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PREFERENCE FOR REINFORCERS UNDER PROGRESSIVE- AND FIXED-RATIO SCHEDULES: A COMPARISON OF SINGLE AND CONCURRENT ARRANGEMENTS

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Progressive-ratio (PR) schedules were used to identify the break point (i.e., the last schedule value completed) for 2 reinforcers under single and concurrent schedules. After the respective break points were established, the same reinforcers were presented under concurrent fixed-ratio (FR) schedules that were yoked to the break points obtained with the PR schedules. Results suggested that the participants responded more for the high-preference item than for the low-preference item, regardless of the presentation arrangement (single or concurrent presentations). This pattern of responding was maintained when the reinforcers were presented under dissimilar FR schedules. The results suggest that responding for differentially preferred stimuli may vary as a function of differences in schedule requirements.

DESCRIPTORS: autism, concurrent schedules, fixed ratio, mental retardation, positive reinforcement, progressive ratio

Preference for a given stimulus is usually determined by comparing the amount of responding emitted for that stimulus to the amount of responding emitted for some other stimulus (i.e., relative response rate; Fisher & Mazur, 1997). There are a number of contextual variables that may influence relative preference for a stimulus, including the concurrent availability of alternative sources of stimulation. Fisher et al. (1992) compared two different methods for identifying preferences for different stimuli among individuals with developmental disabilities. In one method (based on Pace, Ivancic, Edwards, Iwata, & Page, 1985), a single stimulus was presented, and participants were allowed to approach the stimulus. In the other method, stimuli were presented in pairs, and participants could select only one of the two stimuli. When a single item was presented, participants approached nearly all stimuli similarly (i.e., on all presentations). By contrast, when the items were presented concurrently, a hierarchical ordering of stimulus preferences emerged (i.e., some stimuli were approached more than others).

Roscoe, Iwata, and Kahng (1999) compared single- and concurrent-schedule arrangements

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for evaluating differentially preferred stimuli as positive reinforcers. Following a preference assessment that identified two stimuli as differentially preferred, high-preference (HP) and low-preference (LP) stimuli were compared as reinforcers in a concurrent arrangement. Seven of the 8 participants demonstrated consistent responding for the HP stimulus when the stimuli were presented concurrently. In a subsequent analysis, the LP stimulus was evaluated as a reinforcer in a single-schedule arrangement using a fixed-ratio (FR) 1 schedule of reinforcement. In this analysis, 6 of the 7 participants responded at rates for the LP stimulus that were similar to the rates observed for the HP stimulus under the concurrent arrangement.

Compared to single-schedule arrangements, concurrent schedules tend to be more sensitive measures of relative preference because two or more stimuli are in direct competition, and more responding is allocated toward the preferred option (Fisher & Mazur, 1997). The results of Roscoe et al. (1999), however, suggest that concurrent arrangements might affect the absolute reinforcement effects associated with LP stimuli. In other words, an LP stimulus may not appear to be an effective reinforcer when a more preferred stimulus is available simultaneously (i.e., a concurrent-schedule arrangement), but might be an effective reinforcer in the absence of an alternative (i.e., in a single-operant arrangement).

The investigations conducted by Fisher et al. (1992) and Roscoe et al. (1999) evaluated preference for different stimuli under relatively dense (i.e., FR 1) reinforcement schedules. However, several investigations have shown that stimuli that are similarly effective reinforcers under low schedule requirements may be differentially effective reinforcers under leaner schedule requirements (e.g., DeLeon, Iwata, Goh, & Worsdell, 1997; Roane, Lerman, & Vorndran, 2001; Tustin, 1994). Thus, in addition to the concurrent availability of alternative stimuli, schedule requirements also might influence relative preference for different stimuli.

Tustin (1994) examined the influence of increasing FR requirements on reinforcer preference for 3 individuals with developmental disabilities. Two stimuli were presented in a single-schedule arrangement, and the schedule requirement increased across days in the following order: FR 1, FR 2, FR 5, FR 10, and FR 20. Results indicated that at low schedule requirements (i.e., FR 1) response rates were identical across reinforcers; however, when the schedule requirement increased, rates of responding were higher for one reinforcer than for the other. Using a similar approach, DeLeon, Iwata, Goh, and Worsdell (1997) evaluated responding for different reinforcers under increasing FR schedules in a concurrent-schedule arrangement. At low schedule requirements responding was similar across reinforcers; however, as the schedule requirements were thinned across sessions (e.g., from FR 1 to FR 10), responding shifted toward one reinforcer, often to the exclusion of the other.

In contrast to FR schedules, progressive-ratio (PR) schedules involve response requirements that increase during the course of a single experimental observation (Hodos, 1961). In a PR schedule, the highest or last schedule value completed is referred to as the *break point*. Thus, in PR schedules, a comparison of relative break points is used to evaluate the relative reinforcing efficacy of different stimuli. Using PR schedules, Roane et al. (2001) evaluated responding for two highly preferred stimuli. The results were similar to those obtained by Tustin (1994) and DeLeon, Iwata, Goh, and Worsdell (1997), in that one of the two compared stimuli was associated with more responding (i.e., a higher break point) under the increasing PR schedule requirements.

