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EXAMINATION OF THE INFLUENCE OF CONTINGENCY ON CHANGES IN REINFORCER VALUE

Iser G. DeLeon

KENNEDY KRIEGER INSTITUTE
AND JOHNS HOPKINS UNIVERSITY SCHOOL OF MEDICINE

Meagan K. Gregory

KENNEDY KRIEGER INSTITUTE

Michelle A. Frank-Crawford

KENNEDY KRIEGER INSTITUTE
AND UNIVERSITY OF MARYLAND, BALTIMORE COUNTY

Melissa J. Allman

KENNEDY KRIEGER INSTITUTE
AND JOHNS HOPKINS UNIVERSITY SCHOOL OF MEDICINE

Arthur E. Wilke

CENTER FOR AUTISM AND RELATED DISORDERS, INC.

Abbey B. Carreau-Webster

KENNEDY KRIEGER INSTITUTE
AND UNIVERSITY OF MARYLAND, BALTIMORE COUNTY

AND

Mandy M. Triggs

KENNEDY KRIEGER INSTITUTE

This study examined how the amount of effort required to produce a reinforcer influenced subsequent preference for, and strength of, that reinforcer in 7 individuals with intellectual disabilities. Preference assessments identified four moderately preferred stimuli for each participant, and progressive-ratio (PR) analyses indexed reinforcer strength. Stimuli were then assigned to one of four conditions for 4 weeks: fixed-ratio (FR) 1 schedule, escalating FR schedule, yoked noncontingent (NCR) delivery, and restricted access. Preference assessments and PR schedules were then repeated to examine changes in selection percentages and PR break points. Selection percentages decreased for all NCR stimuli but increased for most of the restricted stimuli. There were no systematic changes in selection percentages for either of the contingent stimuli. Break points increased, on average, for all conditions, but the increase was highest for the restricted stimuli and lowest for the NCR stimuli. These results are discussed in relation to recent basic research addressing the influence of effort on stimulus value.

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Address correspondence to Iser G. DeLeon, Neurobehavioral Unit, Kennedy Krieger Institute, 707 N. Broadway, Baltimore, Maryland 21205 (e-mail: deleon@kennedykrieger.org).

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One important observation that has emerged from the literature on stimulus preference is that preferences can change over time and experience (Hanley, Iwata, & Roscoe, 2006). Items or events identified as more preferred on one occasion may be less preferred on a separate occasion (Lohrmann-O'Rourke & Browder, 1998; Mason, McGee, Farmer-Dougan, & Risley, 1989; Zhou, Iwata, Goff, & Shore, 2001). These fluctuations in stimulus preference sometimes translate into fluctuations in reinforcer effectiveness (e.g., DeLeon et al., 2001).

Although preferences are dynamic, few studies have directly examined the variables that influence the stability of preferences or durability of reinforcers. The exceptions have often examined the local effects of satiation and deprivation on preference assessment outcomes (Gottschalk, Libby, & Graff, 2000; Hanley, Tiger, Ingvarsson, & Cammilleri, 2009; McAdam et al., 2005). These studies have generally revealed that stimulus deprivation can increase preference rankings and satiation can decrease preference rankings. For example, Hanley et al. (2006) observed that repeated noncontingent delivery of a stimulus resulted in lower indices of preference for that stimulus. However, given that one typically provides reinforcers on a contingent basis, it may also be important to examine changes in stimulus value as a function of contingent reinforcer delivery.

Recent research suggests that events historically associated with producing a stimulus can influence subsequent changes in the value of that stimulus. For example, the effect sometimes termed *within-trial contrast* (Zentall & Singer, 2007a), or the *work ethic effect* (Clement, Feltus, Kaiser, & Zentall, 2000), predicts that "reinforcers that follow relatively aversive events become preferred over those that follow less aversive events" (Singer, Berry, & Zentall, 2007, p. 275). One sort of relatively aversive event is the amount of effort required to produce the stimuli. Thus, stimuli reliably preceded by greater effort become preferred over stimuli preceded by less effort (e.g., Clement et al., 2000; Friedrich & Zentall, 2004; Johnson & Gallagher, 2011; Kacelnik & Marsh, 2002; Klein, Bhatt, & Zentall, 2005). Although some experimenters have been unable to replicate this effect (e.g., Arantes & Grace, 2008; Vasconcelos, Urcuioli, & Lionello-DeNolf, 2007), most studies that have examined within-trial contrast effects have observed positive instances (Zentall & Singer, 2007b). If increases in the effort historically associated with earning a stimulus are positively related with the subsequent value of that stimulus relative to others, it follows that changes in stimulus value over time may vary systematically as a function of whether the stimuli were delivered in a contingent (higher effort) or noncontingent (lower effort) fashion.

Research on changes in the value of a stimulus given past effort generally has examined the effects of these manipulations on preferences for discriminative stimuli associated with symmetrical reinforcers (e.g., S+ associated with greater effort to obtain grain vs. S+ associated with lesser effort to obtain grain). From an applied standpoint, a more pertinent question might be if these effects transfer to the reinforcers themselves when they are qualitatively distinct (e.g., one reinforcer associated with greater effort vs. a different reinforcer associated with lesser effort). Birch, Zimmerman, and Hind (1980) observed something akin to this effect. They first asked preschool children to rate snack foods (peanuts, carrots, crackers, etc.). Four moderately preferred foods were then subjected to various manipulations for several weeks, after which the children again rated the foods. In one manipulation, the

children received the designated snack item as a reward contingent on the display of varying behaviors (e.g., responding to verbal requests, cooperative play) twice a day for 21 days. In another condition, the child received the designated item in a nonsocial context; the items were simply placed in the children's lockers twice a day and the children were free to consume them when they visited their lockers. After 21 days, the children again rated the items, and the experimenters found an overall increase in the ratings of the snack items delivered as rewards, leading them to conclude that ''presenting a food as reward enhances preferences for that food'' (p. 860). By contrast, ratings of the items delivered independent of a programmed contingency did not increase. In a manner consistent with the more recent nonhuman animal research, items associated with an earning requirement increased in rating, and those associated with no effort did not.

