THE EFFECTS OF SINGLE vs. VARIED REINFORCERS ON RESISTANCE TO CHANGE

By

Jessie-Sue Milo, M.A., BCBA
West Virginia University, 2003

A DISSERTATION

Submitted in Partial Fulfillment of the

Requirements for the Degree of

Doctor of Psychology

(in School Psychology)

The University of Southern Maine

April, 2009

Advisory Committee:

F. Charles Mace, Professor of School Psychology

Mark W. Steege, Professor of School Psychology

Michel E. Kelley, Assistant Research Professor of School Psychology
LIBRARY RIGHTS STATEMENT

In presentation this dissertation in partial fulfillment of the requirements for an advanced
degree at the University of Southern Maine, I agree that the library shall make it freely available
for inspection. I further agree that permission for “fair use” copying or publication for scholarly
purposes be granted by the Librarian. It is understood than any copying or publication of this
dissertation for financial gain shall not be allowed without my written permission.

Signature:

Date:
Behavioral momentum is comprised of behavioral mass (resistance to change) and velocity (response rates). Previous research demonstrated that factors affecting preference similarly affect resistance to change. Resistance to change and preference are influenced by factors affecting relative value of a response alternative (e.g., reinforcer quality). Relatively higher quality reinforcers generate higher response rates and greater resistance to change than relatively lower quality reinforcers. The present study demonstrated that varied reinforcers (i.e., qualitatively different reinforcers) were preferred over single reinforcers (i.e., qualitatively same reinforcers). Varied reinforcers maintained higher response rates than single reinforcers. Responding maintained by varied reinforcers was more resistant to change than responding maintained by single reinforcers in the presence of distraction. The present experiment demonstrated a generally consistent relation between reinforcer quality and behavioral momentum.
# TABLE OF CONTENTS

Chapter

1. LITERATURE REVIEW .................................................................. 5

2. METHOD........................................................................................................ 11
   Participants, Setting, and Materials .......................................................... 11
   Response Measurement ........................................................................ 13
   Preference Assessment ......................................................................... 13
   Response Training ............................................................................... 14
   Multiple FR10FR10 Sessions ................................................................. 14
   Distraction Sessions ........................................................................... 15
   Experimental Design ........................................................................... 15

3. RESULTS ........................................................................................................ 16

4. DISCUSSION ................................................................................................... 17
   Preference for varied reinforcers ............................................................ 18
   Effect of varied reinforcers on response rates .................................... 18
   Effects of varied reinforcers on resistance to change ....................... 19
   Implications ......................................................................................... 20
   Limitations and Future Research ......................................................... 21

REFERENCES ................................................................................................. 23

FIGURE CAPTIONS ...................................................................................... 26

TABLES ............................................................................................................ 27

FIGURES .......................................................................................................... 30
Descriptors: behavioral momentum, resistance to change, single vs. varied reinforcers

The Effects of Single vs. Varied Reinforcers on Resistance to Change

An organism’s operant responding is maintained by a schedule of reinforcement. The rate at which responding is reinforced is related to response frequency and the resistance to change of that frequency in the presence of disruption. Nevin, Mandel, and Atak (1983) suggested that the metaphor of physical momentum can be used to describe the persistence of behavior in the presence of opposing forces. An object’s momentum is comprised of its mass and velocity. A behavior’s resistance to change can be calculated by examining its behavioral mass (resistance to change) and velocity (response rate). Previous research has identified that preference and resistance to change are correlated. Factors such as reinforcement rate, magnitude, immediacy, and quality affect preference and resistance to change in similar ways. Perhaps variations in reinforcer quality such as reinforcer type may affect resistance to change.

