit Snack(88)	40	50
	Popcorn (88)	0	31	Star Bursts (88)	27	31
	Fruit Snack (66)	0	38	M&Ms (77)	33	29
Jenny	Starbursts (77)	100	35	Fruit Snacks (88)	65	42
	M&M's (77)	0	33	Popcorn (66)	9	38
	Fruit Snacks (66)	0	32	Chips (66)	26	20
Alex	Starbursts (77)	100	35			
	Sour Patch (66)	0	35	–	–	–
	Skittles (66)	0	30			
Max	Skittle (100)	100	36			
	M&M's (88)	0	31	–	–	–
	Reese's Pieces (77)	0	32			
Alice	Princesses (100)	100	28	Animals (66)	20	46
	Dora (88)	0	36	Dora (66)	40	27
	Ponies (77)	0	36	Hello Kitty (66)	40	27
Mary	Ponies (100)	100	34	Hello Kitty (100)	36	35
	SpongeBob (77)	0	39	Princesses (66)	30	35
	Dora (55)	0	27	SpongeBob (88)	34	30
Tara	Pony (88)	100	38	Hello Kitty (88)	36	36
	SpongeBob (77)	0	31	Dora (77)	21	34
	Dora (66)	0	31	Ponies (77)	43	30
Zack	Ninja-Turtles (88)	100	36	Iron Man (77)	42	35
	Spiderman (88)	0	31	Cars (77)	8	35
	Superman (66)	0	36	Spiderman (66)	50	30
Jane	Hello Kitty (77)	100	43			
	Princesses (77)	0	22	–	–	–
	SpongeBob (66)	0	33			
Lisa	Princesses (88)	100	35			
	Hello Kitty (77)	0	32	–	–	–
	Ponies (77)	0	33			

Note. Numbers in parentheses note the approach responses from the preference assessment.
A "–" represents an analysis that was not completed.

discriminative control could develop, and so that these symbols could be used as initial-link stimuli in preference evaluations.

In the constant reinforcement condition, the item ranked first from the paired-item preference assessment was delivered. In the varied reinforcement condition, either the first, second, or third ranked item from the paired-item preference assessment was randomly delivered in a preset arrangement across blocks of three academic responses, but each item was delivered a relatively equal number of times in a session. In the control condition (extinction), completing the response did not result in the presentation of a reinforcer. Prior to the start of the session, the participant was shown the Wingdings symbol and the condition was described. For example, in the constant condition the experimenter said, "When this picture is on the table, when you write a letter correctly you will receive a princess sticker," while in the varied conditions, the experimenter said, "When this picture is on the table, when you write a letter correctly you will receive either a princess, Hello Kitty, or My Little Pony sticker." In extinction conditions, the experimenter said, "When this picture is on the table, when you write a letter correctly you will not get any stickers." All sessions continued for 3 min, or until a participant exhibited

20 responses. Similar to the reinforcer sensitivity test, across all conditions, materials were available for an alternative response, and generic praise statements were delivered on an FT 1-min schedule. Sessions were conducted in a multielement design.

Choice versus No-choice Exposure Sessions

In the choice and no-choice conditions, response completion was reinforced with one of the three highly preferred reinforcers on an FR-1 schedule. Across all conditions there was an array of 21 reinforcers present in front of the child. The array had seven items for each of the three types of reinforcers. This was programmed so that all three reinforcers could be accessed a relatively equal number of times across sessions. On average, each reinforcer was accessed approximately 34% of the time in the choice condition, and approximately 33% of the time in the no-choice condition, across participants (Table 2).

