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An experimental analysis of preference for rate building

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ABSTRACT

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Educational research suggests that rate-building procedures produce superior academic performance and are preferred by participants when compared to traditional methods. However, these studies have not controlled for critical variables, such as practice, that might influence preference and performance. The current study compared two conditions using behavioral performance and preference measures; one condition had a correct response rate criterion and the other had an overall correct response criterion. Reinforcement and feedback were held constant across conditions. Most participants preferred the condition that did not have a rate criterion. Performance outcomes produced by the two conditions were not substantially different. This implies that outcomes produced by a rate criterion can be achieved using a similar, more preferred method.

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An Experimental Analysis of Preference for Rate Building

Response rate has long been considered a sensitive measure of behavior when contrasted with other measures. For example, Skinner (1966) argued that measures such as response ratios or "amount remembered" are insufficient for the experimental analysis of behavior. Instead, Skinner preferred rate of responding because it quantifies change in behavior over time in one measurement. Lindsley (1992) reported that frequency measures are two to fifty times more sensitive than percentage correct alone when studying drug effects. In addition, Binder (1996) suggested that accuracy measures, like percent correct, are not adequate for measuring educational achievement because they do not reflect a student's fluency when performing a task. Fluency has been defined as behavior that meets a "fluid combination of accuracy plus speed that characterizes competent performance," (Binder, 1996, p. 164). For instance, a student who correctly answers many addition problems per minute might be considered more fluent than a student who correctly answers fewer problems per minute. The second student's lower response rate may suggest that the student has not completely mastered the material. Thus, despite the use of accuracy as the typical measure of educational performance, rate of performance rather than simple accuracy has been established as the primary measurement in behavioral education (Binder).

In addition to adding rate measures to the assessment of educational outcomes, some behavior analysts have suggested using specific procedures to increase response rate. Rate-building exercises typically consist of one-min timings, during which students repeatedly perform a task, such as addition problems, until accuracy and response-rate criteria have been met. Typically, the one-min timings are accompanied by instructions to meet these criteria, with corrective feedback given after the timing as to whether the criteria are met. Students also often

plot their response rate and errors on a progress chart, also called a standard behavior chart. This chart can be used to denote performance goals graphically (for instance, the desired correct response rate).

Rate-building procedures have been reported to lead to better progress when compared to more traditional teaching techniques. Van Houten and Thompson (1976) reported increased correct responses and high levels of accuracy when one-min math problem timings were added after a baseline of self-paced work. Self-paced work involved completing addition and subtraction worksheets for 30 minutes. The booklets were then graded at the end of the day, and returned to the student the following morning. The one-min timing condition consisted of 30 minutes for the students to complete the same arithmetic booklets. However, the teacher now instructed the students to complete problems during a series of one-min timings. At the end of the timings, the students were instructed to stop and draw a line after the last problem completed. Behavior was measured by the rate of correctly answered problems per minute, and accuracy. The timings increased correct rate of responding, while accuracy remained largely unaffected. Similarly, Hartnedy, Mozzoni, and Fahoum (2005) reported both an increase in response rate during one-min timings and a decrease in errors when compared to traditional self-paced work.

Rate building has also been reported to produce differential outcomes represented by the acronym RESAA, which stands for retention, endurance, stability, application, and adduction (Johnson & Layng, 1992). Retention is defined as persistence of correct response rates after a period of time of no practice. Endurance refers to maintaining correct response rates over timing durations longer than those used in training (Weiss, 2001). Stability is defined as continued high rates of correct responding despite of distractions. Application is engaging in previously learned responses in the presence of novel stimuli (Mayfield & Chase, 2002). Adduction is using

previously trained component responses to engage in a composite of those responses for the first time (Johnson & Layng, 1996). For instance, if a student was taught how to complete multiplication and addition of exponent problems, adduction occurs the first time the student answers a problem that requires an untrained combination of those two skills.

In contrast to the claim that rate-building procedures produce improved RESAA outcomes, Doughty, Chase, and O'Shields (2004) found little experimental evidence that RESAA outcomes are the result of rate building. They suggested that other variables known to affect performance, such as reinforcement rates, feedback density, and amount of practice, might account for the purported effects of rate-building techniques. When these factors are controlled, the reported gains of rate building are not apparent. For example, Shirley and Pennypacker (1994) controlled reinforcement rate and amount of practice across a rate building and accuracy condition, and an accuracy alone condition involving the acquisition of spelling words. Results were unclear; although higher correct frequencies were reported in the initial rate-building condition, these results were not replicated in subsequent phases. The failure to produce differential RESAA outcomes when correct response rate is examined in isolation indicates that further research is needed to identify the exact causes of rate building's reported success.

Rate-building procedures may also be preferred over traditional practice exercises. Miller, Hall, and Heward (1995) exposed both regular and special-education students to self-paced and rate-building activities. The experimenters demonstrated that students' accuracies, response rates, and on-task behavior increased during conditions involving rate building when compared to conditions in which the students paced themselves. However, as reported above, controls for practice and other variables were not apparent. In addition, preference was measured using a 3-point scale that asked questions about which condition the students preferred and

which condition they felt helped them learn the most. A majority of the participants reported preferring the rate-building condition over other conditions, and also reported that rate building helped them improve the most.

This study is typical of those that have measured student preferences, in that it used a self-report measure. This is problematic in two respects. First, the participants could be indicating a preference for one of the uncontrolled variables mentioned by Doughty et al. (2004), such as reinforcement rate. Second, verbal assessments such as self-reports do not directly measure preference. Direct behavioral assessments of preference contrasted with verbal reports of choice have often shown inconsistencies. For example, Morgan and Lindsley (1966) demonstrated that when participants were asked their preference between stereophonic and monophonic recordings, all reported a preference for stereophonic. When these types of music were used as reinforcement, however, only half of the participants' responses indicated a strong preference for stereophonic music.

