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The effects of task fluency and concurrent reinforcement schedules on student choice allocation between math tasks

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THE EFFECTS OF TASK FLUENCY AND CONCURRENT REINFORCEMENT SCHEDULES ON STUDENT CHOICE ALLOCATION BETWEEN MATH TASKS

by

Maliha Zaman

An Abstract

Of a thesis submitted in partial fulfillment of the requirements
for the Doctor of Philosophy degree in
Teaching and Learning (Special Education)
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Thesis Supervisors: Professor David P. Wacker
Assistant Professor Youjia Hua

ABSTRACT

Students may avoid working on difficult tasks because it takes them longer to complete those tasks, which results in a delay to reinforcement. Research studies show that reinforcer and response dimensions can be manipulated within a concurrent operants framework to bias choice allocation toward more difficult tasks. The current study extends previous literature on concurrent choice assessments by examining the effects of reinforcement schedules and fluency interventions on the choice allocation between low and high effort math tasks. The study was conducted with 4 second graders in an elementary school. The choice assessment conducted prior to fluency training (Phase 1) examined the effects of enriching the reinforcement schedule for the high effort tasks on student choice. During fluency training (Phase 2), strategies to increase fluency rates on high effort tasks were implemented. The choice assessment following fluency training (Phase 3) examined changes in choice pattern when the same choice alternatives were available as in Phase 1. A concurrent schedules with reversal design was used to identify student response allocation to tasks under different reinforcement conditions during the choice assessments. The fluency training phase was conducted as a case study design. The three important findings of this study were: (a) Prior to fluency training, the 4 students allocated more time to low effort tasks when equal reinforcement was provided for both types of math tasks; the students then shifted to high effort tasks as the reinforcement schedule was enriched for these tasks; (b) fluency training strategies were effective in increasing the rate at which high effort tasks were accurately completed; and (c) all 4 students shifted more quickly to high effort tasks following fluency training. Implications for educators are discussed.

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PH.D. THESIS

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To my best friend, Dhritiman

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CHAPTER I

INTRODUCTION

Academic performance in schools can be enhanced by increasing the probability of students choosing to engage in tasks (McCurdy, Skinner, Grantham, Watson, & Hindman, 2001). When students are engaged in tasks, they are more likely to learn the skills being taught and to practice these skills independently (Billington, Skinner, Hutchins, & Malone, 2004). Multiple opportunities to perform skills also enhance a student's fluency or the rate at which a student accurately completes a task. For example, in arithmetic, students need to remain on task to learn and maintain skills and thereby attain fluency on the task (Calderhead, Filter, & Albin, 2006). Students who choose to remain engaged in tasks are also less likely to engage in disruptive behaviors (Dunlap & Kern, 1996). Researchers have implemented a number of procedures to increase student engagement on tasks. Some of these procedures include increasing the time needed to complete a task or reducing the effort needed to complete a task (Kern, Childs, Dunlap, Clarke, & Falk, 1994). Task demand or effort can be reduced by replacing new materials with previously learned materials. Another way to make tasks less effortful is by shortening the length of the task. For example, task length can be reduced by providing the students fewer problems to complete or substituting easier and briefer problems for the longer problems (Cooke, Guzaukas, Pressley, & Kerr, 1993). These procedures might shift students' preferences toward easier and shorter tasks and increase the probability of the students remaining engaged in these tasks (Kern et al., 1994). However, easier tasks may not enhance the academic performance of students who are already experiencing difficulties in learning (Roberts & Shapiro, 1996). Thus, educators are often reluctant to reduce the demand level of tasks. One way to increase task engagement and concurrently reduce disruptive behaviors is by providing students with opportunities to choose their assigned tasks (Dunlap et al., 1994).

An evaluation of choice in applied settings examines how an individual allocates responding between simultaneously available options. Choice allocation is an important applied issue because multiple reinforcers are available at the same time in the natural environment (Kodak, Lerman, Volkert, & Trosclair, 2007). Previous research has shown that reinforcement dimensions, such as schedule, quality, delay, and the effort needed to obtain reinforcement, influence choice allocation between reinforcers (Neef, Mace, Shea, & Shade, 1992; Neef, Shade, & Miller, 1994). The variables that influence choice are usually examined in a concurrent operants arrangement in which two or more concurrently available responses are associated with independent reinforcement schedules. When choices are available on concurrent variable interval (VI) schedules, individuals switch back and forth between the two alternatives and distribute responding between them such that over time the rate of responding tends to match the proportion of reinforcement obtained on each independent schedule. Choice behavior that results in the rate of responding being proportional to the rate of reinforcement is known as matching (Herrnstein 1961, 1970). When choices are associated with concurrent ratio schedules, individuals do not switch between choices and tend to allocate all or the majority of their responses to the choice with the denser fixed-ratio (FR) or variable ratio (VR) schedule of reinforcement. The matching law also applies to ratio schedules because when an individual exclusively responds to the choice correlated with the denser schedule of reinforcement, he or she obtains maximum reinforcement from the schedule associated with that choice (Fisher & Mazur, 1997).

Fisher and Mazur (1997) discussed relative response rates and how they may deviate from the predictions of the matching law. Response bias describes situations in which individuals consistently choose one response over the other more than would be predicted by the matching law. As discussed by McDowell (1989), deviations from the matching law often occur when concurrent choice arrangements are asymmetrical. A symmetrical concurrent arrangement is one in which identical responses (e.g., pecking keys) are required to obtain qualitatively identical reinforcers (e.g., 5-s access to food). An asymmetrical concurrent arrangement, in contrast, entails either different responses (e.g., task completion vs. problem behavior) or different reinforcers available from those responses (e.g., food vs. attention). Thus, in an asymmetrical concurrent arrangement, responding by individuals may not be sensitive to relative rates of reinforcement. For example, Neef et al. (1992) examined the effects of altering the schedule and quality of reinforcement on the time allocation between two concurrently available sets of math problems for 3 students in a special education program. Results indicated that when both problem sets were associated with the same quality of reinforcement, students' time allocation was nearly proportional to the rates of reinforcement (i.e., matching). However, when the quality of reinforcers was altered such that the higher quality of reinforcement was associated with the leaner schedule of reinforcement, the students showed a preference for the higher quality reinforcers and shifted responding to the leaner schedule, which resulted in a deviation from the matching law. Neef and Lutz (2001) reported that only 1 of the 11 participants exclusively responded to the choice alternative correlated with the higher rate of reinforcement when the participants were presented with two concurrent sets of math problems that competed on two out of four reinforcer dimensions. For example, in a rate versus quality condition, high quality reinforcers were available on a VI 120-s schedule and low quality reinforcers were available on a VI 30-s reinforcement schedule, with response effort and immediacy of reinforcement remaining constant across the two alternatives. The results of these studies suggest that the availability of reinforcers for concurrent choice options should be taken into account when reinforcement effects on behavior are analyzed in applied settings.

Several studies have shown that choice responding can be analyzed to determine the potency of reinforcers and to identify variables that influence behavior in applied settings. Fisher, Thompson, Piazza, Crosland, and Gotjen (1997) studied the effects of choice on responding using a concurrent operants framework with 3 children in an inpatient unit for individuals with behavior and feeding disorders. When the concurrent choice assessment consisted of a choice (participants selected from available reinforcers) and a no-choice condition (therapist selected the reinforcers) with both alternatives resulting in identical reinforcers, all 3 participants exclusively allocated responding to the choice option. In a subsequent choice assessment, the participants preferred the no-choice option when the choice condition required the participants to choose between two low preferred stimuli and the no-choice condition required the therapist to select a higher quality reinforcer for them. These results suggested that providing choices can increase the reinforcement value of the selected reinforcers. Harding et al. (1999) used a concurrent choice assessment to evaluate how preschool children allocated time between choices that varied the availability of parent attention, parent instruction, and preferred toys in their homes. The results of the choice assessment identified variables that increased compliance with parent instruction with activities that had previously resulted in task avoidance. Gardner, Wacker, and Boelter (2009) conducted a concurrent choice assessment in an outpatient behavioral clinic to examine how manipulation of the quality of attention (high vs. low) could bias responding towards academic tasks for 2 children who engaged in problem behaviors to escape from task completion. Both children showed lower percentages of problem behavior when clinic staff provided task demands associated with high quality attention, suggesting that positive reinforcement in the form of attention could effectively compete with negative reinforcers associated with task avoidance.

Variables affecting choice in academic tasks also have been studied within a concurrent operants arrangement in school settings. Neef et al. (2004) used a concurrent operants framework to compare the effects of instruction versus modeling on the choices of 3 students with ADHD and 3 typically developing children whose academic responding initially was not sensitive to concurrent variable-interval (VI) schedules of reinforcement. During the instruction and modeling conditions, student responding was nearly proportional to the rates of reinforcement (matching). Matching persisted and the students continued to display sensitivity to reinforcement schedules even when instruction or modeling was no longer provided. Hoch, McComas, Johnson, Faranda, and Guenther (2002) showed how concurrent reinforcement schedules could be arranged to decrease problem behavior and increase academic task completion (math, vocational tasks) with 3 students with autism. The three intervention conditions implemented in the school were (a) a no-reinforcement condition during which no programmed consequences were provided for task completion, (b) a negative reinforcement/preferred activities condition during which accurate task completion resulted in access to a break and preferred activities on an fixed ratio (FR1) schedule, and (c) a negative reinforcement condition during which students were provided with a break after every task that they completed correctly. During all three conditions, every occurrence of problem behavior resulted in a break from the task. Results indicated that problem behavior decreased and task completion increased during the negative reinforcement/preferred activities condition as compared to the other two conditions and that these results were maintained during the follow-up sessions when the response requirement was increased and the reinforcement schedule made leaner. These results showed that the manipulation of both positive and negative reinforcement was effective in reducing problem behavior and increasing adaptive classroom behavior. Previous studies have shown that a concurrent operants framework can be applied successfully to academic programs and used to identify variables influencing academic behaviors. One such important variable in classroom instruction is task difficulty or the effort required to complete a task. Task difficulty is based on the interaction between the material presented and the skill level of the student (Lannie & Martens, 2004). As the difficulty level of classroom assignments increases, students tend to respond at lower rates on those tasks as compared to easy tasks and thereby receive fewer opportunities to obtain reinforcement contingent on accurate responding on the difficult tasks (Lannie & Martens, 2004). This suggests that in situations in which students are presented with a choice between easy tasks that are on a lean schedule of reinforcement and difficult tasks that are associated with a denser schedule of reinforcement, they may choose the easy task because they can complete the easy tasks at a faster rate. Thus, task difficulty is an important variable to consider when examining the choice allocation of students in classroom settings.

Neef et al. (1994) operationalized academic task difficulty as response effort. When presented with a choice between two behaviors, students tend to choose to engage in behaviors that require less effort to complete (Horner & Day, 1991). In most research studies with humans on choice allocation in concurrent schedules, response effort was kept constant while other reinforcement dimensions were varied. There are few studies that examined the combined effects of response effort and reinforcer dimensions with humans (Cuvo, Lerch, Leurquin, Gaffaney, & Poppin, 1998, Lannie & Martens, 2004; Neef et al., 1994). Lannie and Martens (2004) showed that 4 students in a regular education classroom preferred different types of reinforcement contingencies depending on their level of skill proficiency. Results indicated that matching the type of contingency (time based or accuracy based) to the level of difficulty of the task (easy or difficult) may increase the student’s motivation to respond to the task by increasing the obtained rates of reinforcement. Mace, Neef, Shade, and Mauro (1996) separately examined the effects of task difficulty on choice and the interactive effects of task difficulty and reinforcer quality on student choice allocation in a concurrent operants framework with 2 children in a special education program. Varying task difficulty did not affect response allocation as compared to the baseline condition when the participants’ rate of responding matched the rate of reinforcement available from the responses. Manipulating reinforcer quality, in contrast, altered the baseline choice patterns. Participants showed a preference for the higher quality reinforcer even when it was combined with more difficult tasks and a leaner schedule of reinforcement.

Cuvo et al. (1998) examined choice allocation under concurrent FR schedules along with varying work requirements with typically developing preschool children. The investigators tested whether the participants shifted their response allocation from tasks involving less work when the programmed FR schedule became leaner for the easy task or whether participants continued to select the easier work requirement regardless of a less favorable reinforcement schedule. Results of the study showed that participants chose the easier task when schedules of reinforcement were identical for both easy and difficult tasks. When the schedule was thinned for the easier choice, participants tended to allocate their responding to the more difficult alternative (tossing s beanbag from a longer distance) associated with a richer reinforcement schedule.

The general purpose of the current study was to extend the literature on choice allocation using a concurrent operants framework with students experiencing learning and behavioral difficulties in a school setting. As shown in previous research (Bradshaw, Ruddle, & Szabadi, 1981), a relatively denser schedule of reinforcement may not be sufficient to bias choice responding towards a task requiring higher effort. This is because an increase in the difficulty level of the task can be associated with a lower probability of meeting the concurrent fixed-ratio schedule requirements and obtaining reinforcement (Cuvo et al., 1998). Phase 1 of the current study evaluated the combined effects of manipulating positive reinforcement (a richer schedule associated with high effort tasks vs. leaner schedule for low effort tasks) and response effort (low and high effort tasks) on choice allocation of the students. Phase 1 addressed the questions:

1. Do students show a response bias towards low effort tasks regardless of the reinforcement schedule associated with the tasks?

2. Do students allocate more time to the high effort tasks which are correlated with a denser schedule of reinforcement?

Thus, Phase 1 of the study was conducted to determine whether positive reinforcement manipulation would shift choice responding from tasks requiring less effort to those requiring higher effort.

Phase 2 of the study examined the effects of fluency training strategies on the same choice alternatives that were presented to the students prior to fluency training in Phase 1. Fluency training procedures were implemented with high effort tasks to alter the level of difficulty of those tasks. Academic task difficulty could be altered in several ways to affect choice allocation of students. Task difficulty or response effort could be lowered by substituting difficult or time-consuming parts of the assignment with easy tasks or tasks that require less time (Calderhead et al., 2006). The disadvantage of reducing the difficulty level of assignments is that it may further reduce the achievement level of students who are already performing poorly on academic tasks (Roberts & Shapiro, 1996). The current investigation implemented fluency training strategies to increase the fluency rate of students on high effort math tasks, such that the difficulty levels of both easy and difficult tasks were equivalent. Phase 2 of the study then examined the effects of fluency training on choice allocation in a concurrent operants framework. The research questions addressed in Phase 2 were:

3. Are similar choice patterns observed in Phases 1 and 2?
4. Do students show a preference for the high effort tasks following fluency training?

Fluency refers to the ease and accuracy with which a skill is performed (Locuniak & Jordan, 2008). An “instructional hierarchy” describes the four stages of learning a new skill: acquisition, fluency, generalization, and adaptation. The acquisition phase is the first stage when the student begins to learn a new skill. Once the student learns the skill, he or she tries to perform the skill accurately and fluently during the fluency stage. This stage requires practice and reinforcement of the skill. During the generalization and adaptation stage, the student begins to apply the skill in novel ways and across various contexts. In the context of math instruction, the instructional hierarchy predicts that students fluent in basic math computation skills perform better on more complex and abstract skills (Axtell, McCallum, Mee Bell, & Poncy, 2009). Students who are fluent in basic math facts show higher task completion rates and therefore receive more opportunities to practice their skills which further enhances their accuracy, fluency, and maintenance. Several interventions have been successfully implemented to increase speed and accuracy of responding and maintenance in math tasks. Model-prompt-check and partial sums addition were two strategies that comprised the instructional components of evidence-based procedures such as constant time delay and 1-minute timings (Miller & Hudson, 2007). These two strategies were implemented in the current study to increase fluency and accuracy of math skills. The instructional components included presentation of a stimulus (e.g., flashcard), modeling the correct response, immediate feedback, accurate responding, and appropriate responding (vocal or written responses). The 1-minute timings procedure provided students with multiple opportunities to practice their skills and was used to monitor students' performance on timed worksheets that consisted of more problems than they could complete in 1 min. Students graphed their progress at the end of each 1-min session and improvements in performance were likely to motivate them to further increase their fluency and automaticity with the math skill being practiced (Miller & Hudson, 2007).

There were two purposes of the current study. First, the study evaluated the effects of manipulating response effort and positive reinforcement on student's choice allocation and math task completion. The students were presented with two choice alternatives. They could select a math problem from two stacks of math tasks (low effort and high effort) presented to them, with each stack associated with a different fixed-ratio reinforcement schedule. The study investigated whether students with learning and behavioral problems would choose the high effort task that was associated with a relatively denser schedule of positive reinforcement or would choose the low effort task regardless of its leaner schedule of reinforcement. The study evaluated what schedule of positive reinforcement associated with high effort tasks was necessary for students to switch from choosing low effort to high effort tasks. Second, the study examined whether there was a change in choice patterns when the same choice alternatives were available following fluency training on high effort tasks. The study investigated whether students more often selected high effort tasks following fluency training. If so, what schedule of positive reinforcement was needed for the students to again select the low effort tasks?

CHAPTER II

LITERATURE REVIEW

An evaluation of choice in applied settings is generally conducted within a concurrent schedules design in which two or more choice options are simultaneously available and each is correlated with an independent schedule of reinforcement. A concurrent choice assessment permits an examination of the environmental conditions under which an individual allocates responding among available options. Basic and applied researchers have shown that choice responding within a concurrent schedules design is influenced by reinforcement and response dimensions such as rate, quality, and immediacy of reinforcement, and the effort required to respond.

Manipulations of reinforcement and response dimensions can be analyzed via a phenomenon called matching. Matching occurs when the relative rate of responding on concurrently available choices is equal to the relative rate of reinforcement obtained from these choices (Herrnstein, 1961, 1970). For example, in a symmetrical concurrent schedules arrangement, in which identical response options (pecks on keys) result in identical reinforcers (food) available on independent variable interval (VI) schedules (VI 30-s and VI 60-s), responding occurs on a 2:1 ratio to maximize the reinforcement obtained. The matching law has been used to analyze choice responding among multiple response options (Fisher & Mazur, 1997). Deviations that occur from matching have been reported in applied settings and are often due to perceptions of variables such as the quality of reinforcement paired with each choice option (Fisher & Mazur, 1997).