In the choice condition, the participant had the opportunity to choose an item from the array following each response. In the no-choice condition, contingent on each response, either the first, second, or third ranked item was delivered by the experimenter. For Jesse, Tara, Mary and Zack, reinforcers were delivered in a fixed order throughout the session (i.e., first, second, third, first, second, third, etc.). For Jenny and Alice, the no-choice condition was identical to the varied reinforcement condition from the varied versus constant comparison. Reinforcers were delivered randomly across blocks of three academic responses. This difference was to emulate two different types of reinforcer delivery a child may experience in a classroom or programmed by caregivers and expand on the generality of this preference of choice. In the control condition, completing the response did not result in the presentation of a reinforcer. Prior to the start of each session, the condition was explained to the participant. For example, in the choice condition the experimenter said, "When this picture is on the table, and you answer correctly, you can choose either a fruit snack, M&M, or Starburst," in the fixed no-choice condition the experimenter said, "When this picture is on the table, and you answer correctly, I will give you a candy. It will always be in the order of fruit snack, M&M, then Starburst," and in the varied no-choice condition the experimenter said, "When this picture is on the table, and you answer correctly, I will give you a candy, but you won't know which one it will be." All sessions continued for 3 min, or until a participant exhibited 20 responses. Similar to previous conditions, across all conditions, materials were available for an alternative response, and generic praise statements were delivered on an FT 1-min schedule. Sessions were conducted in a multielement design.

Preference Evaluations

Preference evaluation sessions were conducted following the exposure sessions for the constant versus varied reinforcement delivery, and again following the choice versus no-choice reinforcement conditions using a concurrent-chains arrangement. Laminated Wingdings symbols that were previously presented in the exposure sessions were placed on the table in front of the participant and served as the initial-link stimuli signaling the different conditions operating in the terminal links. The location of the Wingding symbols in the presented array was randomized across sessions. Stimuli were rotated in a prearranged order between left, center, and right. At the beginning of each session, the experimenter prompted the participant to pick a condition by saying, "Pick one." Choosing a symbol resulted in immediate praise (e.g., "Nice job picking one") and all other symbols were removed from the table. The experimenter then put the materials for

the selected condition on the table, and a 3-min session was completed. Preference was demonstrated when one condition was selected four more cumulative selections than any other conditions. If at any point a condition was selected for four more times than other conditions it was considered preferred (Luczynski & Hanley, 2009, 2010). The preference evaluation was stopped if preference was not demonstrated within 12 sessions.

Results

The left columns of Figure 1 show the rate of academic responding across varied reinforcement, constant reinforcement, and extinction sessions for each participant during exposure sessions. Constant and varied reinforcement resulted in similar rates of academic responding that were higher relative to extinction conditions across all participants. Alice and Mary had slightly higher rates of responding in the constant reinforcement condition. Alice emitted an average of 6.5 responses per minute in the constant reinforcement condition compared to 4.5 responses per minute in the varied reinforcement condition. Mary emitted an average of 8.1 responses per minute in the constant reinforcement condition, and 6.3 in the varied reinforcement condition. The only participants who responded in the extinction condition were Max (mean of 1.8 responses per minute), Jane (mean of 2.0 responses per minute), and Lisa (mean of 8.2 responses per minute).