In addition, self report of prior performance may be inaccurate. Critchfield and Perone (1990) had participants report on a delayed-matching-to-sample (DMTS) task that required both accuracy and speed requirements. In a feedback component, participants were told that if they did not earn points after a trial, their choice was either incorrect, their response was too slow, or both. Feedback took the form of trials being followed by the presentation or absence of points. In the no-feedback component, trials were not followed by any information about the target response. During self-report conditions, participants were asked to report if their response was sufficient to produce reinforcement. Critchfield and Perone found that the participants were frequently inaccurate when self reporting when the session involved no feedback. Furthermore,

one participant was also biased in his inaccurate reporting. This participant would frequently report that his response was sufficient to produce reinforcement when it had not.

Although self report is a convenient measure of preference, methods that directly measure behavioral choice may be more valid. Baer, Wolf, & Risley (1968, p. 93) provided an impetus for applied behavioral research to examine behavioral preference directly: "… a subject's verbal description of his own non-verbal behavior usually would not be accepted as a measure of his actual behavior unless it was independently substantiated. Hence there is little applied value in the demonstration that an impotent man can be made to say that he no longer is impotent. The relevant question is not what he can say, but what he can do."

Behavioral measures of preference already exist. For example, Fisher et al. (1992) developed a procedure during which potential reinforcers are presented concurrently. A subject's approach towards one of the items was taken as a measure of preference. This concurrent preference assessment has been modified for use in educational settings. Foster-Johnson, Ferro, and Dunlap (1994) used such behavioral measures to assess preferred and non-preferred learning activities for three developmentally delayed children. The experimenters measured time spent interacting with learning materials, moving towards materials when they were placed a short distance away, and resisting the materials being removed. The participants where then exposed to a single non-preferred activity across multiple sessions, followed by a single preferred task across multiple sessions. These conditions were repeated, and both desirable and problem behaviors were measured across each condition. The experimenters reported consistently more problem behavior and less desirable behavior when the participant was exposed to a non-preferred activity than a preferred activity.

Studies like the one conducted by Foster-Johnson and colleagues (1994) have demonstrated the advantages of determining preferred tasks and teaching methods through direct measurement of choice, and furthered our understanding of how to assess preference in educational settings. Yet, studies have not assessed preference for rate-building procedures using choice as a direct measurement.

Statement of the Problem

Rate-building proponents state that training to a rate criterion results in the educational outcomes of RESAA, and are preferred by students over traditional practice exercises. While research has compared rate building to other methods of practice, the results are ambiguous when critical alternative explanations, such as amount of practice and rate of reinforcement, have been controlled. In addition, preference for rate building has been assessed only with self-reports of preference and satisfaction. This may be problematic for two reasons. First, research has demonstrated both the inaccuracy of verbal reports and inconsistencies between verbal reports of preference and direct measures of choice. Second, while students might have reported that they liked rate-building techniques over other methods of practice, the studies that have been conducted have not determined if students prefer rate building or other critical variables that were not controlled experimentally. The current study presented participants with math timings that manipulated the presence of rate criteria while equating practice and reinforcement across conditions. Of specific interest was whether a behavioral measurement of preference favored rate-building or practice conditions. In addition, measures of retention, endurance, and application were used to determine if subjects perform differentially across conditions.

Methods

Participants

Thirteen female college undergraduates were recruited from introductory psychology courses. Of these thirteen participants, four completed the study. Ages of the participants ranged from 18 to 25 years, with 21.5 being the average age. The students were financially compensated and received extra credit in their psychology course for their participation in the study. Prior to the study, each was asked to sign a Consent and Information Form (Appendix A).

Settings and Apparatus

Participants worked in a 2 m^2 carrel containing a chair, desk, and materials. The carrel was equipped with a .3 m^2 door connected to the experimenter's control room for communicating with the experimenter. Pencils were located on the desk, and worksheets were passed to the participants through the small door. Different worksheets were given during different conditions, and are described below. The experimenter used a stopwatch to time trials. The participants were also given charts to show the criteria they must meet in each condition, to record their performance, and to provide graphic feedback of their performance. There were two charts on which the participants recorded their feedback, a rate chart and a practice chart. The rate chart consisted of an equal interval x-axis for measuring timings, and a semi-log scale y-axis for measuring correct responses per minute (Appendix B). The practice chart consisted of an equal interval x-axis for timings, and a semi-log scale y-axis for correct cumulative responses (Appendix C).

General Procedure

Sessions were conducted three to five days a week. The sessions lasted for approximately 1 hour, with a 5 minute break given after 30 minutes. Sessions were conducted with one participant at a time. Figure 1 shows the phases of the experiment. Participants were first exposed to a pre-training assessment of writing speed (rate assessment). Each participant was then exposed to 5 iterations of the experimental conditions: a rate building condition, a practice condition yoked to the rate building condition, and a preference condition. These iterations were called condition cycles. After at least two weeks following the last condition, the participants were asked to return for retention tests. The actual break between the last condition and the retention test ranged from 14 to 22 days.

Procedure

Rate Assessment. Throughout the entire experiment, the experimenter sat in the control room, passed materials, and read instructions through the .3 m^2 door to the carrel where the participant was seated. For rate assessment sessions, participants were given a task to measure the rate of two-digit numbers written per minute. The experimenter read the following instructions to the participant, “Welcome to the Mathematics Learning Lab! Get comfortable and when you are ready to read the instructions for the study, please tell me.”

