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THE EFFECTS OF CONSTANT VERSUS VARIED REINFORCERS ON PREFERENCE AND RESISTANCE TO CHANGE

JESSIE-SUE MILO[1], F. CHARLES MACE[1], AND JOHN A. NEVIN[2]

[1]UNIVERSITY OF SOUTHERN MAINE
[2]UNIVERSITY OF NEW HAMPSHIRE

Previous research has demonstrated that factors such as reinforcer frequency, amount, and delay have similar effects on resistance to change and preference. In the present study, 4 boys with autism made choices between a constant reinforcer (one that was the same food item every trial) and a varied food reinforcer (one that varied randomly between three possible food items). For all 4 boys, varied reinforcers were preferred over constant reinforcers, and they maintained higher response rates than constant reinforcers. In addition, when a distraction (a video clip) was introduced, responding maintained by varied reinforcers was more resistant to distraction than responding maintained by constant reinforcers. Thus, the present experiment extended the generality of the relation between preference and resistance to change to variation in reinforcer quality.

Key words: behavioral momentum, resistance to change, preference, varied vs constant reinforcers, boys with autism

Basic research on free-operant behavior has found that response rates are more resistant to change in conditions where reinforcers are more frequent, larger, or more immediate. In addition, more frequent, larger, or more immediate reinforcers are generally preferred over less frequent, smaller, or more delayed reinforcers (e.g., Grace, Bedell, & Nevin, 2002; Nevin & Grace, 2000).

Similar results may hold for differences in reinforcer quality. With rats as subjects, Mace, Mauro, Boyajian, and Eckert (1997) maintained lever pressing on a multiple variable-interval (VI) 60-s, VI 60-s schedule with sucrose and citric acid as reinforcers in different components. They found that sucrose reinforcers generated greater resistance to extinction than citric acid reinforcers even though the rates of reinforcement and baseline response rates generated by those reinforcers were comparable. Mace et al. (1997) also conducted a two-bottle preference test and found that all subjects preferred the sucrose solution. Thus, preference and resistance to change covaried even though reinforcer rate and immediacy remained constant. The present study extends these findings to qualitative variations in reinforcers employed in a translational setting.

Most basic research studies of response rate and resistance to change in relation to the conditions of reinforcement have employed VI schedules because response rates have relatively little effect on obtained reinforcer rates. Likewise, most basic research on preference between conditions of reinforcement has employed concurrent or concurrent-chain VI VI schedules to ensure exposure to both alternatives. By contrast, contingencies in applied settings are often ratio-like, as when reinforcers are given for compliance with instructions to complete a task (e.g., Lalli et al., 1999), and preference assessments often provide one or another consequence after a single response (for a recent example see Winborn-Kemmerer, Ringdahl, Wacker, & Kitsukawa, 2009). Accordingly, we arranged fixed-ratio 1 (FR 1) contingencies to evaluate preference between varied and constant alternatives, and then employed FR schedules of varied or constant reinforcers during baseline training and tests of resistance to change.

Some applied analyses have compared varied and constant reinforcers. After conducting a two-stimulus, forced-choice preference assessment, Bowman, Piazza, Fisher, Hagopian, and Kogan (1997) arranged concurrent FR 1 schedules where one response delivered a constant, high quality reinforcer (1st ranked

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Address correspondence to F. Charles Mace, 407 Bailey Hall, University of Southern Maine, Gorham, ME 04038 (e-mail: fcmace@usm.maine.edu).

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according to the preference assessment), and another response delivered varied reinforcers (items ranked 2nd, 3rd, and 4th) of slightly lower quality. Four of 7 participants engaged more often in the response that produced the varied but lower quality reinforcers. However, 2 participants preferred the constant, higher quality reinforcer, and one showed no systematic preference. Therefore, varied lower quality reinforcers may be preferred to constant higher quality reinforcers, but intersubject variability precludes firm conclusions. Moreover, Koehler, Iwata, Roscoe, Rolider, and O'Steen (2005) found that varied reinforcers were not preferred to constant reinforcers when a set of varied reinforcers included stimuli that were not approached during a constant-stimulus preference assessment. The latter result suggests that it is necessary to use the same set of stimuli when comparing the effects of reinforcer variation and constancy.