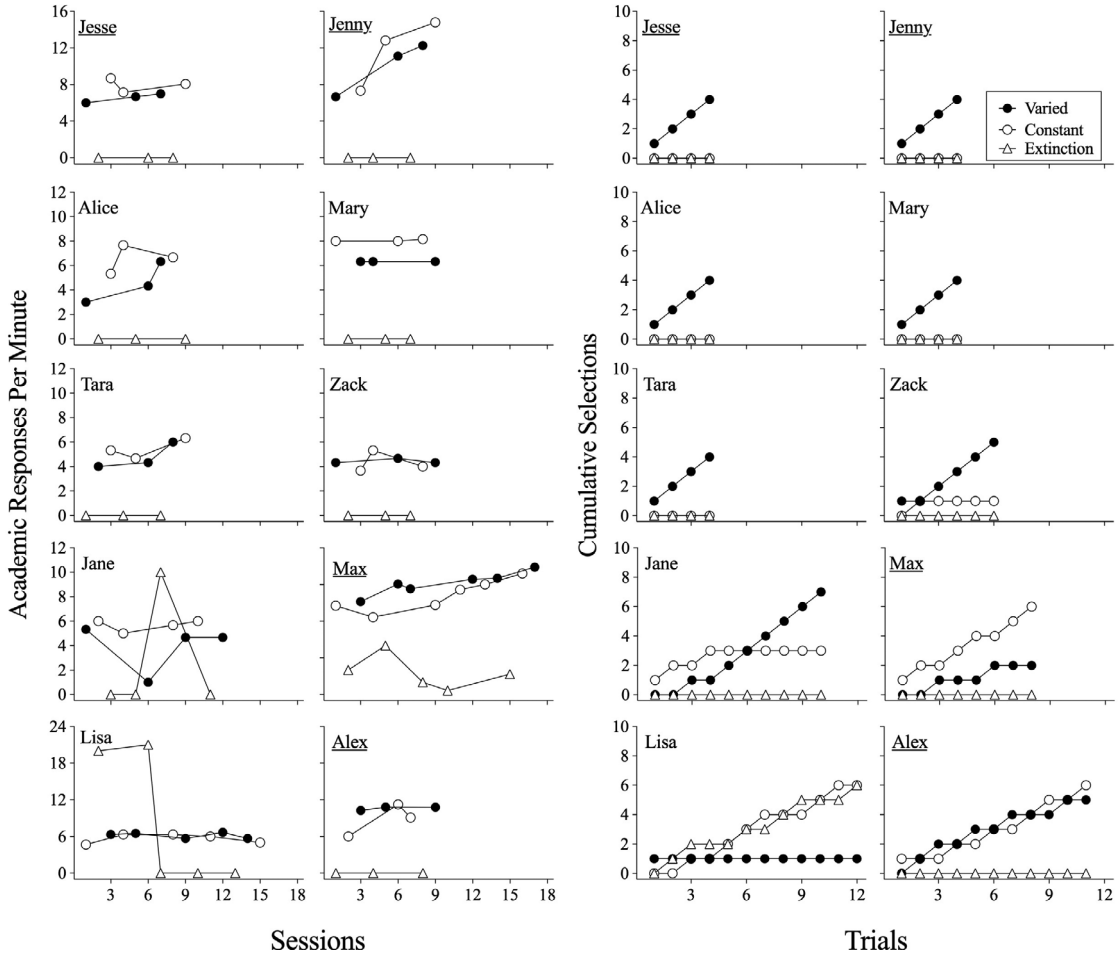
The right columns of Figure 1 show the cumulative selections of initial links in the concurrent-chains arrangement for the varied reinforcement, constant reinforcement, and extinction conditions for each participant. Of the 10 participants, seven (Jesse, Jenny, Alice, Mary, Tara, Zack, and Jane) preferred varied reinforcement delivery with Jesse, Jenny, Alice, Mary, and Tara all exclusively choosing the varied reinforcement condition in the concurrent-chains arrangement. Max preferred constant reinforcement delivery. Alex demonstrated indifference between the reinforcement conditions, alternating between the constant and the varied reinforcement conditions. Lisa demonstrated undifferentiated responding and alternated choices between the constant reinforcement and the extinction conditions.

The left column of Figure 2 shows the rate of academic responses in the choice, no-choice, and extinction sessions for each participant during exposure sessions. The choice and no-choice conditions resulted in similar rates of academic responses for three participants (Jenny, Tara, Mary), with both reinforcement conditions yielding higher rates relative to extinction conditions. Jenny averaged 2.6 responses per minute in both the choice and no-choice conditions. Tara averaged 5.4 responses per minute in the choice condition and 5.0 responses per minute in the no-choice condition. Mary averaged 7.6 academic responses per minute in the choice condition and 8.1 responses per minute in the no-choice condition. The no-choice condition resulted in slightly higher rates of responding for two participants in the exposure sessions (Alice and Zack). Alice emitted an average rate of 8.6 responses per minute in the no-choice condition relative to an average rate of 4.6 responses per minute in the choice condition. Zack averaged 7.1 academic responses per minute in the no-choice condition and 4.0 responses per minute in the choice condition. By contrast, Jesse had slightly higher rates of responding in the choice condition with an average rate of 5.6 responses per minute relative to an average rate of 4.0 responses per minute in the no-choice condition. All rates were higher in the reinforcement than extinction conditions across participants.