The purpose of this literature review is to describe choice assessments conducted in school settings. Specifically, I reviewed studies that evaluated the effects of dimensions and classes of reinforcement on choice responding with students with severe emotional, learning, behavioral, and ADHD difficulties and socially meaningful target responses (completion of math problems, vocational tasks). I attempted to address two questions: (a) What are the variables that influence choice allocation across concurrently available response options with these students? and (b) what are the practical implications of conducting concurrent choice assessments in the schools? In order to address the above questions, a three-step process was followed. First, studies were selected for review that met the following eligibility criteria: (a) were published in peer-reviewed journals from 1990 to 2010, (b) were conducted in a school, (c) used a single-case design methodology for evaluating choice patterns, and (d) examined student choice behavior within concurrent schedules of reinforcement. Second, Educational Resources Information Center (ERIC) and Psychological Information (PsycInfo) were searched for relevant studies using the following keywords: concurrent schedules, choice allocation, school, academic tasks, and learning disabilities. Third, the references of the selected articles were searched for additional articles that met the eligibility criteria. There were 12 articles that met the eligibility criteria and were selected for review. A summary of the studies that I reviewed for this chapter is presented in Appendix A.

Effects of Dimensions of Reinforcement on Choice

Neef, Mace, and colleagues (Neef et al., 1994; Neef, Mace, & Shade, 1993; Neef et al. 1992; Mace, Neef, Shade, & Mauro, 1994) showed the effects of varying reinforcement and response dimensions such as delay, quality, rate, and response effort on the choice allocation of students with math tasks. Neef et al. (1992) evaluated the effects of varying rate and quality of reinforcement on the choice allocation across two concurrently available math tasks. The participants in the study were 3 students with behavior and learning difficulties in a special education program. Students were presented with two stacks of math problems with the same type of problem written on each card. The two stacks were associated with independent concurrent variable-interval (VI) reinforcement schedules (VI-30s and VI-120s). Nickels and program money were the high and low quality reinforcers that were presented contingent on correct completion of math problems. During the equal reinforcer condition, the quality of the two reinforcers was the same across the two stacks of math problems. During the unequal reinforcer condition, the high quality reinforcers were associated with the leaner schedule of reinforcement (VI-120s) while the low quality reinforcers were correlated with the richer reinforcement schedule (VI-30s). Results indicated that the students allocated their time to the richer schedule when identical reinforcers were available. During the unequal reinforcer quality condition, students showed a strong preference for the higher quality reinforcers which were on a leaner reinforcement schedule of reinforcement. Rate of choice responding was proportional to the reinforcement rates (i.e. matching occurred) only when the reinforcers were of equal quality.

Neef et al. (1993) and Neef et al. (1994) evaluated the effects of delay to reinforcement and task difficulty, respectively, on choice allocation across concurrently available math tasks with youth with behavior and learning difficulties in a special education program. In Neef et al. (1993), the two types of math tasks were initially associated with the same VI reinforcement schedules and access to reinforcement was immediate for both tasks. During a subsequent condition, the unequal delay to reinforcer access, the task that resulted in a delay in reinforcement was associated with the richer schedule. Results showed that both students allocated their time to the richer schedule of reinforcement when reinforcers were immediately available contingent on task completion. During conditions with unequal delay to reinforcement, the students showed a preference for those tasks that were associated with shorter delays to reinforcement, even when paired with leaner schedules of reinforcement. The authors then examined the combined effects of reinforcer quality, delay, and rate of reinforcement on choice allocation. For one of the students, the effects of reinforcer quality trumped the effects of reinforcer rate and delay. The other student showed a preference for the more immediate reinforcers. Individual differences were observed in student allocation of responding across math tasks indicating the importance of the use of single case designs in the analysis of these studies.

Neef et al. (1994) studied the combined effects of rate, quality, delay, and response effort on the choice allocation of 6 youth with learning and behavior difficulties. Task difficulty or response the effort is a variable that influences choice allocation between concurrent reinforcement schedules. The students were presented with two concurrent sets of math problems that were equal on two dimensions of reinforcement and competed on two other dimensions. For example, in the rate versus quality condition, higher quality reinforcers were available at a lower rate of reinforcement compared to lower quality reinforcers at a higher rate, with delay and response effort kept constant. Results indicated that response allocation of all the participants were differentially affected by the reinforcement dimensions. With respect to task difficulty, results showed that time allocation matched rate of reinforcement independent of problem difficulty. Similar results were obtained in Mace et al. (1996) who studied the combined effects of reinforcer quality, reinforcement rate, and task difficulty on choice behavior. These authors showed that manipulating task difficulty had little effect on how the participants allocated their responses across concurrent alternatives, and especially in comparison to rate and quality of reinforcement.

Neef, Bicard, and Endo (2001) examined the relative influence of reinforcer and response dimensions (rate, quality, immediacy, and effort) on the choice allocation of 3 students with ADHD across concurrently available math problems. They conducted a brief computer-based assessment in which one of the reinforcer dimensions was in direct competition with another dimension. Results indicated that choice was most influenced by immediacy of reinforcement. Neef, Marckel, Ferreri, Bicard, Endo, Aman, and Armstrong (2005) used a similar computer-based assessment to assess the relative influence of various reinforcer dimensions (rate, quality, and response effort) on choice responding with 58 children with and without ADHD. Similar to the procedures in Neef et al. (2001), one of the dimensions (rate, quality, immediacy, or effort) associated with one set of math problems was placed in direct competition with another dimension associated with the other set of problems. The results of the study indicated that the choices of children with ADHD were influenced primarily by reinforcer immediacy and quality and least by rate and effort. The choices of children without a diagnosis of ADHD were influenced principally by reinforcer quality. These results indicated that the children were differentially affected by variations in reinforcement dimensions, thereby suggesting the need to conduct individual analyses to evaluate choice responding.

Cuvo et al. (1998) and Reed and Martens (2008) demonstrated the effects of varying task difficulty on choice responding. Reed and Martens (2008) evaluated the choice responding of 3 children across two workstations (blue and orange workstations) under conditions of equal and unequal response effort. During Experiment 1, easy math problems were presented at both the blue and orange workstations. The two sets of easy math problems corresponded with independent VI schedules of reinforcement. The students were allowed to choose to work on either of the stacks and alternate between the two workstations at any time during the session. Auditory signals were provided to help the students discriminate between the two reinforcement schedules. The students could earn tokens by correctly completing the math problems and exchange those tokens for reinforcers at the end of the session. The procedures in Experiment 2 were the same as in Experiment 1, except for a change in the difficulty level of the math problems. In Experiment 2, easy problems were presented at the blue station while difficult problems were presented at the orange station. Results of Experiment 1 showed that for 2 of the 3 participants, the relative rates of responding across the two workstations was proportional to the rates of reinforcement obtained from task completion, indicating that matching was established with these 2 participants. Choice responding of the third participant was not sensitive to the relative rates of reinforcement. The results of Experiment 2 showed that responding shifted towards the easier task when response effort was manipulated across the two workstations, indicating that changes in task difficulty caused deviations from matching. These results are consistent with the findings by other investigators (Cuvo et al., 1998; Lannie & Martens, 2004; Neef & Lutz, 2001; Neef et al., 1994).

Cuvo et al. (1998) showed how students shifted their preference towards the more difficult task by altering reinforcement schedules. Cuvo et al. (1998) examined the effects of task difficulty and reinforcement schedule on the choice allocation of typically developing preschool children. Task difficulty was manipulated by tossing a beanbag into a box from either a shorter (low effort task) or a longer distance (high effort task). The investigators arranged the reinforcement schedule such that both low and high effort tasks were initially correlated with identical schedules of reinforcement (Continuous Reinforcement [CRF]). In the subsequent conditions, the schedule for the high effort task was gradually enriched compared to the low effort tasks. For example, under concurrent FR 5/low- CRF/high, participants received reinforcement after correctly tossing five beanbags in the box from the shorter distance while they earned a reinforcer every time they correctly tossed a beanbag from the longer distance. Results of this study indicated that when the programmed reinforcement schedules were the same for both tasks, participants chose the easier option which had a high probability of success. When the difficult task was associated with the richer schedule, participants switched preferences towards these tasks although they had a lower probability of success.

The findings by Cuvo et al. (1998) showed that student responding can be biased towards the more difficult tasks when they are on a relatively richer schedule of reinforcement. The authors showed that the difficulty level of the work task affected the probability of reinforcement. As the difficulty level of a task increased, it reduced the probability of obtaining reinforcement from completing that task. Therefore, although both tasks were on the same FR schedule, the probability of reinforcement was on different VR schedules. In this case, participants' choice allocation may have been actually influenced by the concurrent VR schedules.

Effects of Task-Related Contingencies on Choice

Studies have examined the relation between on-task behavior and academic performance following the use of task-related reinforcement contingencies (Lannie & Martens, 2004; Lentz, 1988; Rosenberg, Sindelar, & Stedt, 1985). Some examples of task-related contingencies were reinforcement contingent on correct task completion or on on-task behavior. In previous studies, students were assigned reinforcement contingencies and were not allowed to choose among the contingencies associated with the tasks. The purpose of the study by Lannie and Martens (2004) was to examine student's choice allocation across two stacks of math worksheets as a function of type of reinforcement contingency with easy and difficult problems. During the easy problem condition, the students could choose between two stacks of easy or mastery skill level problems with each stack associated with a different reinforcement contingency (accuracy-based or time-based). During the accuracy-based contingency, students earned a token for correctly completing a certain number of math problems. During the time-based contingency, students earned tokens each time they were observed to be engaging in on-task behavior. During the difficult problem condition, the students could choose between two stacks of problems which were at a difficult or frustrational skill level. One of the sets of math problems was associated with the accuracy-based contingency while the other was associated with the time-based contingency. Students could alternate between the two stacks at any time during each of the two conditions. Results indicated that 3 of the 4 students increased their obtained reinforcement rates by completing more digits correctly under the accuracy-based contingency with easy problems and by completing more digits correctly under the time-based contingency with difficult problems. The mean number of tokens earned by the students suggested that the pattern in which the students allocated their choices across tasks and contingencies resulted in an increase in the obtained rates of reinforcement in each condition. The results suggested that it might be helpful to match reinforcement contingencies with a student's proficiency level because students might prefer specific task contingencies (accuracy-based or time-based) depending on their skill level (mastery or frustrational level) and their preferences might result in an increase in the obtained rates of reinforcement when working on the task.

Effects of Types of Reinforcement on Choice

Although the majority of research studies have examined the effects of altering positive reinforcement on choice responding, applied studies have also studied manipulations of negative reinforcement within a concurrent schedules arrangement (Harding et al., 1999; Hoch et al., 2002; Peck et al. 1996; Piazza et al., 1997). For example, Hoch et al. (2002) studied the effects of positive and negative reinforcement on task completion and problem behavior of 3 children within a concurrent operants design in a school setting. A functional analysis was first conducted to identify the reinforcement contingencies maintaining problem behavior. Results of the functional analyses showed that problem behavior was maintained by negative reinforcement. During intervention, specific contingencies were arranged for task completion and problem behavior in each condition. During all three intervention conditions, every occurrence of problem behavior resulted in negative reinforcement (i.e., FR1 schedule) in the form of escape from the tasks for a brief period of time. The specific contingencies that applied to task completion were as follows: (a) During the no-reinforcement condition, there was no reinforcement provided for task completion; (b) during the negative reinforcement/preferred activities condition, students were provided with a break and given access to preferred activities contingent on the completion of one task; and (c) during the negative reinforcement condition, students were provided with a break from work after the completion of one task but did not have access to preferred activities during that break. Results of the intervention conditions indicated that immediate and sustained decreases in problem behavior and increases in task completion occurred during the negative reinforcement/preferred activities condition when problem behavior resulted in a break and task completion produced a break with access to preferred activities. Following the intervention conditions, maintenance of behavioral outcomes was evaluated under conditions of increased response requirements and leaner schedules of reinforcement. Problem behaviors continued to be reinforced with a break on an FR1 schedule during the maintenance sessions. The contingencies for task completion during the maintenance sessions were as follows: (a) Students were required to complete a larger number of academic or vocational tasks to receive a break with access to preferred activities, (b) the duration of reinforcement (the break with preferred activities) was increased to a length of time comparable to the duration of work breaks given to the student's peers, and (c) maintenance sessions were conducted with novel people or teachers who used novel tasks. During the maintenance sessions, participants completed all their tasks and problem behaviors never occurred, indicating that treatment gains were maintained during these follow-up sessions.

Peterson, Frieder, Smith, Quigley, and Van Norman (2009) evaluated the effects of varying the quality and duration of negative reinforcement on three concurrently available response options, problem behavior, mands for breaks, and mands for work with 7 children with developmental disabilities. A functional analysis conducted with the children revealed that problem behaviors were maintained by negative reinforcement (breaks from task demands). Reinforcer dimensions such as quality and duration of reinforcement was manipulated by providing a longer break with access to preferred toys and attention for mands relative to a shorter break with no access to preferred toys or attention for problems behavior. Results of this study indicated that all the participants' choice responding was sensitive to changes in quality and duration of reinforcement and they always preferred the response option associated with the highest quality and longest duration reinforcer. Thus, increases in quality and duration of reinforcement biased choice responding towards mands even though problem behaviors produced breaks from task demands.

Implications of Choice Evaluation

The studies by Neef, Mace, and colleagues on concurrent choice assessment showed how the relative potency of different variables can be measured in a school setting. For example, in Neef et al. (1992), when the reinforcers associated with both tasks were of equal quality, there was correspondence between time allocation and obtained reinforcement, suggesting that matching occurred. However, when the quality of the reinforcers was manipulated, the participants allocated more time to the math tasks resulting in the higher quality reinforcer (nickels), even when they were provided on a leaner schedule of reinforcement. These results suggested that the effects of reinforcer quality overrode the effects of reinforcer rate for all 3 participants. The results demonstrated that matching is an outcome based on the interaction of multiple variables rather than a process of choice allocation across tasks. Neef et al. (1993) suggested that an assessment of individual sensitivities to dimensions of reinforcement might be useful in developing more effective treatment programs. Specifically, the study showed that response allocation of individuals who are impulsive in making choices can be biased towards a targeted response by reducing the delay to reinforcement. The authors manipulated dimensions of reinforcement and found that increasing the quality of the delayed reinforcers influenced the choice responding of 1 student. The results also suggested that preferences may be changed by increasing the delay to reinforcement. Thus, increasing delays to reinforcement may be one strategy for decreasing problem behavior.

Neef et al. (2001) examined the effects of manipulating dimensions of reinforcement and showed that choice of students with ADHD was primarily influenced by reinforcer immediacy. The assessment also identified a reinforcer dimension that effectively competed with immediacy, and this was then used in combination with gradually increasing delays to reduce impulsivity. For example, the results of 1 student showed that immediacy and quality of reinforcement were identified as the most influential dimensions. When both of these dimensions were manipulated, this student favored the higher quality (preferred) alternative even when the delay to the reinforcer was systematically increased. Thus, the study showed how choice evaluations can be used to develop effective interventions.

Neef et al. (1994) extended previous findings (Mace et al., 1994; Neef et al., 1992; Neef et al., 1993) by examining the combined effects of response and reinforcement dimensions on time allocation between the two sets of concurrently available math problem. Results of the study indicated that choice responding was differentially affected by response and reinforcer dimensions and that these patterns of choice responding varied across the participants. In a concurrent choice assessment, the value of the reinforcer needs to be analyzed in relation to the other reinforcers that are available. The study potentially extends the research on functional analysis in two ways. First, analyses might be conducted on the reinforcers available in the natural setting for competing responses within a concurrent schedules design. These results could be compared to those obtained within a single reinforcement schedule to determine under what schedule conditions variability occur in these behaviors. Second, choice assessments would evaluate the reinforcement dimensions that influence concurrently available alternatives to behavior. The results of these analyses would appear to have important treatment implications for individuals engaging in problem behaviors. For example, if the results of the assessment reveal that an individual's choice is most influenced by the immediacy of reinforcement, then treatment strategies should arrange for immediate reinforcers following desirable behavior.

Similar to the results in Neef et al. (1994), the study by Cuvo et al. (1998) showed that reinforcer and response dimensions have a combined influence on choice allocation in applied settings. The authors suggested that educators be sensitive to the need to adjust dimensions of reinforcement and task variables to influence choice patterns. For example, the results of Experiment 2 showed that the preschoolers selected the easier task when identical reinforcements were available for both easy and difficult tasks. Shifts in choice responding towards the difficult tasks occurred when the schedule for easy tasks was thinned in comparison to the more difficult tasks, suggesting that schedules or rates of reinforcement were influential dimensions that affected choice. Thus, student preferences might be biased towards difficult tasks by associating these tasks with a richer schedule of reinforcement.

In relation to task difficulty, Lannie and Martens (2004) showed that students increased their obtained rates of reinforcement by selecting the accuracy-based task contingency (rewards based on problems correctly completed) when completing easy problems and by choosing the time-based contingency (rewards based on on-task behavior) with difficult problems. Results indicated that matching the type of contingency to the difficulty level of the task may increase the obtained rates of reinforcement from that task. For example, students might earn more rewards when a time-based task contingency is paired with difficult tasks. Higher obtained reinforcement rates may thereby increase the student's motivation to engage in the difficult task. The results suggested that as a student's skill level improves, the task contingencies should be changed to appropriately match it with the student's skills. For example, if a student performs a task at the acquisition skill level, a time-based task contingency might be provided for completing those tasks. As the skill level of the student improves and he or she begins to perform the task fluently, the task contingency might also be altered by matching an accuracy-based contingency with those tasks. Sometimes teachers are reluctant to provide easy tasks to students even when the students may not possess the necessary skills to complete more difficult tasks. In such a situation, teachers may increase reinforcement and student motivation by arranging a time-based reinforcement contingency for completing the difficult tasks.