Some models of behavioral momentum predict resistance to change based on relative reinforcement rates or immediacy. In some cases, however, resistance to change is correlated with other factors related to preference beyond rate, magnitude, or immediacy. Grace and Nevin (2000) examined the relation between preference and resistance to change in constant and variable duration terminal links. Pigeon’s keypecking was maintained on a concurrent chain schedule. Initial links both operated on a variable interval (VI) 15-s schedule. The terminal links operated on a VI 13.33-s or VI 26.67-s schedule. Terminal link entry resulted in a fixed duration of access to the schedule (constant duration) or access to the schedule until reinforcer delivery (variable duration). All subjects demonstrated preference for the constant duration terminal link. Resistance to change was examined by superimposing response-independent food deliveries during the initial links. Responding during the constant duration terminal link was
more resistant to change than responding during the variable duration terminal link. Grace and Nevin suggested that models based on reinforcement rate and immediacy do not account for their results. Instead, reinforcement numerosity, such as the variability in the number of reinforcers delivered per terminal link entry, may account for the effect on preference and resistance to change. Perhaps variability in reinforcer numerosity degraded reinforcer quality (e.g. terminal links that did not result in reinforcement functioned as an extinction component) thereby affecting resistance to change.

Mace, Mauro, Boyajian, and Eckert (1997) also demonstrated that qualitatively different reinforcers generate different levels of resistance to change even when the rate of reinforcement and response rates generated by those reinforcers are comparable. Mace et al. maintained rats’ lever presses using sucrose and citric acid solution. First, a two-bottle preference assessment was arranged using a sucrose and a citric acid solution. All subjects preferred the sucrose solution. Subsequently, lever pressing was maintained on a multiple VI 60-s, VI 60-s schedule. Responding was maintained by access to the sucrose solution in one component and by access to the citric acid solution in the other component. Response rates and reinforcement rates during each component were comparable. A test of extinction was implemented. Responding in the presence of the stimulus associated with the sucrose component was more resistant to change than responding in the presence of the stimulus associated with the citric acid component. These results suggest that reinforcer quality affected preference and resistance to change even though reinforcement rate and immediacy remained constant.

These findings were extended in an applied setting using a high-probability procedure (high-p). Low probability instructions (low-p) (those generating ≤ 40% compliance) and high-p instructions (those generating > 90% compliance) were identified. Three to four high-p
instructions were delivered in succession in 10-s intervals followed by a low-p instruction within 3-5 seconds of compliance with the last high-p instruction. The high-p procedure increased the rate of compliance with low-p instructions relative to baseline when the high-p instructions were reinforced with food, but not when the high-p instructions were reinforced with praise. Resistance to change was tested by delivering 5 low-p instructions in succession following the high-p instructional sequence. Compliance with low-p instructions was more resistant to change when the high-p direction was reinforced with food than when reinforced with praise. Food may have been more preferred than praise (i.e. a higher quality reinforcer). Reinforcer quality, therefore, may have determined preference and resistance to change.

Another factor that may affect preference and resistance to change is reinforcer variation. Varied reinforcers typically were preferred to single reinforcers even when varied reinforcers were of lower quality than a single reinforcer. Bowman, Piazza, Fisher, Hogapain, & Kogan (1997) conducted a two-stimuli, forced-choice preference assessment for each of 7 participants. During the experiment three concurrently available responses were reinforced according to a fixed-ratio (FR) 1 schedule. One response had no consequence, one response delivered a single, high-quality reinforcer (1st ranked according to the preference assessment), and the remaining response delivered varied reinforcers (items ranked 2nd, 3rd, and 4th) of slightly lower quality. Four of seven participants preferred (i.e. engaged most often in) the response that produced the varied, but lower quality reinforcers. Two participants preferred the single, high quality reinforcer. The remaining participant did not show a systematic difference in time engaged in either response as a function of reinforcer constancy or variation. Variation in reinforcer type, therefore, may affect reinforcer quality producing a preference for varied (albeit slightly lower quality) reinforcers. The effect of varied reinforcers on responding, in this experiment, may not
have been reliable due to the use of only lower quality reinforcers in the varied reinforcer condition. The quality of the most highly preferred reinforcer in the single reinforcer condition may have influenced the results of the experiment.