One potential limitation of the Roane et al. (2001) investigation was that the relative reinforcing effects of the stimuli were evaluated in a single-schedule arrangement, whereas other investigations (e.g., DeLeon, Iwata, Goh, &

Worsdell, 1997; Tustin, 1994) have employed both single- and concurrent-schedule arrangements. Thus, it is unknown if concurrent PR schedules would produce similar response patterns to those observed under single-schedule arrangements. That is, single-schedule arrangements may be useful for determining the total amount of responding that might be emitted for a given reinforcer (i.e., absolute response rate). Alternatively, concurrent arrangements are useful for determining the amount of responding allocated to one reinforcer relative to the amount of responding allocated across all available reinforcers (i.e., relative response rate). The determination of relative and absolute response rates is a by-product of the schedule arrangement (i.e., single or concurrent) and is independent of the specific type of schedule or specific schedule requirements that are in place (Fisher & Mazur, 1997). Nevertheless, given the simultaneous availability of alternative reinforcers in concurrent arrangements, it is possible that PR schedules presented under single or concurrent schedules would yield different response patterns.

The present investigation sought to replicate and extend the findings of Roane et al. (2001) by assessing the extent to which single- and concurrent-schedule arrangements would produce varied outcomes for differentially preferred stimuli under PR schedules. Once the mean for the break points was obtained under single and concurrent PR schedules, responding was evaluated under concurrent FR schedules that were yoked to the break points obtained in the PR schedules. The purpose of this manipulation was to determine if participants would allocate more responding toward a highly preferred stimulus that was presented under a relatively high FR schedule or a less preferred stimulus presented under a relatively low FR schedule.

GENERAL METHOD

Participants, Settings, and Materials

Three individuals who had been admitted to a program for the assessment and treatment of destructive behavior participated in this investigation. These participants were the first 3 individuals for whom a treatment for destructive behavior had been developed as part of their admission to the program. Calvin was a 15-year-old boy with a diagnosis of autism and moderate mental retardation who had received treatment for aggression (i.e., pinching others) and pica. Kyle was a 10-year-old boy with a diagnosis of autism who had received treatment for aggression (i.e., grabbing). Allen was a 16-year-old boy with a diagnosis of autism and mild mental retardation who had received treatment for aggression (i.e., hitting, kicking, biting), property destruction (i.e., breaking objects), and self-injurious behavior (i.e., head banging, self-biting). Calvin communicated through a combination of American sign language and idiosyncratic gestures, whereas Kyle and Allen communicated through a combination of three- to five-word utterances and idiosyncratic gestures. All participants could follow one- to two-step instructions.

All sessions were conducted in a padded room measuring approximately 4 m by 4 m. Materials in the room varied according to the experimental condition in effect, but usually included chairs, a table, toys, and task materials. The experimenter was in the room with the participant during all sessions. For Experiment 1, all sessions were terminated after 30 min or 5 min without the emission of the target response (Roane et al., 2001; Tustin, 1994) on either alternative. For Experiment 2, sessions were terminated when either 10 total reinforcers had been earned or when 5 min elapsed without the emission of the target response on either alternative. If the participants responded at any time, the 5-min interval was reset. For example, if 4 min elapsed without any responses and then a participant responded on either alternative, the 5-min interval was reset. The session terminated after 10 total reinforcers in Experiment 2 to control for session duration as a function of the relatively large schedule

requirements in place for some participants. If a session was terminated after 5 min without a response, an approximately 5-min break was provided before the onset of the next session. Across all conditions, two to five sessions were conducted daily, 2 to 5 days per week.

During Experiment 1, the experimenter monitored implementation of the PR schedules with a guide sheet that listed the number of responses for each response requirement (e.g., six) as well as the cumulative number of responses corresponding to that schedule requirement (e.g., 21). The experimenter recorded the number of responses on a handheld tally counter and delivered reinforcers according to the schedule requirement in place. The experimenter employed a similar procedure for implementation of the FR schedules in Experiment 2.

Response Measurement and Interobserver Agreement

During both experiments, frequency data were collected on task completion and the number of reinforcers earned. *Task completion* was defined as the participant independently emitting a specific response, which was individually determined based on educational goals developed by the participants' local school systems. For Calvin, task completion was defined as any part of his hand touching a piece of tape located on the wall at a height previously identified by having Calvin stand on his toes and touch the wall (approximately 195 cm), which was a physical exercise goal identified in his educational plan. For Kyle, task completion was defined as filing manila folders in a bin, one folder at a time. If he placed multiple folders in the bin simultaneously, it was recorded as one response. For Allen, task completion was defined as correctly solving one-digit addition problems (sums to 18) on a worksheet. The *number of reinforcers earned* was defined as the experimenter delivering a reinforcer for 20 s by placing the stimulus on the table in front of the participant, and if needed, activating the stimulus (e.g., turning on the television). Across all analyses, reinforcers were delivered based on completion of the respective schedule requirement in effect.

During Experiment 1, the primary dependent measure was task completion, which was analyzed by converting the frequency to a rate measure by dividing the number of responses by the duration of the session in minutes (session duration varied as a function of response persistence under the PR schedules) to yield the number of responses per minute. It should be noted that the duration of reinforcer access was removed from the overall session duration for this calculation. The rate calculation included the duration of time that the response could occur (i.e., all interresponse intervals including the 5-min termination criterion described above). In addition, the break point (i.e., last completed PR schedule value) obtained for each reinforcer under the respective schedule arrangement was compared for each session. The primary dependent measure in Experiment 2 was the frequency of task completion, which was analyzed by recoding the number of task completions for either alternative and comparing this number to the number of possible responses that could have occurred based on the schedule in effect for either alternative (described below).

