

*EMERGENCE OF REINFORCER PREFERENCE AS A  
FUNCTION OF SCHEDULE REQUIREMENTS AND  
STIMULUS SIMILARITY*

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Tustin (1994) recently observed that an individual's preference for one of two concurrently available reinforcers under low schedule requirements (concurrent fixed-ratio [FR] 1) switched to the other reinforcer when the schedule requirements were high (concurrent FR 10). We extended this line of research by examining preference for similar and dissimilar reinforcers (i.e., those affecting the same sensory modality and those affecting different sensory modalities). Two individuals with developmental disabilities were exposed to an arrangement in which pressing two different panels produced two different reinforcers according to progressively increasing, concurrent-ratio schedules. When two dissimilar stimuli were concurrently available (food and a leisure item), no clear preference for one item over the other was observed, regardless of the FR schedules in effect (FR 1, 2, 5, 10, and 20). By contrast, when two similar stimuli were concurrently available (two food items), a clear preference for one item emerged as the schedule requirements were increased from FR 1 to FR 5 or FR 10. These results are discussed in terms of implications for conducting preference assessments and for selecting reinforcers to be used under training conditions in which response requirements are relatively high or effortful.

DESCRIPTORS: behavioral economics, preference, reinforcer assessment

Recent work in applied behavior analysis has begun to examine the variables that influence choice among reinforcement options. Much of this research has involved extensions to human behavior of laboratory studies on the matching law, which states that the distribution of responding under concurrent schedules of reinforcement will approximate the rates of reinforcement available under those schedules (Herrnstein, 1961). For example, Mace, McCurdy, and Quigley (1990) showed that when a student received reinforcement for completing either multiplication or division problems on concurrent variable-ratio (VR) 2 schedules of food delivery, the student completed roughly equal numbers of the two types of problems. However, when the rate of reinforcement for

multiplication problems was doubled by lowering its schedule requirement to fixed-ratio (FR) 1, the student completed far more multiplication problems than division problems.

This study and others like it serve as important demonstrations of human matching and illustrate the effects of varying reinforcement parameters, such as rate, quantity, or delay, on choice. However, the type of reinforcement delivered in such studies has typically been held constant. Thus, relationships that might be observed when qualitatively different reinforcers are delivered are less clear (Hursh, 1980; Neef, Mace, Shea, & Shade, 1992). This is an important topic for consideration because, in many applied situations, choice often involves selection from among different reinforcers (Fuqua, 1984).

An evolving line of research that specifically examines preference for different types of reinforcers can be found in a series of

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studies on reinforcer identification. A number of investigators have developed methods for assessing preference for stimuli presented singly (Pace, Ivancic, Edwards, Iwata, & Page, 1985), in pairs (Fisher *et al.*, 1992), or in multistimulus arrays (DeLeon & Iwata, 1996; Windsor, Piche, & Locke, 1994), and for determining the extent to which such preferences predict the effectiveness of reinforcers in maintaining operant behavior. In studies on reinforcer effectiveness, procedures are often arranged singly, in which different stimuli are delivered on FR 1 schedules during different conditions (e.g., Pace *et al.*) or in a concurrent arrangement usually consisting of FR 1 schedules. An example of the concurrent procedure is the study by Fisher *et al.* in which participants were presented with two items simultaneously and were permitted to choose an item by approaching it, after which the participant was given some period of access to the selected item.

Tustin (1994) recently expressed concern that preference assessments in which the response requirement for delivery of reinforcement is low (e.g., FR 1 schedules) may not accurately predict preference under higher schedule requirements. He tested this possibility using progressive concurrent schedules in which the number of responses required to earn each of two available reinforcers increased simultaneously. Tustin found that the participant's initial preference for one stimulus over another reversed as the schedule requirements increased; that is, the preference revealed under the concurrent FR 1 condition did not prove to be durable when the response requirement for obtaining reinforcement increased.