Once the participants stated they were ready, the experimenter passed the rate assessment instructions (Appendix D) to the participants and then read the instructions aloud. After the participant stated she was ready, rate assessment worksheets were passed to them. The participant was instructed to keep the worksheets face-down in front of them until told otherwise. Rate assessment worksheets consisted of rows of two-digit numbers generated quasi-randomly, such that the same number did not occur more than two times in a row. A blank line was located

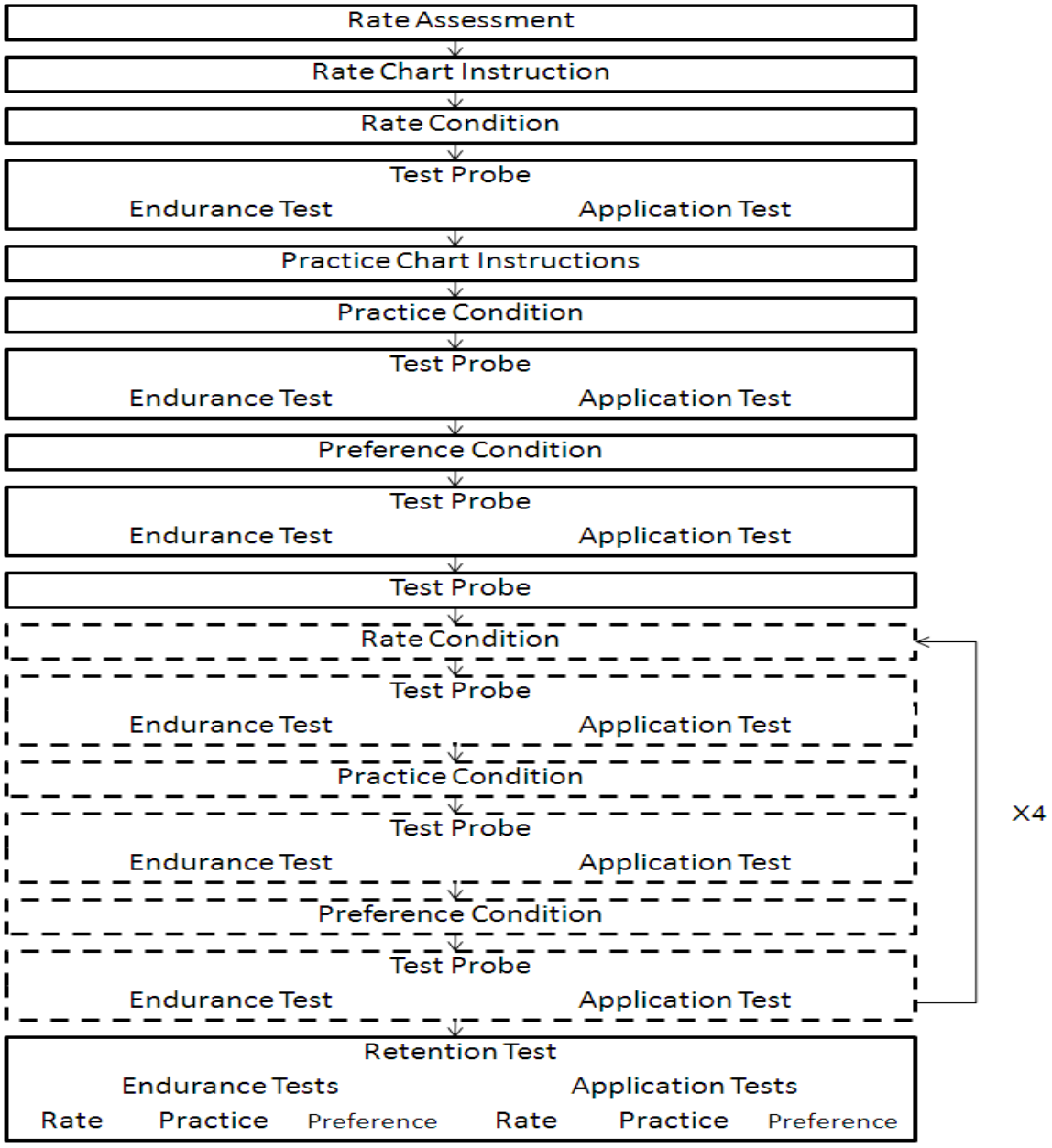

Figure 1. The sequence of conditions, instructions, and tests throughout the experiment. The dotted line around conditions indicates that the order for those condition cycles is random.

to the right of each number, providing a space for the participant to record her responses (Appendix E). The experimenter then said "When I say begin, you can turn the worksheets over and begin. Ready, and begin." The experimenter started the timer and the one-min timing began.

At the end of one min, the experimenter said, “Please stop and put your pencil down. The one-min timing is complete, please give your worksheet to me so I can score it and give you feedback.”

The experimenter corrected the worksheets and recorded the number of correct and incorrect responses made during an approximately one-min long break. After the break had elapsed, the experimenter provided oral feedback by saying, “Excellent, you wrote X numbers correctly during your one-min timing and you were XX percent correct. When you are ready for another minute timing, please tell me.”

The first timing of this procedure was conducted as a warm up, and did not count towards the assessment of writing rate. The participant was then exposed to at least three more timings using the same procedure. After each one-min timing, accuracy was assessed by calculating percent correct responding for that timing. Correct numbers per minute, or correct response rate, was also calculated after the timing to assess stability. Stability was defined as the rate of correct responding on the first and last timing for the last three timings being within 10% of the mean of the last three timings, with no increasing or decreasing trends. The stability criterion and all mathematical computations were performed by entering the correct and incorrect responses into a computer spreadsheet, was displayed in front of the experimenter at all times on a laptop. If the participant failed to meet the stability criterion or did not write 40 two-digit numbers per minute, she was given the feedback reported above and another one-min timing. If the participant failed to meet the accuracy, stability, and 40 numbers-per-min criterion within 6 timings, she was dismissed from the study. If the participant met the three criteria, the following feedback was

given orally, “Congratulations, you have reached our criteria for assessing your writing speed. Please tell me when you are ready to continue.”