Throughout all sessions, observers were seated behind a one-way mirror that overlooked the room. Interobserver agreement was assessed by having a second trained observer simultaneously but independently collect data; data were collected during 23%, 43%, and 27% of sessions in Experiment 1 and during 30%, 31%, and 21% of sessions in Experiment 2 for Calvin, Kyle, and Allen, respectively. Interobserver agreement was calculated on an interval-by-interval basis by partitioning each session into 10-s intervals. An exact agreement was defined as both observers scoring the same frequency of responses within a given 10-s interval. A disagreement was defined as the two observers scoring a different frequency of responses within a given 10-s interval. The

overall agreement was the number of 10-s intervals with agreement divided by the number of 10-s intervals with agreement plus the number of intervals with disagreement multiplied by 100%.

In Experiment 1, mean interobserver agreement for task completion and the number of reinforcers earned was 97% (range, 91% to 100%) and 98% (range, 90% to 100%), respectively, for Calvin. Mean agreement for task completion and the number of reinforcers earned was 99.9% (range, 99.4% to 100%) and 100%, respectively, for Kyle. Mean agreement for task completion and number of reinforcers earned was 96% (range, 80% to 100%) and 99% (range, 90% to 100%), respectively, for Allen. In Experiment 2, mean agreement for the frequency of task completion was 95% (range, 83% to 100%), 97% (range, 76% to 100%), and 100% for Calvin, Kyle, and Allen, respectively.

EXPERIMENT 1: COMPARISON OF RESPONDING UNDER SINGLE AND CONCURRENT PR SCHEDULES

Procedure

Preference assessment. A paired-stimulus preference assessment (based on Fisher et al., 1992) was conducted to identify HP and LP stimuli for the subsequent analyses. Stimuli were included in the preference assessment based on caregiver report (Fisher, Piazza, Bowman, & Amari, 1996). During the preference assessment, each stimulus was paired once with every other stimulus in a random order to allow comparisons of all possible stimulus pairs. On each trial, the experimenter placed two stimuli approximately 30 cm apart on a table in front of the participant and the participant was prompted to make a choice (e.g., the therapist said, ''pick one''). An approach response (i.e., the participant reaching for and touching) to one of the stimuli resulted in 20-s access to that stimulus, and the other stimulus was removed immediately. The results of the preference assessment were analyzed by dividing the number of trials that each item was approached by the number of trials in which it was presented, multiplied by 100%. Stimuli approached between 80% and 100% of trials during the preference assessment were identified as HP stimuli, and stimuli chosen on fewer than 25% of trials or stimuli that were presented but never selected during the preference assessment were identified as LP stimuli (Roscoe et al., 1999).

Progressive-ratio analysis. During the PR analysis, identical tasks were used for the HP and LP stimuli; however, each task was associated with specific colors to enhance discrimination between the two schedules. For Calvin, a black piece of tape was associated with the HP stimulus, and a silver piece of tape was associated with the LP stimulus. For Kyle, green folders were associated with the HP stimulus, and red folders were associated with the LP stimulus. For Allen, white worksheets were associated with the HP stimulus, and orange worksheets were associated with the LP stimulus. Both the single and concurrent PR conditions were preceded by a no-reinforcement baseline during which no contingencies were arranged for the emission of the target response. All baseline sessions were 10 min.

During the single PR condition, the task materials for each participant and either the HP or LP stimulus were placed next to the experimenter in the room. Prior to each session, the experimenter provided brief instructions (e.g., ''If you would like your [e.g., video], you have to [e.g., do math]''), physically guided the participant to complete one response, and provided 20-s access to the stimulus being evaluated in that condition. During the ensuing session, the participant was presented with the task (e.g., math problems) according to the PR schedule in effect. No other prompts were delivered; thus, if the participant did not respond, the session terminated after 5 min. Completion of each PR requirement produced

20-s access to the participant's HP or LP stimulus, depending on the condition in effect. Identical additive PR schedules were arranged in which the requirement increased by one response following reinforcer delivery for the previously completed schedule requirement (e.g., one response, two responses, three responses). The conditions associated with the HP and LP stimuli were compared in an alternating treatments design. Throughout all sessions, task materials were removed when the HP or LP stimuli were delivered, and any occurrence of problem behavior resulted in no differential consequences.

During the concurrent PR condition, the same additive PR schedule used in the single PR schedule was used to identify the break points for the HP and LP stimuli. However, during the concurrent PR condition, two versions of the same task were presented simultaneously. For example, during Calvin's concurrent PR assessment, a black piece of tape and a silver piece of tape were placed on the wall at the same height approximately 20 cm apart. Thus, during this condition, the participant had the opportunity to emit a response on either task.

Prior to each concurrent PR session, the experimenter provided brief instructions (e.g., "If you would like your [e.g., video], you have to [e.g., do math here] and if you would like your [e.g., puzzle], you will have to [e.g., do math here]"), physically guided the participant to complete both responses, and delivered 20-s access to the stimulus being evaluated in that condition. Following the initial instructions, the participant was positioned between the two response options, and throughout the sessions the participant could alternate responding between either alternative.