There is some evidence that varied reinforcers maintain higher response rates and are preferred over constant reinforcers. In basic research with rats, Steinman (1968a) arranged a three-component multiple schedule where responding was reinforced with pellets, sucrose solution, or pellets and sucrose solution alternately in the different components, according to the same VI 45-s schedule. The sucrose solution generated higher response rates than did pellet reinforcers, but response rates were higher in the varied reinforcer component than in either of the two constant reinforcer components. Steinman (1968b) replicated this finding in 10 out of 12 rats after equating response rates in the pellet and sucrose components by diluting the concentration of sucrose in the solution as necessary. Overall, these results suggest that varied reinforcers maintained higher response rates than constant reinforcers.

Two applied analyses have shown that varied reinforcers are more effective than constant reinforcers for children with autism. Egel (1980) used varied vs. constant reinforcers to maintain lever-pressing behavior. Three previously identified edible reinforcers, specific to each participant, were chosen prior to the study. Lever-pressing was maintained on an FR 1 schedule using one randomly chosen reinforcer. A varied reinforcer condition then was implemented in which one of the two remaining reinforcers, chosen randomly, was delivered for every third lever-press. Participants continued lever-pressing in the varied reinforcer condition longer than in the constant reinforcer condition. Egel (1981) used the same general method to examine the effects of varied versus constant reinforcers on response accuracy and on-task behavior during a receptive identification task. Typically, the percentage of correct responses and the percentage of intervals spent on-task were higher during the varied than the constant reinforcer condition. Further examination of the data suggested that although accuracy and on-task behavior were similar in the constant and varied conditions during the beginning of each condition, both aspects of performance decreased as the constant-reinforcer condition progressed. Overall, Egel's results suggest that responding maintained by varied reinforcers is more resistant to satiation than responding maintained by constant reinforcers.

Basic research by Tonneau, Rios, and Cabrera (2006) has suggested that satiation is functionally similar to other tests of resistance to change. They found that rats' lever-pressing occurred at a higher rate and was more resistant to satiation in a VI 15-s (rich) component than in a VI 60-s (lean) component of a multiple schedule, consistent with many other studies that have employed disruptors such as presession feeding, alternative reinforcement, or extinction.

Satiation is also of interest in applied settings because if the same consumable reinforcer is used throughout a treatment session, it may lose its effectiveness as the session progresses. Egel's (1980, 1981) studies suggest that the effects of satiation on the maintenance of responding may be minimized by varying the reinforcer from one presentation to the next. Accordingly, the present study compares the effects of varied versus constant reinforcers on reinforcer effectiveness as measured by response rate, resistance to change and preference in children with autism.

METHOD

Participants, Setting and Materials

Four boys, ages 6–10 years, diagnosed with Autistic Disorder served as participants in the experiment. All participants attended a special-purpose private school. All participants

displayed behavior typical of autism, including tantrums, noncompliance, hand flapping, object flicking, etc. Peter was 11 years old and communicated using a Dynavox MT-4 augmentative communication device. He could make simple requests and follow one-step directions. Sammy was 6 years old and made one-word requests using the Picture Exchange Communication System (PECS), some single-syllable approximations, and modified American Sign Language. He could follow some one-step directions. Dean was 10 years old and communicated using his natural voice and made requests using simple sentences. He could identify members of a category and follow two-step directions. Frank was 10 years old and communicated using American Sign Language because he was deaf. He made multiple requests for items and information. He could read primer level books and complete simple mathematical problems. Each participant demonstrated stable preference for at least three food items.

All sessions were conducted in a small office at the school. The room was furnished with a chair, desk, computer, and cabinet with sink. A Dell Dimension® computer was used to present visual images and record responses. Contingencies were programmed and data were recorded using Visual Basic® 6.0 Professional Edition. The experimenter, an ASL interpreter, the participant, and school instructor were present in the room during sessions. Sessions were conducted at least 1.5 hr prior to food consumption.

Responses were made using two, 12.7-cm diameter, Big Red® switches manufactured by Ablenet. The switches were located on the desktop in front of the computer monitor, 5.08 cm in front of the monitor stand and 15.2 cm apart. The switches were placed on 12.7-cm diameter circles of Dycem® to prevent the switches from slipping. The switches were connected to a USB multiswitch interface device manufactured by Quizworks Company® to record responses. A 25.4-cm combination television and VCR was placed 0.91 m from the subject on the cabinet countertop and was visible from the chair.