Tustin's (1994) data may have important implications for the selection of reinforcers used during training and treatment for individuals with developmental disabilities. Most methods for establishing stimulus preference require only a single approach re-

sponse (to one or more options) followed by delivery of the selected item, which amounts to an FR 1 schedule of reinforcement. To the extent that Tustin's results are generalizable, current assessment methods may make inaccurate predictions about reinforcer efficacy when the tasks used in training regimens require either more responses or more effort prior the delivery of reinforcement.

The present study is an attempt to replicate and extend Tustin's (1994) findings. His data on the effects of progressive concurrent schedules were based on observations of 1 individual (Subject 3), for whom only three sessions were conducted at each schedule value. As such, the extent to which similar results would be obtained with other individuals is unclear, and the possibility that observed findings were due to random variability in a small sample of behavior cannot be ruled out. We attempted to extend the generality of these findings by replicating the procedures with additional individuals and through more extended phases at each schedule value. In addition, the reinforcers in Tustin's study (computer-generated visual patterns and tones) may have been somewhat atypical. In the present analysis, small edible reinforcers and manipulable items more commonly used as reinforcers in training or treatment programs were selected for assessment.

We also sought to initiate the investigation of conditions under which shifts in preference under identical but increasing schedules of reinforcement will and will not occur by making comparisons of categorically similar and categorically dissimilar reinforcers (i.e., those that operate through the same sensory modality and those that operate primarily through different sensory modalities). In Tustin's (1994) study, the reinforcers that were concurrently available overlapped to a certain degree. In the present study, we examined the effects produced by increasing schedule requirements for similar

and dissimilar reinforcers by using two food items (similar reinforcers) and a food item and a leisure item (dissimilar reinforcers) in separate analyses. It is possible that similar reinforcers may share more functional characteristics and show greater substitutability than do dissimilar reinforcers. If so, preference between similar reinforcers may be more sensitive to concurrent schedule manipulations than is preference between dissimilar reinforcers.

## METHOD

### *Participants, Setting, and Materials*

The 2 participants lived in a state residential facility for individuals with developmental disabilities. Rick was a 28-year-old man who had been diagnosed with Down syndrome and profound mental retardation. He could follow several simple requests, but his expressive skills were limited to a few manual gestures and signs. Elaine was a 24-year-old woman who had been diagnosed with moderate mental retardation. She could carry on a simple conversation, although her speech was very difficult to understand.

Sessions were conducted in one room of a day treatment facility for individuals with behavior problems. Each room contained tables, chairs, and a small wheeled cart that held the response apparatus. This apparatus consisted of a foam board on which two microswitch panels were mounted 4 cm apart. Each panel measured 20.5 cm by 12.5 cm. Depression of the panel resulted in the illumination of a small light in its center. Both panels were made of yellow plastic, but the left panel was covered with blue construction paper to aid in discriminability.

Seven stimuli were selected for use in the study based on the results obtained during a reinforcer assessment procedure (described below). Chocolate chip cookie halves, cheese crackers, and a vibrating massager were selected for Rick. The experimenter turned on

the massager prior to handing it to Rick, who would invariably place it against his throat, providing stimulation to that area. The stimuli selected for Elaine included small pretzels, potato chips, an orange-flavored drink delivered in a small plastic cup, and an inflated balloon. When presented with the inflated balloon, Elaine would typically toss it in the air and bat it back and forth with the experimenter. In addition to other considerations described below, these items were selected because two sets were similar (e.g., cookie and cracker for Rick, pretzel and potato chip for Elaine), but could be recombined to produce dissimilar sets (e.g., cookie and massager for Rick, drink and balloon for Elaine).

### *Reinforcer Selection Procedure*

*Stimulus preference assessment.* Several reinforcers were identified for both participants using a multiple-stimulus presentation format (DeLeon & Iwata, 1996) in which the individual was asked to select one item from an array of seven stimuli that were presented on a table approximately 5 cm apart from one another. Following a selection, the individual was permitted to consume the item (food) or was given 30-s access to the item (leisure item); that is, reinforcement was delivered on an FR 1 schedule. Reinforcer access time remained constant throughout all phases of the study. Before the next trial, the item just selected was not replaced (food) or was removed (leisure), and the remaining items were rotated by moving the item on the left end of the array to the right end and shifting the remaining items so that all items were again equally spaced and directly in front of the individual. The next trial began by again asking the individual to choose one of the items. This procedure continued until each item had been selected or until the individual failed to make a selection within 30 s of the presentation of the array. For each assessment,

these procedures were repeated five times across five separate sessions. Two sets of these assessments were conducted for each individual. The first included food items exclusively; the second included only leisure items. Thus, food and leisure items were assessed separately.