Varied reinforcers may be preferred to single reinforcers, however, the quality of each reinforcer type may influence preference. Varied reinforcers are not preferred to single reinforcers when a set of varied reinforcers includes non-preferred stimuli (Koehler, Iwata, Roscoe, Rolider, & O’Steen, 2005). Reinforcers were identified and ranked using a paired-stimulus preference assessment (Fisher et al., 1992). Non-preferred stimuli were identified using a single-stimulus preference assessment (Pace et al., 1985). Non-preferred stimuli were randomly chosen from stimuli that were not approached during the single-stimulus preference assessment. Varied reinforcers may not have been preferred due to the method of reinforcer and non-preferred stimulus selection. Different methods of reinforcer selection may yield varying degrees of efficacy in identification. A stimulus chosen during presentation later may not function as a reinforcer. A stimulus that was not selected during the preference assessment may have been not only “non-preferred”, but aversive suppressing overall responding in the varied reinforcer condition. Alternatively, preference for varied reinforcers may be present only when reinforcers of comparable quality are delivered in each condition. The inclusion of lower quality reinforcers or non-preferred stimuli may devalue the potency of other reinforcers within the set.

This account would predict the results of Koehler et al. suggesting preference for the high quality reinforcer over a set of varied reinforcers that includes lesser quality reinforcers.

Factors related to the preference also commonly affect response rates. Steinman (1968a) found that responding maintained by varied reinforcers occurred at higher rates than responding maintained by one single reinforcer. Rats’ lever-presses were maintained on a multiple VI 45-s
VI 45-s VI 45-s schedule. Tones of 400, 1900, or 4000 cps respectively were correlated with each of the 300-s components. Responding was reinforced with either pellets, sucrose solution, or pellets and sucrose solution, in the different components. Each component was separated by a no-tone period during which a differential-reinforcement-of-other-behavior (DRO) 15-s schedule was in effect. The no tone period ended following 15 seconds in the absence of responding. Food deliveries alternated between sucrose and pellets in the varied reinforcer component.

Sucrose solution generated higher response rates than did pellet reinforcers. The varied reinforcer condition generated higher response rates than did either of the two single reinforcer components. These results suggest that the delivery of varied reinforcers affected responding beyond the predictions made by reinforcement rate alone.

The effect of varied reinforcers on response rates was replicated when the quality of the reinforcers in the single components were titrated until they generated equal response rates. Steinman (1968b) diluted the concentration of sucrose in the solution until response rates in the pellet and sucrose components were equal. Ten of twelve rats produced higher response rates in the varied than the single reinforcer components. The other two rats’ response rates during the varied reinforcer component were indiscriminable from responding during the single reinforcer components. Steinman's experiments generally suggest that presenting varied reinforcers produces higher rates of responding than those produced by single reinforcers.

The delivery of varied reinforcers also may increase the accuracy of responding in comparison to responding maintained by single reinforcers. Egel (1981) examined the effects of varied vs. single reinforcers on the response accuracy and on-task behavior during a receptive identification task of children with autism. Three previously established reinforcers were identified and delivered according to a FR 1 schedule. The single reinforcer condition delivered
the same reinforcer following each response. The varied reinforcer condition operated the same as the single condition with the exception that one of the remaining reinforcers (randomly chosen) was delivered following every third response. Typically, the percentage of correct responses and the percentage of intervals spent on-task were higher during the varied than the single reinforcer condition. Further examination of the raw data suggests that accuracy and on-task behavior in the single and varied conditions was comparable during the beginning of the condition. Accuracy and on-task began to decrease as the single reinforcer condition progressed. Satiation during the single reinforcer condition may have produced the effect.