Response Measurement and Interobserver Agreement

Response rates for each session were recorded electronically. Proportions of baseline response rates were calculated for each distraction session by dividing the response rate during each component for each distraction session by the average rate of responding in each component of the last five sessions during constant and varied reinforcer conditions. These proportions were transformed to logarithms for presentation and subsequent analyses in relation to preference.

Preference data were collected in a series of trials. Interobserver agreement on preference assessment trials was obtained by two independent observers on 75% of the assessment trials. Exact agreement on a trial-by-trial basis was calculated as the number of agreements divided by the number of agreements plus disagreements multiplied by 100%. Mean interobserver agreement was 100%.

Procedure

Preference assessment. The Reinforcer Assessment for Individuals with Severe Disabilities (RAISD) (Fisher, Piazza, Bowman & Amari, 1996) was administered to service providers familiar with each participant and a list of 10 preferred food items was generated. A multiple-stimulus-without-replacement (MSWO) preference assessment (DeLeon & Iwata, 1996) was conducted for each participant using the 10 items identified during the RAISD. The participant was allowed to sample each item prior to the start of the assessment. All items were equally spaced and presented on a tray. At the beginning of each trial, the participant was asked to select one item. Attempts to choose multiple items were blocked. Selection resulted in access to the item. The remaining items were randomly reordered. The selected item was not replaced. This process was repeated until all items were selected or until the participant did not make a selection for 30 consecutive seconds. Three blocks of 15 trials were conducted. The first, second, and third chosen items (A, B, C) were selected for use in the experiment. An additional preference assessment was conducted using the same methodology to identify the most preferred video that was used as a distraction stimulus during tests of resistance to change. Participants selected from an array of familiar videotapes. Stable preference was obtained for each participant.

Preliminary training. Participants were trained to press the switch using physical modeling and an instruction to ''Do this.''

Table 1

Order of conditions for each participant.

Order of Conditions, Color Associations, and Switch Orientations				
Participant	Peter	Sammy	Dean	Frank
Color-Switch Assoc.	Green-Left	Green-Right	Red-Right	Red-Left
Conditions Order	Reinforcer B Reinforcer C Reinforcer A	Reinforcer A Reinforcer B Reinforcer C	Reinforcer C Reinforcer A Reinforcer B	Reinforcer A Reinforcer B Reinforcer C

All of the participants were able to imitate simple motor movements and imitation training was sufficient to establish the response. For all participants, the initial schedule of reinforcement was FR 1 using one randomly chosen reinforcer identified in the MSWO preference assessment.

Constant versus varied reinforcer preference assessment. Three sessions were conducted to determine preference between constant and varied reinforcers. A concurrent FR 1 FR 1 operated for 5 min or until 30 reinforcers were delivered. Each press on the right switch resulted in access to one constant reinforcer. Each successive press on the left switch resulted in access to a different randomly chosen reinforcer (A, B, or C). Three sessions were conducted during which the constant reinforcer was A in one session, B in the second session and C in the third session. The switch orientations and session orders were counterbalanced across participants.

Baseline multiple FR 10 FR 10. A series of three conditions was conducted for each participant. In each condition, one of the items ranked 1st, 2nd, and 3rd in the MSWO preference assessment (designated A, B, and C) was delivered in the constant reinforcer component of a multiple schedule, and items A, B, and C were delivered in irregular order in the varied reinforcer component (see Table 1). Sessions were conducted in each condition until response rates over five consecutive sessions showed no substantial trend or variability. The order of conditions, switch orientations, and screen colors associated with each component were randomized across participants.

Each session began with an instruction to ''Start.'' A multiple FR 10 FR 10 schedule operated during both components, which alternated every 2 min. A 10.2-cm grey square was presented in the center of a red screen during the constant component. Responses on the right button resulted in the manual delivery of one constant reinforcer (A); responses to the left button had no consequence. The screen was green during the varied reinforcer component. Responses on the left button resulted in the manual delivery of one randomly chosen reinforce (A, B, or C); responses on the right button had no consequence. Sessions operated until 50 reinforcers were delivered or until the participant responded less than three times in 3 consecutive minutes. Sessions terminated with the removal of the button, a white screen, and a verbal indication or sign that the session was ''All done.''