Each task was associated with identical but independent additive PR schedules. As a result, a participant could complete a schedule for one stimulus while in the middle of responding on the schedule for the other stimulus. Thus, within the concurrent PR schedules, if the participant earned a reinforcer for the HP stimulus, the schedule requirement for that stimulus increased by one response while the schedule requirement for the LP stimulus remained the same. Completion of either PR requirement produced 20-s access to the participant's HP or LP stimulus (depending on the response). Both PR schedules increased in an additive manner (e.g., one response, two responses, three responses) and were identical to the PR schedules used in the single PR condition. In addition, the task materials associated with the specific stimulus were removed during the presentation of that stimulus (i.e., the other materials remained available), and any occurrence of problem behavior produced no differential consequences.

Results

Preference assessment. For Calvin the HP stimulus identified in the preference assessment was a video (approached on 100% of trials) and the LP stimulus was social attention (never approached). For Kyle the HP stimulus was a DVD player (approached on 100% of trials) and the LP stimulus was markers and paper (approached on 20% of trials). The HP stimulus for Allen was a video (approached on 100% of trials) and the LP stimulus was a puzzle (never approached). Trial-by-trial and summary data for all participants are available from the second author.

Progressive-ratio analysis. The data for Calvin's single and concurrent PR evaluation are presented in Figure 1. During baseline when there were no contingencies arranged for the emission of the target response, low rates of responding occurred. During the single-schedule arrangement, more responding occurred for the HP stimulus (i.e., video; $M = 3.6$ responses per minute; range, 3.0 to 3.9) than for the LP stimulus (i.e., attention; $M = 0.9$ responses per minute; range, 0.7 to 1.0). The second phase consisted of concurrent schedules in which both stimuli (i.e., video and attention) were presented under simultaneous PR schedules. Mean

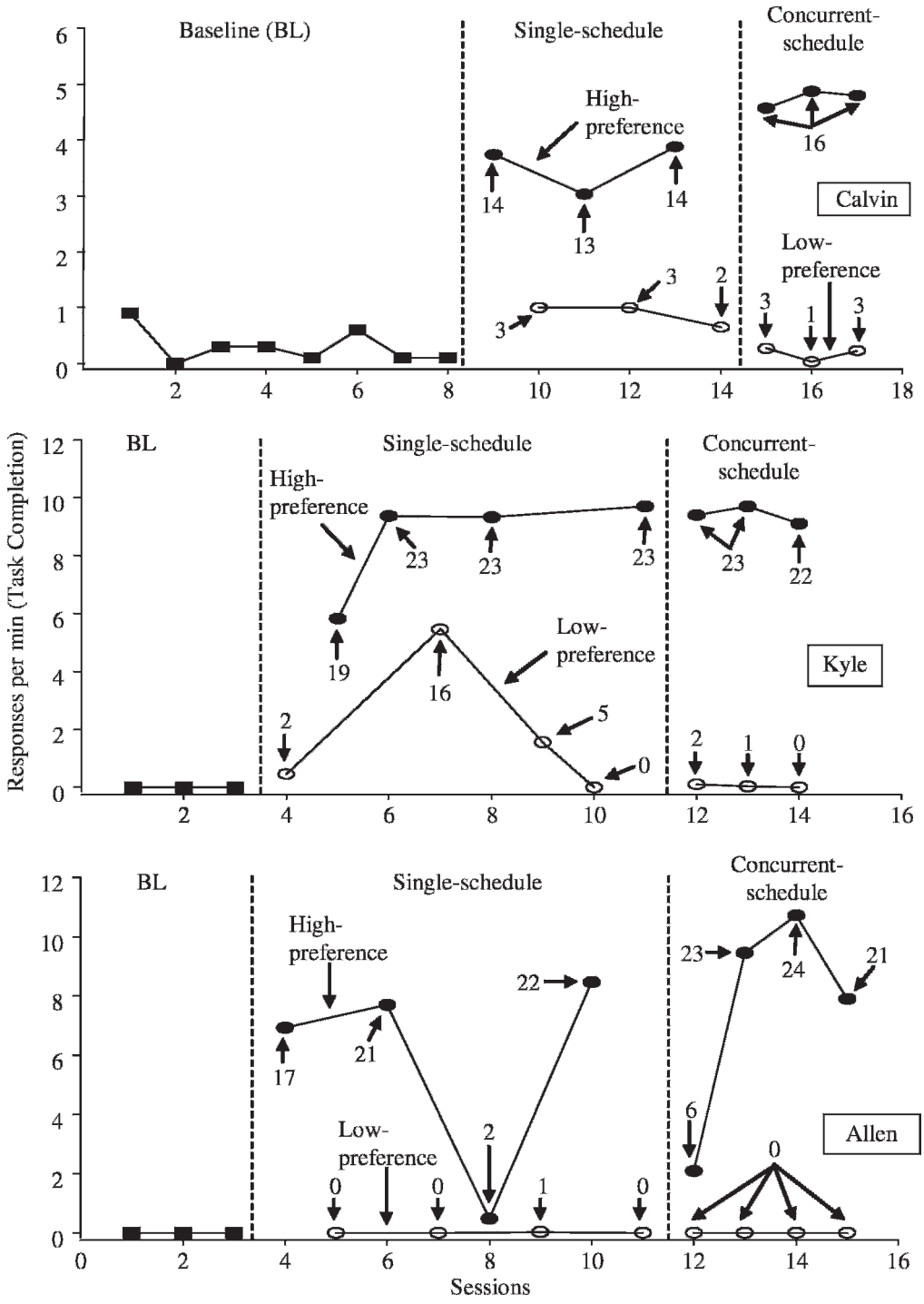

Figure 1. Rate of task completion during the single and concurrent PR conditions for Calvin (top), Kyle (middle), and Allen (bottom). Numbers represent the break point for the session.

response rate for the HP stimulus during the concurrent PR sessions was 4.8 (range, 4.6 to 4.9), whereas lower levels of responding were observed for the LP stimulus (M = 0.2 responses per minute; range, 0.03 to 0.3).