The right columns of Figure 2 show the cumulative selections of initial links in the concurrent-chains arrangement for the choice, no-choice, and extinction conditions for each participant. Five of six participants (Jesse,

Figure 1

Academic Responses and Cumulative Selections During Constant, Varied, and Extinction Sessions



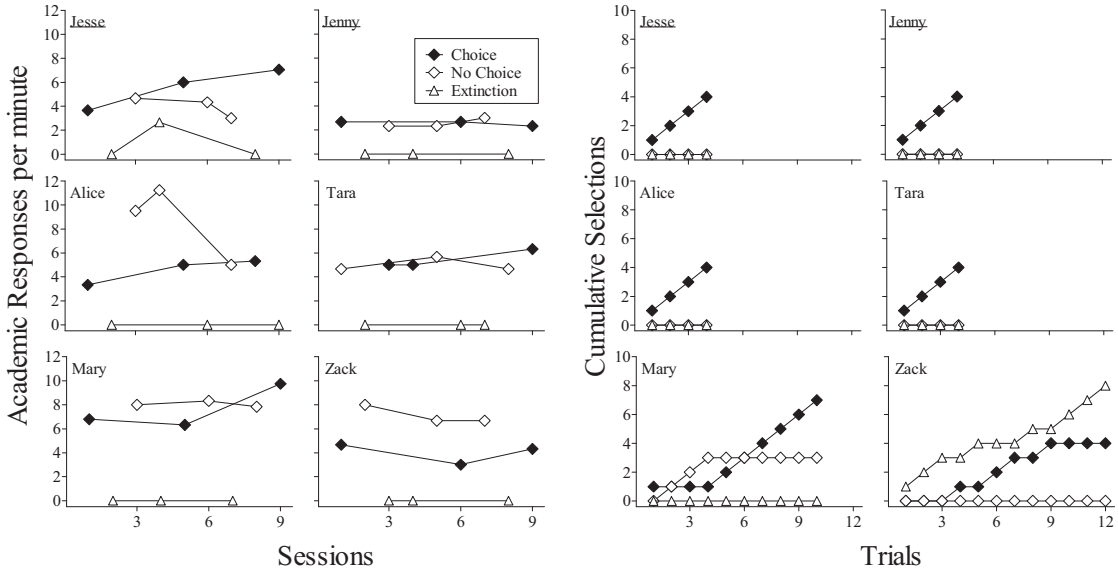
Note. Academic responses during exposure sessions are indicated in the left column and cumulative selections during preference evaluations are indicated in the right column. Students whose names are underlined were enrolled in special education classrooms.

Jenny, Alice, Mary, and Tara) showed a preference for the condition in which choice was available and one participant (Zack) showed a preference for the extinction condition. Of the participants who showed a preference for the choice condition, four participants (Jesse, Jenny, Alice, and Tara) exclusively selected the choice condition.

The top panel of Figure 3 shows the aggregate data for the average rate of responding across reinforcement conditions. The mean rate of academic responding for all participants was 7.1 responses per minute in the constant reinforcement condition, 6.7 responses per minute in the varied reinforcement condition, and 1.7 responses per minute in extinction conditions. In the choice evaluations, the mean rate of academic responding for all participants was 5.0 responses per minute in the choice reinforcement condition, 5.9 responses per minute in the no-choice condition, and 0.1 responses per minute in extinction conditions. The bottom

Figure 2

Academic Responses and Cumulative Selections During Choice, No-Choice, and Extinction Sessions



Note. Exposure sessions are on the left, and preference evaluations are on the right. Students whose names are underlined were enrolled in special education classrooms.

panel of Figure 3 shows the number of participants who demonstrated a preference for each of the reinforcement conditions. A majority of participants chose the varied reinforcement condition compared to the constant reinforcement and extinction conditions, and in the subsequent comparison, demonstrated a preference for choice compared to no-choice and extinction conditions.