Distraction test. Each condition was followed by a series of 4-min distraction sessions to test resistance to change (Mace et al., 1990). The sessions operated in the same manner as the baseline conditions with the addition of the distraction stimuli; the first component arranged varied or constant reinforcers in irregular order across sessions. A video identified during the preference assessment described above was played throughout the duration of each distraction session. For Sammy, the presentation of the video resulted in aggressive and disruptive behavior during the last distraction session in the first condition. During distraction sessions in the second and third conditions for Sammy, only the audio portion of the video was presented and the television was out of his sight. Distraction sessions were conducted for four sessions with the exceptions of Peter and Dean receiving three distraction sessions in the first condition. The first distraction condition was shortened due to a long holiday break for these 2 participants. For Sammy, the presentation of the video resulted in aggressive and disruptive behavior during the last distraction session in the first condition resulting in only two

Table 2

Results of the MSWO preference assessment for each participant.

Items chosen during MSWO preference assessment by ranking				
Participant	Peter	Sammy	Dean	Frank
Item Ranking				
1st	Skittle®	Diet cola	Cookie	Cheez-It®
2nd	Cookie	Cheese curl	Cool Ranch Dorito®	Starburst®
3rd	Gummy bear	Cool Ranch Dorito®	Diet cola	Cookie

distraction sessions in the first and second conditions. During distraction sessions in the second and third conditions for Sammy, only the audio portion of the video was presented and the television was out of his sight.

RESULTS

Table 2 depicts the results of the MSWO preference assessment for each participant. The three highest-ranked items for each participant were as follows: Peter, Skittles®, cookie, gummy bear; Sammy, Diet Cola, cheese curl, Cool Ranch Doritos®; Dean, cookie, Cool Ranch Doritos®, diet cola; and Frank, Cheez-Its®, Starbursts®, and cookie. Table 3 shows the rate of responding on each switch during the concurrent FR1 FR1 preference assessment. Participants typically responded at higher rates on the switch associated with varied reinforcer delivery than on the switch associated with constant reinforcer presentation. Peter preferred varied reinforcers to constant reinforcers during two of three sessions, with exclusive preference for varied reinforcers over constant reinforcer B. Sammy preferred varied reinforcers during three of three sessions, Dean preferred varied reinforcers during three of three sessions, and Frank preferred varied reinforcers during two of three sessions. In general, participants allocated more responses toward the switch associated with varied reinforcer delivery across sessions, indicating preference for varied over constant reinforcer presentation.

Figure 1 depicts response rates during each multiple-schedule session across experimental conditions. Response rates during the varied component were higher during 21 of 24 (87.5%) sessions for Peter, 27 of 28 (96.4%) sessions for Sammy, 23 of 25 (92%) sessions for Dean, and 17 of 24 (70.8%) sessions for Frank. All 4 participants exhibited higher response rates in the varied component when data for the last five sessions of each condition were averaged across conditions (Table 4).

Figure 2 presents the log proportion of baseline response rates for each distraction session. Responding during the varied component was generally more resistant to change than responding in the constant component. Responding was more resistant to change in the varied component during 10 of 11 (90.9%) sessions for Peter, 6 of 8 (75%) sessions for Sammy, 10 of 11 sessions (90.9%) for Dean, and 11 of 12 (91.6%) sessions for Frank.

Nevin and Grace (2000) suggested that resistance to change and preference might provide converging measures of the strengthening effects of the conditions of reinforcement. Grace, et al. (2002) showed that differences in resistance to change were highly

Table 3

Response rates on the switch associated with constant vs. the switch associated with varied reinforcer delivery during the concurrent FR1 FR1 preference assessment for each session for each participant.