Hoch et al. (2002) and Peterson et al. (2009) examined the use of concurrent reinforcement schedules to reduce negatively reinforced problem behaviors without the use of procedures such as escape extinction which involve the termination of negative reinforcement following problem behaviors. Caregivers often find it difficult to consistently implement extinction procedures in applied settings. This is because extinction procedures may result in bursts of problem behaviors or the occurrence of new topographies of problem behavior. Also, in some situations, it may not be feasible to continue presenting tasks to an individual displaying problem behavior. A concurrent schedules arrangement in which schedules of reinforcement are manipulated for alternative responses may be a more feasible approach of reducing problems behaviors maintained by negative reinforcement. Results of the study by Hoch et al. (2002) indicated that immediate and sustained decreases in problem behavior and increases in an alternative appropriate behavior (task completion) occurred when task completion produced a break with access to preferred activities while problem behavior resulted in a break without preferred activities. Similarly, Peterson et al. (2009) showed that when both mands and problem behaviors produced breaks from task demands, participants preferred mands that were associated with a higher quality and longer duration of break relative to the problem behaviors.

Reed and Martens (2008) provided further evidence that matching assignments with student's skill levels may result in higher rates of work completion and increased motivation for task engagement. Students may not engage in difficult tasks when easier task alternatives are concurrently available to them. Thus, providing students with assignments that are appropriate for their skill levels may enhance task engagement and completion. On the other hand, when students are not provided with instructionally matched assignments, they may feel frustrated and avoid engaging in those tasks. Reed and Martens (2008) showed that when students were given a choice between an easy and a difficult task, they showed a bias for the easier choice option even when the difficult task was associated with a richer schedule of reinforcement. Thus, enriching schedules of reinforcement may not be sufficient to shift student preferences towards the more difficult tasks.

Summary

The current investigation extended previous literature that identified variables affecting choice responding of academic tasks in school settings. As discussed in this chapter, choice allocation across concurrently available tasks is most often influenced by an interaction of response (task difficulty) and reinforcement (rate, quality, immediacy, and magnitude) dimensions. Studies have shown how students allocate their responding between tasks of varying difficulty levels (e.g., easy and difficult task). Particularly, studies have identified environmental conditions under which students shift their preferences from one response choice to the other. Researchers are interested in increasing student engagement in academic tasks without decreasing the demand level of the task. Thus, more studies are needed that would manipulate reinforcer dimensions and task difficulty in a concurrent schedules design to increase the probability that students choose the more difficult tasks over the easier ones.

Most of the previous studies on choice assessments show how reinforcement and response dimensions affect choice responding. There is very little research on the use of antecedent academic variables such as instructional strategies on student choice of tasks across difficulty levels. Implementation of instructional strategies is important as researchers (Neef et al., 1994; Reed & Martens, 2008) have shown that enriching reinforcement schedules associated with difficult tasks may not be sufficient to shift student preferences towards these tasks. The purpose of the current study was to evaluate the combined effects of manipulating positive reinforcement (a richer schedule associated with high effort tasks vs. leaner schedule for low effort tasks) and response effort (low and high effort tasks) on choice allocation of students. The current investigation implemented fluency training strategies to increase the fluency rate of students on difficult math tasks, such that the difficulty levels of both easy and difficult tasks were equivalent. The study further evaluated how students changed their choice allocation across tasks following the use of these fluency strategies.

CHAPTER III

METHODOLOGY

Participants

Participants were 4 children (see Table 1) who attended second grade in an elementary school in eastern Iowa. The criteria for inclusion in this study were: (a) participant was between the ages of 6 and 12 years, (b) participant's math fluency level was below grade level based on curriculum-based assessment, (c) participant was referred by his or her teacher as benefiting from additional math instructional support, and (d) participant was receiving academic intervention services (e.g., math strategies, extra classroom time) to improve math performance. The primary investigator obtained consent from the participants' parents to enroll the children in this study.

Alex was significantly below his peers in math, reading, written language, and behavior. His Individual Education Plan (IEP) indicated that on second-grade mixed addition and subtraction math computation probes, he scored three digits correct, which is at the 3rd percentile. He had been on intensive instruction plans for math and reading since first grade, and his progress showed that he was in need of academic IEP goals in the areas of math, reading, writing, and behavior. His teacher reported that Alex used his fingers to count single-digit addition problems. He could not independently complete two-digit plus one-digit addition problems and needed manipulatives such as post-it notes to cover one side of the problem to solve it.

Tina was below grade level in math and reading. Tina had a diagnosis of Disruptive Behavior Disorder and had an IEP for behavior concerns. Her IEP also indicated that she was making steady growth in math and reading, but was still performing below her peers. She received one-on-one instruction in math and social skills during her school day, and her progress continued to be assessed as the year progressed. Information from her teacher indicated that she could independently complete one-digit plus one-digit addition problems. She had difficulty with two-digit plus one-digit addition problems and required instructional strategies and manipulatives (e.g., number line, post-it notes) to complete these tasks.

Henry had an IEP for behavior concerns. His IEP indicated that he was most successful with adult support and in small group settings. He had difficulty attending to tasks that were not preferred. His class report card indicated that he was working to become proficient with basic addition, subtraction, time, and money skills. Teacher recommendations included continuing to study basic addition and subtraction facts. Henry was integrated into the general education setting for all but 1 hr of his school day when he was pulled out for individual math instruction and social skills instruction. According to teacher information, Henry used his fingers (touched fingers to nose to count total) to solve one-digit addition problems. He could not complete two-digit plus one-digit addition problems independently and needed assistance (e.g., prompts to recall concepts) to solve them.

Jake's class report card indicated that he demonstrated proficiency with basic addition and subtraction facts some of the time. He needed support from school staff to apply appropriate strategies to solve mathematical problems. He struggled with counting money and identifying coins and needed practice in that area. During the school year, he had a successful 45-day trial out of special education services and had shown that he was ready to participate in the general education curriculum without special education services. His teacher reported that he could independently complete one-digit addition problems but needed frequent prompts and instruction to recall concepts to complete two-digit plus one-digit addition problems.

Setting

The study was conducted in the participants' elementary school. The investigator visited the participants' school four times per week between 9:30 and 11:30 a.m. to conduct the sessions. This 2-hr time period occurred when the participants usually received additional one-on-one instructional support in academic areas such as math and reading. All sessions were conducted in a behavior disorder classroom down the hall from the students' classrooms. The participant was seated on a chair in front of a round desk with the investigator sitting on a chair beside the participant.

Materials

Preliminary Assessment Materials

Preliminary curriculum-based assessment probes (Shapiro, 1996) were administered to assess each student's math computational skills. Based on teacher information, math worksheets were created such that each worksheet consisted of problems at a specific difficulty level. The worksheets for Alex and Henry consisted of counting objects (up to 5) and one- plus one-digit addition problems that summed up to 10. The worksheets for Tina consisted of counting objects (up to 7) and one- plus one-digit addition problems that summed up to 10. The worksheets for Jake included one- plus one-digit addition problems that summed up to 10 and two- plus one-digit addition problems that summed up to 30 with regrouping. The one- plus one-digit problems that summed up to 10 and two- plus one-digit problems with regrouping that summed up to 30 were created from a website (www.interventioncentral.org), and the counting objects worksheets were created by the investigator. All worksheets were printed on 8.5- by 11-in. white paper and consisted of more math problems than the students could complete in the allotted 1-min period. The investigator used a timer to inform the participants of the beginning and end of each session. A USB digital video camera was placed on a tripod about 2 ft in front of the participant's desk to record the sessions.

Preference Assessment Materials

A multiple-stimulus (without replacement) preference assessment (DeLeon & Iwata, 1996) was conducted prior to each of the experimental conditions in the choice assessment Phases 1 and 2 to identify participants' preferred items and activities. The two categories of potential reinforcers that were identified for each student consisted of tangible items (e.g., ball, pen, bubble tubes, stencil) and classroom activities (e.g., computer time, reading books, carpet toys, board game). A USB digital video camera mounted on a tripod was used to record each preference assessment session.

Concurrent Choice Assessment Materials

During the choice assessment conditions, two stacks of index cards with math problems written on them were placed on the desk in front of the participant. Each stack consisted of unlined index cards (7.6 cm by 12.7 cm) with one math problem vertically written in the center of each card. One of the stacks consisted of white index cards and the other stack was colored index cards. The stack of white index cards consisted of math problems that were identified as low effort tasks for the 4 participants. The stack of colored index cards consisted of math problems that were identified as high effort tasks for the 4 participants. The colors of the index cards varied across the participants: yellow for Alex and Tina, green for Jake, and orange for Henry. The white and colored stacks of index cards served as discriminative stimuli for the different reinforcement schedules and helped the secondary observer to record choice responses of the participants from the video recordings. Two prompt cards were placed beside each stack of index cards and consisted of unlined index cards (7.6 cm by 12.7 cm) with a number written in the center of each card. The number on the card represented the number of problems the participant was required to complete correctly to earn a token. The color of the prompt cards matched the color of the two stacks of index cards. For example, if the two stacks of index cards consisted of white and yellow cards, the two prompt cards were also white and yellow in color and placed next to each stack. Prompt cards were used as visual cues to indicate to the participants the number of problems they were required to successfully complete to earn tokens. Three sharpened pencils were placed beside the index cards. The investigator used a timer to indicate to the participant the beginning and end of each session. Two transparent plastic cups were placed in front of each stack of index cards. During the experimental conditions, tokens in the form of golden colored coins were placed in the plastic cups. The investigator used recording sheets (see Appendix B) to score the participants' responses during both choice assessment phases. One of the students, Tina, used a manipulative to complete high effort problems during the first choice assessment phase. The manipulative consisted of an 8.5- by 11-in. white paper with a number line drawn in the center of the page. A USB digital video camera was used to record each session. The video camera was placed on a tripod about 2 ft in front of the participant's desk to record the sessions.

Fluency Training Materials

The fluency training sessions were conducted to increase fluency rate on high effort tasks. White flashcards (8 cm by 12 cm) with one- plus one-digit addition problems (that summed up to 10) written vertically were used during training with a model-prompt-check strategy (Miller & Hudson, 2007). During the partial sums addition strategy (University of Chicago School Mathematics Project, 2007), a prompt card consisting of an orange unlined index card (7.6 cm by 12.7 cm) was placed on the desk in front of the participant. The different steps of the strategy were written in the center of the prompt card. Unlined orange index cards (7.6 cm by 12.7 cm) with one high effort math problem written vertically in the center of each card were used to provide the participant with multiple opportunities to practice this strategy. Following fluency training, students were presented with math worksheets that consisted of 8.5- by 11-in. white papers with high effort math problems written on them. The investigator used a timer to inform the participants about the beginning and end of each probe. The participants were provided with pencils and at the end of each session were required to graph their digits correct per minute (DCPM) scores on 8.5- by 11-in. graph papers.

Dependent Variables

Percentage of Time Allocation

The primary dependent variable in this study was the percentage of time the student allocated to low effort or high effort math problems. During each 5-min session, the student could choose to work on tasks from either the low effort stack or the high effort stack of index cards. Once a student chose a card, he/she was required to complete the problem written on that card. After completing the problem, the student could then choose another card from the same stack or a card from the other stack. The timer was started when the student began writing on the index card that he/she selected from the stack. The timer sounded after 5 min and the student was instructed to stop writing. If the student switched between the two stacks of index cards (e.g., from low effort to high effort tasks) during the session, the observer who was recording data paused the timer that recorded the amount of time the student allocated to the low effort stack once he/she reached for an index card from the other stack (high effort tasks). The timer recording time allocation to the high effort stack was started when the student began writing on the index card that he/she selected. Data were collected on the total time the student allocated to completing the low effort or high effort math problems. Percentage of time allocated to low effort tasks was then calculated by dividing the total time spent completing low effort problems by the total session time (5 min) and multiplying this fraction by 100. Similarly, percentage of time allocated to high effort tasks was calculated by dividing the total time spent completing high effort problems by the total session time (5 min) and multiplying this fraction by 100.

Digits Correct per Minute (DCPM)

DCPM was calculated based on student performance on math probes. DCPM is used as a measure of math accuracy and fluency (Roberts & Shapiro, 1996). DCPM is sensitive to changes in instructional interventions and can be used to measure student's skill level in mathematics (Lannie & Martens, 2004). DCPM was calculated by scoring the number of correct digits in their proper place divided by the time spent working on the math probes. For example, an addition problem, 18 + 4 = 22, would be scored as 2 digits correct, whereas 18 + 4 = 20 would be scored as 1 digit correct.

Total Token Coins Delivered

Token coins were delivered contingent on correct completion of math problems (depending on the reinforcement schedule during the experimental condition). During each experimental condition, the students were instructed that they could earn token coins for a given number of problems completed correctly. The number of problems depended on the condition in effect. The visual prompt card indicating the number of problems the student was required to complete correctly to receive a token coin was placed beside each stack of index cards. The investigator delivered token coins in the two plastic cups placed in front of each stack of index cards. At the end of each 5-min session, the students counted the number of tokens they received and exchanged them for reinforcers that they had selected prior to each condition. The students could exchange every three tokens earned for one preferred reinforcer at the end of each session.

Independent Variables

Concurrent Reinforcement Schedules

The participants were allowed to choose a math problem from two stacks of index cards consisting of low effort and high effort math problems. The paired fixed-ratio (FR) reinforcement schedules associated with the index cards were as follows: FR8 FR8, FR8 FR4, FR8 FR2, FR8 FR1, and FR4 FR8. The first number in each pair represented the schedule value for the low effort tasks and the second number represented the schedule value for the high effort tasks. All reinforcement schedules except for FR4 FR8 required more work for the low effort tasks versus the high effort tasks to earn the tokens that could be exchanged for back-up reinforcers at the end of each experimental session. Under the FR4 FR8 reinforcement schedule, twice the amount of low effort work was needed to earn a token as compared to high effort tasks.

Low and High Effort Math Problems

There were two stacks of index cards. One consisted of low effort and the other of high effort math problems. The performance of the students on the preliminary curriculum-based assessment (DCPM) was used to determine these two types of problem sets. The low effort problems (DCPM between 14 and 31) and high effort problems (DCPM less than 14) matched the guidelines for instructional and frustrational levels, respectively, in the second grade (Burns, VanDerHeyden, & Jiban, 2006).

Fluency Training Strategies

Group fluency training was conducted with Alex, Tina, and Henry, and individual fluency training sessions were conducted with Jake. Fluency training was conducted to increase math fluency on high effort tasks to levels that were at least equivalent to low effort tasks. A model-prompt-check strategy was implemented with Alex, Tina, and Henry, and a partial sums addition method was implemented with Jake. The fluency training strategies provided students with multiple practice opportunities to ensure mastery of the skills being taught.

Data Collection and Observation System

During the preliminary curriculum-based assessment, the investigator presented the students with math worksheets, with each worksheet consisting of problems at the same difficulty level. For example, one worksheet consisted of only one-digit plus one-digit addition problems and another worksheet consisted of counting objects up to seven. The math worksheets consisted of many more problems than the student could complete in 1 min, and at the end of the session the investigator calculated the DCPM and wrote it on the worksheet. The median score of three 1-min sessions was used to identify the low effort and high effort tasks.

During the preference assessment, the investigator recorded the order in which each participant selected a stimulus during all three trials on a preference assessment recording form (see Appendix C). The potential reinforcers were listed on the left side of the recording form. There were four tangible items and four classroom activities available. Selection percentages were calculated by dividing the number of times an item/activity was chosen by the number of trials in which it was available. These percentages were then rank ordered from 1 (highest) to 8 (lowest).

During the forced choice sessions and the concurrent choice assessments, data on the participant's choice behavior, time spent on low effort and high effort problems, digits correct per minute, and total tokens delivered were recorded via an event recording system. During each session, the investigator used a separate recording form (see Appendix B). The top portion of each recording form included the date, name of the primary or reliability recorder, name of the participant, and the condition and session in which the data were recorded. The middle portion of each recording form consisted of two columns titled low effort and high effort. In the left column, the recorder marked the number of low effort math problems that the student completed. In the right column, the recorder noted the number of high effort math problems that were completed. The investigator marked 1, 2, 3, as the student solved the 1^{st}, 2^{nd}, and 3^{rd} problems correctly from either the low effort or high effort stack of index cards. A correct response was assigned a number and an incorrect response was marked as a cross. This scoring system signaled to the investigator the total number of problems correctly completed and when it was time for reinforcement delivery. As the student proceeded with completing the problems, the investigator delivered token coins in the two transparent plastic cups placed in front of each stack of index cards (depending on the reinforcement schedule during that condition). The bottom section of the recording form included a table for calculating the following variables at the end of each session: total number of tokens delivered; total digits correctly completed; the digits correct per minute (DCPM), which was calculated by scoring the number of correct digits in their proper place divided by the time spent working on the math probes; total time engaged in completing problems; and the percentage of time spent responding to low effort or high effort problems, which was calculated by dividing the time spent on either stack of cards by the total session time (5 min) and multiplying the fraction by 100.

During the fluency training phase, the investigator calculated the DCPM on the 1-min timed math worksheets consisting of high effort problems. Each participant then graphed his/her own score on a graph paper. The X-axis on the graph paper represented the number of sessions and the Y-axis represented the DCPM. Each participant had a goal line on the graph that represented the DCPM that he/she was required to achieve for three consecutive sessions. This goal was equivalent to the DCPM on the low effort task that was calculated from the preliminary curriculum-based assessment.