Although this study suggested that contingency might be positively related to subsequent reinforcer value, the only dependent measure was children's ratings of the items. Verbal self-reports of relative preferences, however, may not always correspond with behavioral measures of the relative strength of the stimuli in supporting operant behavior (e.g., Northup, 2000; Northup, George, Jones, Broussard, & Vollmer, 1996). Therefore, in addition to some index of changes in relative preference, as offered by established stimulus preference assessments, it is important to conduct a more direct test of changes in reinforcer strength before and after arranging manipulations of effort. One measure that has received increasing attention in the applied behavioral literature is the break point on a progressive-ratio (PR) schedule (Hodos, 1961). Under a PR schedule, reinforcers are contingent on the completion of response requirements that increase within sessions. The schedule continues to increase until reaching some termination criterion, usually some period of time without responding. The last ratio requirement met, termed the break point, provides an index of the amount of work the reinforcer will support. Comparison of mean break points provides a gauge of relative potency across stimuli. Recent applied studies (e.g., DeLeon, Frank, Gregory, & Allman, 2009; Francisco, Borrero, & Sy, 2008; Glover, Roane, Kadey, & Grow, 2008) suggest that PR schedules perform fairly well in validating differences in preference levels by gauging independent stimulus value.

An added advantage of using PR break points is that reinforcer potency can be gauged for one stimulus independent of the potency of other stimuli. Recent examinations of within-trial contrast effects have been restricted to measuring relative preferences among two or more stimuli, arranged in concurrent schedules. Although these studies have shown that prior manipulations of effort can influence relative response allocation to one stimulus over another concurrently available stimulus, differences in relative response allocation under concurrent schedules do not always indicate a difference in the absolute strength of a reinforcer in supporting operant behavior on independent (nonconcurrent) schedules (Roscoe, Iwata, & Kahng, 1999). It is therefore important to determine whether changes in relative preference translate into meaningful changes in the independent strength of the stimuli as reinforcers. DeLeon, Williams, Gregory, and Hagopian (2005) reported pilot data for two individuals with developmental disabilities from such an analysis. The experimenters delivered moderately preferred stimuli on an FR 1 schedule during daily training sessions and noncontingently on a schedule yoked to the FR 1 schedule. Thus, the individuals received equivalent exposure to the two stimuli, but they worked for one and not the other. PR analyses conducted before and after these arrangements revealed increases in break points for the contingent stimuli but decreases for the noncontingent stimuli, again suggesting a positive

relation between prior effort and changes in stimulus value.

The present study sought to expand this line of investigation on the relation between contingency and subsequent stimulus value. The influence of contingent and noncontingent delivery on changes over time was measured by (a) changes in preference assessment selection percentages and (b) changes in reinforcer strength via PR schedules. To further examine the effects of the amount of effort, the current study evaluated two levels of contingent effort: contingent delivery on a constant FR 1 schedule and contingent delivery on an escalating FR schedule in which the schedule requirements increased across successive weeks. Finally, the same measures were applied to stimuli entirely restricted (i.e., no exposure) between preference assessments and PR analyses. This latter condition served as a control to assess what might happen in the absence of any effort manipulation.

METHOD

Participants and Settings

Seven individuals with developmental disabilities admitted to an inpatient unit for the assessment and treatment of behavior disorders participated in the study (see Table 1 for participant description and stimuli assigned to each condition). Four of the participants (Cathy, Courtney, Mary, and Thomas) had been previously involved in a study examining the correspondence between preference assessment outcomes and PR schedule analyses (DeLeon et al., 2009), and thus were familiar with the PR schedule analyses.

Sessions were conducted in different areas of the inpatient hospital. Sessions for Mary and Thomas took place in a session room (2.4 m by 3 m) equipped with a one-way observation window, two chairs, and a table. April's sessions took place at one of two tables located on the main living area (9.4 m by 9.4 m) of the inpatient hospital unit. Jonathan's and Courtney's sessions took place at a table located in the center of a room (7.7 m by 7.7 m) adjacent to the main living area. Sessions for Todd and Cathy took place at a workstation (desk and two chairs) located in the classroom (6.8 m by 6.8 m) where they completed their daily academics. Partitions divided the workstations.

Response Definitions, Data Collection, and Interobserver Agreement

Trained graduate students and research assistants served as data collectors for all assessments. Observers used laptop computers to collect data for preference assessments and reinforcer-value manipulation sessions. During the preference assessments, the therapist recorded responses in the presence of stimuli including selection, avoidance, and no response. Selection included touching, reaching toward, or asking for the toy or food item. An avoidance response was scored if the participant actively pushed or threw the stimulus away, moved away from the stimulus within 3 s of presentation, or engaged in negative vocalization such as crying or saying "no." No response was scored if the participant exhibited no reaction to the stimuli within 5 s of presentation.

During reinforcer-value manipulation sessions, observers scored task completion each time the participant completed the task following a verbal or gestural prompt. The task for Mary and Thomas was placing a block in a bucket (scored when the block passed the lip of the bucket and the participant let it go). Jonathan's task was to sort paper clips by size. The therapist placed two baskets on the table in front of him, one with a small clip attached to it and one with a large clip attached. A correct response involved placing a clip in the basket with the same-sized clip attached. The task for Todd, Cathy, April, and Courtney was to place a peg in a Peg-Board. Observers scored a correct response when the participant placed the peg completely in any one of 25 holes in the board such that it stood upright when the participant