The results of Kyle's single and concurrent PR analyses are also presented in Figure 1. No responding occurred during baseline. During the single arrangement, the mean rate of responding for the HP stimulus (i.e., DVD player) was 8.6 (range, 5.8 to 9.7), whereas the mean rate of responding for the LP stimulus (i.e., markers and paper) was 1.9 (range, 0 to 5.5). Under concurrent schedules, more responding occurred for the HP stimulus (M = 9.4 responses per minute; range, 9.1 to 9.7), than for the LP stimulus (M = 0.04 responses per minute; range, 0 to 0.1).

The data for Allen's single and concurrent PR analyses are presented in Figure 1. No responding occurred during the baseline condition. During the single-schedule arrangement, the mean rate of responding for the HP stimulus (i.e., video) was 5.9 (range, 0.5 to 8.5), whereas the mean rate of responding for the LP stimulus (i.e., puzzle) was 0.01 (range, 0 to 0.03). When the concurrent schedule was introduced, Allen exclusively responded for the HP stimulus (M = 7.5 responses per minute; range, 2.1 to 10.7).

In summary, all 3 participants responded more for the HP stimulus than for the LP stimulus under both the single- and concurrent-schedule arrangements. Moreover, similar break points were obtained for these stimuli regardless of the manner in which the schedules were presented (single or concurrent arrangement), particularly for the HP stimulus for all participants.

Based on relative response rate, all participants showed a clear preference for the HP stimulus. It is unknown, however, if these preference patterns would persist under conditions in which the stimuli were presented under dissimilar, fixed schedule requirements. Thus, following the PR analyses, responding was examined under concurrent FR schedules that were yoked to the break points obtained in Experiment 1. In addition, we evaluated whether the LP stimuli would function as reinforcers in the absence of the HP stimuli under an FR requirement (cf. Roscoe et al., 1999).

EXPERIMENT 2: EVALUATION OF RESPONDING UNDER YOKED FR SCHEDULES

Procedure

Fixed-ratio analysis. For the FR analyses, the FR schedule values for the LP stimuli were developed by examining the obtained break points in both PR conditions from Experiment 1 and selecting an FR requirement that most closely matched two of the three measures of central tendency (mean, median, mode). This process was designed to account for any discrepancies between the mean break points in the LP single PR and LP concurrent PR conditions. If two of the three measures of central tendency did not match, a schedule was chosen based on the most common break point obtained during both PR analyses (i.e., the mode). The mean obtained break point from the concurrent PR condition of Experiment 1 was used to develop the FR schedule value for the HP stimulus for the concurrent FR analysis.

For Calvin, the break points during the concurrent PR condition for the HP stimulus were PR 16, PR 16, and PR 16; thus, an FR 16 schedule was used for the HP stimulus. The break points during the single PR condition for the LP stimulus were PR 3, PR 3, and PR 2, whereas the break points during the concurrent PR condition for the LP stimulus were PR 3, PR 1, and PR 3. Thus, an FR 3 schedule was implemented for the LP stimulus.

For Kyle, the mean break point for the HP stimulus during the concurrent PR condition was 22.7; thus, an FR 23 schedule was used for the HP stimulus. Because none of the measures of central tendency produced similar results across the single and concurrent PR conditions

for Kyle, an FR 2 schedule was chosen for the LP stimulus because PR 2 was completed in both the single and concurrent conditions of the PR analysis.

For Allen, the mean break point for the HP stimulus during the concurrent condition was 18.5; thus, an FR 19 schedule was used for the HP stimulus. Because Allen completed only one PR requirement for the LP stimulus across both the single and concurrent PR conditions, an FR 1 schedule was used for the LP stimulus.

In the concurrent FR condition, two FR schedules (i.e., one each for the HP and LP stimuli) were arranged based on the break points obtained in the PR analysis. During the concurrent FR condition, the same tasks and discriminative stimuli presented in the PR analysis were used. Two independently operating reinforcement schedules were arranged, one associated with the HP stimulus and the other associated with the LP stimulus. As a result, the participant could complete a schedule for one stimulus (e.g., FR 3 for attention for Calvin) while he was in the middle of completing the schedule for the alternate stimulus (e.g., FR 16 for video for Calvin). Completion of either schedule requirement resulted in 20-s access to the stimulus associated with the specific schedule. Prior to each session, instructions and physical guidance were used to demonstrate the contingencies in effect (as described in the concurrent PR condition above). The task materials associated with a specific stimulus were removed during the presentation of that stimulus (i.e., the other materials remained available), and any occurrence of problem behavior resulted in no differential consequences. All sessions were terminated either when 10 total reinforcers had been earned or after 5 min elapsed without emission of the target response on both alternatives (Roane et al., 2001; Tustin, 1994).