Experimental Design

The investigation was conducted in three phases: (a) Concurrent Choice Assessment 1, (b) Fluency Training, and (c) Concurrent Choice Assessment 2. A concurrent schedules with reversal design was used to identify student response allocation to low and high effort problems under different reinforcement conditions during both choice assessment phases. During the Concurrent Choice Assessment Phase 1, a no-reinforcement contingency was followed by experimental conditions during which choice options were available on concurrent FR schedules. The reinforcement schedule associated with the low effort task remained the same (FR8) while the FR schedule associated with the high effort task was enriched by gradually increasing the number of tokens (by 50%) that the participant could earn by completing the high effort task. Reinforcement schedules continued to be altered until the participant began selecting the high effort tasks. Thus, the concurrent reinforcement schedules following the baseline or no-reinforcement condition were (a) FR8 FR8, (b) FR8 FR4, (c) FR8 FR2, and (d) FR8 FR1. The ordering of the conditions varied across the four participants, and each participant had a unique point when he/she switched from selecting low effort to high effort tasks. Each phase continued until a stable data path of two or more data points was observed or the participant selected one contingency more than 40% of the time consecutively in two sessions. A reversal to the previous reinforcement contingency was implemented when the participant allocated more than 40% of the session time to the high effort tasks for two consecutive sessions. The reversal was conducted to observe whether the students' choices changed after they successfully completed the high effort tasks and whether they switched back to completing low effort tasks when the schedule of reinforcement was reversed to the previous condition. During the Concurrent Choice Assessment Phase 2, the no-reinforcement condition and the schedule manipulations were conducted using the same procedures as in Phase 1. In addition, an FR4 FR8 condition was implemented following the FR8 FR8 condition for Jake and Tina. During the FR4 FR8 condition, the participants were required to complete half the number of low effort problems as compared to high effort problems to earn a token. This condition was implemented to observe whether the two participants switched to selecting low effort tasks after exclusively allocating their time to high effort tasks under the no-reinforcement and FR8 FR8 conditions.

The fluency training phase was conducted as an AB case study design in which A represented pre-fluency training DCPM data on high effort tasks and B represented the post-fluency training DCPM data on those tasks.

Procedures

Preliminary Curriculum-Based Assessment

A curriculum-based assessment screening procedure was administered to each student to identify low effort and high effort math problems (Roberts & Shapiro, 1996). During this assessment, students were presented with brief 1-min timed worksheets, each containing one specific type of math problem (e.g., adding two one-digit numbers that sum up to 10). The problems were selected from first- to third-grade level math skills as determined by classroom math text books and teacher information. Each participant's teacher was provided with a list of problem types and asked to identify (a) problems that the student could complete accurately and fluently, and (b) problems that the student could complete accurately but not fluently. Each worksheet consisted of more problems than the student could complete in 1 min. The investigator read a standard instruction to the student before presenting the worksheet each day. A timer was used to indicate to the student when he/she was required to start and stop writing on the worksheet. When the timer sounded after 1 min, DCPM scores were calculated to determine each student's performance. Worksheets with problems at the same difficulty level were presented three times in a row, and the median DCPM score was obtained. The median DCPM score was used to determine the low effort and high effort tasks for each participant. The low effort problems (DCPM between 14 and 31) and high effort problems (DCPM less than 14) matched the guidelines for instructional and frustrational levels, respectively, in the second grade (Burns et al., 2006). The results of the curriculum-based assessment indicated that the low effort problems for Alex and Henry consisted of counting objects up to 5, the low effort problems for Tina consisted of counting objects up to 7, and the low effort problems for Jake consisted of one- plus one-digit addition problems that summed up to 10. The high effort problems for Alex, Tina, and Henry consisted of one- plus one-digit addition problems that summed up to 10, and for Jake these problems included two- plus one-digit addition problems with regrouping that summed up to 30.

Preference Assessment

The preference assessment was conducted prior to each of the experimental conditions during the first and second choice assessment phases. The items and activities included in the preference assessment were selected based on preliminary information provided by the participants. During each preference assessment session, the investigator placed an array of eight stimuli consisting of tangibles and pictures of activities on the table in front of the participant. The participant was instructed to choose the item that he/she liked the most and then received 10 s of access to that item or activity. After the participant received access to the item or activity, it was removed from the table, and the remaining items were repositioned in a randomized manner. The participant was instructed to choose the item that he/she liked the most from the remaining seven stimuli on the table. This process continued until all eight stimuli were selected and then the entire process was repeated consecutively two more times with each participant. The investigator ranked the participants' choices in the order they were selected on a preference assessment sheet (Appendix C). Selection percentages were calculated by dividing the number of times a stimulus was chosen by the number of trials in which it was available (Carr, Nicolson, & Higbee, 2000). These percentages were rank ordered from 1 (highest) to 8 (lowest). The top five stimuli were then included in the rewards menu that was presented at the end of each experimental session during the choice assessments.

Concurrent Choice Assessment Phase 1

Baseline. Two stacks of index cards, one consisting of low effort problems and the other of high effort problems, were placed in front of the participant. The participants could choose to work on tasks from either of the stacks. Once they chose a card, they had to complete the problem written on that card. After completing the problem, they could then choose another card from the same stack or a card from the other stack. They were instructed to complete as many problems as they could in 5 min. No reinforcement was provided during the baseline condition.

Forced choice sessions. Forced choice sessions were conducted prior to reinforcement schedule manipulation to expose the participants to the conditions during these contingencies. The investigator read from a script explaining how each participant could earn tokens by correctly completing the problems written on the index cards. The participants were informed that these were practice sessions to help them experience the contingencies during the choice assessment and that no reinforcement would be provided during these sessions. The investigator asked the participants questions to ensure that they understood her instructions. Two identical stacks of index cards were placed in front of the participant. For the first forced choice session in each reinforcement condition, both stacks of index cards consisted of the low effort tasks. For example, in a forced choice session conducted prior to a FR8 FR4 contingency where FR8 represented the reinforcement schedule for the low effort task and FR4 represented the reinforcement schedule for the high effort task, the first forced choice session would include two stacks of eight low effort index cards. Transparent plastic cups were placed in front of the two stacks and the participant was instructed to choose a card from either of the low effort card stacks and complete the math problem written on the card. The investigator placed a token in the plastic cup once the participant completed eight low effort problems correctly. During the second forced choice session under FR8 FR4, the participant was required to choose a card from either of the two stacks containing four high effort index cards. A token was delivered in the plastic cup placed in front of the two stacks once the participant completed four high effort problems correctly.

Concurrent reinforcement schedules and reversals. Concurrent fixed- ratio (FR) schedules of reinforcement were arranged to identify each participant's choice patterns when presented with low and high effort tasks. Participants were allowed to choose an index card from either of the stacks and could switch between the two stacks at any time during a session. The session started when the timer sounded and the participant picked an index card to complete the problem written on it. The session ended when the timer beeped after 5 min. The concurrent FR schedules implemented after the no-reinforcement condition were as follows: FR8 FR8, FR8 FR4, FR8 FR2, FR8 FR1. Thus, the amount of work associated with each choice varied across conditions such that more work needed to be completed for the low effort tasks versus the high effort tasks to earn the tokens. Specifically, the amount of high effort work required to earn tokens was reduced by 50% in each successive condition.

Concurrent FR8 FR8 schedule. During this condition, both low effort and high effort tasks were associated with identical schedules of reinforcement. The investigator placed a token in the plastic cups once the participant completed eight problems correctly from either the low or high effort tasks. Prompt cards in the form of two index cards with eight written on them were placed beside the two stacks of cards to show the participants the number of problems they were required to complete to earn a token. The participant could exchange every three tokens earned for one preferred item at the end of the 5-minute session. Among the participants, Tina was allowed to use a manipulative (a number line chart) to complete the high effort problems. Phase changes were initiated when a stable data path of two or more points was established or when one contingency was selected for more that 40% of the time for two or more consecutive sessions. The position of the index cards was alternated between the right and left hand side of the participant to control for location preference.

Although less work was required to earn tokens when the participants chose high effort tasks, the initial fluency rates at which the participants completed the tasks were such that they could initially earn more tokens by completing the low effort tasks. The initial fluency rates determined from the results of the curriculum-based assessment are presented in Table 2. Based on these fluency rates, it was expected that Alex could complete 75 low effort problems in 5 min under FR8 FR8. During this condition, the investigator provided one token for every eight problems correctly completed. It was expected that he could earn 9.3 (75/8) tokens for completing low effort problems at the end of the 5-min session. Similarly, for high effort problems, it was expected that Alex could complete 30 problems in 5 min and earn 3.75 (30/8) tokens at the end of the session. These calculations indicate that he could earn 5.5 tokens more by completing low effort problems under the FR8 FR8 schedule. Thus, it was hypothesized that Alex would allocate the majority of his time to selecting low effort problems under FR8 FR8. Similar hypotheses were made for Henry, Tina, and Jake based on the results of the curriculum-based assessment (see Table 2). Under FR8 FR8, Henry could complete 125 low effort and 35 high effort problems in 5 min and thereby earn 15.6 and 4.3 tokens for low and high effort tasks, respectively. Thus, Henry was expected to earn more than three times the number of tokens when completing low effort problems and thus to allocate time to low effort problems. Tina and Jake had the same initial problem completion rate per minute. Both students could complete 100 low effort problems and earn (100/8=12.5) tokens at the end of the session. For high effort tasks, they could complete 15 problems in 5 minutes and thereby earn 1.8 tokens. Thus, Jake and Tina were expected to earn 10.7 more tokens when completing low effort problems and thus allocate most of their time selecting these problems. See Table 3 for a summary of the number of tokens that each participant was expected to earn from completing low and high effort problems.

Concurrent FR8 FR4 schedule. During this condition, the low effort tasks were associated with a leaner schedule of reinforcement as compared to the high effort tasks. During this contingency, the participant was required to complete eight low effort problems in order to earn a token or complete four high effort problems to earn a token, using the procedures described above. In other words, the participant was required to complete twice the amount of work to earn a token if he/she chose to complete the low effort problems.

Based on the initial problem completion rates (Table 2), hypotheses were made regarding how students would allocate their responses between low effort and high effort tasks under the FR8 FR4 reinforcement schedule. Using similar calculations as described above, it was expected that the number of tokens Alex could earn by completing low effort tasks (75/8= 9.3) would be more than those earned from high effort tasks (30/4=7.5). For Henry, it was hypothesized that he would allocate most of his responses to the low effort tasks because he could earn more tokens for completing those tasks than for high effort tasks. Similar hypotheses were made for Jake and Tina, who were expected to earn 8.75 more tokens if they chose low effort tasks as compared to high effort tasks under FR8 FR4.

Concurrent FR8 FR2 schedule. The schedule of reinforcement for the low effort tasks became even leaner as compared to the high effort tasks for this contingency. The participant was required to complete eight low effort problems in order to earn a token or complete two high effort problems to earn a token, using the procedures described above.

Based on the initial problem completion rates, it was expected that Alex and Henry would switch to completing high effort problems under FR8 FR2 as the number of tokens they could earn by completing high effort tasks (30/2=15) would be more than those earned from low effort tasks (75/8=9.3). It was predicted that Tina and Jake would continue to earn more tokens by completing low effort problems under FR8 FR2.

Concurrent FR8 FR1 schedule. During this contingency, the participant was required to complete eight low effort problems in order to earn a token or complete only one high effort problem to earn a token, using the procedures described above. Based on the initial problem completion rates, it was expected that Tina and Jake would switch to completing high effort problems under FR8 FR1 as the number of tokens they could earn by completing high effort tasks would be more than those earned from low effort tasks.

Fluency Training Phase

Group fluency training was conducted with Alex, Tina, and Henry, and individual training sessions were conducted with Jake to increase their math fluency rates on high effort problems such that DCPM on high effort tasks were equivalent or higher than the DCPM on low effort tasks. Model-prompt-check strategy was conducted in a group for Alex, Tina, and Henry because the curriculum-based assessment identified the same high effort tasks (one- plus one-digit addition problems that summed up to 10) for them. Partial sum addition methodology was conducted individually with Jake, whose high effort task included two-digit plus one-digit addition problems (with regrouping) that summed up to 30.

Group fluency training. The group fluency training consisted of three stages: Model-prompt-check, group answer, and individual answer. The investigator used a script to implement the different steps of the training. During the model-prompt-check stage, the investigator showed a flashcard with a math fact written on it and modeled to the participants the correct way to answer the problem. The investigator then prompted the participants to read out the same problem and answer it in a group. Lastly, during this stage, the investigator checked whether the participants understood the correct way to answer the problem by repeating the problem and the answer. The model-prompt-check stage continued until the investigator completed practicing a stack of 10 to 15 flashcards with the participants. During the group answer stage, the investigator instructed the participants to look at the problem on the flashcard, wait for the signal (clap on the table), and then answer it in a group. If a student did not respond with the group, the investigator called out the participant's name and practiced answering the problem with him/her and then repeated it with the group. During the individual answer stage, the investigator showed the flashcard with the math fact to a participant and instructed him/her to answer the problem as fast as he/she could. If the participant responded immediately, the investigator praised him/her and then presented the next flashcard to the next participant. If a participant gave an incorrect response or hesitated (or used fingers), the investigator modeled the correct response by stating the problem and the answer which the participant then repeated.

Partial sum addition methodology. The investigator presented a prompt card to the participant and explained the different steps of the partial sums addition method. She then presented a stack of 10 index cards with two-digit plus one-digit addition problems written on them to the participant and gave him/her 10 to 15 s to provide a correct response. If the participant responded correctly within 15 s, the investigator praised him/her and then presented him/her with the next index card. If the participant provided an incorrect response or did not respond within 15 s, the investigator modeled the correct response by adding the partial sums and writing the answer on the index card. The participant then repeated the model by re-writing the answer on the same index card.

One-minute timings (curriculum-based assessment probes). Following fluency training, the investigator presented all four participants with math worksheets and instructed them to complete as many problems as they could in 1 min. These math probes were conducted to monitor changes in fluency rates on the high effort tasks. The worksheets for Alex, Tina, and Henry consisted of one- plus one-digit addition problems that summed up to 10, and for Jake the worksheets consisted of two-digit plus one-digit addition problems (with regrouping) that summed up to 30. The worksheets consisted of many more problems than the participants could complete in 1 min. At the end of the 1-min timed session, the investigator calculated the DCPM scores on the addition problems and returned the worksheets to the participants who then graphed their individual scores. Each participant had a goal line drawn on their graphs that represented the DCPM score they needed to achieve. This goal was equivalent to the DCPM on the low effort task that was calculated based on the results of the preliminary curriculum-based assessment. The fluency training phase continued until the participants scored on or above their goal line three times in a row.

Concurrent Choice Assessment Phase 2

(Post Fluency Training)

The fluency training phase was followed by Concurrent Choice Assessment Phase 2 during which the effects of reinforcement schedule manipulation and fluency training on choice behavior were examined. The no-reinforcement condition and concurrent FR schedule manipulations (FR8 FR8 and FR8 FR4) were implemented using the same procedures as described in the first choice assessment phase. In addition, for Jake and Tina, an FR4 FR8 reinforcement schedule was implemented following the FR8 FR8 condition. During the FR4 FR8 condition, the low effort tasks were associated with a denser schedule of reinforcement as compared to the high effort tasks. The participants were required to complete four low effort problems in order to earn a token or complete eight high effort problems to earn a token, using the procedures described in the Choice Assessment Phase 1. For Jake and Tina, who exclusively allocated their responding to high effort tasks under the no-reinforcement and FR8 FR8 conditions in Phase 2, the FR4 FR8 condition was conducted to observe whether they changed their choice pattern and selected low effort tasks under this condition.

Visual analysis of the data was used to compare the data obtained in Phase 2 with data from Phase 1. Based on the results of the initial fluency rates, calculations were made that predicted when students would shift response allocation from low effort to high effort tasks in Phase 1. The calculations predicted that Alex and Henry would switch to completing high effort problems under FR8 FR2 because the number of tokens they could earn by completing high effort tasks would be more than those earned from low effort tasks under this condition. It was hypothesized that Tina and Jake would switch and allocate a majority of time to high effort tasks under FR8 FR1. Results of Phase 1 were then compared to Phase 2 to observe whether the shifts in choice allocation to the high effort tasks occurred earlier in Phase 2 as compared to Phase 1.

Reliability and Procedural Integrity

During each preference assessment session, interobserver agreement (IOA) was conducted by having a second observer simultaneously and independently collect data. IOA was calculated during 25% of sessions across all participants and conditions. Percentage agreement was calculated by dividing the number of agreements by the number of agreements and disagreements and multiplying by 100. There was 100% IOA across all sessions during the preference assessment sessions.

During the concurrent choice assessment sessions, IOA was assessed by having the two observers independently score each problem: calculate the DCPM, the total time engaged in completing problems, and the total number of tokens delivered at the end of each session. IOA was obtained during 30% of sessions across all participants and conditions. Percentage agreement was calculated by dividing the number of agreements by the number of agreements and disagreements and multiplying by 100. IOA for Alex’s total time allocation, DCPM, and total tokens was 90.9%, 90.9%, and 100%, respectively. IOA for Henry’s total time allocation, DCPM, and total tokens was 100%. For Jake, IOA for total time allocation, DCPM, and total tokens was calculated at 93%, 87%, and 100%, respectively. For Tina, IOA for total time allocation, DCPM, and total tokens was calculated at 100%, 100%, and 92.8%, respectively.

During the fluency training sessions, both observers independently scored the 1-min timed worksheets and calculated the DCPM score. IOA was calculated during 30% of sessions across all participants. Percentage agreement was calculated by dividing the number of agreements by the number of agreements and disagreements and multiplying by 100. There was 100% IOA during the fluency training sessions.

Procedural Fidelity

The second observer also collected data on procedural fidelity to ensure that the primary investigator adhered to the experimental procedures. For procedural fidelity, scripted experimental protocols were created. During 30% of the sessions, the observer collected data on the occurrence and nonoccurrence of each step of the protocol and recorded whether the primary investigator provided all instructions in the correct order. Procedural fidelity was calculated by dividing the number of agreements by the number of agreements and disagreements and multiplying the fraction by 100. Procedural integrity was 100% across all sessions.