The conditions under which satiation to reinforcers occurs may provide anecdotal evidence regarding resistance to change. The duration of experimental conditions necessary to produce satiation is not a traditional test of resistance to change as it does not disrupt the stimulus-reinforcer relation. However, satiation may occur less quickly in the presence of varied reinforcer delivery than single reinforcer delivery. Responding may persist longer when maintained by two reinforcer types than does responding maintained by a single reinforcer type. Egel (1980) found this effect when he used varied vs. single reinforcers to maintain the lever-pressing behavior of autistic children. Three previously established, 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 from the three established reinforcers. A varied reinforcer condition then was implemented in which a randomly chosen reinforcer (one of the remaining two reinforcers) was delivered for every third lever-press. Participants ceased lever-pressing (responding was reduced to less than 3 responses per minute in three consecutive minutes) more slowly during the varied reinforcer condition than during the single reinforcer condition. Slower satiation in the varied reinforcer condition suggests that responding
maintained by varied reinforcers may be more resistant to change than responding maintained by single reinforcers.

Factors that affect preference, such as reinforcer quality, affect resistance to change. Relatively few studies have investigated the effects of manipulations of reinforcer quality on resistance to change. The present study examined the effect of a distractor stimulus on responding maintained by varied (qualitatively different) vs. single (qualitatively same) reinforcers.

The metaphor of resistance to change has prompted applied researchers to identify applied interventions such as the high-p procedure shown to be effective in producing compliance with instructions that were previously refused (Mace et al., 1988). The high-p procedure has been used in a variety of applied settings such as to reduce latency to compliance (Wehby & Hollahan, 2000), increase compliance during transitions (Ardoin, Martens, & Wolfe, 1999), and increase compliance during medical procedures (McComas, Wacker, & Cooper, 1998). Egel (1981) also used varied reinforcers to increase response accuracy. Nevin (1996) discussed the implications of the use of a behavioral momentum metaphor in applied settings citing the need for more resistant interventions in the natural environment. The identification of factors that influence resistance to change, therefore, can be used to shape behaviors that will be more likely to persist in the presence of the multitude of distracting stimuli present in natural environments.

**Method**

**Participants, Setting, and Materials**

Four boys, 6-10 years old, diagnosed with Autism served as participants in the experiment. All participants attended a special-purpose private school for children with Autism. All participants
displayed behavior typical of autism including tantrum, non-compliance, hand flapping, object flicking, etc. Pseudonyms were used to ensure confidentiality. Peter was 11 years old and communicated using a Dynavox MT-4. 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, Deaf and communicated using American Sign Language. 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 3 food items. Informed consent was obtained for all participants according to the procedures required by the University of Southern Maine Office of Research Compliance.

All sessions were conducted in a small office at the day-treatment facility. 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 day treatment instructor were present in the room during sessions. Sessions were conducted at least 1.5 hours from prior food consumption.

Responses were made using two, 5-inch diameter, Big Red® switches manufactured by Ablenet. The switches were located on the desktop in front of the computer monitor, 2 inches in front of the monitor stand and 6 inches apart. The switches were placed on 5-inch diameter circles of Dycem® to prevent the switches from slipping. The switches were connected to a
USB multi-switch interface device manufactured by Quizworks Company® to record responses. A 10-inch combination television and VCR was placed three feet from the subject on the cabinet countertop and was visible from the chair.

Response Measurement 

Response rates for each session were recorded electronically. Proportion baseline response rates and log proportion baseline response rates were recorded for each distraction session. Proportion of baseline response rates were calculated 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 single and varied reinforcer conditions.

Procedures

Preference Assessment 

The Reinforcer Assessment for Individuals with Severe Disabilities (RAISD) (Fisher, Piazza, Bowman & Amari, 1997) 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 tray. At the beginning of each trial, the participant was encouraged to select one item. Attempts to choose multiple items were blocked. Selection resulted in access to the item. The remaining items were randomly re-ordered. The selected item was not replaced. The 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.