*Pretraining.* During this phase, participants were taught the contingency between switch pressing and delivery of preferred items. Both individuals had previous experience in the use of the microswitch and invariably pressed only one switch at a time throughout the study. However, the following three-phase procedure was implemented to ensure that they could discriminate pressing either one of the panels and delivery of the reinforcer associated with that panel. At the beginning of each session during the first phase, the cart containing the microswitch pads was rolled in front of the individual, who was seated in a chair. A plate containing the previously identified food reinforcers was placed directly behind one of the panels. The experimenter then pointed to the panel that would produce reinforcement and asked the individual to press that panel. If the individual pressed the correct panel with enough force to illuminate the small light, the reinforcer was delivered (FR 1 schedule). If the individual pressed the correct panel without enough force to illuminate the light, pressed the incorrect panel (which produced illumination throughout the study), or emitted no response, the experimenter physically prompted the correct response. On subsequent trials, the position of the plate was alternated randomly from the area behind one panel to the area behind the other panel. The same procedure was used during the second phase, except that the experimenter no longer pointed to the correct panel. During the third phase, an empty plate was added behind the inoperative panel, and the two plates were again placed randomly across trials. Ten trials were conducted during each

session, and movement from one phase to the next occurred when the individual pressed the correct panel on 90% or more of the trials across three consecutive sessions.

*Preference probes.* Following completion of the pretraining sequence, probes were conducted to identify pairs of reinforcers for which preference was roughly equivalent. The comparisons were counterbalanced across individuals: Dissimilar reinforcers (foods vs. leisure items) were tested for Rick first, whereas similar reinforcers (two food items) were tested for Elaine first. The initial pair of reinforcers was selected based on similar rankings during the stimulus preference assessment and on their categorical similarity or dissimilarity (e.g., a similarly ranked food and a leisure item were first compared for Rick). At the beginning of each session, the experimenter pushed the cart directly in front of the individual, placed the two reinforcers on plates (one behind each panel), and asked the individual to press either panel. Both panels were always operative throughout the session. The item located behind the pressed panel was delivered contingent upon each press (FR 1 schedule) and, unlike the training sessions, the placement of items behind each panel remained the same throughout the session. Rick was exposed to 24 trials during each session, whereas Elaine was exposed to 14 trials. If the individual allocated a much larger proportion of responses (e.g., two thirds) toward the panel associated with one of the stimuli for two consecutive sessions, indicating noticeable preference for that reinforcer, the reinforcers were changed for the next session. This process continued until the individual's response allocation to a pair of reinforcers was roughly equivalent. If no differences or only small differences were noted in response allocation across two consecutive sessions, these two probe sessions became the first two sessions of the rest of the analysis, and the study proceeded as described

below. The first set of both similar and dissimilar reinforcers evaluated for Rick produced relatively equal preference between two items. Five sets of dissimilar reinforcers and two sets of similar reinforcers were evaluated for Elaine before meeting the equal preference criterion.

#### *Effects of Increasing Schedule Requirements on Relative Preference*

During all remaining phases, a response consisted of pressing either microswitch pad with enough force to illuminate the light in the center of the pad. Reinforcement was delivered according to concurrent FR schedules. Again, both panels were always operative, and responses to either panel simply accumulated regardless of whether the participant switched between panels before the schedule requirements were met for either. When a schedule was completed on one of the panels, the therapist handed the individual the stimulus corresponding to the panel on which the required number of responses had been made. As in the preexperimental probes, Rick's sessions ended when 24 reinforcers had been delivered, and Elaine's ended when 14 reinforcers had been delivered. Note that we began the analysis first with Rick and simply used a number of trials close to Tustin's (1994) for the sake of replication. We discovered that at the higher schedule values, session length was extremely long, sometimes upwards of 45 min. Therefore, all of Elaine's assessments were based on either 14 trials (preference assessment and probes) or 14 reinforcers earned (schedule assessment).