In the subsequent conditions, 40 correct answers per minute was used as the rate criterion. Johnson and Layng (1996) stated that 80 to 100 correct responses per minute is a rate criterion that typically predicts RESAA outcomes. In typical rate building procedures, individual correct digits are counted as correct responses. Thus, a two-digit answer to a math problem could have either two correct responses, one correct response, or no correct responses. Due to the yoking procedure used in this study, described below, measuring individual correct digits would be difficult. Because of this, the current study defined a correct response as a two-digit number, and divided Johnson and Layng’s suggested fluency aim in half to derive the rate criterion.

Forced-Choice-Rate Condition. After the rate assessment, the participant began the first rate condition with written and oral instructions on how to plot feedback on the charts used in the rate condition. The participant was presented with an example rate chart, the rate chart instructions (Appendix D), and a feedback sheet (Appendix F). The feedback sheet had randomly generated correct response rate and incorrect response rate, as well as the accuracy. After the experimenter read the instructions aloud to the participant, the experimenter answered any questions the participant had. Afterwards, the experimenter said, “Ok, let’s see if you can graph these hypothetical data.” If the participant filled in their rate chart incorrectly, the experimenter said, “That’s incorrect. Here‘s what you did wrong…Please try to plot the rates again.” If the participant filled in their chart correct, the experimenter said, “You plotted the rates correctly.”

After the instructions on charting, the participant was exposed to the rate condition. The experimenter presented a piece of paper to the participant, with the statements “rate condition”

and “practice condition” printed successively on the sheet. The participant was then instructed orally: “You will be asked to complete arithmetic problems under two different experimental conditions, a rate condition and a practice condition. The first one is called a rate condition. Please circle the words rate condition on the paper in front of you.” After the correct response had been made, the experimenter presented the following instructions both orally and in writing, “The rate condition of this study involves answering simple arithmetic problems as quickly and accurately as possible on the worksheets like this one.” The experimenter showed sample worksheet to the participant (Appendix G). These worksheets consisted of two-digit addition problems arranged in rows. These problems were selected from a number array (Appendix H). There were five groups of number arrays, and each group was approximately equal in terms of carrying problems. One group of number arrays was used during each cycle of three conditions, described here and below. This allowed for problems in each cycle of conditions to be roughly equal in terms of carrying difficulty. When generating the worksheets, possible number combinations were chosen at random from a number array until there were no more potential problems. The same number was never used as both the numerator and denominator. This process was repeated until the worksheet had 70 problems. The experimenter then said, “To respond at the highest rate, it is best to complete the problems in order from left to right and top to bottom and not to skip around. For this condition, you will be attempting to reach the following goal.” The experimenter showed the participant a rate chart that was marked with the rate criterion. The experimenter then continued, “When you are ready to begin the rate condition, please tell me.” After the participant said she was ready, the experimenter handed math worksheets facedown to the participant.

The one-min timing began with experimenter saying “Ready, and begin,” as in the rate assessment. After the one-min timing was complete, the experimenter said, “Please stop and put your pencil down. The one minute timing is complete, please give your worksheet(s) to me and wait for feedback.” The experimenter calculated correct response rate, incorrect response rate, and percent correct accuracy using the same spreadsheet used during the rate assessment. The number of correct responses, incorrect responses, and percent correct were then written on a feedback sheet. After approximately a one-min break, the experimenter provided feedback. The experimenter presented the updated feedback sheet and read one of the four rate feedback instructions (Appendix D), depending on which criterion the participant met during the timing.

As mentioned earlier, the rate criterion was 40 correct responses per minute. The accuracy criterion consisted of 95% of the problems being answered correctly. The participant completed one-min timings until both criteria were met. If the participant met the criteria during the first one-min timing, or if they demonstrated no upward trend in correct rate of response within six timings, she was dismissed from the study. After meeting the criteria, the participant was exposed to a test probe, which will be explained later. After the test probe, the participant was then exposed to the practice condition.

Forced-Choice-Practice Condition. The practice condition began with instruction about the practice chart. The experimenter presented the practice chart instructions (Appendix D) orally and in writing.

After reading the instructions, the experimenter answered any questions that the participant had and then said, “Ok, let’s see if you can graph these hypothetical data.” The experimenter gave the participant a practice chart and a practice feedback sheet (Appendix I)

with a randomly generated cumulative correct responses, cumulative incorrect responses, and percent accuracy. If the participant filled in their chart incorrectly, the experimenter stated, "That's incorrect. Here is what you did wrong…Please try to plot the rates again." If the participant filled in their chart correctly, the experimenter gave the following feedback, "You plotted the rates correctly."

The practice condition was the same as the rate condition except the student was asked to circle the words "practice condition" on the initial sheet. The experimenter said to the participant, "The practice condition of this study involves completing the arithmetic worksheets, like during the rate condition. For this condition, you will be attempting to reach the following goal." The experimenter showed the participant a practice chart that was now marked with the horizontal line at the practice criterion. The experimenter then continued, "When you are ready to begin the practice condition, please tell me." The practice condition had the same accuracy criterion as the previous condition, so a specific timing had to have an accuracy of above 95% to meet the criterion. Instead of a rate criterion, the practice criterion was a number of correct trials yoked to the total number of correct responses made during the previous rate condition. For example, if a participant answered 100 problems correctly during the rate condition, then that participant would have to answer 100 problems correctly in the subsequent practice condition. As the participant came close to reaching the yoked number of correct problems, the experimenter placed a vertical red line after the last trial needed to complete the yoked number on a worksheet. The participant was informed to stop once she reached the red line. If the participant was in the middle of a timing when they reached the yoked number of trials, the timing immediately ended and the experimenter recorded the timing duration.