Response Training

For all participants the initial schedule of reinforcement was an FR 1 using one randomly chosen reinforcer identified in the MSWO preference assessment. Participants were trained to press the switch using physical modeling and an instruction to “Do this.” All of the participants were able to imitate simple motor movements and imitation training was sufficient to elicit the response. The reinforcement schedule was leaned to an FR10 that supported reliable response rates of at least 15 responses per minute. A multiple FR10 FR 10 operated for the duration of the experiment.

Single vs. varied reinforcer preference assessment

A series of three sessions were conducted to determine preference between single and varied reinforcers. A concurrent FR1 FR1 operated for 5 minutes or until 30 reinforcers were delivered. Presses on the right switch resulted in access to one single reinforcer. Presses on the left switch resulted in access to one randomly chosen reinforcer (A, B, or C). A total of three sessions were conducted during which the single reinforcer was A in one session, B in another session and C in an additional session. The switch orientations and session orders were counterbalanced across participants.

Multiple FR10FR10 Sessions

Each session began with an instruction to “Start.” A multiple FR 10 FR 10 schedule operated during the remainder of the experiment. Components alternated every 2 minutes. A 4 x 4 inch grey square was presented in the center of the screen on a red screen during the single
component. Responses on the right button resulted in the manual delivery of one single 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 3 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 Sessions**

Each condition was followed by a series of 4-minute distraction sessions to test resistance to change (Mace & Belfiore, 1990). The sessions operated in the same manner as the experimental conditions with the addition of the distraction stimuli. A video identified during the preference assessment described above was played on a concomitant constant time schedule during the duration of the distraction sessions. For Sammy, during the last distraction session in the 1st distraction condition the presentation of the video elicited aggression and interfering behavior. During the 2nd and 3rd distraction conditions for Sammy only the auditory stimuli were presented. The television was hidden and the video soundtrack was played for Sammy during the remaining distraction sessions.

**Experimental Design**

A series of three conditions were implemented for each participant during which the 1st, 2nd, and 3rd items identified using the MSWO preference assessment were delivered to examine the response rates and resistance to change generated by each reinforcer (A, B, and C) when delivered in the single reinforcer component (see Table 1). Sessions were conducted in each condition until response rates over 5 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.

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. Figure 3 depicts the rate of responding on each switch during the concurrent FR1 FR1 preference assessment. Participants typically produced higher rates of responding on the switch associated with varied reinforcer delivery than on the switch associated with single reinforcer presentation. Peter preferred varied reinforcers to single reinforcers during 2 of 3 sessions, Sammy preferred varied reinforcers during 3 of 3 sessions and Frank preferred varied reinforcers during 2 of 3 sessions. In general, participants allocated more responses toward the switch associated with varied reinforcer delivery across sessions indicating preference for varied over single reinforcer presentation.

Figure 1 depicts the response rates during each session across experimental conditions. Response rates typically were higher during the varied component than in the single component across conditions for 3 of 4 participants (Peter, Sammy, and Dean). 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%) for Frank.

A post-hoc data analysis was conducted to compare the actual response rates during the varied components ($r^a$) to the predicted response rates ($r^p$) obtained by averaging response rates generated by each single reinforcer alone. $R^a$ was calculated by averaging the response rates
during the varied component for the last five sessions of each condition for each participant. $R^p$ was calculated by averaging response rates during the single component for the last five sessions of each condition for each participant. For example, $r^p$ was calculated by averaging the response rates maintained by Skittles® ($r_1$), the response rates maintained by Gummy bears ($r_2$), and the response rates maintained by cookies ($r_3$); \[ [(r_1 + r_2 + r_3)/3 = r^p]. \] The average of actual response rates during the varied component ($r^a$) was higher than the predicted response rates ($r^p$) for all 4 participants ($r^a=34.66$, $r^p=27.73$ for Peter, $r^a=46.74$, $r^p=32.06$ for Sammy, $r^a=72.32$, $r^p=63.01$ for Dean, and $r^a=63.92$, $r^p=60.78$, for Frank, see Table 4).