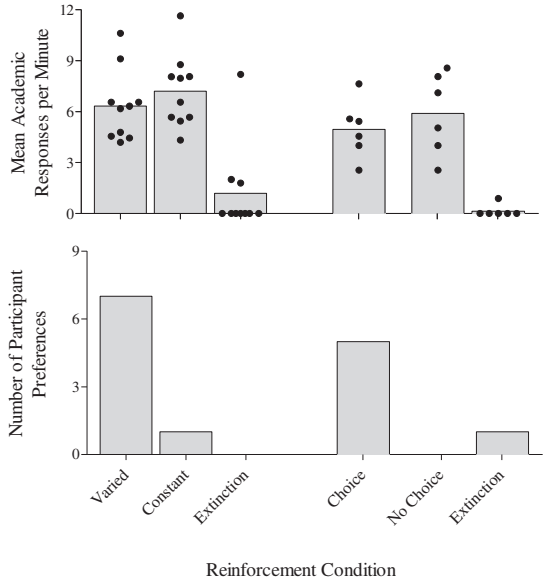
Discussion

Participants demonstrated a preference for a particular reinforcement parameter in 13 out of 16 applications, despite academic responding being similar across reinforcement parameters for these 13 applications. More specifically, most participants demonstrated preference for varied reinforcement and for choice in a subsequent arrangement. Given the continued reliance on single, highly preferred reinforcers in both research (Campanaro et al., 2020) and practice (O'Neill et al., 2018), these results are important and suggest that reinforcement programs are likely to be more preferred by learners when provided with varied reinforcement and choice arrangements.

One participant, Alex, chose both reinforcement conditions in the concurrent-chains arrangement comparing constant and varied reinforcement conditions. This suggests a preference for receiving edible reinforcers compared to the extinction condition, but indifference toward varied or constant reinforcement conditions. Some children demonstrated a preference for extinction conditions (Zack) or made some selections of extinction conditions (Lisa) in preference evaluations. Rather than being indicative of a preference for extinction, these patterns may reflect a preference for negative rather than positive reinforcement conditions (e.g., escape from demands in the form of breaks). Breaks following work may serve as a reinforcer and be more preferred than positive reinforcement as demonstrated in Kodak et al. (2007) who had participants demonstrate

Figure 3

Aggregate Data across Participants



Note. Bars represent the average for all participants and black circles represent individual participant's average rate of responding for all exposure sessions. The bottom panel shows the number of participants who demonstrated a preference for each reinforcement condition.

a preference for a break compared to less preferred edible items. Future research should evaluate how different types of positive reinforcers may interact and compete with negative reinforcement in the form of a break from academics when these parameters of reinforcement are manipulated. For example, researchers may want to evaluate preferences among access to playing with preferred toys, preferred snacks, breaks alone, or time with the teacher, or combinations of these.

Preference for these reinforcement conditions was assessed in a concurrent-chains arrangement, which, in this instance, better isolates preference indices than concurrent-operants arrangements. Concurrent-chains arrangements are more suitable to assess preference for these parameters because participants' responding in the initial links indicates their preference for the experiences in the terminal links while maintaining the integrity of the terminal link schedule (see Catania & Sagvolden, 1980). As discussed previously, in a concurrent-operants arrangement the participant can respond across all operants and access multiple reinforcement arrangements within a session, which may confound the programmed reinforcement arrangement in each session. For example, in Bowman et al. (1997) the participants could access the constant condition in which the high-preference item was delivered, as well as the varied condition in which the items ranked second, third, and fourth were delivered. This allowed the participants to access all four reinforcers in a way that was not programmed by experimenters during the session duration. This pattern of responding was also determined by Bowman et al. to be a demonstration of indifference, as there was responding across multiple reinforcement conditions. In this study, participants' preferences were isolated in the initial links of the chain, allowing for an evaluation of preference independent of the evaluation of reinforcer effects, and with the participant experiencing the arranged reinforcer delivery by the experimenter for a set period of time. By separating the initial link from the terminal responding, we were able to determine preference independent of responses across multiple conditions to access different reinforcer items.