Response rates on concurrent operants				
Participant	Peter	Sammy	Dean	Frank
Constant Reinforcer	Constant | Varied			
Reinforcer A	0.48 | 7.31	4.52 | 18.11	0.43 | 12.60	0.41 | 12.08
Reinforcer B	0.00 | 12.12	5.37 | 12.53	2.36 | 11.84	8.20 | 7.17
Reinforcer C	5.88 | 1.47	4.76 | 15.00	6.73 | 11.63	4.21 | 9.84

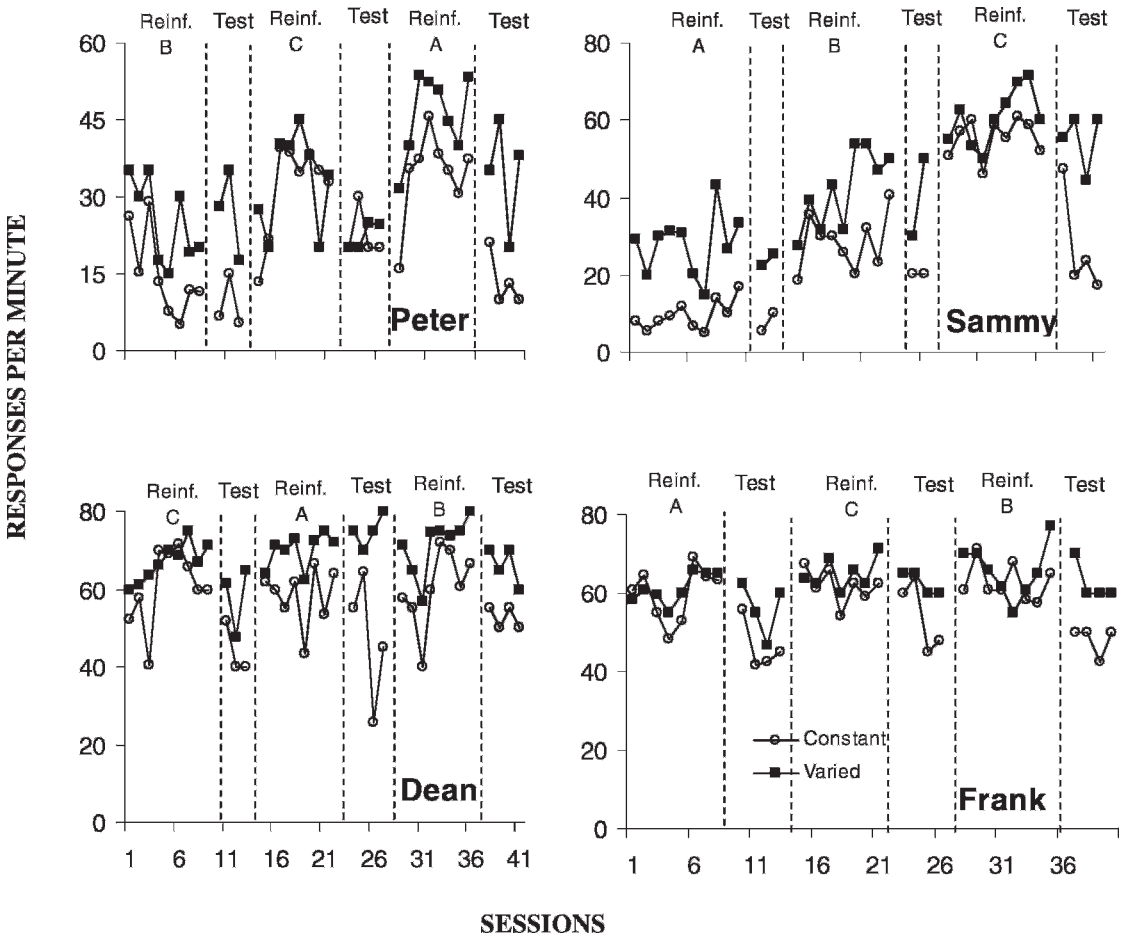

Fig. 1. Mean rates of responding per minute during constant and varied components of the multiple schedule FR 10 FR 10 across experimental conditions.

correlated with preference in seven experiments that assessed these measures in concurrent chain schedules with pigeons as subjects. Preference was measured as the log ratio of responses that produced one or the other terminal link, and differential resistance was measured as the difference between log proportions of baseline response rate in those terminal links or in equivalent multiple-schedule components. To provide a comparable

Table 4

Actual average response rates during varied components and response rates predicted by averaging response rates during constant components for each condition for each participant.