Table 1. Participant Description

Participants	Gender	Age (years)	Grade	Ethnicity
Alex	Male	9	2^{nd}	Hispanic
Tina	Female	8-5	2^{nd}	Hispanic
Henry	Male	9	2^{nd}	Hispanic
Jake	Male	8-5	2^{nd}	Hispanic

Table 2. Results (DCPM) of the Preliminary Curriculum-based Assessment

Participants	Low Effort	High Effort
Alex	15	6
Henry	25	7
Tina	20	3
Jake	20	7

Table 3. Total Tokens the Participants Could Earn Under the Different Reinforcement Schedules

Tina				
	Tokens earned under FR8 FR8	Tokens earned under FR8 FR4	Tokens earned under FR8 FR2	Tokens earned under FR8 FR1
LOW EFFORT	12.5	12.5	12.5	12.5
HIGH EFFORT	1.8	3.75	7.5	15
Alex				
	Tokens earned under FR8 FR8	Tokens earned under FR8 FR4	Tokens earned under FR8 FR2	
LOW EFFORT	9.3	9.3	9.3	
HIGH EFFORT	3.75	7.5	15	
Henry				
	Tokens earned under FR8 FR8	Tokens earned under FR8 FR4	Tokens earned under FR8 FR2	
LOW EFFORT	15.6	15.6	15.6	
HIGH EFFORT	4.3	8.75	17.5	
Jake				
	Tokens earned under FR8 FR8	Tokens earned under FR8 FR4	Tokens earned under FR8 FR2	Tokens earned under FR8 FR1
LOW EFFORT	12.5	12.5	12.5	12.5
HIGH EFFORT	1.8	3.75	7.5	15

CHAPTER IV

RESULTS

Effects of Fluency Training on High Effort Tasks

Table 4 shows the fluency rates on low effort and high effort tasks for all 4 participants prior to fluency training and the fluency rates on high effort tasks post fluency training. The low effort problems (DCPM between 14 and 31) and high effort problems (DCPM less than 14) matched the guidelines for instructional and frustrational levels, respectively, in the second grade (Burns et al., 2006). The low effort problems for Alex and Henry consisted of counting objects up to 5 and those for Tina consisted of counting objects up to 7. The high effort problems for these 3 participants consisted of one- plus one-digit addition problems (sum up to 10). The low and high effort problems for Jake consisted of one- plus one-digit addition problems that summed up to 10 and two- plus one-digit addition problems that summed up to 30 (with regrouping). The right column in Table 1 shows that fluency training increased the DCPM on high effort tasks for all 4 participants such that post training fluency rates were higher than the fluency rates on both low effort and high effort tasks obtained prior to training.

Alex

Choice Allocation in Concurrent Choice Assessment

Phases 1 and 2

The results for Phases 1 and 2 are shown in Figures 1 and 2, respectively. The top panel of Figure 1 shows that Alex allocated more time to low effort tasks (Mean = 99.4%) as compared to the high effort tasks during the initial no-reinforcement contingency (baseline) in Phase 1, which was conducted prior to fluency training. Alex continued to exclusively choose low effort tasks under the FR8 FR8 and FR8 FR4 conditions except for the first session under FR8 FR4. He switched to exclusively selecting high effort tasks under the FR8 FR2 condition**.** During a reversal to FR8 FR4, Alex chose the high effort task for the first session and then switched back to completing low effort tasks during the remaining three sessions. Alex continued to select low effort tasks for 100% of the session time when the no-reinforcement condition was repeated. Thus, prior to fluency training, Alex chose the low effort tasks until the FR8 FR2 schedule condition, meaning that he required four times the reinforcement to select the high effort task

In Phase 2 (top panel of Figure 2), which was post fluency training, Alex exclusively chose low effort tasks under the initial no reinforcement contingency (baseline) and FR8 FR8 conditions. However, he exclusively selected high effort tasks during the FR8 FR4 condition. This result indicated that the switch from low to high effort tasks occurred earlier in Phase 2 as compared to Phase 1when it occurred during the FR8 FR2 condition. A return to FR8 FR8 resulted in his selection of the low effort tasks.

Task Completion and Tokens Earned in Concurrent Choice

Assessment Phases 1 and 2

The data on percentage of time allocation and mean DCPM that are displayed in Figures 1 and 2 are also summarized in Table 5 (Phase 1) and Table 6 (Phase 2). In addition, these tables show the total number of tokens the participants earned during each of the conditions. The bottom panel of Figure 1 shows that the mean DCPM calculated on the low effort tasks across the no-reinforcement (baseline) and the reinforcement conditions was 6.42 (range, 0 to 10.6). The mean DCPM calculated on high effort tasks across the no-reinforcement and reinforcement conditions was 1.87 (range, 0 to 10). Alex earned the highest number of tokens (48) under the FR8 FR2 condition in Phase 1.

The bottom panel of Figure 2 (Phase 2) shows that the mean DCPM calculated on the low effort tasks across the no-reinforcement and reinforcement conditions was 7.1 (range, 0 to 11.4). In the context of high effort tasks, the mean DCPM was 3.0 (range, 0 to 14). Thus, these data indicate that there was a percentage increase in the mean DCPM on both the low effort (10.5%) and high effort (60.4%) tasks from Phase 1 to Phase 2.

The highest number of tokens (43) during Phase 2 was earned during the FR8 FR4 condition. Thus, the highest number of tokens in both Phases 1 and 2 were earned during conditions when Alex switched from low to high effort tasks.

Henry

Choice Allocation in Concurrent Choice Assessment

Phases 1 and 2

The results of Phases 1 and 2 are displayed in Figures 3 and 4, respectively. During Phase 1, Henry responded exclusively to low effort tasks under the no reinforcement (baseline), FR8 FR8, and FR8 FR4 conditions (top panel of Figure 3). During the FR8 FR2 condition, he switched to high effort tasks for 100% of the time for two consecutive sessions. When a reversal to the FR8 FR4 condition was conducted, he allocated responses to both high effort problems (Mean=41.6%) and low effort problems (Mean=56.3%) with an increasing trend for low effort tasks. During a reversal to FR8 FR8, he exclusively chose the option with low effort tasks and persisted with these tasks when the no-reinforcement contingency was repeated. Thus, the switch to high effort tasks occurred under the FR8 FR2 condition, meaning that Henry required four times the reinforcement to switch from low to high effort tasks.

During Phase 2 (top panel of Figure 4) following fluency training, Henry allocated 100% of the time to completing high effort tasks during two consecutive sessions under the no-reinforcement contingency (baseline). The no-reinforcement contingency was followed by FR8 FR8 during which Henry switched back to selecting low effort tasks for the entire time during the last three consecutive sessions. When the schedule of reinforcement was made richer for the high effort tasks during the FR8 FR4 condition, Henry again allocated all of his responses to the high effort tasks. His choice pattern switched when a reversal to FR8 FR8 was conducted during which he allocated his responses to the low effort problems. Thus, these data show that exclusive selection of high effort tasks occurred earlier under the no-reinforcement contingency in Phase 2 as compared to Phase 1, during which it occurred under the FR8 FR2 condition.

Task Completion and Tokens Earned in Concurrent Choice

Assessment Phases 1 and 2

The data on percentage of time allocation and mean DCPM that are displayed in Figures 3 and 4 are also summarized in Table 7 (Phase 1) and Table 8 (Phase 2). In addition, these tables show the total number of tokens the participants earned during each of the conditions. As shown in the bottom panel of Figure 3 (Phase 1), the mean DCPM calculated on the low effort tasks across the no reinforcement (baseline) and the reinforcement conditions was 10.7 (range, 0 to 14.9). The mean DCPM calculated on the high effort tasks across these conditions was 2.1 (range, 0 to 10.9). The highest number of tokens (29) was earned when selecting high effort tasks during the FR8 FR2 condition.

The bottom panel of Figure 4 (Phase 2) shows that the mean DCPM calculated on the low effort and high effort tasks across the no-reinforcement (baseline) and reinforcement conditions were 8.1 (range, 0 to 20) and 6.6 (range, 0 to 15), respectively. Thus, these data indicate that there was a percentage decrease of 24.2% in the mean DCPM calculated on the low effort tasks and a substantial percentage increase of 214.2% in the mean DCPM calculated on the high effort tasks from Phase 1 to Phase 2. In the context of tokens earned, Henry earned the highest number of tokens (42) during the FR8 FR4 condition in Phase 2. Thus, Henry earned the highest number of tokens in Phases 1 and 2 during conditions in which he switched his choice allocation from low to high effort tasks.

Tina

Choice Allocation in Concurrent Choice Assessment

Phases 1 and 2

The results of Phases 1 and 2 are shown in Figures 5 and 6, respectively. The top panel in Figure 5 shows a preference for the low effort tasks across all the sessions under the no-reinforcement (baseline), FR8 FR8, and FR8 FR4 conditions. Tina also allocated a higher percentage of time to the low effort tasks under the FR8 FR2 condition but with an upward trend occurring for the high effort tasks. She switched to exclusively selecting high effort tasks under the FR8 FR1 condition. When reversals to FR8 FR2 and FR8 FR4 were conducted, Tina continued to select high effort tasks. She switched back to selecting low effort tasks when the programmed FR schedule was identical for the two choices (FR8 FR8), and she continued with this choice when the no-reinforcement contingency was repeated. Thus, the switch from low to high effort tasks occurred under FR8 FR1, indicating that Tina selected the high effort tasks only when she had to complete eight times more of the low effort task.

As shown in the top panel in Figure 6, Tina allocated 100% of the time to high effort tasks under the no-reinforcement (baseline) and FR8 FR8 conditions in Phase 2 following fluency training. During the FR4 FR8 condition, when the schedule of reinforcement associated with the high effort tasks was thinned compared to the reinforcement schedule associated with the low effort tasks, Tina switched back to completing low effort problems and continued with this choice under FR8 FR8. She switched choices again and allocated all responses to the high effort tasks under FR8 FR4 when she was required to complete twice the amount of low effort tasks to earn a reinforcer as compared to the high effort tasks. These data show that selection of high effort tasks occurred earlier under the no-reinforcement contingency in Phase 2 as compared to Phase 1 during which it occurred under the FR8 FR1 condition.

Task Completion and Tokens Earned in Concurrent Choice Assessment Phases 1 and 2

The data on percentage of time allocation and mean DCPM that are displayed in Figures 5 and 6 are also summarized in Table 9 (Phase 1) and Table 10 (Phase 2). In addition, these tables show the total number of tokens Tina earned during each of the conditions. The bottom panel of Figure 5 shows that the mean DCPM calculated on the low effort tasks across the no-reinforcement (baseline) and the reinforcement contingencies was 8.1 (range, 0 to 15.2). The mean DCPM calculated on the high effort tasks across all the conditions was 2.8 (range, 0 to 8.2). Tina earned the highest number of tokens (98) when she selected the high effort tasks under the FR8 FR1 condition.

The bottom panel of Figure 6 shows that that the mean DCPM calculated on the low effort tasks across the no-reinforcement (baseline) and reinforcement conditions was 5.2 (range, 0 to 16). In the context of high effort tasks, the mean DCPM calculated across the conditions was 7 (range, 0 to 16). The highest number of tokens (56) during Phase 2 was earned during the FR4 FR8 condition. Thus, these data indicate that there was a percentage decrease of 35.8% in the mean DCPM calculated on the low effort tasks and a percentage increase of 150% in the mean DCPM calculated on the high effort tasks across all the conditions between Phase 1 and Phase 2. The data also show that in contrast to Phase 1 when the highest number of tokens was earned while exclusively selecting high effort tasks under FR8 FR1, the maximum tokens in Phase 2 were earned under FR4 FR8 when Tina chose the low effort tasks alone.

Jake

Choice Allocation in Concurrent Choice Assessment

Phases 1 and 2

Figures 7 and 8 display the results of Choice Assessment Phases 1 and 2, respectively. The top panel of Figure 7 shows that Jake responded exclusively to low effort tasks under the no-reinforcement (baseline) and the FR8 FR8 conditions except for the first session under the no-reinforcement condition. During the FR8 FR4 condition, he allocated a higher percentage of time to high effort tasks (Mean=52.8) as compared to low effort tasks (Mean=44.8). During a reversal to FR8 FR8, he initially selected both low effort (Mean=84.8) and high effort (Mean=14.8) tasks and then responded exclusively to low effort tasks in the last two sessions. He continued to choose the low effort task option when the no-reinforcement contingency was repeated. Thus, these data show that the switch from low effort to high effort tasks occurred under the FR8 FR4 condition in Phase 1.

In Phase 2 (top panel of Figure 8), Jake allocated 100% of the time to high effort tasks during all sessions under the no-reinforcement (baseline) and FR8 FR8 conditions except for one session under FR8 FR8. When the schedule of reinforcement was made relatively denser for the low effort tasks, Jake altered his choice pattern and selected the low effort tasks under the FR4 FR8 condition. During a reversal to FR8 FR8, Jake switched back to the high effort tasks. Thus, these data indicate that allocation of a higher percentage of time to high effort tasks occurred earlier under the no-reinforcement condition in Phase 2 as compared to Phase 1 during which it occurred under the FR8 FR4 condition.

Task Completion and Tokens Earned in Concurrent Choice

Assessment Phases 1 and 2

The data on percentage of time allocation and mean DCPM that are displayed in Figures 7 and 8 are also summarized in Table 11 (Phase 1) and Table 12 (Phase 2). In addition, these tables show the total number of tokens Jake earned during each of the conditions. The bottom panel of Figure 7 shows that the mean DCPM calculated on the low effort tasks across the no-reinforcement (baseline) and the reinforcement conditions was 12.3 (range, 9.2 to 16.6). The mean DCPM calculated on high effort tasks across the no-reinforcement and reinforcement conditions was 2.7 (range, 0 to 12.8). Jake earned the highest number of tokens (27) under the second FR8 FR8 condition in Phase 1.

The bottom panel of Figure 8 (Phase 2) shows that the mean DCPM calculated on the low effort tasks across the no-reinforcement (baseline) and reinforcement conditions was 4.2 (range, 0 to 13.8). In the context of high effort tasks, the mean DCPM was 7.9 (range, 0 to 13.4). Thus, these data indicate that there was a percentage decrease of 65.8% in the mean DCPM on the low effort tasks and a percentage increase of 192.5% in the mean DCPM on the high effort tasks from Phase 1 to Phase 2. The highest number of tokens (52) during Phase 2 was earned during the FR4 FR8 condition. Thus, the highest number of tokens was earned when Jake selected low effort tasks in Phases 1and 2.

Table 4. Median Digits Correct per Minute (DCPM) on Low Effort and High Effort Tasks Prior to and Following the Fluency Training Phase

Participants	**Pre-fluency training Low Effort**	**Pre-fluency training High Effort**	**Post- fluency training High Effort**
Alex	15	6	20
Henry	25	7	27
Tina	20	3	22
Jake	20	7	22

Table 5. Mean % of Time Allocation, Mean DCPM, and Total Tokens Earned Across Low Effort and High Effort Tasks in Phase 1 for Alex

	Low effort tasks			**High effort tasks**		
Experimental conditions	**Mean % of time**	**Mean DCPM**	**Total Tokens**	**Mean % of time**	**Mean DCPM**	**Total Tokens**
No Reinforcement (Baseline)	99.4	9.2	Not applicable	0.4	2	Not applicable
FR8 FR8	100	8.4	15	0	0	0
FR8 FR4	75	6.9	15	25	0.85	2
FR8 FR2	0	0	0	100	6.8	48
FR8 FR4	74	5.7	13	26	3.1	9
No Reinforcement (Baseline)	100	7.1	Not applicable	0	0	Not applicable

Table 6. Mean % of Time Allocation, Mean DCPM, and Total Tokens Earned Across Low Effort and High Effort Tasks in Phase 2 for Alex

	Low effort tasks			**High effort tasks**		
Experimental conditions	**Mean % of time**	**Mean DCPM**	**Total Tokens**	**Mean % of time**	**Mean DCPM**	**Total Tokens**
No reinforcement (Baseline)	100	9.1	Not applicable	0	0	Not applicable
FR8 FR8	100	9.9	18	0	0	0
FR8 FR4	0	0	0	100	12.3	43
FR8 FR8	100	9.4	17	0	0	0

Table 7. Mean % of Time Allocation, Mean DCPM, and Total Tokens Earned Across Low Effort and High Effort Tasks in Phase 1 for Henry

	Low effort tasks			**High effort tasks**		
Experimental conditions	**Mean % of time**	**Mean DCPM**	**Total Tokens**	**Mean % of time**	**Mean DCPM**	**Total Tokens**
No reinforcement	100	12.7	Not applicable	0	0	Not applicable
FR8 FR8	100	11.6	20	0	0	0
FR8 FR4	100	12.6	22	0	0	0
FR8 FR2	31.6	4.3	7	67.8	7.5	29
FR8 FR4	56.3	9.2	12	41.6	6.1	9
FR8 FR8	100	12.8	15	0	0	0
No reinforcement	100	13	Not applicable	0	0	Not applicable

Table 8. Mean % of Time Allocation, Mean DCPM, and Total Tokens Earned Across Low Effort and High Effort Tasks in Phase 2 for Henry

	Low effort tasks			**High effort tasks**		
Experimental conditions	**Mean % of time**	**Mean DCPM**	**Total Tokens**	**Mean % of time**	**Mean DCPM**	**Total Tokens**
No reinforcement	0.3	6.6	Not applicable	99.6	12.4	Not applicable
FR8 FR8	66.6	10	36	33.3	3.8	12
FR8 FR4	0	0	0	100	13.2	42
FR8 FR8	100	13.8	25	0	0	0

Table 9. Mean % of Time Allocation, Mean DCPM, and Total Tokens Earned Across Low Effort and High Effort Tasks in Phase 1 for Tina

	Low effort tasks			**High effort tasks**		
Experimental conditions	**Mean % of time**	**Mean DCPM**	**Total Tokens**	**Mean % of time**	**Mean DCPM**	**Total Tokens**
No reinforcement	100	11	Not applicable	0	0	Not applicable
FR8 FR8	100	11.7	20	0	0	0
FR8 FR4	100	14.3	26	0	0	0
FR8 FR2	73.7	11.9	14	25.6	4.9	7
FR8 FR1	0	0	0	100	6.5	98
FR8 FR2	0	0	0	100	6	44
FR8 FR4	0	0	0	100	7.4	25
FR8 FR8	66.6	10	18	33.3	2.4	4
No reinforcement	100	12.2	Not applicable	0	0	Not applicable