Table 1
Participant Description and Stimuli Assigned to Each Condition

Name	Age	Gender	Diagnosis	Condition	Stimulus
Mary	9	female	autism, moderate mental retardation, mood disorder (NOS)	FR 1 NCR escl FR FR rest	music radio band phone ball popper
Jonathan	13	male	autism, severe mental retardation, pervasive developmental disorder (PDD)	FR 1 NCR escl FR rest	popcorn chips crackers M&Ms
Todd	11	male	autism, disruptive behavior disorder (NOS), stereotypic movement disorder with self-injury	FR 1 NCR escl FR rest	sphere ball popper caterpillar drum
Cathy	11	female	autism, moderate mental retardation, stereotypic movement disorder with self-injury	FR 1 NCR escl FR rest	radio shaking dog ball popper band
April	10	female	mental retardation (NOS), PDD, stereotypic movement disorder with self-injury	FR 1 NCR escl FR rest	radio play dough ball popper Elmo book
Courtney	20	female	cri du chat, severe mental retardation	FR 1 NCR escl FR rest	play dough caterpillar shaking dog spin toy
Thomas	16	male	mental retardation (NOS), PDD, stereotypic movement disorder with self-injury	FR 1 NCR escl FR rest	squishy ball Spongebob worm ball car

Note. NOS = not otherwise specified; FR 1 = fixed-ratio 1; NCR = noncontingent reinforcement; escl FR = escalating fixed ratio; rest = restricted.

let it go. For all participants, stimulus delivery consisted of placing the stimulus directly in front of the participant. Stimulus interaction included touching, turning on, or otherwise interacting with the item. For Jonathan only, consumption consisted of moving the food item past the plane of his lips.

During the PR analyses, trained observers used paper and pencil to record each completed FR schedule value. The data sheet listed individual FR values ranging from FR 1 to FR 25. Next to each FR value was a box for the data collector to check after the participant completed the respective schedule value.

A second independent observer collected data during an average of 87%, 58%, and 29% of paired-choice preference assessments, PR analyses, and reinforcer-value manipulation sessions, respectively. Agreement during the preference assessments consisted of both observers recording the same selection, avoidance, or no response during each trial. Mean percentage agreement across participants for the paired-choice preference assessments was 97% (range across sessions, 81% to 100%). During the PR analyses, an agreement consisted of both observers placing a check or no check next to each FR schedule value. Mean percentage agreement across participants for the PR analyses was 99% (range, 92% to 100%). Interobserver agreement data for the reinforcer manipulation sessions were calculated for compliance with prompts, delivery of the stimulus, and item interaction using the exact agreement within intervals method (Mudford, Martin, Hui, & Taylor, 2009). Sessions were divided into consecutive 10-s intervals. Intervals in which the same number was scored by both

observers were assigned a value of 1. Intervals in which one observer scored 0 target responses and the other scored anything other than 0 were assigned a value of 0. For intervals in which different numbers were scored, the smaller number of responses scored was divided by the larger number. These quotients were summed, divided by the total number of intervals in the session, multiplied by 100%, and averaged across sessions. Mean percentage agreement across participants for reinforcer-value manipulation sessions was 95% (range, 57% to 100%), 89% (range, 42% to 100%), and 86% (range, 53% to 100%) for compliance, stimulus delivery, and item interaction, respectively.

Procedure

Paired-choice preference assessment. The paired-choice preference assessments (Fisher et al., 1992) included 12 leisure or food items identified by caregivers or hospital staff. Each item was paired once with every other item in a quasirandom order for a total of 66 trials. During each trial, the therapist presented two items to the participant. If he or she selected either item, the therapist provided 30-s access to the leisure item or delivered a small piece of the food to consume. The therapist blocked all attempts to select both items simultaneously. If the participant made no response toward both items, the therapist physically guided him or her to sample each item for 5 s and then initiated a second trial. The assessment was repeated twice more, and the selection percentages were averaged across the three assessments. Selection percentage was determined by calculating the percentage of assessment trials in which stimuli were selected when available. The items were then arranged in descending order according to their selection percentages (i.e., the item selected with the greatest percentage was ranked 1, the item with the second highest selection percentage was ranked 2, etc.).

The middle four stimuli (i.e., those ranked fifth, sixth, seventh, and eighth in the combined preference assessment results) were selected from the preference assessment for inclusion in the experimental manipulations for each participant, with two exceptions. For Mary, the ninth-ranked stimulus (the ball popper) replaced the eighth-ranked stimulus (the rattle) because she engaged in self-injury with the rattle. Thomas's seventh-ranked stimulus (the musical band) was broken after the initial three preference assessments were completed. Therefore, the fourth-ranked stimulus (the worm ball) was used during the PR analysis and reinforcer value manipulation sessions. The musical band continued to be included in the preference assessments. Across all participants, the difference in selection percentage for the stimuli chosen for inclusion in the remainder of the study was no greater than 28%. All stimuli were entirely restricted from the participants' environment outside the experimental conditions. This seemed important because uncontrolled access to the stimuli could affect subsequent preference rankings.

Progressive-ratio analyses. Three PR sessions were conducted, in a randomized order, with each of the four selected stimuli for each participant (i.e., 12 PR sessions per participant). A task that the participant could readily complete was chosen from prior educational plans. Before each session, the therapist prompted the participant to complete the task three times using successive verbal, gestural, and physical prompts. After completion of each task, regardless of the level of prompting, the therapist delivered the appropriate stimulus for 30 s. When the session began, the therapist placed the available stimulus within the view of the participant and issued a single verbal prompt to engage in the task. No additional prompting was delivered. The stimulus being assessed during a given session was delivered for 30 s on a PR schedule beginning with a single response (i.e., the stimulus was delivered for a single correct completion of the task). During each trial thereafter, the schedule requirement

was increased by one in an arithmetic progression (e.g., two responses, three responses, etc.). The therapist removed task materials after the delivery of each reinforcer and returned them as soon as the 30-s reinforcement period had elapsed. Sessions continued until the participant ceased to respond for 1 min. The highest schedule requirement completed before meeting the termination criterion constituted the break point for the session.