Average Response rates during constant and varied components for each condition				
Response Rates	Constant ǀVaried			
Participant	Peter	Sammy	Dean	Frank
Condition 1	9.9 ǀ 20.3	10.5 ǀ 27.8	65.2 ǀ 70.4	59.6 ǀ 62.2
Condition 2	35.9 ǀ 35.5	28.4 ǀ 47.3	57.9 ǀ 70.9	60.8 ǀ 65.6
Condition 3	37.4 ǀ 48.2	57.3 ǀ 65.2	65.9 ǀ 75.7	61.9 ǀ 64.0
Average	27.7 ǀ 34.7	32.1 ǀ 46.8	63.0 ǀ 72.3	60.8 ǀ 63.9

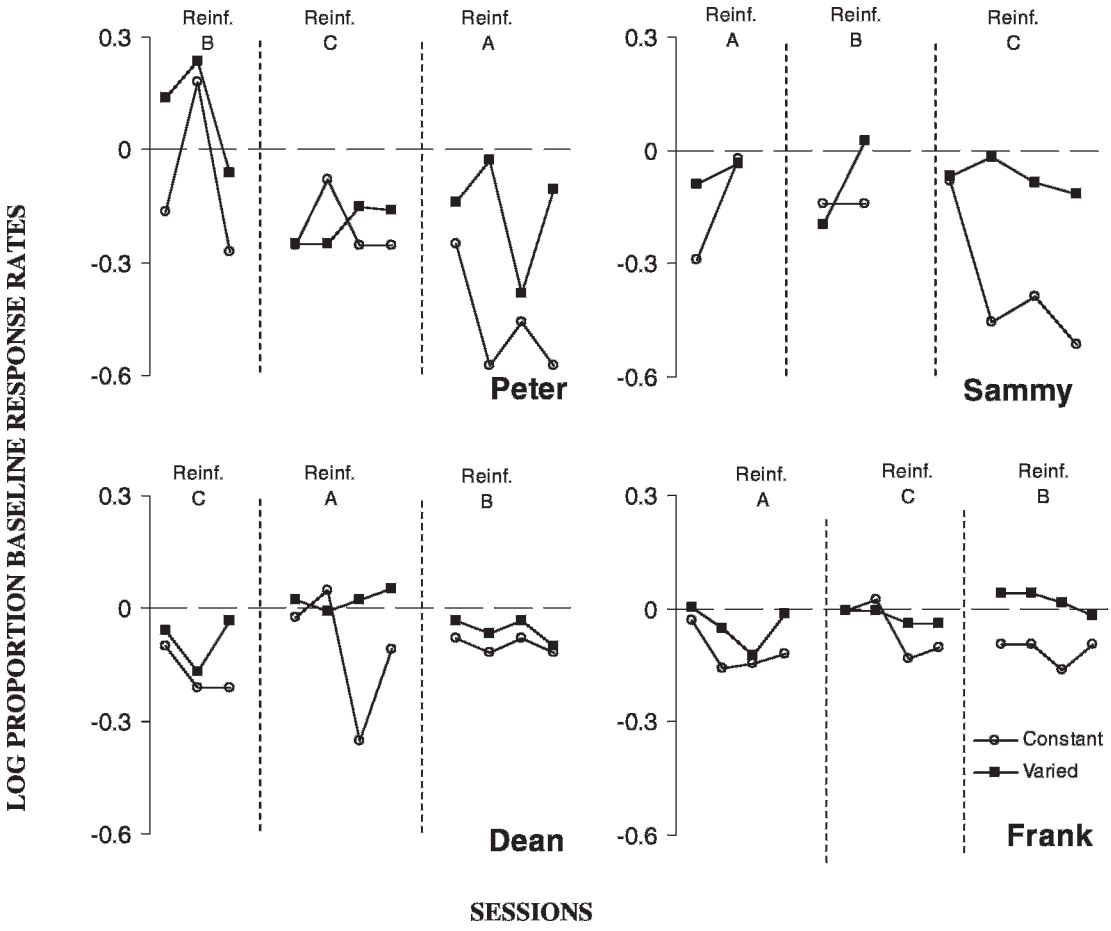

Fig. 2. Log proportion of baseline response rates during distraction sessions for constant and varied components when each reinforcer (A, B, and C) was the constant reinforcer in the multiple schedule.