Table 10. Mean % of Time Allocation, Mean DCPM, and Total Tokens Earned Across Low Effort and High Effort Tasks in Phase 2 for Tina

	Low effort tasks			**High effort tasks**		
Experimental conditions	**Mean % of time**	**Mean DCPM**	**Total Tokens**	**Mean % of time**	**Mean DCPM**	**Total Tokens**
No reinforcement	0	0	Not applicable	100	7	Not applicable
FR8 FR8	0	0	0	100	15.4	25
FR4 FR8	100	15.1	56	0	0	0
FR8 FR8	100	10.9	18	0	0	0
FR8 FR4	0	0	0	100	11.6	37

Table 11. Mean % of Time Allocation, Mean DCPM, and Total Tokens Earned Across Low Effort and High Effort Tasks in Phase 1 for Jake

	Low effort tasks			**High effort tasks**		
Experimental conditions	**Mean % of time**	**Mean DCPM**	**Total Tokens**	**Mean % of time**	**Mean DCPM**	**Total Tokens**
No reinforcement	98.5	12	Not applicable	1.4	0.56	Not applicable
FR8 FR8	100	10.6	18	0	0	0
FR8 FR4	44.8	12	6	52.8	12.1	8
FR8 FR8	84.8	13.3	27	14.8	4.8	1
No reinforcement	100	13.4	Not applicable	0	0	Not applicable

Table 12. Mean % of Time Allocation, Mean DCPM, and Total Tokens Earned Across Low Effort and High Effort Tasks in Phase 2 for Jake

	Low effort tasks			**High effort tasks**		
Experimental conditions	**Mean % of time**	**Mean DCPM**	**Total Tokens**	**Mean % of time**	**Mean DCPM**	**Total Tokens**
No reinforcement	0	0	Not applicable	100	12.4	Not applicable
FR8 FR8	7.4	2.2	2	91.9	10.9	13
FR4 FR8	100	13.2	52	0	0	0
FR8 FR8	0	0	0	100	8.9	7

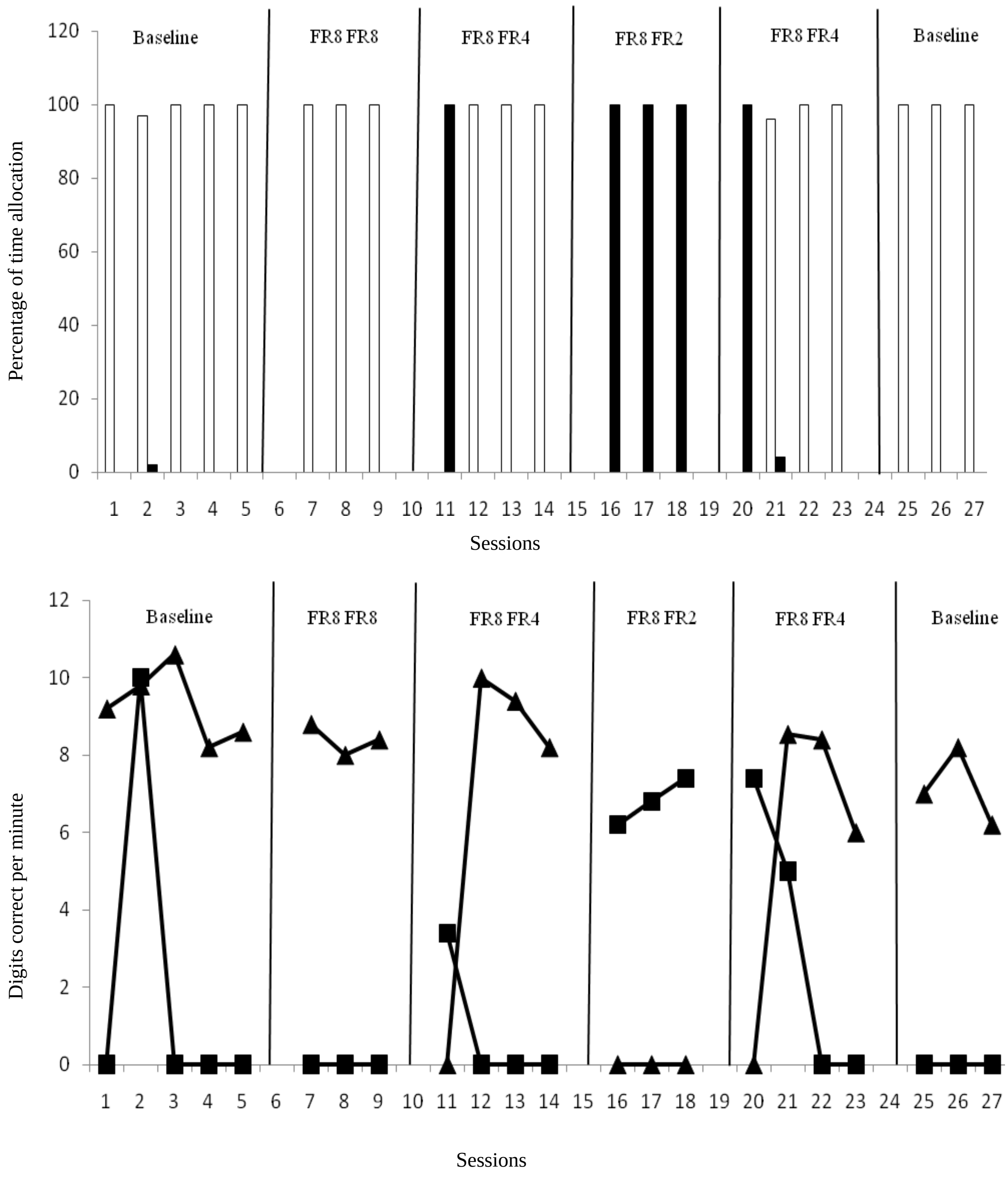

Figure 1. Concurrent Choice Assessment Phase 1 (Alex)

The top panel shows the percentage of time allocation to low effort (white bars) and high effort (dark bars) tasks by Alex in Phase 1; the bottom panel shows the digits correct per minute on low effort (closed triangle) and high effort (closed square) tasks by Alex in Phase 1.

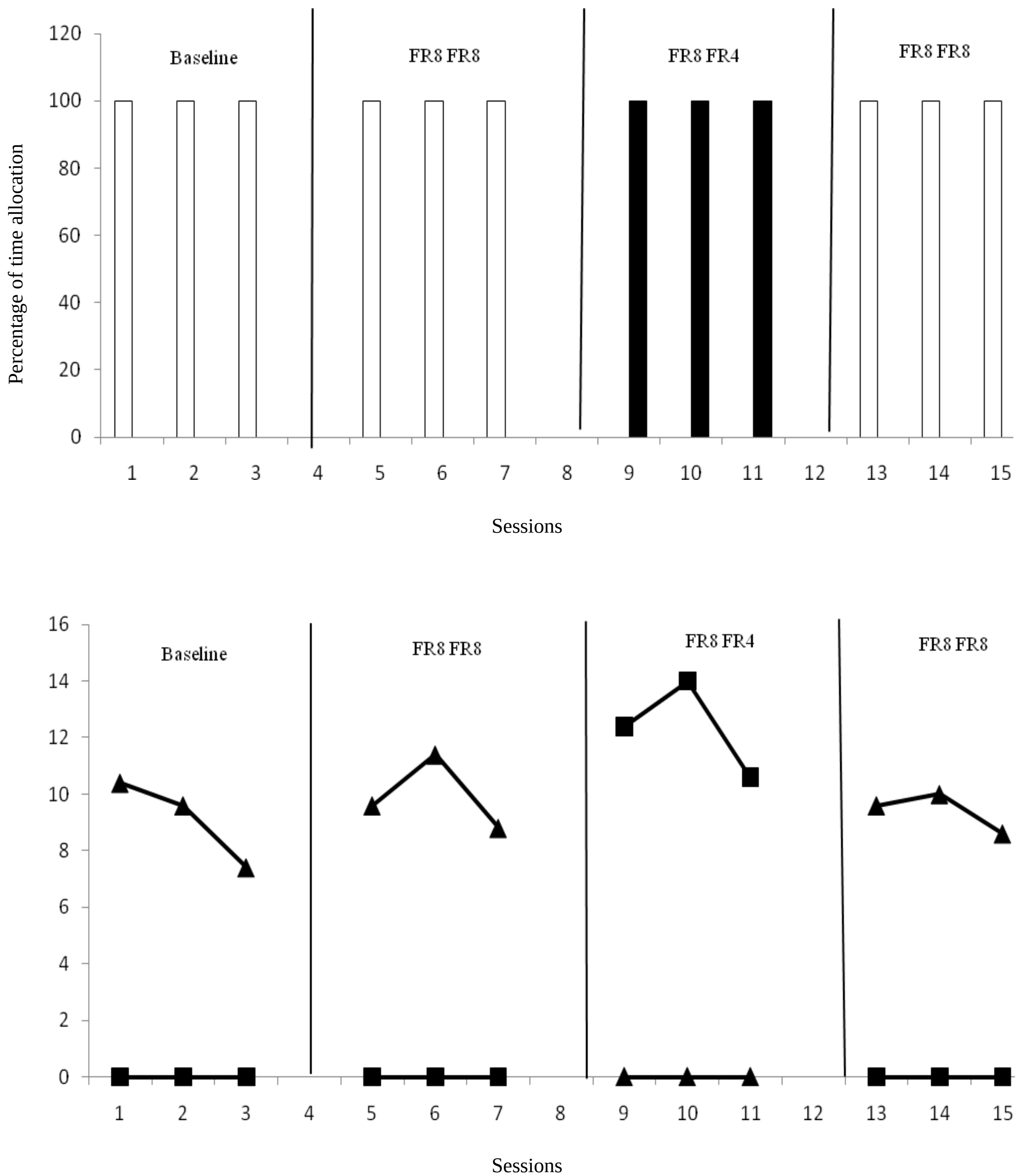

Figure 2. Concurrent Choice Assessment Phase 2 (Alex)

The top panel shows the percentage of time allocation to low effort (white bars) and high effort (dark bars) tasks by Alex in Phase 2; the bottom panel shows the digits correct per minute on low effort (closed triangle) and high effort (closed square) tasks by Alex in Phase 2.

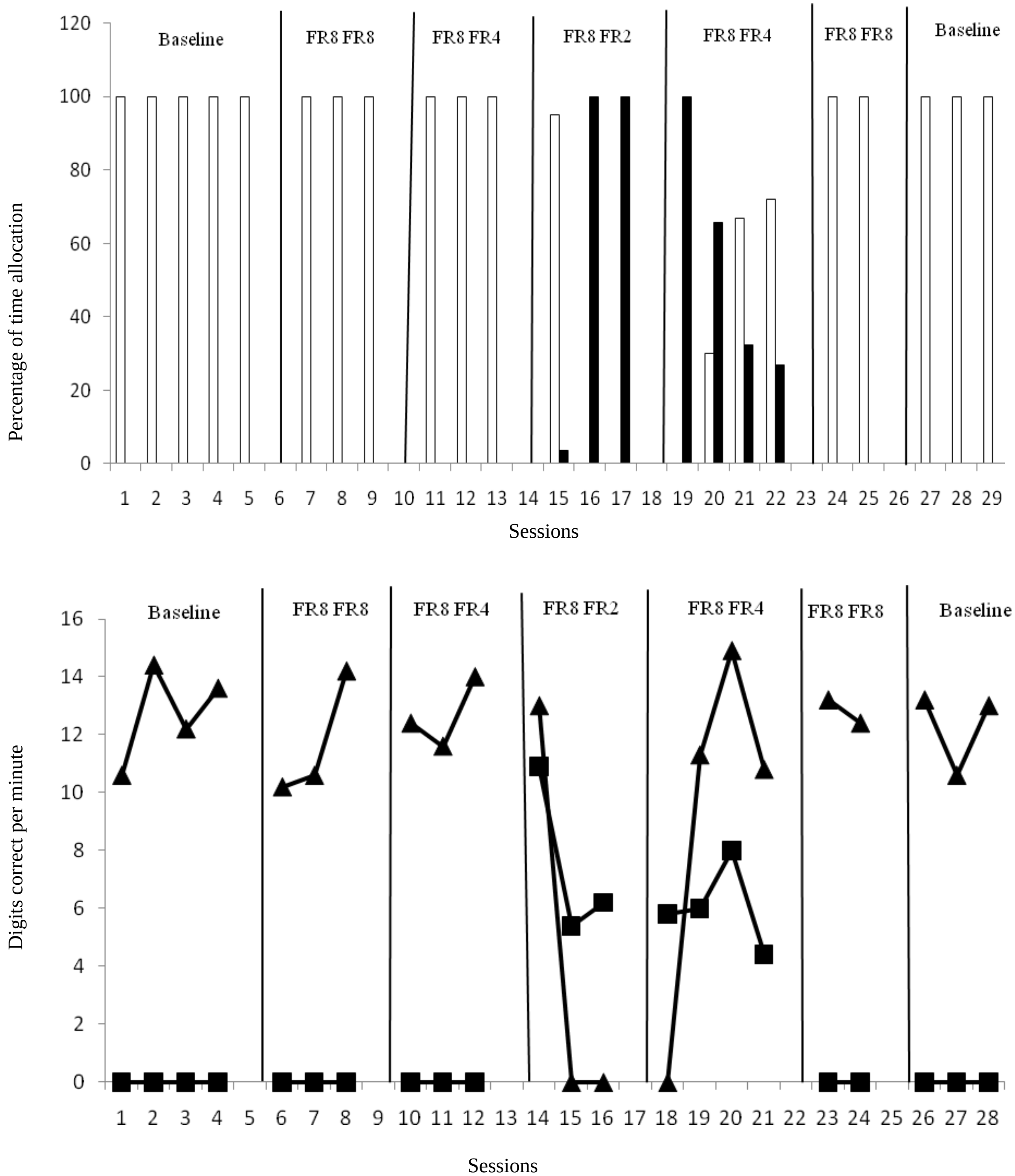

Figure 3. Concurrent Choice Assessment Phase 1 (Henry)

The top panel shows the percentage of time allocation to low effort (white bars) and high effort (dark bars) tasks by Henry in Phase 1; the bottom panel shows the digits correct per minute on low effort (closed triangle) and high effort (closed square) tasks by Henry in Phase 1.

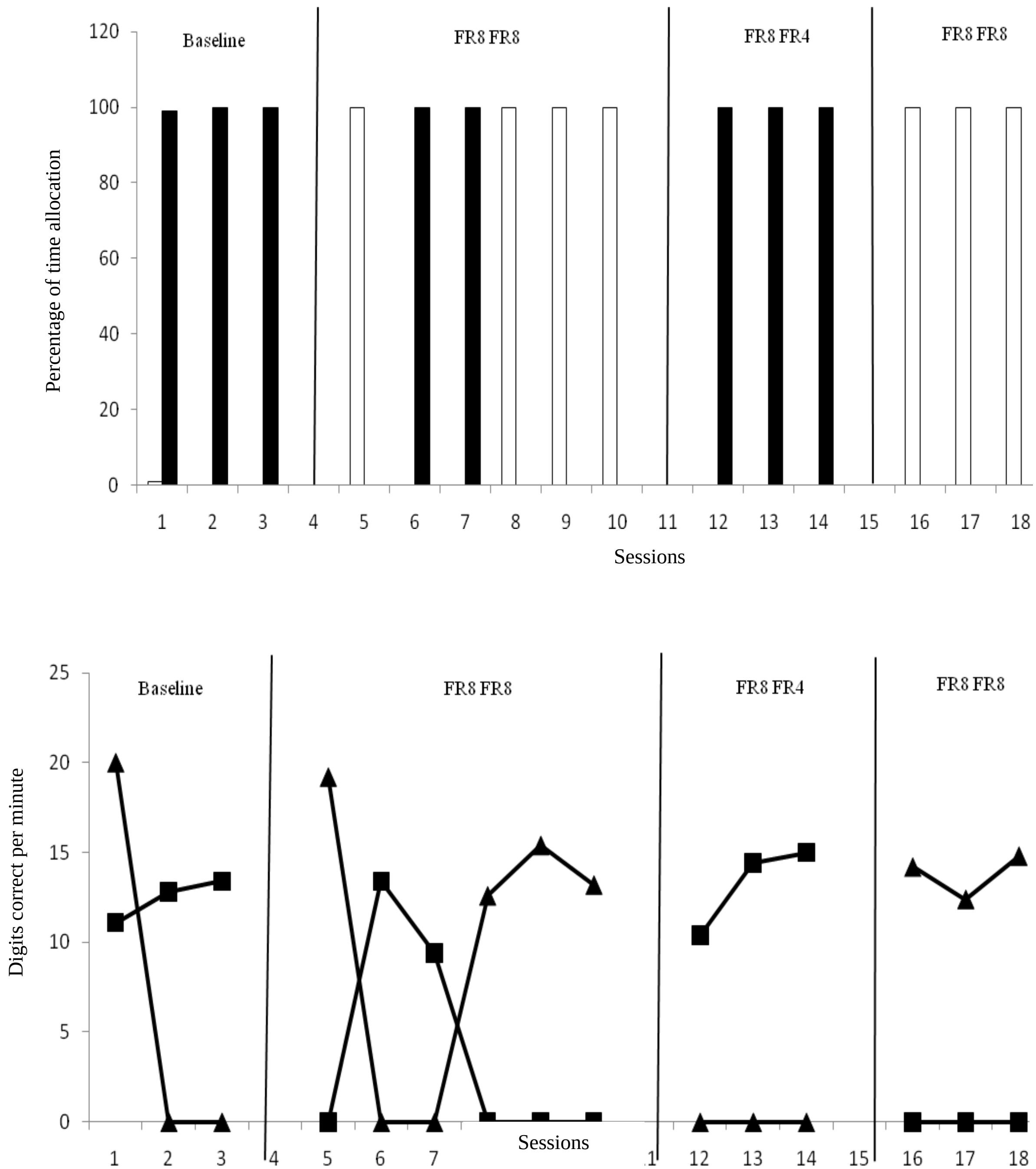

Figure 4. Concurrent Choice Assessment Phase 2 (Henry)

The top panel shows the percentage of time allocation to low effort (white bars) and high effort (dark bars) tasks by Henry in Phase 2; the bottom panel shows the digits correct per minute on low effort (closed triangle) and high effort (closed square) tasks by Henry in Phase 2.