Figure 2 depicts the proportion baseline response rates for each distraction session. Responding during the varied component was generally more resistant to change than responding in the single component. Responding was more resistant to change in the varied component during 10 of 11 (90%) of sessions for Peter, 6 of 8 (75%) sessions for Sammy, 10 of 11 sessions (90%) for Dean, and 11 of 12 (91.6%) sessions for Frank.

Figure 3 depicts the log proportion baseline response rates for each distraction session. Responding was more resistant to change in the varied component during 10 of 11 (90%) of sessions for Peter, 6 of 8 (75%) sessions for Sammy, 10 of 11 sessions (90%) for Dean, and 11 of 12 (91.6%) sessions for Frank. Responding during the varied component was generally more resistant to change than responding in the single component.

Discussion

The results of this experiment demonstrate a generally consistent relation between reinforcer quality and behavioral momentum. Responding maintained by varied reinforcers was generally more resistant to change than responding maintained by single reinforcers. These results establish variation in reinforcer presentation as a factor affecting reinforcer quality and
extend the work of Mace, Mauro, Boyajian, and Eckert (1997) who demonstrated that qualitatively different reinforcers generate different levels of resistance to change.

Varied reinforcers generally were preferred to single reinforcers as demonstrated by higher rates of responding on the switch associated with varied reinforcer delivery than on the switch associated with single reinforcer delivery during the concurrent FR1 FR 1 preference assessment. Preference for varied reinforcers was consistent with the results of Bowman, Piazza, Fisher, Hogapain, & Kogan (1997). Preference for varied reinforcers was more pronounced in the present experiment (4 of 4 subjects) than in Bowman et al.’s experiment (4 of 7 subjects). The differences in procedure between the current experiment and Bowman et al. including (respectively) MSWO vs. two-stimuli, forced-choice preference assessment, three highest-ranked items used in the varied reinforcer presentation vs. two highest-ranked items and one lower-ranked item, two concurrent operants vs. three concurrent operants, and switch pressing vs. standing in squares, switch pressing, and folding letters may have led to the disparate degrees of preference.

The present experiment demonstrated reliable preference for varied reinforcers using a concurrent FR1 FR 1 schedule of reinforcement. Other studies have suggested that low response requirements may not generate reliable preference between substitutable reinforcers (e.g., two food items are substitutable vs. a food item and a tangible are not substitutable); (DeLeon, Iwata, Goh, & Worsdell, 1997). For 3 of 4 subjects (Peter, Sammy, and Dean) preference under concurrent FR1 FR1 schedule requirements was consistent with higher response rates during the varied component when the multiple FR10 FR10 schedule was in effect. Frank demonstrated preference for varied reinforcers during 2 of 3 sessions under the concurrent FR1 FR1 schedule, but during the multiple FR10 FR10 schedule his response rates were not consistently higher.
during the varied component. The difference between Frank’s preference for varied reinforcers on the concurrent FR1 FR1 schedule and lack of consistent preference during the multiple FR10 FR10 schedule is consistent with the findings of Tustin (1994). Tustin found that preference at low response requirements may shift to the other reinforcer when response requirements are increased (reinforcement schedules are leaned). It should be noted that Tustin’s study utilized a small sample of behavior with only 2 subjects. DeLeon, Iwata, Goh, and Wordsdell (1997) extended Tunstin’s study to find that preference was sometimes non-existent at low response requirements, but did not reliably switch as response requirements increased.

Response rates maintained by varied reinforcers were higher than response rates maintained by single reinforcers for 3 of 4 subjects (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. These results are consistent with previous findings in both human (Egel, 1980) and animal studies (Steinman, 1968a). Response rates on switches associated with varied vs. single reinforcer delivery during the concurrent FR1 FR1 preference assessment generally were consistent with response rates generated during the multiple FR10 FR10 schedule. In most cases, participants preferred varied to single reinforcers and generated higher response rates during the varied components. The response rates obtained during the preference assessment also were predictive of subsequent response rates during the multiple schedule when varied reinforcers were not preferred. For example, Peter demonstrated preference for single reinforcer B over varied reinforcers and demonstrated higher response rates during the single reinforcer component during 6 of 8 sessions in the condition where reinforcer B was the single reinforcer.