The schedules of reinforcement were increased progressively across phases. Both individuals began with concurrent FR 1 FR 1 schedules. When responding (preference) stabilized, the ratio requirement for both reinforcers was simultaneously increased to FR 2, FR 5, FR 10, and, in both cases of dissimilar reinforcers, FR 20. The schedule in-

creases ended when no consistent preference was observed during the concurrent FR 20 FR 20 comparison or at the value at which consistent preference was observed for one item over the other. At that point, a reversal to the original schedules was conducted for Elaine by returning to FR 1 schedules.

#### *Response Measurement and Interobserver Agreement*

Observers were graduate and undergraduate students who had demonstrated proficiency with the type of data collection used in this study by attaining a minimum of 90% agreement with a previously trained observer for three consecutive sessions. During the stimulus preference assessment, an observer recorded the order of selections. Items were subsequently ranked according to a percentage score that was calculated by dividing the number of times each item was selected across the five sessions by the number of times the item was available and multiplying by 100%. During 20% of the trials, a second observer also recorded the order of selections. When comparing observers' records, an agreement was scored if both observers recorded the same order of selection for each item. Interobserver agreement was calculated by dividing the number of selections on which observers agreed by the total number of selections and multiplying by 100%. Across assessments, interobserver agreement never deviated from 100%.

During all sessions involving panel pressing, an observer used a handheld computer (Assistant, Model A102) to record the number of responses on each panel and the number of each type of reinforcer delivered. Interobserver agreement was assessed by having a second observer record events during 39.3% of the sessions. When comparing observers' records, session time was divided into 10-s intervals, and agreement was calculated on an interval-by-interval basis by dividing the smaller number of recorded events by the larger number.