Like the rate condition, one of four practice feedback instructions (Appendix D) was given after each timing, depending on the participant's performance.

Test Probes. After each condition, the participant was exposed to an endurance probe and an application probe. Each probe tested the participant's fluency in the addition problems from the previous condition. The endurance probe consisted of administering a four-min timing instead of a one-min timing. The same addition worksheets were used from the previous condition. The endurance probe began with the experimenter saying, "We are about to test your mastery of the arithmetic you just did with a longer test. When you are ready to begin, please tell me." At the end of the timing, the experimenter followed the same procedure as in the normal condition. Specifically, the participant was told to stop, the experimenter graded the worksheets, and calculated the correct response rate, incorrect response rate, and accuracy. The experimenter then said, "Your correct rate was XX responses per minute and YY incorrect responses per minute. Your percent correct was XX%. Please hand me your unused worksheets and wait for me to prepare the next test."

The application probe began with the following message, "We are about to test your mastery of the material you just learned with some word problems. You have unlimited time to complete this worksheet; I am just timing this to calculate a response rate. When you are ready please tell me." When the participant indicated that she was ready, the experimenter presented her with a face-down worksheet (Appendix J). The experiment then began the test with the same, "Ready, and begin," statement. The worksheet consisted of five word problems, each followed by a blank space for the answer. As noted in the instructions, the participant had unlimited time to complete the application probe but was still timed. At the end of the probe, the experimenter

stopped timing, and said, “Please give your worksheet to me and wait for feedback.” The experimenter then recorded the total correct responses, the total errors, and the duration of the timing. The experimenter then calculated the correct response rate, incorrect response rate, and percent correct. The participant was then given the following feedback orally, “Your correct rate was XX responses per minute and YY incorrect responses per minute. Your percent correct was XX%. Please give me your old chart and wait for me to prepare the next condition.”

Preference Condition. After the participant had completed one rate condition, one practice condition, and the subsequent test probes for each condition, she was then exposed to a preference condition. The preference condition consisted of presenting the participant with the sheet that had the phrases “rate condition” and “practice condition” printed on them, as during the previous conditions. However, the participant was now told the following instructions, “For a new set of problems we are giving you a choice of whether you would rather have to meet a rate criterion or a practice criterion. Please circle the condition you would rather complete. The problems will be the same no matter which condition you choose.” The rate condition was conducted in the same fashion as described above. Specifically, the participant had to make 40 correct responses during a one-min timing with an accuracy of 95% to complete the condition. If the participant chose the practice condition, the yoked number of correct trials was derived from the number of correct trials in most recent rate condition.

During the first cycle of conditions, the order of conditions was rate, practice, and preference, with test probes occurring after each. After the first cycle, however, the conditions occurred in one of three orders, with the qualification that the same order of conditions only occurred for two consecutive condition cycles. The three orders were as follows: rate then

practice then preference, rate then preference then practice, or preference then rate then practice. Although the preference condition could occur at any position within a cycle of conditions, the rate condition always preceded the practice condition in a cycle. This allowed for the yoking of the practice criterion to the correct responses made in the preceding rate condition.

Retention Tests. After the participant had successfully completed 5 cycles of the conditions, they were asked to return to the lab after at least two weeks had passed to take retention tests. Upon the participants' return, she was assessed on up to four endurance probes and up to four application probes. The participant was exposed to these probes quasi-randomly, with the qualification that they did not get two endurance probes or two application probes in a row. The procedure for the endurance and application probes were generally the same as those used previously, except one application probe and one endurance probe was based on the material from all rate conditions, one application and one endurance probe was based on all practice conditions, one application and one endurance probe was based on the material from all the preference conditions in which rate was chosen, and one endurance probe and one application probe was based on the material from all the preference conditions in which practice was chosen. If the participant consistently picked one condition during the preference conditions, she was only given three endurance tests and three application tests during the retention test. For each probe, problems were selected quasi-randomly from the five respective rate, practice or preference conditions. Specifically, after a problem from a particular condition was selected, another problem from the same condition was not selected again until all of the other conditions had been exhausted. Furthermore, the same problem that was selected was not selected again until all of the problems from that particular condition had been exhausted. Each endurance probe began with the experimenter making the following statement: "We are going to test how

well you can perform on the material you learned two weeks ago with a four-min test. When you are ready, please tell me." The subsequent procedure, such as grading and feedback, was the same as a normal endurance probe. The application probes began with the experimenter making the following statement: "We are going to test how well you can apply what you learned two weeks ago with word problems. When you are ready, please tell me." The subsequent procedure was the same as a normal application probe.

After the participant completed the final probe, the participant was presented with a survey and the following oral instructions, "Thank you for participating in our study. Before you leave, please fill out this brief survey." The participant was presented with a 5 point Likert-scale survey, which served as a self-report of both preference and performance (Appendix K).