The single FR condition was similar to the concurrent FR condition; however, the LP stimulus was presented on a constant FR schedule and there was no alternative reinforcement schedule (i.e., the HP stimulus was unavailable). The FR schedule associated with the LP stimulus was the same FR schedule used in the concurrent FR condition, and the same tasks used in the previous conditions were presented. Completion of the previously determined FR schedule produced 20-s access to the LP stimulus. Prior to each session, instructions and physical guidance were used to demonstrate the contingencies in effect (as described in the single PR condition above). The task materials were removed during the presentation of the LP stimulus, and any occurrences of problem behavior resulted in no differential consequences. All sessions were terminated when 10 total reinforcers had been earned or after 5 min elapsed without emission of the target response.

The single and concurrent FR conditions were preceded by a 10-min baseline, which was identical to that described in Experiment 1. For all participants, responding during the concurrent and single FR conditions was evaluated using reversal designs.

Results

Fixed-ratio analysis. Figure 2 depicts the frequency of task completion by Calvin. Low and variable levels of task completion occurred during the initial baseline condition. Based on the schedules in effect and the maximum number of reinforcers available per session (i.e., 10), the maximum number of tasks he could have completed for the HP stimulus was 160 and for the LP stimulus was 30. He completed more tasks for the video ($M = 154$ task completions) than for attention ($M = 1$ task completion) when the video and attention were presented concurrently. However, when the LP stimulus was presented alone, Calvin completed the maximum number of tasks (i.e., 30) during six of the nine sessions ($M = 27$ task completions).

The data for Kyle's FR analysis are also presented in Figure 2. He engaged in no task completion during baseline. Based on the schedules in effect and the maximum number of reinforcers available per session (i.e., 10), the

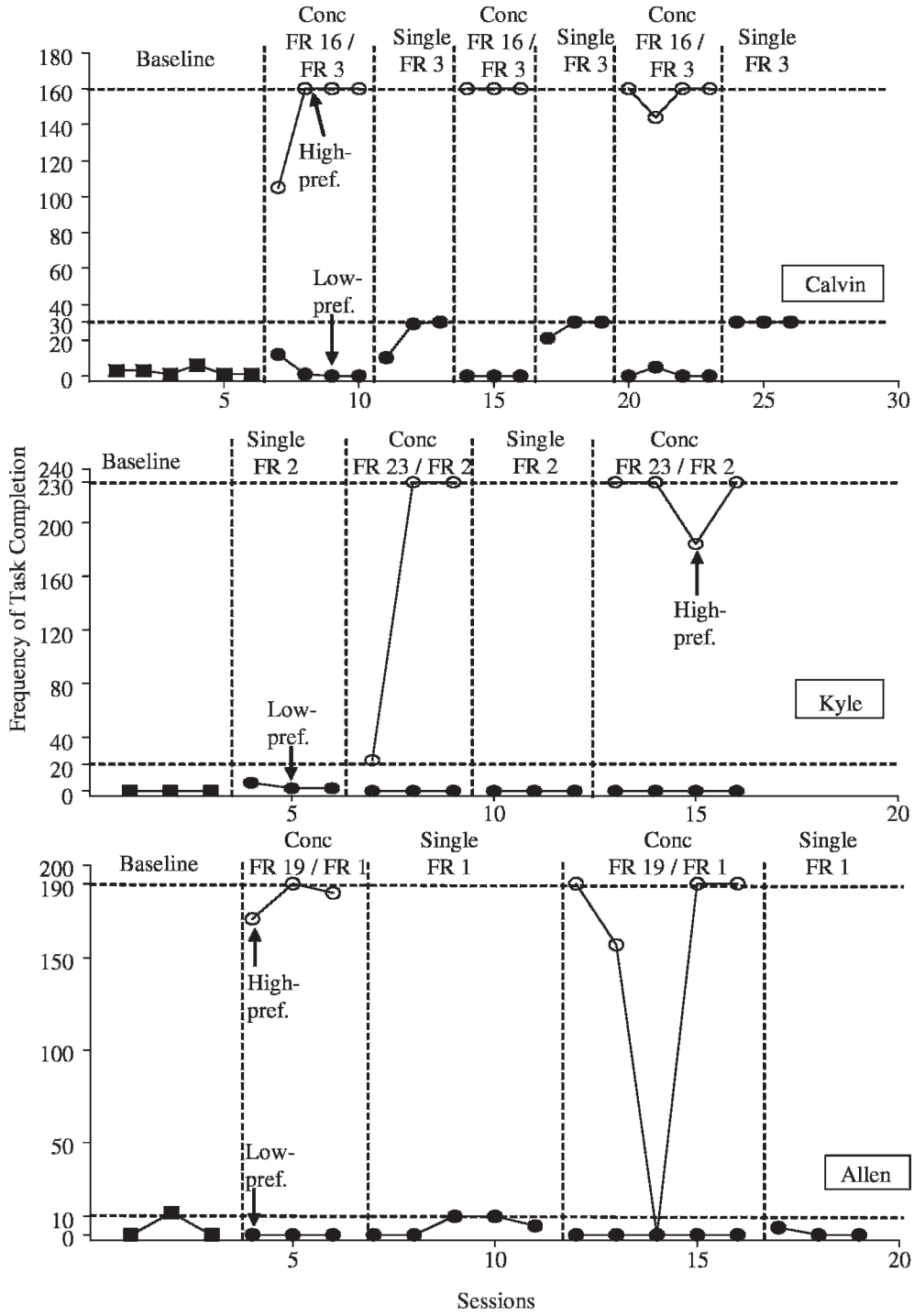

Figure 2. Frequency of task completion during the single and concurrent FR analysis for Calvin (top), Kyle (middle), and Allen (bottom). The upper horizontal dashed lines indicate the maximum number of tasks that could be completed under the FR values for the HP stimulus. The lower horizontal dashed lines indicate the maximum number of tasks that could be completed under the FR values for the LP stimulus.