Table 2 shows the percentage of trials in which each reinforcer was delivered across comparisons and individuals. On average, the high-preference item was delivered for 34.5% of responses in the varied reinforcement condition. In the choice versus no-choice comparison, there were some differences in the amount of each reinforcer that was obtained. Zack chose the item ranked third 50% of the time in the choice condition, suggesting there may have been a change in preference from the time of the item-based preference assessment to the parameter preference assessment.

Preference changes over time, and satiation effects to single reinforcers may be less likely to impact responding in varied conditions and with choice of reinforcers as there are other reinforcers to obtain. That is, the opportunity to choose reinforcers allows individuals to select the reinforcer most preferred at that time. Varied reinforcement, as well as choice of reinforcers have an added advantage of possibly preventing satiation of these potent reinforcers, as reinforcement programs are in place for a longer period of time (Vollmer & Iwata, 1991). As sessions were relatively short in duration and the number of sessions each participant experienced was few, we did not observe satiation effects. Future research should consider the effects that motivating operations have on the efficacy of and preference for these reinforcer arrangements, as session durations and frequency increase.

It is plausible that the analytic context we adopted, which relied on maintenance responses, was insensitive to meaningful differences that may be produced by the manipulated reinforcement variables. It is important to note that reinforcers were assessed on an FR 1 schedule because this is a common schedule of reinforcement in teaching contexts, and because we wanted to maximize experience with each reinforcement condition in the exposure sessions. In order to further understand if there are differences in the efficacy of these parameters, some changes should be considered in future research. For example, other schedules of reinforcement, including variable-interval schedules that are less susceptible to the effects of satiation, as well as thinned schedules of reinforcement may yield more differences in response rates (Milo et al., 2010).

Responding was assessed in short sessions with an academic response, but it is unclear how responding and preference for these parameters of reinforcement may change as responses increase in difficulty. Jesse, Jenny, and Alex were exposed to changing academic responses as the comparisons progressed, which may closer approximate how a typical classroom curriculum would progress; however, all responses were previously learned. Although these maintenance responses are a good starting point for research, most reinforcement procedures are used for the development and maintenance of new skills (DeLeon et al., 2013). Future evaluations should include more difficult responses, or acquisition responses, to determine if the general preferences observed extend to these conditions, and if teaching under preferred conditions leads to more robust learning outcomes, including faster acquisition. This research extension is important because these arrangements closer approximate the conditions in which reinforcers are used in educational settings.

Overall, despite the lack of differences in response rates produced by the reinforcement parameters studied here, participants exhibited a clear preference for one reinforcer parameter relative to another (Figure 3). These outcomes suggest that, although they are sometimes correlated (Hanley, 2010), effects of reinforcement contingencies and preference for those same contingencies appear to be independent measures. Based on the results, if a behavior change agent cannot evaluate individual preferences quickly (e.g., a teacher in a large class, or in cases in which a program needs to be put in place quickly) it would be prudent to program choice of reinforcers from a varied array, as most participants preferred this arrangement.

Combining reinforcer parameters may lead to more robust differences in responding and preferences. These types of outcomes are implied by the results of Athens and Vollmer (2010), in which reinforcer quality, delay, and duration were shown to influence responding towards more favorable responses in isolation, as well as when they were concurrently manipulated (e.g., duration, quality, and delay all favored desired responding). Future research should further examine the effects of

choice and variation in combination with other parameters already demonstrated to influence responding including quality, duration, and delay. Concurrently manipulating these parameters may create a larger differential between reinforcement schedules to favor desirable responding by creating a larger contrast between conditions.