Compensation. Participants were given extra credit and money as compensation for participating in the study. Participants earned $1.00 for every day they attended their scheduled session. If they missed an appointment, the $1.00 bonus was not given for the rescheduled session. In addition, participants earned $0.02 cents for each correct response during the rate assessment. The participants earned $1.75 every time they met the criteria for a condition. Furthermore, they earned $0.01 for each correct response during endurance probes and $0.28 for each correct response during application probes. At the end of each session, the participant was presented with a summary of their earnings. Payment and proof of participation were given at the end of the study. Participants earned on average $8.80 per session, with a range from $1.00 to $20.10.

Results

Data are presented for 4 participants with comparisons made during preference conditions, each cycle of conditions, and on the retention test. Of the 13 participants recruited, 9 were dismissed during the initial rate condition due to a failure to demonstrate an upward trend in correct responses per minute and a failure to achieve 40 correct responses in a minute during the first forced-choice-rate condition. Furthermore, due to a yoking error, Participant 101's third condition cycle is not included in the analyses. Finally, the yoking procedure complicated the analysis of the final timings from each practice condition. As mentioned in the forced-choice-practice-condition, participants were stopped in the middle of one-min timings when they reached the yoked number of correct responses. This produced last timings for each practice condition that varied from four sec to one min in duration. When the last timing's duration was short, it produced aberrant response rates, which were not indicative of the participants' earlier performance. Therefore, any final timing from a practice condition was not included in the analyses of rate, unless that final timing was one min in duration.

Table 1 shows the percentage of the preference conditions in which the participants chose the practice criterion. This percentage was derived by dividing the number of preference conditions in which the practice criterion was chosen by all of the preference conditions to which the participant was exposed. Participants 101 and 113 always selected the practice criteria during preference conditions. Participant 104 selected the practice criteria for four of the five preference conditions. Participant 102 chose the practice criteria for two of the five preference conditions. Therefore, three of the four participants indicated a preference for the practice criteria when presented with a choice. Two of those three participants never chose the rate criteria during a

Table 1

Total Time (in minutes) Spent In the Rate and Practice Conditions, and Percentage of Preference Conditions for which the Practice Criterion Was Chosen

Participant	Total Time in Rate	Total Time in Practice	Percent Choices of Practice
101	63	65.95	100%
102	25	26.65	40%
104	31	29.67	80%
113	25	30.07	100%

preference condition. Although Participant 102 chose the rate condition for most preference conditions, she also chose the practice condition twice, thus showing some ambivalence for rate over practice. Overall, practice was selected for 16 of the 20 preference conditions (80%) across participants.

Table 1 also shows the total time needed in minutes that each participant needed to complete all of the rate conditions and all of the practice conditions. The total time was calculated by adding the timing durations from every forced-choice-rate condition and every forced-choice-practice condition. With the exception of Participant 104, all of the participants completed rate conditions more rapidly than practice conditions. The differences in time needed to complete the two conditions ranged from 1.33 minutes to 5.01 minutes.

Table 2 shows the participants' average accuracy for each condition cycle and overall average accuracy. Overall average accuracy is defined as the mean accuracy of every timing in

Table 2

Average Accuracy by Condition Cycles for All Participants

		Condition Cycles					
Participant		1	2	3	4	5	Overall
101							
	Rate	100%	100%	x	100%	99.87%	99.94%
	Practice	100%	100%	x	100%	99.90%	99.95%
102							
	Rate	98.92%	98.28%	100%	97.87%	96.99%	98.05%
	Practice	97.19%	98.37%	100%	100%	99.60%	98.72%
104							
	Rate	100%	100%	99.14%	100%	100%	99.64%
	Practice	100%	99.66%	100%	100%	100%	99.93%
113							
	Rate	99.44%	95.84%	100%	100%	100%	99.03%
	Practice	99.51%	100%	98.80%	100%	95.24%	98.92%

each condition. There were no systematic differences between the two conditions in terms of accuracy. The average difference between accuracy achieved in the two conditions was .95%.

Furthermore, none of the participants had an overall average accuracy that differed by more than 0.67%. Overall, incorrect responses were both infrequent and inconsistent.

Figure 2 shows the terminal response rate, defined as the average of the last three timings of a condition. If a condition's criteria were met before three timings were completed, then all of the timings from that condition were used to calculate the terminal rate. For Participant 101, the rate condition produced the highest terminal rate for three of her four condition cycles. Again, condition cycle 3 was omitted due to a yoking error, so only four of Participant 101's condition cycles can be analyzed. Participants 102 and 113 achieved the highest terminal rate in the rate condition for four of the five condition cycles. In condition cycle four, both the rate condition and the practice condition produced equal terminal rates for Participant 102. In contrast, Participant 104 achieved the highest terminal rate during the rate condition for only two of the five condition cycles. Overall, the rate condition produced the highest terminal rate for 13 of the 19 condition cycles included in the analysis.

Figure 2 also shows the highest rate achieved, denoted by the top of the error bars. The rate condition produced the highest response rate for all cycles for Participants 101 and 113. Participant 102 achieved the highest response rate during rate conditions for four of the five condition cycles. For Participant 104, the rate condition produced the highest response rate for three of the five condition cycles. Overall, the rate condition produced the highest correct response rate for 16 of the 19 condition cycles.