maximum number of responses Kyle could have emitted for the HP stimulus was 230 tasks and for the LP stimulus was 20 tasks. During the single arrangement, he exhibited some responding for the markers and paper ($M = 2$ task completions) but did not complete the maximum number of tasks (i.e., 20) that were possible under the experimental constraints. During the concurrent arrangement, he completed the maximum number of tasks for the DVD player during the majority of the sessions (60%, $M = 194$ task completions) and never responded for the markers and paper.

The data for Allen's FR analysis are also presented in Figure 2. Variable but generally low levels of task completion were observed during baseline. Based on the schedules in effect and the maximum number of reinforcers available per session (i.e., 10), the maximum number of responses he could have emitted for the HP stimulus was 190 tasks and for the LP stimulus was 10 tasks. During the concurrent arrangement, he responded at high levels for the video ($M = 159$ task completions) and occasionally emitted the maximum number of tasks possible (i.e., 190); he did not respond for the puzzle. However, during the single arrangement, he engaged in some task completions for the puzzle, maximizing responding in two of the eight sessions, although his responding overall during these conditions was variable ($M = 4$ task completions).

GENERAL DISCUSSION

In the current investigation we attempted to evaluate whether PR schedules would produce similar outcomes when two stimuli were evaluated in both single- and concurrent-schedule arrangements. Under the PR schedules, all 3 participants responded more for the HP stimulus than for the LP stimulus, regardless of the presentation format (i.e., single or concurrent arrangements), and similar break points were obtained for the stimuli across both procedures. The response rates for the LP stimulus for Calvin and Kyle were higher in the single PR condition, suggesting that the concurrent presence of the HP stimulus suppressed responding for the LP stimulus during the concurrent PR condition. Allen displayed little responding for the LP stimulus in either PR schedule condition.

Once break points were obtained for the two stimuli in Experiment 1, we evaluated responding under FR schedule requirements that were yoked to the break points obtained under the PR schedules. All participants responded more for the HP stimulus than for the LP stimulus when both were presented under concurrent FR schedules. This result is noteworthy in relation to the substantial differences in the schedule requirements for the HP and LP stimuli. By contrast, when the LP stimulus was presented in a single arrangement, results were more variable across participants. Calvin emitted the maximum number of responses in the single-schedule condition in the majority of sessions, Allen engaged in the maximum number of possible responses in two of eight sessions in which the LP stimulus was presented singly, and Kyle rarely responded for the LP stimulus when it was presented in either arrangement.

Taken together, the current results suggest that levels of responding for HP stimuli observed under the PR schedules (Experiment 1) were not disrupted by the concurrent availability of alternative LP stimuli available at lower response requirements (Experiment 2). It should be noted that these findings were obtained under schedule requirements that were 5 to 19 times greater for the HP stimuli than for the LP stimuli. These results suggest that preferences observed under single and concurrent PR schedules may be indicative of relative preference in other contexts (i.e., dissimilar FR requirements). This outcome is also noteworthy considering that the LP stimulus was somewhat effective as a reinforcer under a single-schedule arrangement for 2 of the participants, although only Calvin demonstrated a repeated reinforce-

ment effect for the LP stimulus under the single FR schedule arrangement.

The current results are also similar to those obtained by Tustin (1994), DeLeon, Iwata, Goh, and Worsdell (1997), and Roane et al. (2001), in that at higher schedule requirements, rates of responding varied across different stimuli such that near-exclusive response allocation to one stimulus occurred. Likewise, the current results are similar to those obtained in previous investigations, in that all participants responded at some level for the LP stimuli under schedule requirements that were much lower (e.g., PR 1, FR 1) than those associated with the HP stimuli (as indicated by differences in the break points across the stimuli for all participants). Finally, the current results are similar to recent basic experiments presented by Johnson and Bickel (2006) in which similar patterns of responding were obtained across PR schedules presented in both single and concurrent arrangements.

The results of Experiment 2 were inconsistent with those obtained by Roscoe et al. (1999), who showed that when a LP reinforcer was presented in a single-schedule arrangement, 6 of 7 participants displayed increases in responding for LP stimuli under single FR schedules. In Experiment 2 of the current investigation, only 1 of the participants consistently responded at levels that were near the maximum number of responses that could occur when the LP stimulus was presented in a single arrangement. One possible reason for these discrepant results may be related to the schedules of reinforcement implemented in the present analysis and those in the Roscoe et al. investigation. In the Roscoe et al. study, FR 1 schedules were implemented for all participants, whereas in the current investigation the schedule requirements ranged from FR 1 to FR 3 across participants. However, the single result (Calvin) that was most similar to those reported by Roscoe et al. was also the participant for whom schedules were most discrepant (FR 3) from those implemented by Roscoe et al. Roscoe et al. also incorporated LP foods, whereas the current investigation employed LP nonfood stimuli. It is possible that food items are generally more potent reinforcers than nonfood items (e.g., Bojak & Carr, 1999; DeLeon, Iwata, & Roscoe, 1997), which may have accounted for the differences between the current results and those of Roscoe et al. Finally, the stimuli chosen for Calvin and Allen were never selected during the preference assessment. Given that these stimuli were not selected on any trials in the preference assessment, it was unknown how participants would have responded for them under the various schedule requirements. Interestingly, Calvin frequently responded for the LP stimulus, whereas Allen rarely responded for the LP stimulus. Future research could assess the conditions under which stimuli that were never approached during a preference assessment may function as reinforcers.