The current analysis demonstrated that reinforcer variation and choice are reinforcement parameters that should be considered. Differences in preferences for these parameters did not appear to be driven by differences in quality of reinforcers, and these manipulations should be considered in reinforcement programs.

REFERENCES

Athens, E. S., & Vollmer, T. R. (2010). An investigation of differential reinforcement of alternative behavior without extinction. *Journal of Applied Behavior Analysis*, *43*(4), 569-589. https://doi.org/10.1901/jaba.2010.43-569

Bowman, L. G., Piazza, C. C., Fisher, W. W., Hagopian, L. P., & Kogan, J. S. (1997). Assessment of preference for varied versus single reinforcers. *Journal of Applied Behavior Analysis*, *30*(3), 451-458. https://doi.org/10.1901/jaba.1997.30-451

Campanaro, A. M., Vladescu, J. C., Kodak, T., DeBar, R. M., & Nippes, K. C. (2020). Comparing skill acquisition under varying onsets of differential reinforcement: A preliminary analysis. *Journal of Applied Behavior Analysis*, *53*(2), 690-706. https://doi.org/10.1002/jaba.615

Carey, T. A., & Bourbon, W. T. (2004). Counter control: A new look at some old problems. *Intervention in School and Clinic*, *40*(1), 3-9. https://doi.org/10.1177/10534512040400010101

Catania, A. C., & Sagvolden, T. (1980). Preference for free choice over forced choice in pigeons. *Journal of the Experimental Analysis of Behavior*, *34*(1), 77-86. https://doi.org/10.1901/jeab.1980.34-77

DeLeon, I. G., Bullock, C. E., & Catania, A. C. (2013). Arranging reinforcement contingencies in applied settings: Fundamentals and implications of recent basic and applied research. In G. J. Madden, W. V. Dube, T. D. Hackenberg, G. P. Hanley, & K. A. Lattal (Eds.), *APA handbook of behavior analysis: Vol. 2. Translating principles into practice* (pp. 47-75). American Psychological Association. https://doi.org/10.1037/13938-003

Egel, A. L. (1980). The effects of constant vs. varied-reinforcer presentation on responding by autistic children. *Journal of Experimental Child Psychology*, *30*(3), 455-463. https://doi.org/10.1016/0022-0965(80)90050-8

Egel, A. L. (1981). Reinforcer variation: Implications for motivating developmentally disabled children. *Journal of Applied Behavior Analysis*, *14*(3), 345-350. https://doi.org/10.1901/jaba.1981.14-345

Fisher, W., Piazza, C. C., Bowman, L. G., Hagopian, L. P., Owens, J. C., & Slevin, I. (1992). A comparison of two approaches for identifying reinforcers for persons with severe and profound disabilities. *Journal of Applied Behavior Analysis*, *25*(2), 491-498. https://doi.org/10.1901/jaba.1992.25-491

Hanley, G. P. (2010). Toward effective and preferred programming: A case for the objective measurement of social validity with recipients of behavior-change programs. *Behavior Analysis in Practice*, *3*(1), 13–21. https://doi.org/10.1007/BF03391754

Hoch, H., McComas, J. J., Johnson, L., Faranda, N., & Guenther, S. L. (2002). The effects of magnitude and quality of reinforcement on choice responding during play activities. *Journal of Applied Behavior Analysis*, *35*(2), 171-181. https://doi.org/10.1901/jaba.2002.35-171

Kodak, T., Lerman, D. C., Volkert, V. M., & Trosclair, N. (2007). Further examination of factors that influence preference for positive versus negative reinforcement. *Journal of Applied Behavior Analysis*, *40*(1), 25-44. https://doi.org/10.1901/jaba.2007.151-05

Luczynksi, K. C., & Hanley, G. P. (2009). Do children prefer contingencies? An evaluation of the efficacy of and preference for contingent versus noncontingent social reinforcement during play. *Journal of Applied Behavior Analysis*, *42*(1), 511-525. https://doi.org/10.1901/jaba.2009.42-511