analysis of the present data, we pooled the data from the three concurrent FR1 FR1 preference assessments for each subject (Table 3) and calculated the log ratio of responses for varied reinforcers to those for constant reinforcers. Likewise, we averaged the proportions of baseline for the three assessments of resistance to distraction (Figure 2) and calculated the difference in log proportions of baseline between components with varied and constant reinforcers. Figure 3 presents the relation between these measures, where each subject contributed one data point, together with the best-fitting line of the structural relation (slope = 0.29) for the pigeon data summarized by Grace et al. Values of preference and resistance to distraction are positive for all 4 participants, and Peter's data correspond exactly to the relation suggested by Grace et al.

In summary, varied reinforcers were preferred to constant reinforcers, and varied reinforcers maintained higher response rates and greater resistance to distraction than constant reinforcers in multiple schedules.

DISCUSSION

During baseline training, response rates in daily sessions maintained by varied reinforcers were generally higher than response rates maintained by constant reinforcers for Peter, Sammy, and Dean. This effect was not as reliable for Frank as response rates were higher in the varied component for only 70% of sessions. Averaged across sessions and

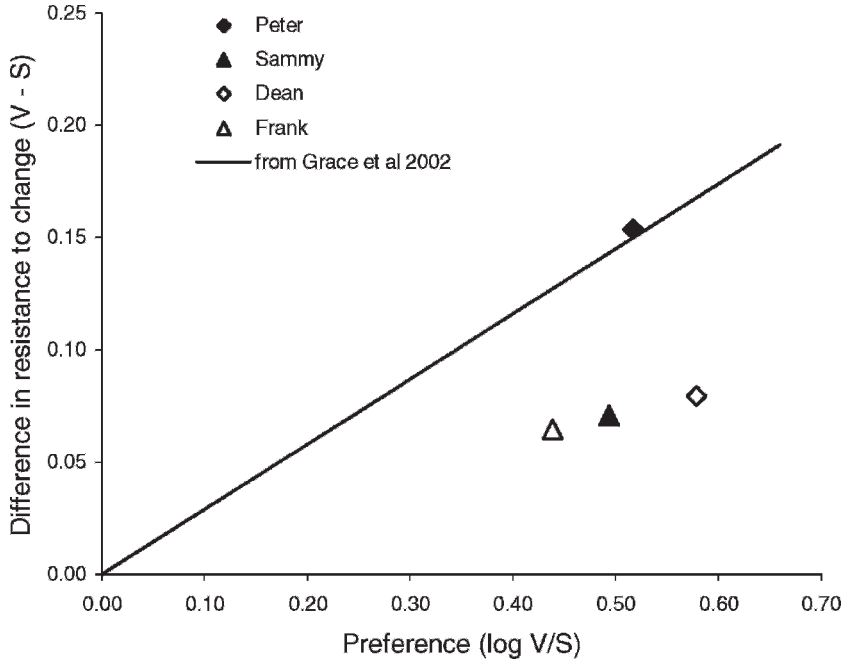

Fig. 3. A scatterplot relating the difference in resistance to distraction between components with varied and constant reinforcers (averages over conditions from Figure 2) to preference for varied over constant reinforcers (averages from Table 3) for individual participants. The solid line represents the structural relation between differences in resistance to change and preference from Grace et al. (2002). See text for explanation.

conditions, varied reinforcers maintained higher response rates than constant reinforcers for all participants. These results are consistent with previous findings in both human (Egel, 1980, 1981) and animal studies (Steinman, 1968a,b).

In addition, responding maintained by varied reinforcers was generally more resistant to distraction than responding maintained by constant reinforcers. This result is consistent with Egel's (1980) finding that children's lever pressing persisted longer when maintained by varied reinforcers than by constant reinforcers, suggesting that responding maintained by varied reinforcers was more resistant to satiation.

Because reinforcers were arranged according to FR 10 schedules in both varied-reinforcer and constant-reinforcer components, and because baseline response rates were generally higher in the varied-reinforcer component, obtained reinforcer rates were also higher in that component. The difference in resistance to distraction could have resulted from this difference in obtained reinforcers. Figure 4 presents a scatterplot relating the difference in resistance to distraction to the difference in response rates, which is about 10 times the difference in reinforcer rates. The relation is positive for Peter, but it is negative for Sammy and Frank, and there is no relation for Dean. Thus, it is unlikely that the differences in obtained reinforcers can account for the result.