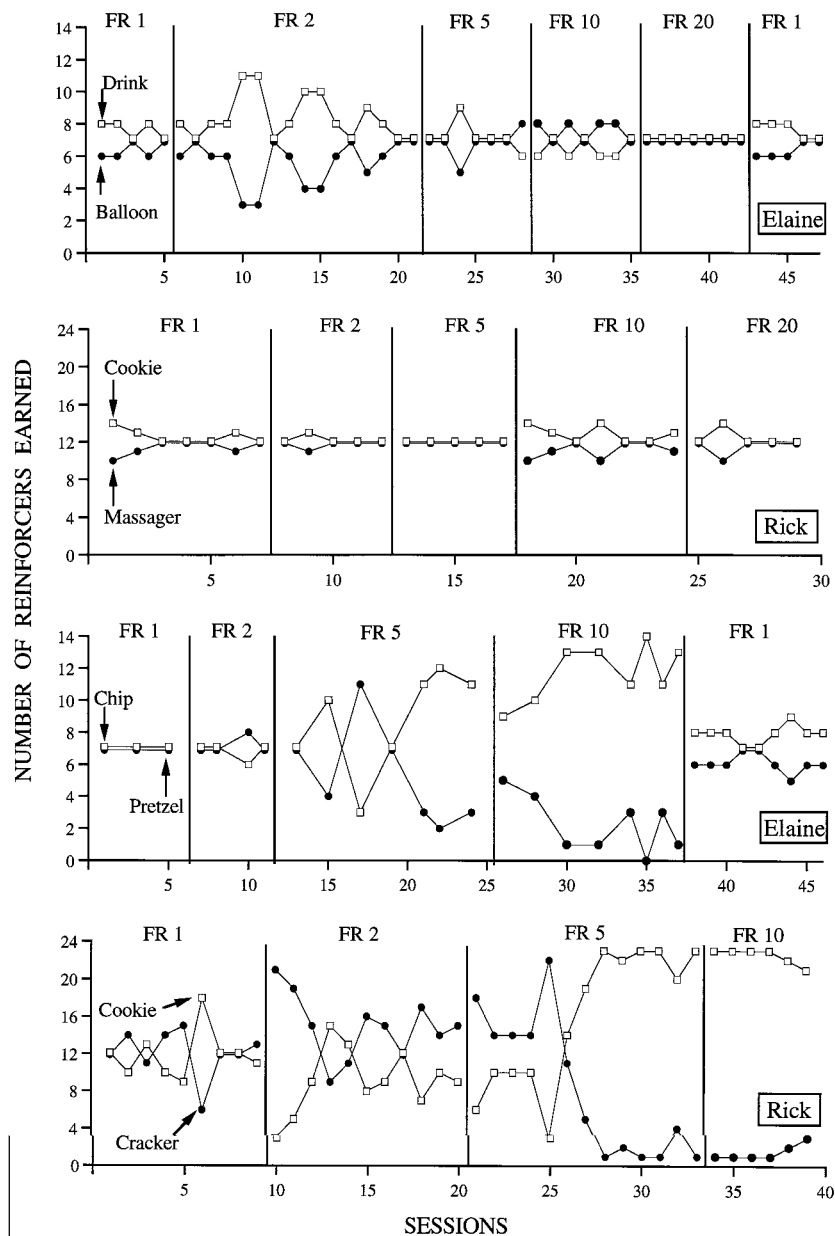


Figure 1. Response allocation for dissimilar (top two panels) and similar (bottom two panels) reinforcers by both participants under concurrent fixed-ratio schedules, expressed as the number of reinforcers earned under each schedule.

These quotients were then summed across intervals, divided by the total number of intervals in the session, and multiplied by 100%. Mean interobserver agreement for panel pressing was 96.3% (range, 86.3% to 100%). Mean agreement for reinforcer delivery was 98.3% (range, 90.7% to 100%).

## RESULTS

Figure 1 shows the allocation of responses by both participants during the comparison of dissimilar reinforcers and similar reinforcers, expressed as the number of reinforcers earned per session from presses on the two panels.

Data in the top graph show that when two dissimilar items (drink and balloon) were concurrently available to Elaine on FR 1 schedules, responses were allocated slightly more towards the panel associated with the drink, although responding was roughly equivalent for both reinforcers. During the FR 2 condition, the drink was clearly more preferred during 5 of the 16 sessions, but no consistent preference was observed, in that choice allocation always reconverged toward an equal distribution. With the exception of Session 24 during the FR 5 condition, response allocation during the FR 5, FR 10, and FR 20 conditions revealed no consistent preference for either of the two stimuli. This lack of preference continued to be evident during the final condition, which consisted of a return to concurrent FR 1 schedules.

A similar pattern was observed for Rick, whose data in the second graph show results obtained during the comparison of dissimilar reinforcers (cookie and massager). Rick showed little preference between the cookie and massager when both were concurrently available on FR 1, and subsequently on FR 2 and FR 5, schedules of reinforcement. At FR 10, Rick seemed to show a slight preference for the cookie, but it later disappeared when both reinforcers were available on an FR 20 schedule.

During Elaine's comparison of similar reinforcers (chip and pretzel, third graph), initial daily inspection of the data revealed systematic differences in her allocation of choices, which were related to temporal sequence, beginning with the FR 5 comparison. That is, when two sessions were conducted on the same day, the first session consistently showed either no clear preference or a preference for the chip, whereas the second session of the day showed a preference for the pretzel. We attributed this consistent shifting to satiation to the chips during the first session. Subsequently, we replotted the entire analysis up to the 33rd session using only the first session of the day and, beginning

with the 34th session, conducted a single session per day (the entire data set is available from the authors upon request). This analysis revealed no consistent preference during the FR 1 and FR 2 conditions. During the FR 5 condition, some between-session switching in preference was observed initially, but a clear preference for the chip emerged over the last three sessions, and this trend continued throughout the FR 10 condition. When the schedule requirements were reset to FR 1, preference that had emerged through the FR 5 and FR 10 conditions was greatly diminished, such that the distribution of choices was roughly similar to that observed during the initial FR 1 comparison.