Reinforcer-value manipulations. Following the completion of the PR analyses, the four stimuli were randomly assigned to one of four experimental conditions: FR 1, escalating FR, noncontingent reinforcement (NCR), or restricted (see Table 1 for assignment of stimuli to conditions). Sessions were conducted each day, 5 days per week for 4 weeks. Each day, three experimental conditions were conducted in the following order: FR 1, escalating FR, and NCR. For all conditions, sessions were terminated after the stimulus assigned to that condition was delivered 10 times. Thus, session length varied while the total number of reinforcers delivered per session for each condition remained constant.

During the FR 1 condition, the participant and therapist sat next to each other at a table. The therapist presented the task using a three-step prompting procedure that consisted of sequential verbal, gestural, and physical prompts. The task used for each participant was identical to the tasks used during the PR analyses. Three-step prompting was used for both effort manipulations (i.e., FR 1 and escalating FR conditions). The therapist initially delivered a verbal prompt to complete the task. If the participant did not comply with the verbal prompt, a gestural prompt was delivered (i.e., the correct response was modeled for the participants). If the participant still did not comply, he or she was physically guided to complete the task. Each time the participant completed the task, regardless of the level of prompting, the FR 1 stimulus was delivered for 1 min. For Jonathan only, a small piece of food was delivered. At the end of the reinforcement interval, the FR 1 stimulus was removed and the next prompt to complete the task was issued. The therapist issued the next prompt for Jonathan after he consumed the food. This continued until the participant had earned the stimulus 10 times.

The escalating FR condition was identical to the FR 1 condition, with the exception that the FR schedule value increased after every fifth session. Three-step prompting was again used to ensure completion of each task presented. The therapist delivered the escalating FR stimulus after the predetermined schedule requirements had been met, regardless of the level of prompting required. During the 1st week, the participant earned the item on an FR 1 schedule identical to that described for the FR 1 condition. The reinforcement schedule was increased to FR 2 during the 2nd week, FR 5 during the 3rd week, and FR 10 during the 4th week. The response requirements used in the Escalating FR condition were adopted from prior studies in which these values produced meaningful outcomes in related analyses (e.g., DeLeon, Iwata, Goh, & Worsdell, 1997). All sessions, regardless of the reinforcement schedule in place, were terminated after the participant earned the escalating FR stimulus 10 times.

During the NCR condition, no academic task was present. The therapist delivered the stimulus assigned to this condition for 1 min on a fixed-time (FT) schedule that was yoked to the schedule of delivery for the stimulus in the preceding FR 1 condition. The FT schedule was determined by dividing the duration of the FR 1 session by 10 (i.e., the number of times the participant earned the reinforcer in the FR 1 condition). For example, if the participant earned the FR 1 stimulus 10 times and the session lasted 12 min, the NCR session would be 12 min in duration and the stimulus would be delivered every 72 s, with the first reinforcer

being delivered at the start of session. The therapist removed the stimulus when the reinforcement interval elapsed and withheld the stimulus until the next scheduled interval. NCR sessions ended when the stimulus had been delivered 10 times.

The stimulus assigned to the restricted condition was placed in a locked closet such that the participant would not have contact with or see the stimulus. The restricted item was used only during subsequent preference assessments and PR analyses.

Prior research on events that may affect stimulus preference have suggested that (a) noncontingent stimulus delivery can result in a decrease in preference indices (e.g., Hanley et al., 2006), (b) stimuli that require greater effort to obtain may be preferred relative to those that require less effort (e.g., Friedrich & Zentall, 2004), and (c) stimulus deprivation can increase preference (e.g., McAdam et al., 2005). We therefore hypothesized that preferences (indicated by selection percentage) and effectiveness (measured by PR break points) for the stimulus assigned to the NCR condition would decrease when compared to preferences for the stimuli assigned to the three other experimental conditions. Furthermore, preference for the Escalating FR stimulus was expected to increase to a greater extent than that for the FR 1 stimulus. Finally, we hypothesized that deprivation resulting from restricted access would result in an increase in preference for the restricted stimulus relative to that for the noncontingent stimulus.

Design and Data Analysis

At the end of Week 4, three preference assessments were again conducted with all participants. In addition, the three PR sessions were repeated with the stimuli assigned to each condition (i.e., 12 PR sessions per participant). A before-and-after comparison was used to assess changes in the value of a given stimulus. The dependent variables included the selection percentages across preference assessments for the four stimuli identified for each participant and the break-point values for each of the four stimuli during the PR schedule analyses. Changes in selection percentage were determined by comparing selection percentages for each of the stimuli during the initial preference assessments and preference assessments that followed the reinforcer value manipulations. Changes in break-point values were determined by comparing the means of the last completed FR schedule in the three initial PR analyses and final three PR analyses with each stimulus.

RESULTS

Figure 1 displays change scores (postmanipulation average minus premanipulation average) in the preference assessment selection percentages for each type of stimulus for each participant. Selection percentages for the NCR stimuli decreased for all seven participants. The restricted stimuli moved upwards in selection percentage for five of the seven participants and moved down for two participants. As noted previously, the restricted stimuli served as a form of control to indicate what might happen across evaluations in the absence of stimulus access between preference assessments. The FR 1 stimuli showed a mixed pattern, increasing in selection percentage for four of the participants, but decreasing for the remaining three participants. The escalating FR stimuli also showed a mixed pattern, but decreases in selection percentages were more common than increases.