Varied reinforcers generally were preferred to constant reinforcers as demonstrated by more frequent responding for varied reinforcer delivery than for constant reinforcer delivery during the concurrent FR 1 FR 1 preference assessment. Preference for varied reinforcers in the present experiment was more reliable (4 out of 4 participants) than the results of Bowman et al. (1997, 4 out of 7 participants). The numerous differences in procedure between the present experiment and Bowman et al. may have led to the difference in reliability of preference for varied reinforcers.

Basic research has shown that reinforcer rate, amount, and immediacy have similar effects on preference and resistance to change (e.g., Grace et al., 2002; Nevin & Grace, 2000). Reinforcer quality has also been shown to

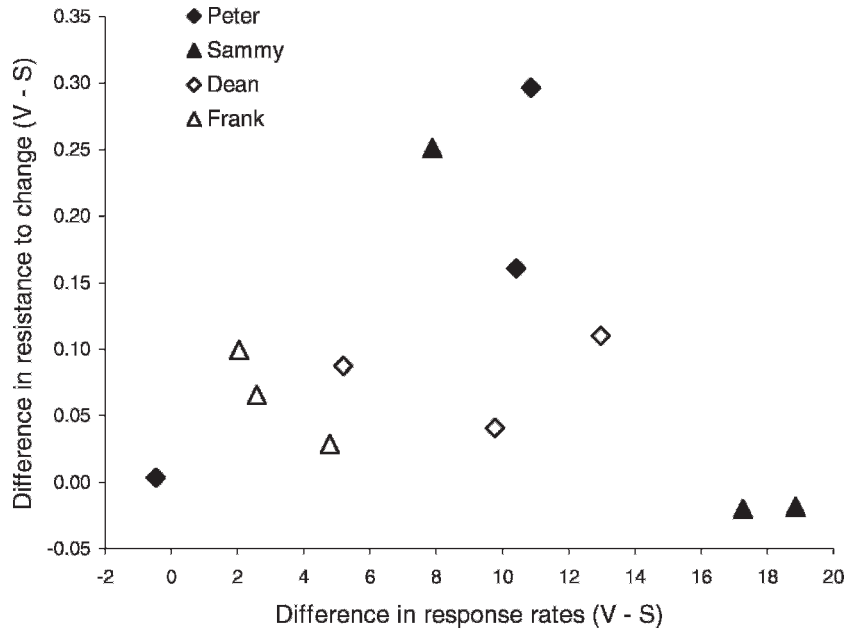

Fig. 4. A scatterplot relating between-component differences in resistance to distraction (from Figure 2) to differences in response rate (from Table 3) with varied and constant reinforcers for each participant and condition.

affect preference and resistance to change similarly (Mace et al., 1997). The present experiment extends these findings by demonstrating that reinforcer variation enhanced both preference and resistance to change relative to constant reinforcer presentation. Moreover, the present experiment employed FR1 schedules during preference assessment and FR 10 schedules during baseline and tests of resistance to change, whereas most of the relevant basic studies have employed VI schedules. Evidence of generality to ratio schedules is especially relevant to applied settings where ratio-like contingencies are the norm.

Research on the determiners of resistance to change may suggest ways in which prosocial behavior can be made more persistent in the face of response disruptors. Disrupting stimuli in the form of noise, visual distractors, adult and peer behavior, and competing sources of reinforcement in general are present in most natural environments. This requires practitioners to design interventions that support prosocial responding that is highly resistant to change. When ongoing prosocial behavior is disrupted, it can be replaced with problem behavior that is resistant to change. For example, Hagopian, Bruzek, Bowman and Jennett (2007) found that adult instructions that interrupted prosocial behaviors such as play and social interaction resulted in cessation of prosocial behavior and evocation of aggressive and self-injurious behavior in children with autism. The present study suggests that reinforcer variation can be utilized by practitioners to increase the rate of a desirable response during an intervention and to increase its persistence when behavior encounters disruptive challenges.

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