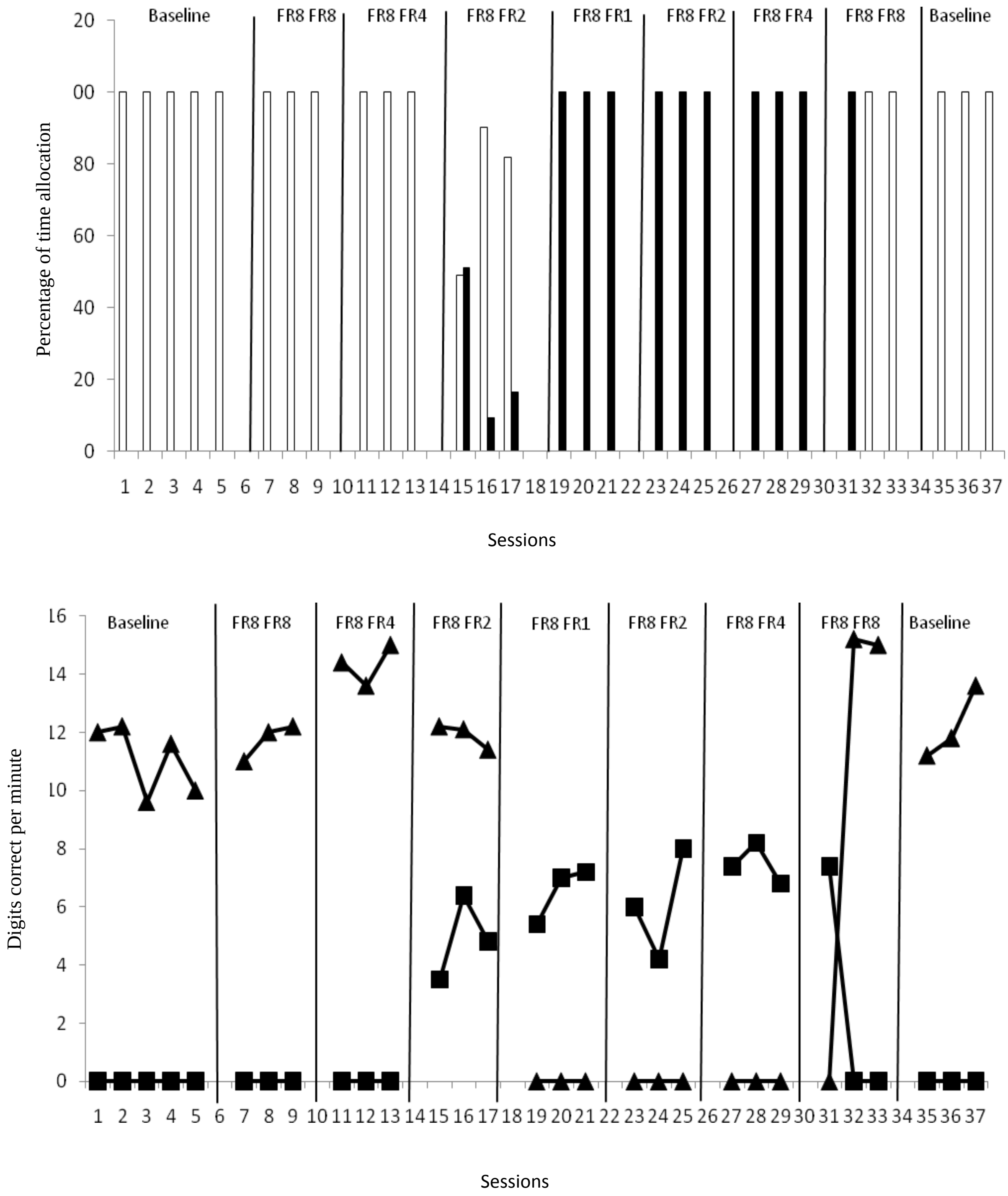

Figure 5. Concurrent Choice Assessment Phase 1 (Tina)

The top panel shows the percentage of time allocation to low effort (white bars) and high effort (dark bars) tasks by Tina in Phase 1; the bottom panel shows the digits correct per minute on low effort (closed triangle) and high effort (closed square) tasks by Tina in Phase 1.

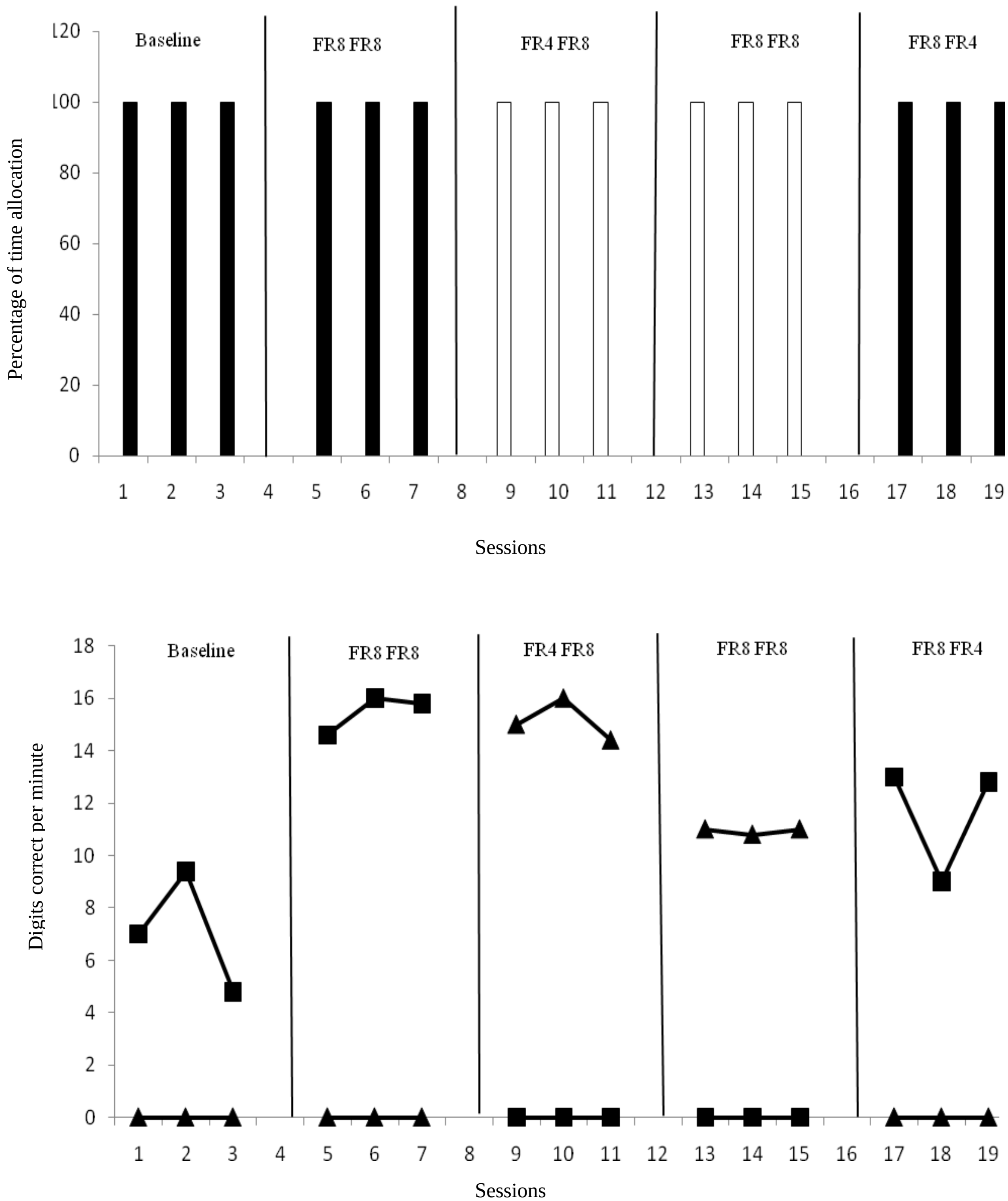

Figure 6. Concurrent Choice Assessment Phase 2 (Tina)

The top panel shows the percentage of time allocation to low effort (white bars) and high effort (dark bars) tasks by Tina in Phase 2; the bottom panel shows the digits correct per minute on low effort (closed triangle) and high effort (closed square) tasks by Tina in Phase 2.

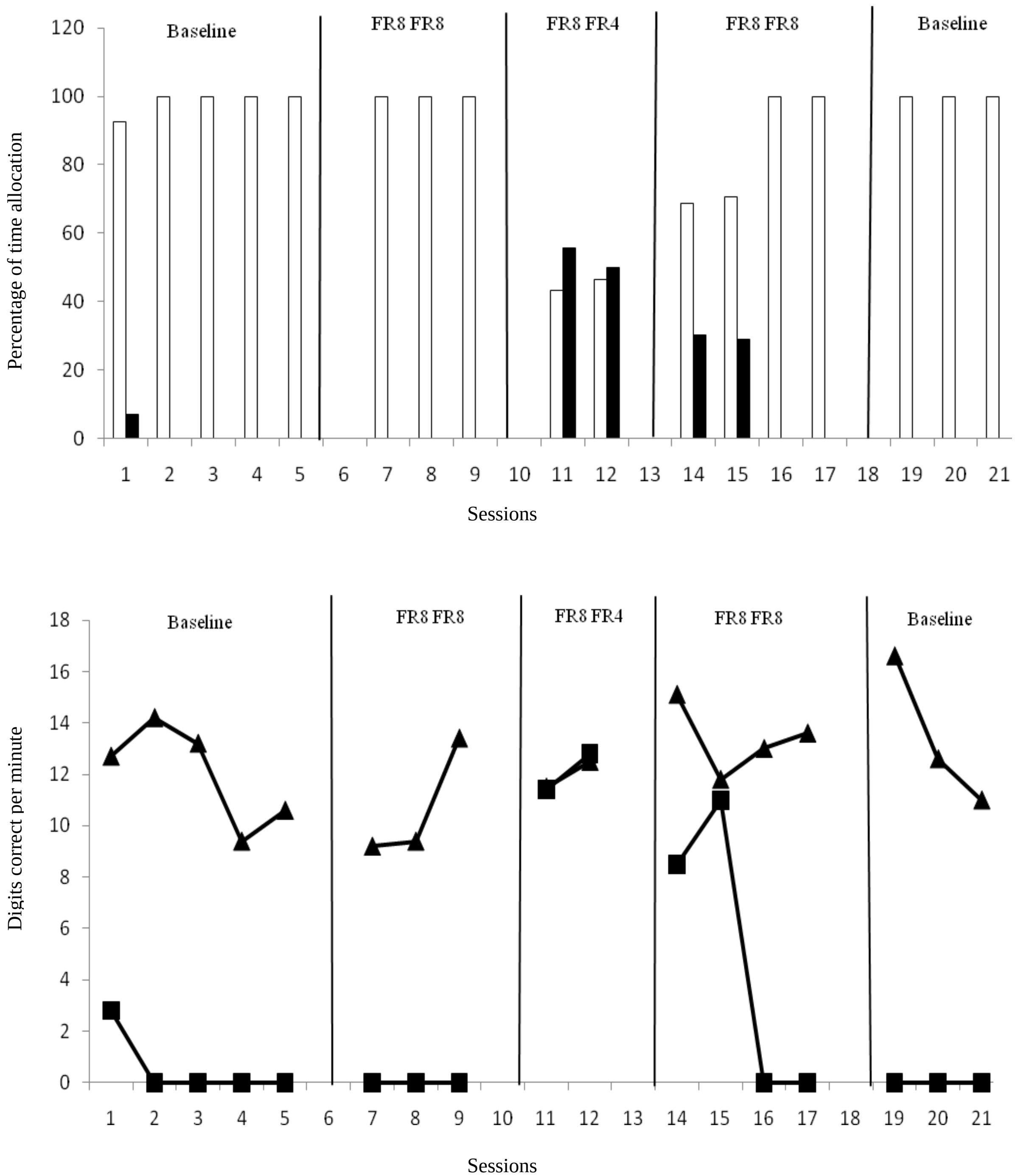

Figure 7. Concurrent Choice Assessment Phase 1 (Jake)

The top panel shows the percentage of time allocation to low effort (white bars) and high effort (dark bars) tasks by Jake in Phase 1; the bottom panel shows the digits correct per minute on low effort (closed triangle) and high effort (closed square) tasks by Jake in Phase 1.

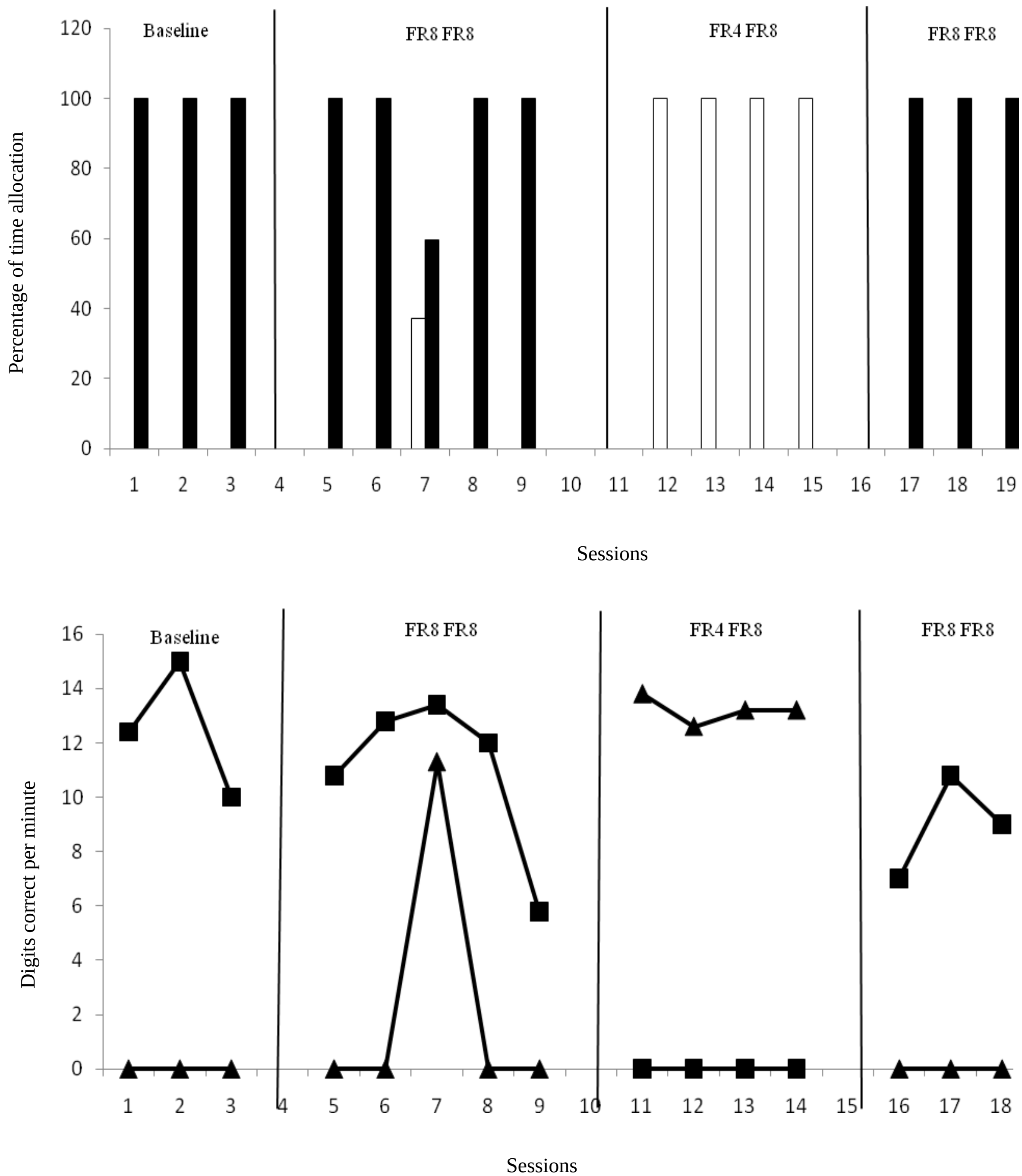

Figure 8. Concurrent Choice Assessment Phase 2 (Jake)

The top panel shows the percentage of time allocation to low effort (white bars) and high effort (dark bars) tasks by Jake in Phase 2; the bottom panel shows the digits correct per minute on low effort (closed triangle) and high effort (closed square) tasks by Jake in Phase 2.

CHAPTER V

DISCUSSION

There were two purposes of the current study. First, the study evaluated the effects of manipulating reinforcement schedules on students’ choice allocation between low and high effort tasks prior to fluency training. Second, the study examined whether there was a change in choice patterns during the same choice alternatives following fluency training on high effort tasks. The research questions addressed in this study were:

1. Prior to fluency training, do students show a response bias towards low effort tasks regardless of the reinforcement schedule associated with the tasks or do they allocate more time to the high effort tasks which are correlated with a richer schedule of reinforcement?
2. What are the effects of fluency training on choice allocation?
3. Do students show a preference for the high effort tasks following fluency training?

Choice Allocation Prior to Fluency Training

All 4 participants showed a preference for the low effort tasks when no reinforcement was provided and when the reinforcement schedules were identical for both types of tasks. Choice allocation tended to minimize effort and maximize reinforcement when available under these two conditions. The students gradually changed their response allocation and shifted their preference from low to high effort tasks when the schedule of reinforcement for low effort tasks was thinned in comparison to the high effort task. Jake allocated the majority of the session time to high effort tasks during the FR8 FR4 condition. Alex and Henry exclusively chose high effort tasks during the FR8 FR2 condition. Tina began to choose the high effort tasks during FR8 FR1. Mace et al. (1996) reported that task difficulty did not affect response allocation and the participants did not show a preference for the difficult task when it was associated with the richer schedule of reinforcement. The current findings showed an interactive effect of response effort and reinforcement schedule on choice allocation. The participants of the current study chose low effort tasks over high effort tasks when both tasks were associated with identical schedules of reinforcement. They shifted preference to the high effort tasks when the schedule associated with those tasks was enriched by gradually increasing the number of tokens that the participants could earn by completing the high effort tasks.