Figure 2 depicts the percentage change scores in the PR break points for each type of stimulus for each of the participants. The change scores were calculated by subtracting the mean premanipulation break point from the mean postmanipulation break point, dividing the difference by the mean premanipulation break point, and multiplying by 100%. Percentage change, rather than raw change, was used because an absolute change in the mean break-point value would have very different interpretations depending on the base value

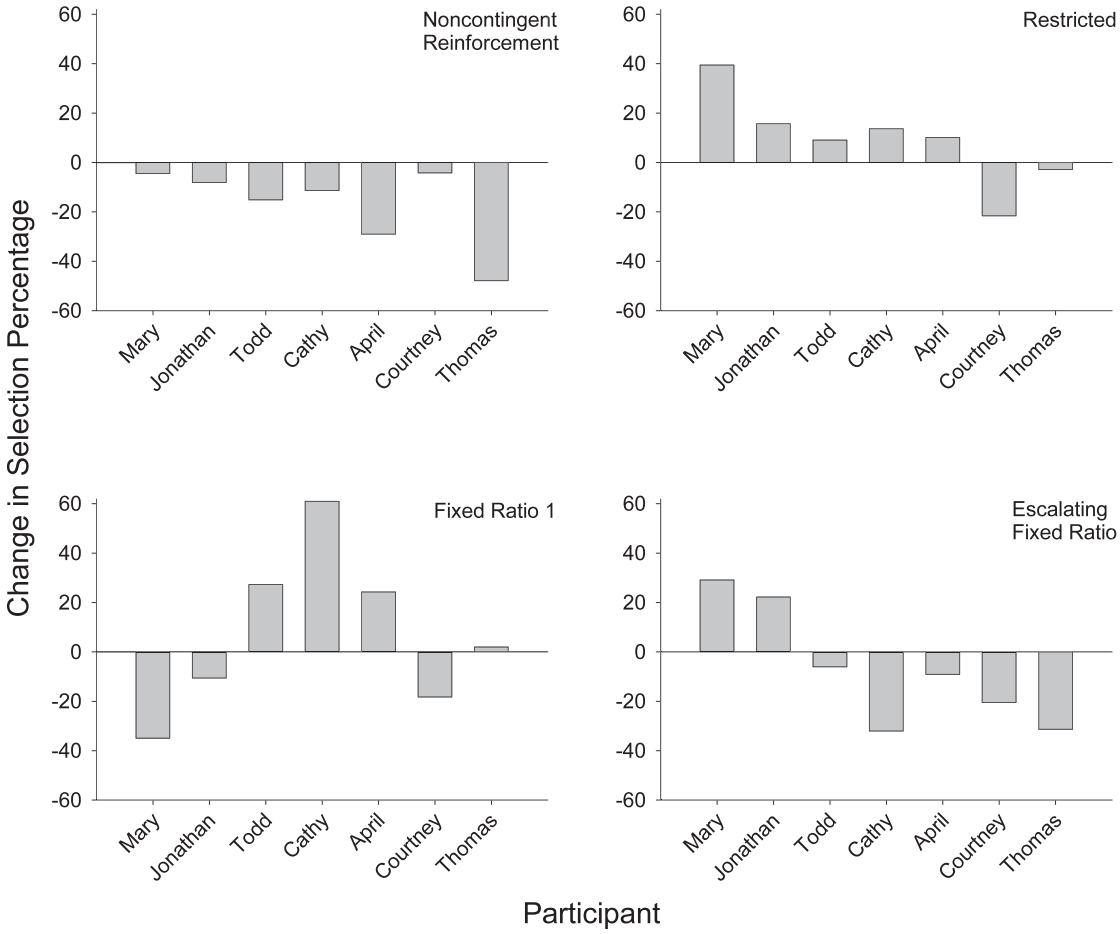

Figure 1. Differences in selection percentages between the preference assessments conducted before and after the experimental manipulations for each participant.

(e.g., an increase of two mean responses is a substantial increase for a stimulus with a premanipulation mean break point of one response but not for a stimulus with a mean premanipulation break point of 20).

A great deal of variability was observed during the second PR analysis, with PR break points increasing for 17 of the 28 stimuli, decreasing for nine of the 28 stimuli, and not changing for two stimuli. The mean break point decreased for four of the NCR stimuli, increased in two cases, and remained the same in one case. The mean break point increased for five of seven restricted stimuli, decreased for one, and stayed the same for one. Percentage increases in mean break points were observed for six of the seven FR 1 stimuli, with a decrease in one stimulus. Finally, mean break points increased for four of seven escalating FR stimuli and decreased for three stimuli. Although break points increased from the first to the second administration in all conditions, increases occurred less often in the NCR condition (two of seven cases) than in the other three conditions. These results provide further support for the notion that the noncontingent delivery of a stimulus can result in a reduction in the value of that stimulus.

Figure 3 (top) depicts the mean change in selection percentage for each type of stimulus