Figure 3 shows correct responses per minute during the endurance probes across successive conditions. Participant 101 typically achieved the highest endurance rates following rate conditions. The only exception was the first cycle of conditions, in which she achieved the

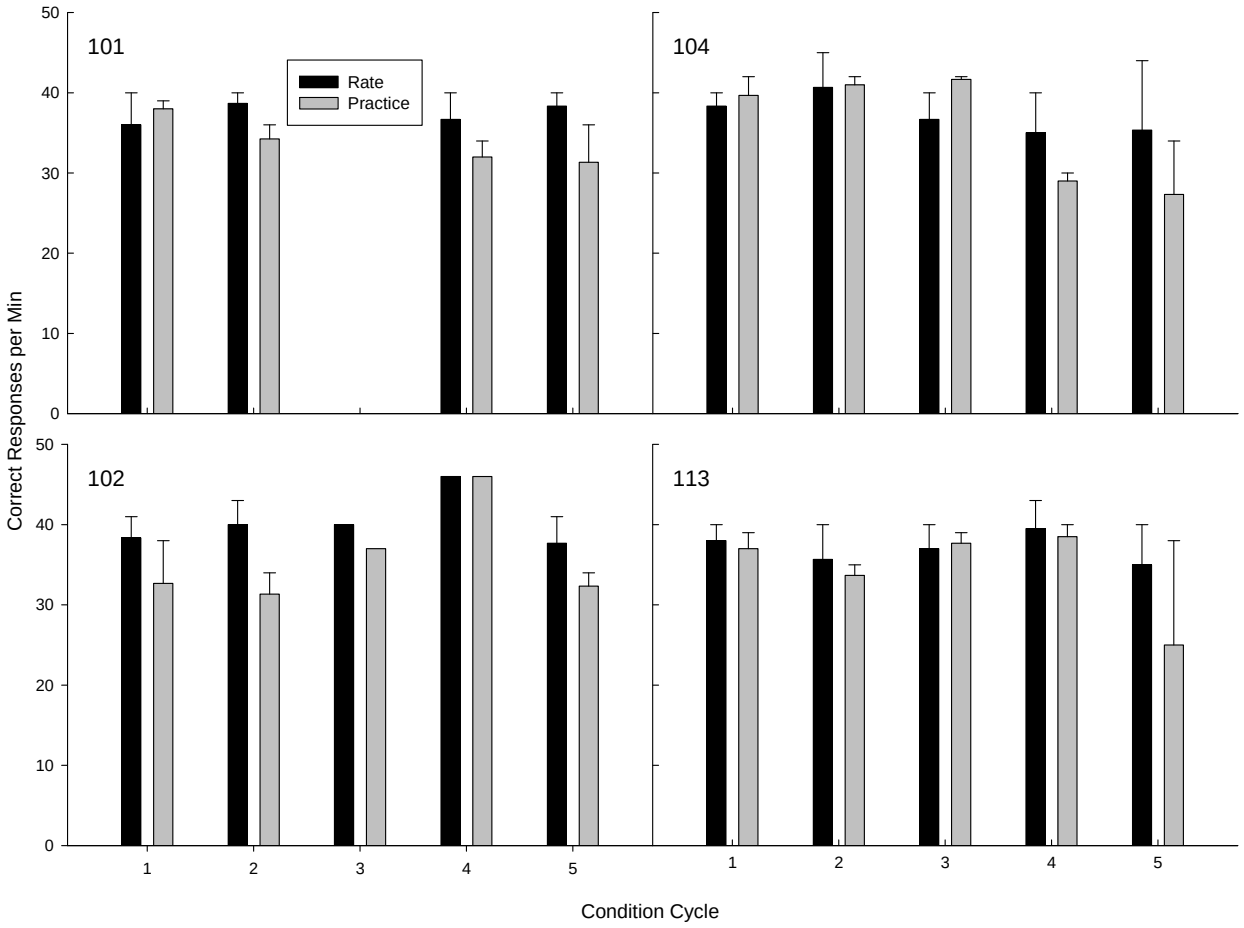

Figure 2. The average correct rate of response from the last three timings for each condition. The error bar denotes the highest correct rate achieved during the condition.

highest endurance rate following the practice condition. Participants 102 and 104, however, achieved higher endurance rates following three of the five practice conditions. For Participant 113, the highest endurance rate was always achieved following practice conditions. However, endurance rates produced by the rate condition and the practice condition in condition cycles two