Based on the initial fluency rates (DCPM) determined from the results of the preliminary curriculum-based assessment, hypotheses were developed regarding the reinforcement schedule under which the participants would begin to choose high effort tasks. The total number of tokens that the students could earn under each reinforcement condition was calculated. It was hypothesized that the students would switch from low effort to high effort tasks when the tokens earned from high effort tasks would be more than those earned from the low effort tasks. This hypothesis was confirmed for 3 of the 4 participants. Alex and Henry switched to high effort tasks under the FR8 FR2 schedule, and Tina switched under the FR8 FR1 schedule. Based on Jake’s initial fluency rates, it was predicted that he would choose high effort tasks only under the FR8 FR1 schedule. Jake, however, selected high effort tasks under the FR8 FR4 schedule. A possible explanation for Jake’s results is that only two sessions were conducted under FR8 FR4. Over time, his choice pattern may have been different if more sessions had been conducted under that condition. However, a reversal to the previous condition confirmed our supposition that he would switch back to low effort tasks under identical schedules of reinforcement.

Similar predictions regarding students’ choice allocation to accuracy-based and time-based contingencies across easy and difficult tasks were made in the study by Lannie and Martens (2004). Information on the average number of correct problems per session and the maximum number of tokens earned during the time-based contingency was used to design reinforcement schedules that provided identical rates of reinforcement between the two contingencies. As hypothesized, the majority of students earned more tokens when completing easy tasks by choosing the accuracy-based contingency and by responding to the time-based contingency when completing the difficult tasks.

The results of the current study contribute to the literature that manipulated positive reinforcement to influence response allocation on tasks (Cuvo et al., 1998; Gardner et al., 2009; Harding et al., 1999). For example, Gardner et al. (2009) showed that changes in the quality of positive reinforcement in the form of attention can bias choice responding towards academic tasks in demand contexts. The results of the current investigation also showed the effects of varying positive reinforcement on choice behavior. The 4 participants in the current study shifted their choice responding to academic tasks that required more effort as the opportunities to earn positive reinforcers from completing these tasks were increased. These results are consistent with the findings of Peck et al. (1996), who showed that increasing the quality and duration of reinforcement could bias student responding towards a desired behavior (engaging in mands) instead of an inappropriate or undesired behavior. The current investigation replicated the findings by Cuvo et al. (1998), who showed that typically developing children and adults with mental retardation chose more difficult tasks when the schedule associated with those tasks was dense relative to easier tasks. The current results extend these findings by showing that predictions can be made regarding when the participants will switch from easy to more difficult math tasks. The current results further suggested that simply providing more positive reinforcement for accurately completing the difficult tasks would not be sufficient to change students' choices. Students shifted their choices to the task requiring higher effort when the number of reinforcers earned from easy tasks was less than those earned from difficult tasks.

Once students chose the high effort tasks, the schedule of positive reinforcement was reversed to determine if they would again select the low effort tasks. Alex and Jake returned to selecting low effort tasks immediately when reversals to the previous conditions were conducted. Henry allocated time to both low and high effort tasks with an increasing trend for low effort tasks during the reversal condition. The results of these 3 participants showed that enriching the schedule associated with high effort tasks shifted preferences from low to high effort tasks but only when the enriched schedule was maintained. Tina’s results, however, indicated that she persisted with her choice to complete high effort tasks during the reversal conditions (FR8 FR2 and FR8 FR4). Tina selected the low effort tasks only when equal reinforcement was available from task completion during the second FR8 FR8 condition. The results of the current study extend previous research on the influence of reinforcer dimensions on choice behavior (Neef et al., 1992, Neef et al., 1994). Specifically, the current results showed that response allocation was influenced by an interaction of response effort and reinforcement schedule, which is similar to Neef et al. (1994)

Choice Allocation Post Fluency Training

The second purpose of the study was to examine the effects of fluency training on high effort tasks on the choice allocation of the participants. McComas, Wacker, Cooper, Asmus, Richman, and Stoner (1996) showed that the identification of effective instructional interventions that promoted accurate responding occurred only under conditions involving difficult tasks. In the current study, the choice patterns of the students prior to and post fluency training were analyzed to determine when they switched their preferences from low effort to high effort tasks. It was hypothesized that post fluency training, students would be able to complete both low and high effort tasks at the same rates and thus would be indifferent to the difficulty level of the tasks. It was also hypothesized that the participants would select high effort tasks earlier in Phase 2 as compared to their choice allocation in Phase 1. Results confirmed these hypotheses and indicated that all 4 participants showed a preference for high effort tasks earlier in Phase 2 as compared to Phase 1. Henry, Tina, and Jake exclusively selected high effort tasks under the no-reinforcement or baseline condition in Phase 2. This was in contrast to their choice pattern in Phase 1 when they showed a clear preference for low effort tasks. The results of these 3 participants suggested that fluency interventions alone changed their preferences for tasks. A probable explanation for this choice pattern was that the students could complete high effort tasks more quickly and accurately post fluency training and this improvement in skills motivated them to choose high effort tasks over the tasks requiring lower effort. Similar findings were obtained by McComas, Hoch, Paone, and El-Roy (2000), who showed that the implementation of instructional strategies to improve accuracy resulted in an increase in compliance with tasks and a decrease in disruptive behavior without reducing the instructional level of the task demands. The current investigation, however, showed that the effects of fluency training were not sufficient to maintain these preferences for Henry, who gradually shifted to low effort tasks during the FR8 FR8 condition. Tina and Jake continued with their selection of high effort tasks under the FR8 FR8 schedule. Following FR8 FR8, an FR4 FR8 condition, in which the schedule associated with low effort tasks was enriched compared to the high effort task, was implemented. Results showed that changes in positive reinforcement affected the choices of Tina and Jake, who switched back to low effort tasks. Alex selected low effort tasks under the no-reinforcement and FR8 FR8 conditions and allocated exclusively to high effort tasks under the FR8 FR4 condition in Phase 2. Thus, Alex also switched from low to high effort tasks earlier in Phase 2 as compared to Phase 1.

Implications for Practice

Students often avoid difficult tasks as they have fewer opportunities to obtain reinforcement from completing those tasks versus completing easier tasks (Roberts, Marshall, Nelson, & Albers, 2001). To increase the probability that students will choose a desired response, previous researchers have manipulated dimensions of reinforcement and examined their effects on choice (Horner & Day, 1991; Peck et al., 1996). In the current study, the students were allowed to choose between an easy and a difficult task with each task correlated with an independent schedule of reinforcement. The study identified variables that biased students' choices from easy to more difficult tasks. These results suggest that educators may be able to increase students' choices towards more difficult task by increasing the amount of positive reinforcement available for completing these tasks. Increased task engagement may improve academic performance as the student gets more opportunities to practice the skill.

The results of the current study showed the effects of fluency training on choice behavior. Fluency training that was comprised of components such as modeling, prompting, goal setting, timed practice, and immediate feedback increased the rate of accurate completion of difficult tasks. Following fluency training, students showed a preference for the more difficult tasks even under conditions in which equal reinforcement was provided. Teachers may find it beneficial to conduct fluency training strategies to increase compliance with more difficult tasks. Roberts et al. (2001) suggested that implementing interventions (e.g., cover, copy, and compare strategy) that improved students' fluency levels may be effective in reducing off-task classroom behaviors which were motivated by escape from difficult tasks. Fluency training in combination with positive reinforcement may increase the students' opportunities to obtain positive reinforcement for completing difficult tasks because they reduce the student's motivation to escape from completing those tasks.

Fluency training as shown in this study can be conducted individually or in a group. The fluency training strategies are easy to implement procedures that can be individualized according to the needs of the students. The implementation of the 1-Minute Timings procedure helps teachers to develop a monitoring system to identify the problems the student answers correctly and those that he/she does not (Miller & Hudson, 2007). Teaches can use this methodology to monitor the performance of several students together by providing all of them with worksheets, with each student working on the specific problems that they need practice with.

Future Directions

An extension of this study might evaluate the effects of increasing task difficulty on students' choice patterns following fluency training. The results of the current study showed that Jake, Tina, and Henry exclusively selected high effort tasks under the no-reinforcement condition following fluency training. In future studies when participants display similar choice responding, the difficulty level of the high effort task might be increased in subsequent reinforcement conditions to examine whether choice is affected more by increases in response effort or decreases in positive reinforcement for the high effort tasks. During the reinforcement conditions, the schedule for the high effort tasks might be thinned in comparison to the schedule for low effort tasks. If students persist with their selection of high effort tasks under these reinforcement schedules, the difficulty level of the high effort tasks might continue to be increased until a shift in choice allocation towards the low effort problems is observed. Similar to the Concurrent Choice Assessment Phase 1 of the current study, predictions might be made regarding when the participants will shift from low to high effort math tasks following fluency training. Students may continue to select the more difficult task because of repeated practice effects with these high effort tasks (Belfiore, Lee, Vargas, & Skinner, 1997). Thus, future studies might examine the combined effects of manipulating task difficulty and changes in the schedule of positive reinforcement on the choice allocation of students.

The current study focused on academic performance and evaluated the effects of fluency training and reinforcer dimensions on student choice allocation and task completion. Future researchers might consider examining the effects of these variables on problem behaviors (e.g., destructive behavior, non-compliance) displayed by students with behavior disorders. Correlational effects have been reported for difficulty of curricular tasks with off-task classroom behavior (Roberts et al., 2001). Dunlap et al. (1994) showed that there was an increase in task engagement and a decrease in problem behaviors when students with emotional and behavioral difficulties were allowed to choose between academic assignments. An extension of the current study might investigate whether an inverse relationship is established between task engagement and off-task behaviors when (a) students are provided with choice-making opportunities between easy and difficult tasks and (b) interventions to increase fluency on difficult tasks are conducted.

In the current study, there was a correlation between the implementation of fluency strategies and an increase in DCPM on high effort tasks. An extension of this study might use a more robust design, such as a multiple baseline design across participants or a multi-element design, to evaluate the effects of fluency training on DCPM. A large number of instructional procedures are available for increasing fluency levels in math. An assessment procedure that directly compares the different strategies within a multi-element design may be an effective way to identify the most efficient strategy that promotes fluency (Daly & Martens, 1994). A multiple baseline design in which fluency interventions are sequentially introduced one tier at a time after consistent baseline patterns may also be appropriate to analyze the effects of fluency strategies on the DCPM.

Limitations

One limitation of this study is that a small number of sessions were conducted in each phase throughout the study. For example, only two sessions were conducted under the FR8 FR4 condition for Jake before implementing a reversal to the previous choice condition in which both tasks were associated with equal reinforcement schedules (FR8 FR8). During FR8 FR4, he selected both high and low effort tasks with an increasing trend for the high effort tasks. A change in the condition was initiated immediately after two sessions in order to examine whether Jake switched back to low effort tasks under the second FR8 FR8 condition. Based on his initial fluency rates, it was hypothesized that he would select the high effort tasks only under FR8 FR1 when the number of tokens he could earn from the high effort tasks would be more than those earned from the low effort task. Jake's response allocation may have shifted from high to the low effort tasks over time if more sessions had been conducted under FR8 FR4. Thus, future studies should consider conducting longer phases in which more sessions are conducted.

A second limitation is that visual cues were used to assist the student to discriminate between the two choice contingencies. These visual cues were in the form of prompt cards with a number written in the center of each card to represent the number of problems the participant was required to complete correctly to earn a token. The use of these adjunct procedures to help students differentiate between the two reinforcement schedules associated with the tasks may not always be feasible to implement in applied settings. Future studies might consider the use of explicit verbal instruction or models to aid the students in discriminating between the two choices. For example, Neef et al. (2004) demonstrated how modeling and prior verbal instruction affected students' response allocation by making it sensitive to changes in the concurrent reinforcement schedules correlated with math tasks.

A third limitation is that the fluency training phase was conducted within an AB case study design in which A represented pre-fluency training DCPM data on high effort tasks and B represented the post-fluency training DCPM data on those tasks. Future studies might use single case designs such as a multiple baseline design across participants to examine the effects of fluency strategies on DCPM. Unlike case studies, single case designs provide a more rigorous degree of experimental control (Kennedy, 2005).

Conclusion

The three important findings of this study were: (a) Prior to fluency training in Phase 1, students allocated responses to low effort tasks when no reinforcement and equal reinforcement were provided for the math tasks; the students then shifted their preferences to the high effort tasks as the reinforcement schedule was enriched for the high effort tasks in comparison to the tasks requiring less effort; (b) fluency training strategies were effective in increasing the rate at which high effort tasks were accurately completed; and (c) all 4 students selected the high effort tasks earlier in Phase 2 following fluency training as compared to Phase 1, suggesting that fluency training in combination with positive reinforcement affected their preferences.

APPENDIX A

SUMMARY OF STUDIES EVALUATING CHOICE ASSESSMENTS CONDUCTED IN SCHOOL SETTINGS

Table A1. Summary of Studies Evaluating Choice Assessments Conducted in School Settings

Articles	**Participants**	**Tasks**	**Purpose**	**Results**
Cuvo et al. (1998) Experiment 2	Four typically developing preschool children aged 4 to 5 years	Tossing beanbags	To examine the combined effects of reinforcement rate and task difficulty on choice responding	Students chose low effort task when equal reinforcement available. Preferences shifted towards high effort tasks as its schedule was enriched.
Hoch et al. (2002)	Three children aged 9 to11 years with developmental disabilities	Math tasks and vocational tasks	To examine the effects of positive and negative reinforcement on task completion and problem behavior	Problem behavior was eliminated and task completion occurred when problem behavior produced a break and task completion resulted in a break and access to preferred activities.
Lannie & Martens (2004)	Four fourth-graders (9 years old)	Math tasks	To examine choice allocation across math worksheets as a function of type of reinforcement contingency with easy and difficult problems	Students increased obtained reinforcement rates under accuracy-based contingency with easy problems and under time-based contingency with difficult problems.
Mace et al. (1996)	Two youth aged18 and 14 years with behavior disorders and learning difficulties	Math tasks	To examine the combined influence of reinforcer quality, rate, and task difficulty on choice responding	Compared to rate and quality of reinforcement, task difficulty had little effect on choice allocation.
Mace et al. (1994)	Three students aged 15 to19 years with behavior disorders and learning difficulties	Math tasks	To examine whether (a) choice responding varied with changes in concurrent VI schedules and (b) adjust procedures were necessary to increase sensitivity to schedule changes.	Overall, rates of responding were proportional to the rates of reinforcement. Changes in schedules were followed by changes in choice patterns only after the use of adjunct procedures.

Table A1 (continued)

Neef et al. (2001)	Three elementary students aged 9 to11 years with ADHD	Math tasks	To examine the combined effects of reinforcer dimensions and delay fading on choice responding	Choices of all students were most influenced by immediacy of reinforcement. Students preferred tasks with richer schedules and higher quality reinforcers even with delays to reinforcement.
Neef et al. (2005)	Fifty-eight elementary students aged 7 to 14 years with and without ADHD	Math tasks	To assess the relative influence of rate, quality, and response effort on choice responding	Choices of children with ADHD were influenced by reinforcer immediacy and quality and least by rate and effort. Choices of children without ADHD were influenced by reinforcer quality.
Neef et al. (1992)	Three students aged 14 to18 years with behavior disorders and learning difficulties	Math tasks	To examine the effects of rate and quality of reinforcement on choice allocation	Students chose richer schedule when reinforcers were the same. When quality of reinforcers were unequal, they chose higher quality reinforcer on the leaner schedule.
Neef et al. (1993)	Two students aged 13 to 19 years with behavior disorders and learning difficulties	Math tasks	To show (a) the effects of reinforcer immediacy on choice responding, and (b) the combined effects of reinforcer immediacy, quality, and rate on choice responding	Students chose richer schedule with equal delay to reinforcer access. With unequal delays, they chose the more immediate reinforcer on the leaner schedule. When all three variables varied, response allocation was differentially affected by the reinforcement dimensions.
Neef et al. (1994)	Six youth aged14 to18 years with learning and behavior difficulties	Math tasks	To examine the combined influence of reinforcer rate, quality, delay, and response effort on choice responding	Response allocation was differentially affected by the reinforcement dimensions. Time allocation matched reinforcement rate independent of problem difficulty.

Table A1 (continued)

Peterson et al. (2009)	Seven children aged 5 to 12 years with developmental disabilities	Classroom materials such as math worksheets and reading workbooks	To evaluate the effects of durations and qualities of breaks on three concurrently available response options, problem behavior, mands for breaks, and mands to work	Participants allocated their responding in favor of mands rather than problem behavior, even when problem behavior continued to produce reinforcement.
Reed & Martens (2008)	Three third-graders aged 8 to 9 years	Math tasks	Evaluated choice responding under conditions of equal and unequal response effort	Under equal response effort condition, rate of responding was proportional to the reinforcement rate. Choice responding shifted towards the easier task when response effort was varied.

APPENDIX B

CONCURRENT CHOICE ASSESSMENT DATA SHEET

Recording Form

Date: __________ **Recorder (Primary/Reliability):**

____

Participant: ______________ **Condition and Session:**

____

Low Effort **High**

Effort

	LOW	HIGH
DCPM (Total digits/total time) X 60		
TOTAL DIGITS		
TOTAL TIME (in seconds)		
% of time (total time/300)		
TOKENS		

APPENDIX C

EXAMPLE OF A PREFERENCE ASSESSMENT SHEET

Table C1. Example of a Preference Assessment Sheet

Stimuli	Trial 1	Trial 2	Trial 3
Pencils			
Pens			
Skateboard			
Bubble			
Art activity			
Carpet toys			
Computer time			
Puzzles			

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