Data in the bottom graph show results obtained during the comparison of similar reinforcers (cookie and cracker) for Rick. At FR 1, there was a great deal of between-session switching with respect to the item chosen most frequently. At the beginning of the FR 2 condition, Rick chose the cracker more often, but this pattern switched on Session 13 and then reemerged to a lesser extent from Session 15 onward. Preference for the cracker continued during the first few sessions of the FR 5 condition, but switched on Session 26. Thereafter, a notable preference for the cookie was observed for the remainder of the FR 5 condition and throughout the FR 10 condition.

## DISCUSSION

When two similar reinforcers (foods), for which preference was established to be roughly equivalent, were available under concurrent FR 1 schedules, both participants showed little preference for either stimulus. However, increasing the schedule requirements revealed clear preference by both individuals for one of the foods during the FR 5 condition, and these preferences were maintained when the schedules were again increased to FR 10. Thus, our findings with

respect to similar reinforcers are comparable to those reported by Tustin (1994). By contrast, neither individual showed a strong preference for one of the dissimilar reinforcers (a food or a leisure item) across progressive schedule increases, even at the FR 20 value. These results differed markedly from those reported by Tustin: His participant showed a modest switch in preference under FR 2 schedules, pronounced preference at the FR 10 value, and exclusive responding for the preferred reinforcer at the FR 20 value. However, we must note that shifts in preference may be idiosyncratic across individuals. It is possible that schedule requirements higher than FR 20 may have produced shifts in preference for dissimilar reinforcers by our participants, although such schedules may not be encountered frequently under typical training conditions.

Clear and consistent preferences emerged when initially equivalent and similar reinforcers (foods) were compared under increasing schedule requirements. This finding suggests that, for some classes of reinforcers, simultaneous increases in schedule requirements may magnify small differences in preference that are undetected when requirements are low. In such cases, a stimulus preference assessment involving low response requirements (FR 1 schedules) did not accurately predict the relative potency of reinforcers under increased response requirements.

Because Rick was exposed only to increasing schedule values across phases with no reversal to a previous value, it is possible that emergent preference between similar reinforcers may be partially a function of the passage of time or sequence effects. However, Elaine's preference for chips, which emerged under FR 5 and FR 10 requirements, largely disappeared when the schedules were reset to FR 1. Similarly, Tustin (1994, see Subject 3) used increasing, decreasing, and then increasing schedule values across three conditions and observed a clear

reversal between the preference patterns observed under low versus high schedule requirements. Taken together, the data for Elaine and those presented by Tustin suggest that shifts in preference under high schedule requirements may be reversible and are not due solely to temporal or sequence effects.

The different outcomes observed when similar and dissimilar reinforcers were compared must be considered preliminary because data were presented for only 2 participants. Furthermore, Tustin (1994) observed a reversal of preference between two stimuli that might be considered dissimilar in several respects. Nevertheless, to the extent that our results are reliable, they may reflect the effects of increasing work requirements on choice between reinforcers that are substitutable to a greater or lesser degree. The relation between substitutable reinforcers is such that an increase in the price of one reinforcer (e.g., an increase in the ratio requirement) leads to decreased consumption of that reinforcer and increased consumption of a concurrently available substitute (Hursh, 1980). For example, to the extent that Coke® and Pepsi® are substitutable, increases in the price of Coke® should produce decreases in its consumption and corresponding increases in the consumption of Pepsi®. Green and Freed (1993) suggested that substitutable stimuli are frequently those that serve similar functions (e.g., Coke® and Pepsi® both alleviate thirst and have a cola taste) and that consumption of a particular reinforcer is influenced by the availability of other reinforcers that serve the same function.

Continuation of this analogy might help to explain the results obtained in the present study. Assuming that Coke® and Pepsi® are both available for \$1.00 per serving and that a person has only a slight preference for Coke®, the individual may allocate choices rather evenly, perhaps as a function of periodic satiation for the preferred item, but



with slightly more overall selections of Coke®. Now assume that the cost of each is increased to \$5.00 per serving. At this price, the preference for Coke® is likely to be expressed. By contrast, a similar arrangement involving Coke® and bus tokens may produce different results. Again, at \$1.00 per item, roughly equal selection between the two options would not be surprising, assuming that the establishing operation for each dictates that both are momentarily equally valuable. However, these items serve distinctly different functions and are not substitutable; that is, the person is not free to trade one for the other and to continue to receive functionally similar reinforcement at the same rate. The person is more likely to continue choosing equally, even when the price for both reinforcers increases substantially.