Varied reinforcer presentations generated higher response rates than those predicted by summing and averaging the response rates generated by each single reinforcer alone. These
results extend the findings of Steinman (1968a, 1968b) who found that animal subjects generally produced higher response rates under varied reinforcer contingencies than were predicted by the average response rates generated by the single reinforcers alone (which comprised the varied reinforcer contingency). Although the current experiment did not attempt to equate response rates generated by the single reinforcers as in Steinman 1968b, these results provide further evidence that varied reinforcers have a greater than additive effect on response rates.

There is an established relation between factors that influence preference and behavioral momentum (e.g., Nevin & Grace, 2000). Factors that influence preference include reinforcer quality. Reinforcer quality has been shown similarly to affect preference and subsequently resistance to change in both animal and human studies (Mace, Mauro, Boyajian, & Eckert, 1997). The present experiment demonstrated that variation in reinforcer presentation increased reinforcer quality, thereby generating preference for and greater resistance to change than single reinforcer presentation.

Preference for varied reinforcers, greater resistance to change, and the multiplicative effect of varied reinforcers on response rates, could be explained using the construct of motivating operations. Motivating operations alter the reinforcing value of a stimulus and alter the frequency (i.e., in this case rate) of behavior that has been reinforced by that stimulus. In this case, the consumption of a single reinforcer type may have had an abolishing effect on responding on the switch associated with single reinforcer delivery. Said another way, single reinforcer consumption may have created satiation (an abolishing effect) faster than varied reinforcers. The relative value of varied reinforcers thereby increases as consumption of single reinforcers creates satiation.

The findings of Egel (1980) showed that children’s lever pressing persisted longer when
maintained by varied reinforcers than by single reinforcers. The delivery of single reinforcers may have had an abolishing effect, thereby increasing the relative reinforcing value of varied reinforcer delivery. Responding maintained by varied reinforcers was less susceptible to satiation creating greater resistance to change. Examined together the results of this experiment and Egel (1980) suggest that motivating operations are higher in the presence of varied reinforcers than with single reinforcers.

The present findings are limited by the use of similar participants from a single day-treatment facility. This experiment and most prior experiments utilized participants with developmental disabilities, mental retardation, autism, etc. It is unclear if these findings will generalize to typically developed populations or to participants with other disabilities such as ADHD or emotional disorders. The present study also used only food items to examine the effect of varied reinforcers on resistance to change. The incorporation of non-food items may have a different effect on resistance to change by operating on multiple motivating operations. If increased resistance to change by varied reinforcer delivery is a product of sustained motivating operations, then the inclusion of food and non-food items in varied reinforcer delivery is likely to have a greater effect on resistance to change. A clinically insignificant response was selected to obtain precisely measurable data in a controlled environment. It remains unclear whether this effect will generalize to clinically significant responses in natural environments.

The results of the current experiment provide further support that factors that affect preference, similarly affect resistance to change. There generally was a consistent relation between reinforcer quality and resistance to change. These basic research findings have direct application in applied environments as increasing behavioral momentum will generate more persistent behavior. Disrupting stimuli are present in most natural environments requiring
practitioners to create contingencies that support responding that is resistant to change. Variation is one aspect of reinforcer quality that can be utilized by applied practitioners to generate higher rates of responding that are more resistant to change. Further research could examine other aspects of reinforcer quality that may reveal additional opportunities to create more robust interventions.
References


and variable duration schedule components. *Journal of the Experimental Analysis of Behavior, 74*, 165-188.


Figure Captions

*Figure 1.* Mean rates of responding per minute during single and varied components of the multiple schedule.

*Figure 2.* Rates of responding during single and varied components for each distraction session are plotted relative to the average response rates in each component during the last five sessions for the preceding baseline condition for each participant.