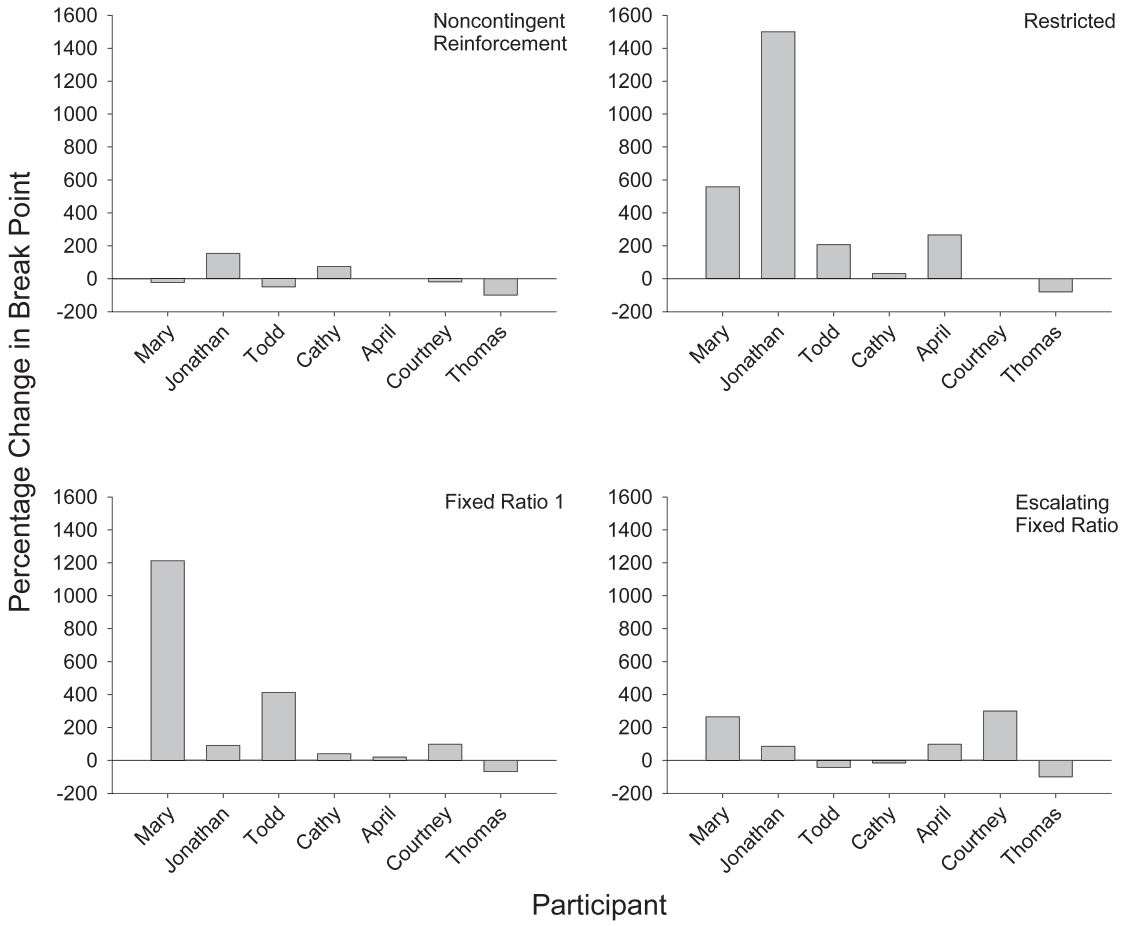

Figure 2. Percentage change scores from the mean premanipulation break point to the postmanipulation break point for each type of stimulus for each participant.

collapsed across participants. Error bars depict the standard deviation. The data for each bar were calculated by subtracting the premanipulation selection percentage from the postmanipulation selection percentage and averaging the differences across all participants. Consistent with the individual data, the mean difference increased for the Restricted stimuli ($M = 9.1$, $SD = 18.6$) and, to a lesser extent, for the FR 1 stimuli ($M = 7.2$, $SD = 32.6$). The mean difference decreased for the Escalating FR stimuli ($M = -6.8$, $SD = 24.4$), but the largest change was a decrease in the selection percentage for the NCR stimuli ($M = -17.2$, $SD = 16$).

Figure 3 (bottom) depicts the mean percentage change in break-point values for each type of stimulus across all participants. Overall, the mean break point increased for each type of stimulus. Mean break points for Restricted stimuli made the largest percentage gain ($M = 355\%$, $SD = 548$), followed in descending order by the FR 1 stimuli ($M = 258.3\%$, $SD = 446.7$), the escalating FR stimuli ($M = 84.6\%$, $SD = 152.3$), and finally, the NCR stimuli ($M = 5.3\%$, $SD = 83.9$). Although there was an average increase in PR break points for the NCR stimuli, it was accounted for by the relatively large increases observed in the only two NCR