The same might be said for the results obtained in the present study. When choices involved two substitutable items, such as a cookie and a cracker, concurrent increases in the cost of each might have “forced” the expression of slight preference for one of the items. However, when reinforcers that were unlikely to be substitutes, such as a cookie and a massager, were concurrently available and equally preferred, increases in cost had little effect on preference.

It is possible that these differences were also a function of the experimental arrangement. Given that our comparisons were made under a concurrent arrangement (in which responding for one reinforcer eliminates delivery of the other) with a fixed number of reinforcers available, the individual had little to lose by foregoing the less preferred reinforcer when the options were similar because food was obtained in either case, but not when the reinforcers were dissimilar. It is not clear whether these patterns would be observed under an arrangement in which each reinforcer is presented singly in different conditions (i.e., under separate

conditions consisting of either low or high FR values). Change of preference in such a context would be reflected in different response rates associated with the different reinforcers under low versus high schedule values, and, as noted previously, values higher than those used in this study might have produced a change in preference for dissimilar reinforcers.

Another difference between our data (for similar reinforcers) and those reported by Tustin (1994) is that we observed the *emergence* of preference for one of two reinforcers that were initially preferred equally, whereas Tustin observed a *reversal* of preference (i.e., the more preferred reinforcer under the low schedule value became the less preferred reinforcer under the high schedule value). Although these may represent different behavioral effects whose relative prevalence is unknown, either outcome suggests that preference (or lack thereof) may be altered as a function of increasing schedule requirements. It would be worthwhile in future studies to determine how common such results are. If the emergence or reversal of preference occurs infrequently, assessment methods that incorporate low response requirements can continue to be used with little concern. However, if the phenomena are commonly observed, reinforcer identification methods may yield more accurate information if response requirements during assessment approximate those used in the eventual training context.

Finally, the present data may also suggest practical strategies with respect to reinforcer use in different situations. For example, it appeared that cookies and crackers may be equally effective reinforcers for Rick under low work requirements, but that cookies may be more effective under high requirements. If so, it may be beneficial to reserve cookies for particularly effortful tasks and to restrict their use during less effortful tasks, given that crackers may work just as well

under the latter conditions. However, we should note that a more thorough analysis is required before it can be concluded that differences of the type found here actually translate to differences for everyday tasks in which relative response effort cannot be measured in units as simple and discriminable as panel presses. Furthermore, even the less preferred reinforcers maintained some responding during the higher ratio values, and it is likely that, outside of a comparison of relative preference, both reinforcers might maintain similar rates of responding if presented as the only reinforcement option (Lerman et al., 1997; Smith, Iwata, & Shore, 1995). Future research might apply the type of analysis used here with tasks that are more typical of those used during training to determine whether differences in relative preference generalize to differences in rate or accuracy of responding with more socially significant activities. If such differences are borne out, briefer versions of this analysis, perhaps similar to that used by Tustin (1994) in which only a few comparisons are made at each schedule value, may prove to be beneficial in maximizing reinforcement effects during training.

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## STUDY QUESTIONS

1. What finding reported by Tustin (1994) did the authors attempt to replicate in the present study, and what extension did they include?

2. What were the purposes of the three-phased reinforcer selection procedure, and what did each phase entail?
3. How did the authors assess the effects of differing schedule requirements on preference?
4. What results were obtained under the dissimilar and similar reinforcement conditions, and how did these results compare with those reported by Tustin (1994)?
5. What unusual response pattern was observed during Elaine's comparison of similar reinforcers, and how was this problem solved?
6. How did the authors relate their findings to the concept of reinforcer substitutability?
7. What is one practical implication of the present results with respect to reinforcer use?
8. In the present study, the effects of identical progressive schedules (e.g., FR 1 FR 1, FR 10 FR 10) were evaluated on baselines of equivalent responding. Given this arrangement, what other types of comparisons might be worth considering in future research?

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