*Figure 3.* Log proportion rates of responding during single and varied components for each distraction session are plotted relative to the average response rates in each component during the last five sessions for the preceding baseline condition for each participant.

*Figure 4.* Log log proportion rates of responding during single and varied components for each distraction session are plotted relative to the average response rates in each component during the last five sessions for the preceding baseline condition for each participant.
Table 1. Order of conditions for each participant.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Color and Orientation</th>
<th>Conditions</th>
<th>Reinforcer A</th>
<th>Reinforcer B</th>
<th>Reinforcer C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peter</td>
<td>Green-Left</td>
<td>Reinforcer B</td>
<td>Reinforcer C</td>
<td>Reinforcer A</td>
<td>Reinforcer C</td>
</tr>
<tr>
<td>Sammy</td>
<td>Green-Right</td>
<td>Reinforcer B</td>
<td>Reinforcer A</td>
<td>Reinforcer C</td>
<td>Reinforcer B</td>
</tr>
<tr>
<td>Dean</td>
<td>Red-Right</td>
<td>Reinforcer C</td>
<td>Reinforcer B</td>
<td>Reinforcer A</td>
<td>Reinforcer B</td>
</tr>
<tr>
<td>Frank</td>
<td>Red-Left</td>
<td>Reinforcer C</td>
<td>Reinforcer B</td>
<td>Reinforcer A</td>
<td>Reinforcer C</td>
</tr>
</tbody>
</table>
Table 2. Results of the MSWO preference assessment for each participant.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Item Ranking</th>
<th>Peter</th>
<th>Sammy</th>
<th>Dean</th>
<th>Frank</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1&lt;sup&gt;st&lt;/sup&gt;</td>
<td>Skittle®</td>
<td>Diet cola</td>
<td>Cookie</td>
<td>Cheez-It®</td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt;</td>
<td>Cookie</td>
<td>Cheese curl</td>
<td>Cool Ranch Dorito®</td>
<td>Starburst®</td>
<td></td>
</tr>
<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt;</td>
<td>Gummy bear</td>
<td>Cool Ranch Dorito®</td>
<td>Diet cola</td>
<td>Cookie</td>
<td></td>
</tr>
</tbody>
</table>
Table 3. Response rates on the switch associated with single vs. the switch associated with varied reinforcer delivery during the concurrent FR1 FR1 preference assessment for each session for each participant.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Response rates on concurrent operants</th>
<th>Single Reinforcer</th>
<th>Varied Reinforcer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0.48</td>
<td>7.31</td>
</tr>
<tr>
<td>Reinforcer A</td>
<td></td>
<td>0.00</td>
<td>12.12</td>
</tr>
<tr>
<td>Reinforcer B</td>
<td></td>
<td>5.88</td>
<td>1.47</td>
</tr>
<tr>
<td>Reinforcer C</td>
<td></td>
<td>3.38</td>
<td>10.53</td>
</tr>
</tbody>
</table>
Table 4. Actual average response rates during varied components and response rates predicted by averaging response rates during single components for each condition for each participant.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Peter</th>
<th>Sammy</th>
<th>Dean</th>
<th>Frank</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Single</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condition 1</td>
<td>9.878</td>
<td>20.30</td>
<td>10.49</td>
<td>27.77</td>
</tr>
<tr>
<td>Condition 2</td>
<td>35.93</td>
<td>35.46</td>
<td>28.39</td>
<td>47.25</td>
</tr>
<tr>
<td>Condition 3</td>
<td>37.38</td>
<td>48.24</td>
<td>57.31</td>
<td>65.20</td>
</tr>
<tr>
<td>Predicted</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>response rates</td>
<td>27.73</td>
<td>32.06</td>
<td>63.01</td>
<td>60.78</td>
</tr>
<tr>
<td>Actual response rates</td>
<td>34.66</td>
<td>46.74</td>
<td>72.32</td>
<td>63.92</td>
</tr>
</tbody>
</table>