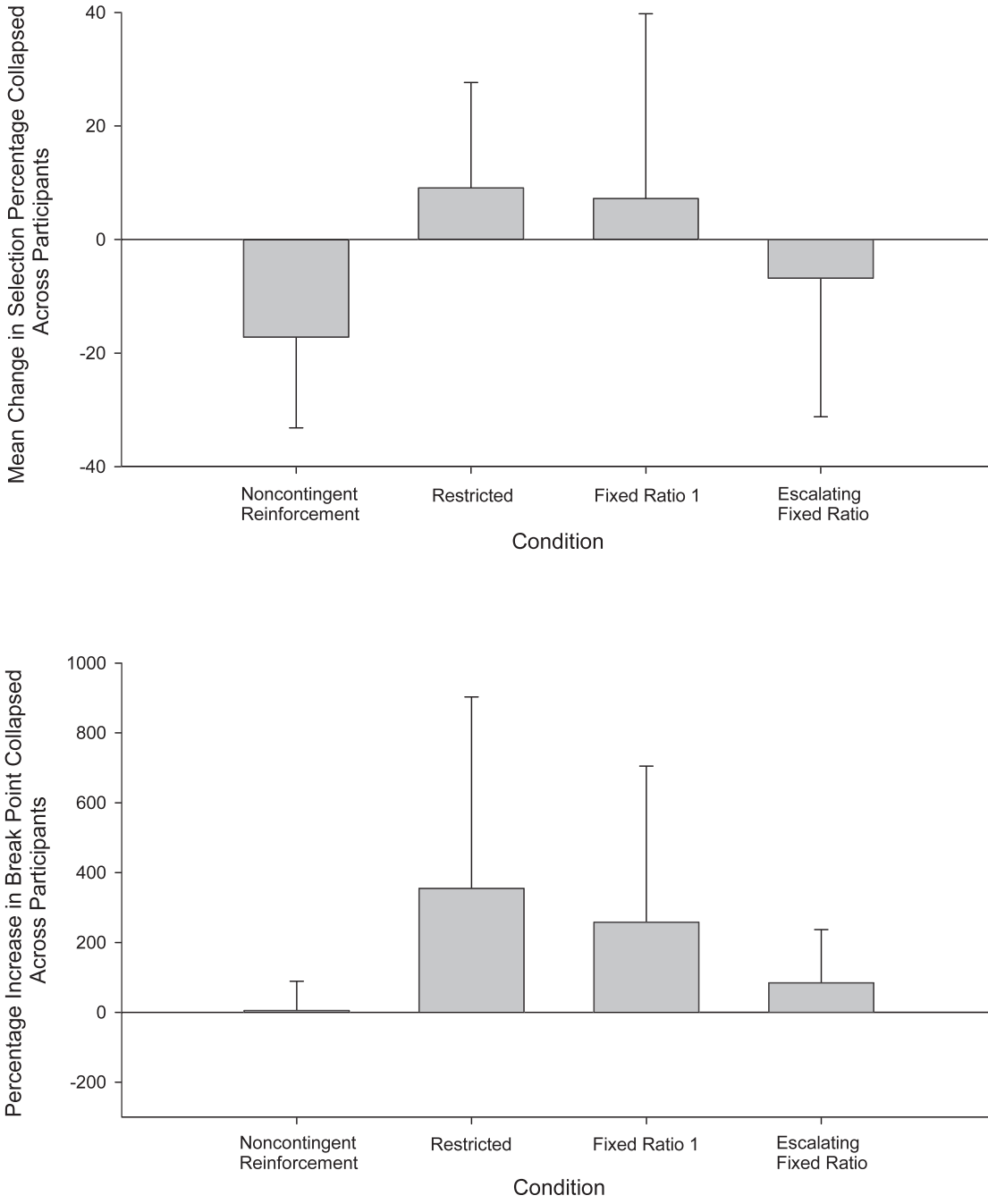

Figure 3. Mean changes in premanipulation and postmanipulation selection percentages from the preference assessments (top) and mean changes in premanipulation and postmanipulation PR break points for the PR analyses (bottom). Error bars indicate the standard deviation.

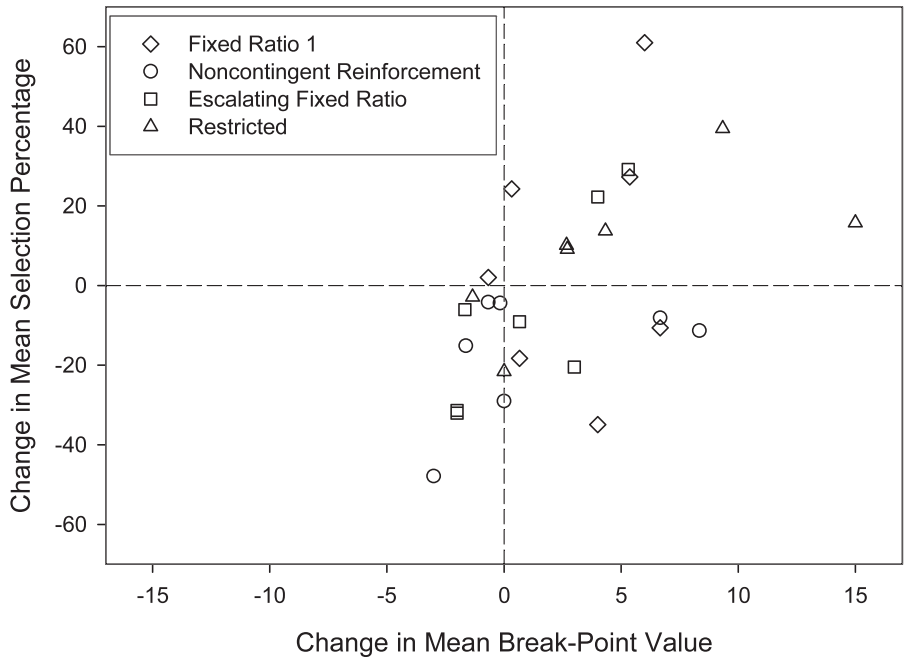

Figure 4. A scatter plot of changes in the mean selection percentage and changes in the mean break-point value for all stimuli.

stimuli that increased on this measure (i.e., the increases observed for Jonathan and Cathy).

Overall, although changes were sometimes in a different direction, there was a fair amount of consistency between the summarized change scores for the selection percentage and break-point data. The NCR stimuli resulted in the largest decrease in selection percentage as well as the lowest overall increase in break-point values. Restricting access to stimuli resulted in a tendency towards increases in both selection percentages and break-point values. This was also true of the FR 1 stimuli, but to a noticeably lesser extent. Lastly, although the escalating FR stimuli displayed an overall decrease in selection percentage, the mean break point increased. Because the PR values, on average, tended to increase and selection percentages tended to show a more even distribution of increases and decreases, it seems that the relation between the two change measures was not strong. However, on close examination, the direction of change (increase vs. decrease) for the two measures matched far more often than not. The scatter plot in Figure 4 reflects this outcome.

DISCUSSION

Results of the present study provide mixed support for the strengthening effect of prior effort on current stimulus value as applied to qualitatively distinct reinforcers for individuals with developmental disabilities. On the one hand, escalating FR stimuli (stimuli associated with the greatest amount of effort) did not increase in preference assessment selection percentages relative to FR 1 stimuli (associated with lesser effort), nor did they result in higher percentile increases in break-point values. On the other hand, although there was a good deal of individual variability, in the aggregate, both of the stimuli delivered contingently fared better in retaining their value than stimuli associated with no effort (the NCR stimuli). Selection percentages for the FR 1 and escalating FR stimuli increased for four and

two of the seven participants, respectively, whereas selection percentages for stimuli in the NCR condition decreased for all seven participants. Furthermore, PR break points increased for six FR 1 stimuli and for four escalating FR stimuli but increased for only two NCR stimuli. Overall, the most consistent effects appeared to be (a) reduction of value for stimuli delivered without an earning requirement (in all seven cases for preference assessment selection percentages and in four of seven cases for break points) and (b) maintenance of value for restricted stimuli (in five of seven cases for both the preference assessment selection percentages and break points). The latter result is consistent with prior research showing that stimulus deprivation may enhance stimulus value, whereas the former is consistent with Hanley et al. (2006) insofar as stimuli delivered noncontingently between preference assessments showed a general decline in preference measures. However, it appears that the manner in which access is provided may sometimes make a difference in the subsequent value of the stimuli. That is, in alignment with previous research on current value given past effort, it appears that contingency may possibly help to preserve value.