Despite the relation of the current investigation to previous studies, the current results are limited by several factors. For example, all 3 participants began Experiment 1 with the single PR schedule condition, which potentially could have affected responding during the subsequent concurrent PR schedules condition. The order of the conditions was determined before the analysis in a random fashion (i.e., selecting a number corresponding with either arrangement). Roscoe et al. (1999) suggested that beginning with the concurrent schedule may minimize a history of responding associated with LP stimuli. That is, given no alternatives, responding may be allocated to the LP stimulus. In turn, this procedural manipulation may increase the value of the low-preferred stimulus, such that greater response allocation to the LP stimulus might occur when a concurrently available HP stimulus is available (compared to conditions in which that prior history was not arranged; i.e., conducting an initial concurrent-schedule condition). The current re-

sults, however, showed similar response patterns for LP stimuli under PR schedules regardless of the arrangement (single or concurrent). Although we were unable to determine the degree to which the order of conditions may have altered the value of the LP stimulus, future research might evaluate the relative differences in responding in single arrangements that are preceded or not preceded by exposure to concurrent schedules. In addition, identical additive PR schedules were used for all 3 participants, which may limit the generality of these results. A third limitation may be that for 2 of the 3 participants, the LP stimulus was not approached on any trials during the preference assessment. Thus, because these stimuli were never selected in the preference assessment, it is reasonable that the participants would not respond for them under increased schedule requirements. However, previous research has shown that stimuli that were never selected in a preference assessment may function as positive reinforcers in some situations (Taravella, Lerman, Contrucci, & Roane, 2000). Similarly, in the current investigation, stimuli that were never approached in the preference assessment resulted in some responding (Allen), and in one case (Calvin) resulted in responding for the maximum number of reinforcers available. However, contingent access to those stimuli did not consistently maintain responding under progressively increasing (Experiment 1) or higher (Experiment 2) schedule values.

DeLeon, Iwata, Goh, and Worsdell (1997) and Roane et al. (2001) compared the differential effects of stimuli that were similarly preferred. By contrast, the current investigation compared the reinforcing efficacy of stimuli that were differentially preferred. HP and LP stimuli were used in the current investigation to maximize any potential differences in reinforcer efficacy that would be seen under the PR schedules. The purpose of Experiment 1 was to determine if PR schedules would produce similar outcomes when presented in single- and concurrent-schedule arrangements. Using differentially preferred stimuli allowed the examination of the different presentation formats without the potential confounding effect of similarity in preference. That is, similarly preferred stimuli may have produced similar levels of responding, which may have made the comparison of the results obtained under single- and concurrent-schedule arrangements unclear. Future research could examine the extent to which preference rankings interact with presentation format during PR schedules.

The current results suggest that individuals with developmental disabilities may display varying levels of responding for different stimuli under different schedule arrangements. For example, when the HP stimulus was available, the participants were less likely to work for the alternate LP stimulus. However, when the HP stimulus was removed, some responding occurred for the LP stimulus. From a practical perspective these results suggest that less preferred stimuli may maintain responding under less strenuous response requirements, whereas more preferred stimuli may be better used as reinforcers for more effortful responses. Thus, during reinforcement-based programs, stimuli could be varied as reinforcers depending on the requirements of the target response or program (e.g., Egel, 1981).

In general, PR schedules are used to evaluate relative reinforcer efficacy in basic experiments (e.g., Baron, Mikorski, & Schlund, 1992) and are not directly analogous to procedures commonly employed in applied settings. Thus, the use of PR schedules may limit the generality of the current results. Additional research could examine the practicality of PR schedules in applied settings. For example, a teacher could request that a student complete a variety of educational activities that approximate PR response requirements. That is, a student could be required to complete multiple tasks in succession in an adaptive skills training program such that the student might first complete one

task (e.g., putting away his book bag), then two tasks (e.g., taking out a piece of paper and a pencil), and so on. Even though rate of responding in an adaptive skills program may remain an important and socially relevant dimension of behavior, the overall amount of academic work completed may represent an equally important, and perhaps more socially relevant, dimension of behavior. The evaluation of PR schedules in more applied contexts may demonstrate and further elucidate this potentially important difference.

Future research could also use PR schedules to evaluate the efficacy of other types of reinforcers. For example, PR schedules could be used to examine responding for an HP reinforcer (e.g., a video) relative to a reinforcer that has been shown to maintain problem behavior based on the results of a functional analysis (Iwata, Dorsey, Slifer, Bauman, & Richman, 1982/1994). Such results might reveal differentiated levels of responding for these reinforcers across increasing schedule requirements, which may lead to the development of effective treatments for problem behavior (Roane et al., 2001).

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