Luczynksi, K. C., & Hanley, G. P. (2010). Examining the generality of children's preference for contingent reinforcement via extension to different responses, reinforcers, and schedules. *Journal of Applied Behavior Analysis*, *43*(3), 397-409. https://doi.org/10.1901/jaba.2010.43-397

Miller, L. K. (1991). Avoiding the countercontrol of applied behavior analysis. *Journal of Applied Behavior Analysis*, *24*(4), 645-647. https://doi.org/10.1901/jaba.1991.24-645

Milo, J. S., Mace, F. C., & Nevin, J. A. (2010). The effects of constant versus varied reinforcers on preference and resistance to change. *Journal of the Experimental Analysis of Behavior*, *93*(3), 385-394. https://doi.org/10.1901/jeab.2010.93-385

Neef, N. A., Bicard, D. F., & Endo, S. (2001). Assessment of impulsivity and the development of self-control in students with attention deficit hyperactivity disorder. *Journal of Applied Behavior Analysis*, *34*

(4), 397-408. https://doi.org/10.1901/jaba.2001.34-397

Neef, N. A., & Lutz, M. N. (2001). A brief computer-based assessment of reinforcer dimensions affecting choice. *Journal of Applied Behavior Analysis*, *34*(1), 57-60. https://doi.org/10.1901/jaba. 2001.34-57

Neef, N. A., Mace, F. C., & Shade, D. (1993). Impulsivity in students with serious emotional disturbance: The interactive effects of reinforcer rate, delay, and quality. *Journal of Applied Behavior Analysis*, *26*(1), 37-52. https://doi.org/10.1901/jaba.1993.26-37

Neef, N. A., Mace, F. C., Shea, M. C., & Shade, D. (1992). Effects of reinforcer rate and reinforcer quality on time allocation: Extensions of matching theory to educational settings. *Journal of Applied Behavior Analysis*, *25*(3), 691-699. https://doi.org/10.1901/jaba.1992.25-691

Neef, N. A., Shade, D., & Miller, M. S. (1994). Assessing influential dimensions of reinforcers on choice in students with serious emotional disturbance. *Journal of Applied Behavior Analysis*, *27*(4), 575-583. https://doi.org/10.1901/jaba.1994.27-575

O'Neill, S. J., McDowell, C., & Leslie, J. C. (2018). A comparison of prompt delays with trial-and-error instruction in conditional discrimination training. *Behavior Analysis in Practice*, *11*(4), 370-380. https://doi.org/10.1007/s40617-018-0261-9

Schmidt, A. C., Hanley, G. P., & Layer, S. A. (2009). A further analysis of the value of choice: Controlling for illusory discriminative stimuli and evaluating the effects of less preferred items. *Journal of Applied Behavior Analysis*, *42*(3), 711-716. https://doi.org/10.1901/jaba.2009.42-711

Tiger, J. H., Hanley, G. P., & Hernandez, E. (2006). A further evaluation of the reinforcing value of choice. *Journal of Applied Behavior Analysis*, *39*(1), 1-16. https://doi.org/10.1901/jaba.2006.158-04

Toussaint, K. A., Kodak, T., & Vladescu, J. C. (2016). An evaluation of choice on instructional efficacy and individual preferences among children with autism. *Journal of Applied Behavior Analysis*, *49*(1), 170-175. https://doi.org/10.1002/jaba.263

Vollmer, T. R., & Iwata, B. A. (1991). Establishing operations and reinforcement effects. *Journal of Applied Behavior Analysis*, *24*(2), 279-291. https://doi.org/10.1901/jaba.1991.24-279

Vollmer, T. R., Roane, H. S., Ringdahl, J. E., & Marcus, B. A. (1999). Evaluating treatment challenges with differential reinforcement of alternative behavior. *Journal of Applied Behavior Analysis*, *32*(1), 9-23. https://doi.org/10.1901/jaba.1999.32-9

Received February 13, 2020
Final acceptance February 22, 2021
Action Editor, Andrew Craig