Still, it remains unclear why the value of the FR 1 stimuli appeared to have held up better than the value of the escalating FR stimuli. Although the extent of individual variability makes it difficult to draw firm conclusions, in the aggregate, sufficiently large effort might dampen the value-enhancing effects of effort. DeLeon et al. (2005) discussed the possibility of a natural trajectory related to the loss of value for the kinds of stimuli sometimes used as reinforcers in teaching and therapeutic arrangements for individuals with developmental disabilities. These authors suggested that the reinforcing efficacy of toys and leisure items may wane over time as a function of repeated exposure, a process perhaps related to, but on a different temporal scale, than more typical satiation effects. For example, a child may receive a new video game and spend considerable time playing with it for the first few days following its receipt. That time may even increase after initial exposure as the child learns how to play the game more effectively, thus ''extracting'' more reinforcement. As days and weeks progress, however, the extent of the child's interaction with the game may begin to decline, presumably as satiation occurs or other activities are introduced as competing sources of reinforcement, resulting in something like an inverted U-shaped function with regard to the value of that stimulus. Requiring the individual to work for the stimulus may result in a deceleration of that natural decline at the end of the function (e.g., the FR 1 stimuli), but if too much effort is required, that deceleration may be counteracted by the repeated pairing of the stimulus with a presumably aversive event (evidence, the Escalating FR stimuli). This account is obviously speculative, but it may provide a starting hypothesis for future work exploring the relation between effort and value over time. Furthermore, this account may help to explain differences between the present outcomes and those of prior experiments that examined the effects of past effort on current value. That is, the stimuli in prior experiments were simply stimuli associated with reinforcers (conditioned reinforcers, not the actual reinforcers themselves) and were always associated with the same reinforcer. Thus, those stimuli might not be subject to the same sort of natural trajectory considered above. One would not expect the same effects of repeated exposure to conditioned stimuli as one would with the toys and activities used in the present study.

The PR break points tended to increase from the first to the second administration for most of the stimuli, except the NCR stimuli. The most likely explanation may be a generalized increase in response efficiency. Because the same task was used throughout the manipulations and in the PR analyses, the participants may

have simply become more skilled and efficient at completing the task over time. Future studies might address this by using different tasks in the pre- and postmanipulation PR analyses. However, although this might provide an unfettered measure of increases or decreases in reinforcer strength between stimuli, it would make within-stimulus comparisons difficult.

On aggregate, changes in stimulus preference and PR break points did not differ considerably for the FR 1 and restricted stimuli. On the other hand, performance in the NCR condition was markedly different from that in the restricted condition. Although these results may lead one to consider whether the FR 1 contingency affected performance differently than restriction, it is important to note that two manipulations may produce similar outcomes but for different reasons (i.e. operating under different mechanisms). In the present study, the FR 1 stimuli, if nothing else, provided an important control for the NCR stimuli in the sense that the participants received both stimuli every day, in the same proportions, but with different overall outcomes. The same cannot be said for the restricted stimuli.

The conclusions drawn above are offered very cautiously for a variety of reasons. First, the comparison involved a relatively weak pretest–posttest design, making it difficult to rule out that observed changes in the dependent measures occurred as a function of uncontrolled sources of variability across time. Future evaluations of the effects of contingency on changes in reinforcer value may be strengthened by the inclusion of preference assessment and PR probes throughout the experimental manipulation phase, allowing one to examine the pace and trajectory of changes in value. As an alternative, or in addition, one could conduct multiple preference assessments and PR analyses across several weeks prior to conducting experimental manipulations to better gauge inherent variability prior to introducing the manipulations.

Second, as indicated by the error lines in Figure 3, there was a great deal of between-subject variability for both dependent measures. The sample was too small for a valid statistical analysis of factors that contribute to the observed variability, but future studies might examine factors such as task difficulty, task complexity, relevant demographic variables (e.g., level of disability), and so on. In addition, the degree to which additional prompts (i.e., gestural and physical) may have affected the obtained variability remains unknown, because data were collected only on the initial verbal prompt to complete the task and compliance with the task (physically guided responses were not scored as compliance). Thus, future studies might also collect data on all levels of prompting to examine the effects of prompting requirements on changes in reinforcer value. It is worth noting that although data were not formally collected, physical guidance was ascertainable by subtracting the number of compliant responses from the number of verbal prompts. It was then determined that physical guidance was required on a small percentage of trials across participants. On average, participants required physical guidance on only 10% of trials during the FR 1 condition and 11% of trials during the escalating FR condition. This differed only for Thomas, who required physical guidance on 54% of trials in the FR 1 condition and on 49% of trials in the escalating FR condition. After omitting Thomas' data, mean trials requiring physical guidance across participants ranged from 0% to 6% in the FR 1 condition and from 0% to 10% in the escalating FR condition. Also, physical guidance was not systematically correlated with the schedule value in the escalating FR condition. Across participants, the percentage of trials that were associated with physical guidance averaged 11%, 11%, 8%, and 12% for the FR 1, FR 2, FR 5, and FR 10 conditions, respectively.

Zentall and colleagues (Zentall, 2008; Zentall & Singer, 2007b) noted that within-trial

contrast effects occur only after extensive overtraining (beyond initial acquisition of simultaneous discriminations), suggesting that failures to replicate within-trial contrast effects may have resulted from an insufficient number of trials. A similar account may apply to the current study, although our procedures were very different from prior attempts to produce related effects. That is, it may be the case that the FR 1 and escalating FR conditions would have produced more consistent effects if we had conducted more than 20 sessions with each.

Finally, it remains unclear whether the reductions observed for the NCR stimuli translate into meaningful changes in the utility of these stimuli in conventional arrangements. Reductions in reinforcer value imply a number of potentially important clinical consequences. Educational programs that depend on effective reinforcers may deteriorate. Quality-of-life programs that rely on arranging opportunities for preferred activities may subject individuals to activities that are, in fact, no longer preferred. Treatments for serious behavior disorders that rely on the effectiveness of reinforcers may lose their effects over time. It may therefore be useful to extend the present line of research to the determination of whether the changes in PR break point or selection percentages are reflected by changes in effectiveness of the stimuli as reinforcers in more conventional therapeutic or educational arrangements.

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