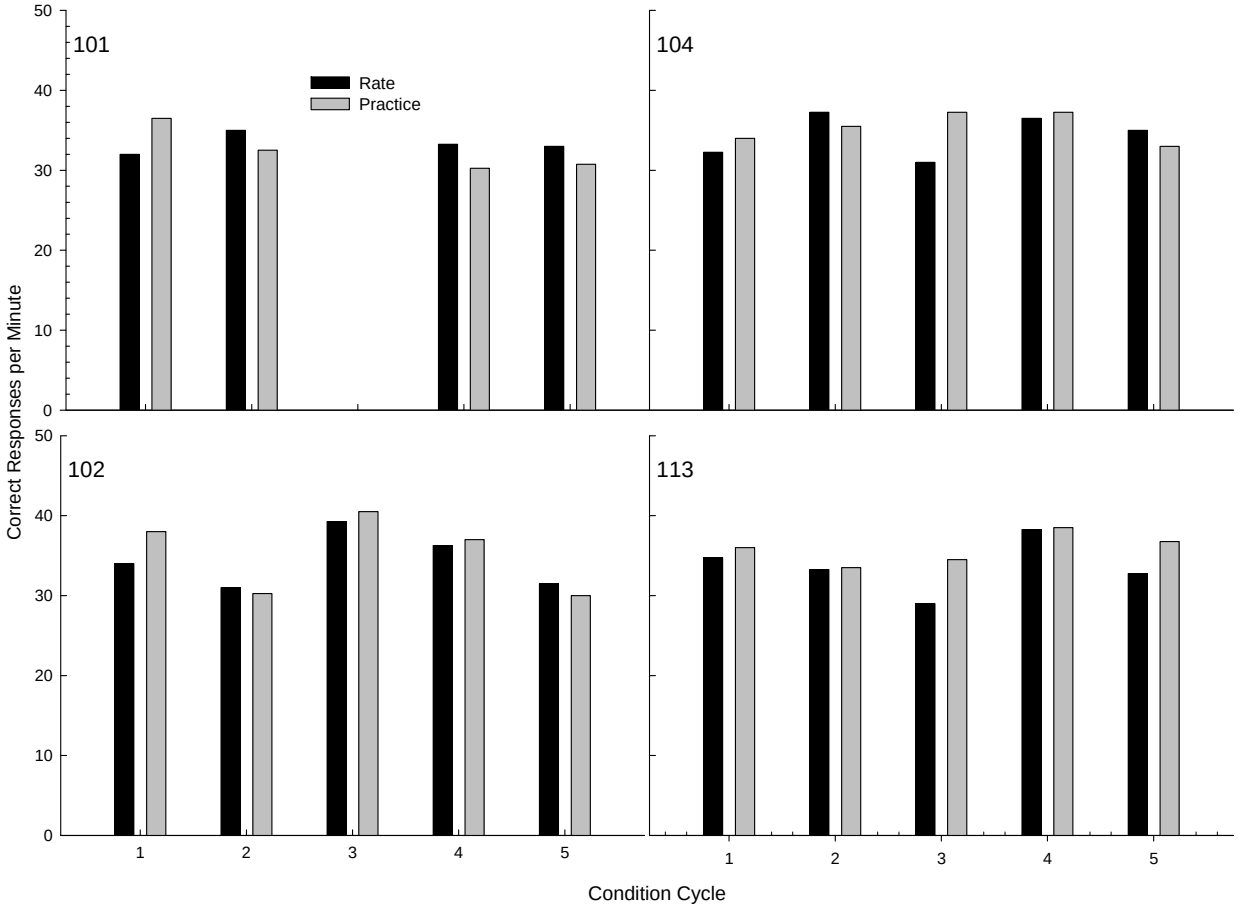

Figure 3. Correct response rate per minute achieved during endurance tests for all conditions.

and four were almost equal. Therefore, the relation between correct response rate on the endurance probes and condition were mixed.

The left panel of Figure 4 shows the mean of the response rates from the last three timings of a condition (terminal rate) as a function of the endurance rate achieved. Each point is scaled using the terminal rate on the y-axis and the endurance rate on the x-axis. Thus, each point represents a single condition. Closed points represent rate conditions and open circles represent practice conditions. Research on rate-building procedures states that RESAA outcomes are a

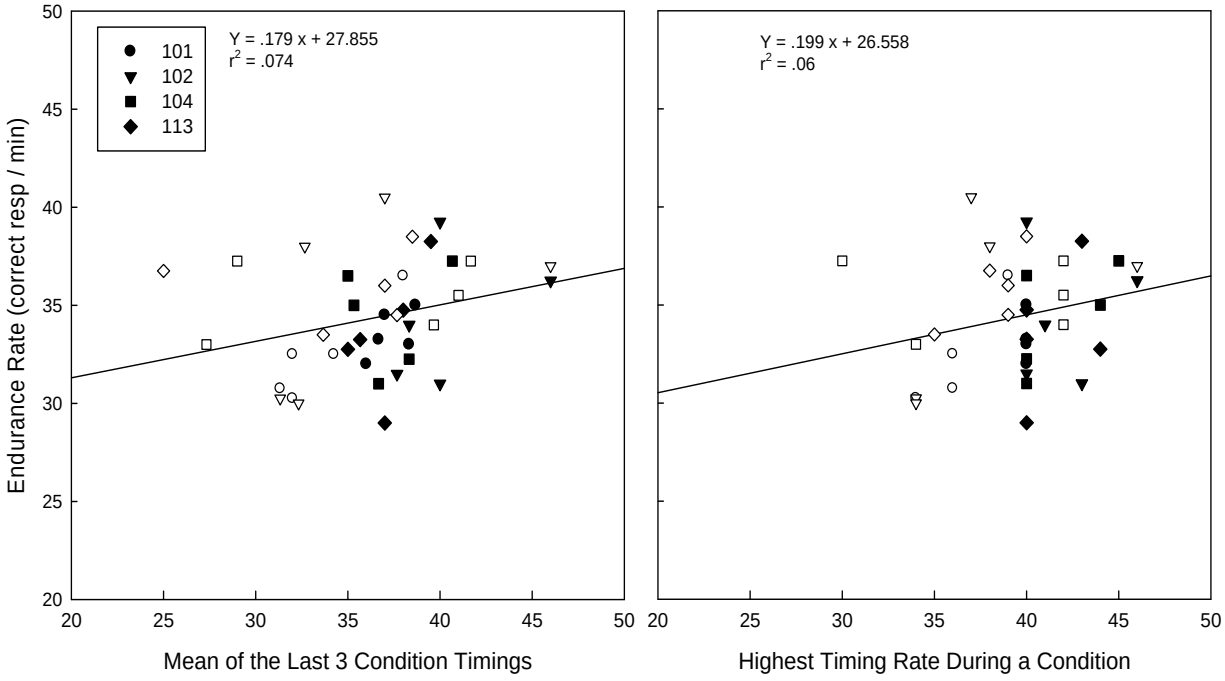

Figure 4. Correct endurance rate as a function of both the mean correct response rate from the last three timings in each condition and the highest rate achieved during a condition. Closed circles represent rate conditions and open circles represent practice conditions. The solid line represents the line of best fit. The linear equation and Pearson's r^2 are also provided.

product of the rates produced by a subject (Johnson & Layng, 1996). Thus, low rates should produce low rates during outcome tests, and high rates should produce high rates. Because Johnson & Layng's statement predicts a linear relation between terminal rate and endurance rate, a line of best fit was plotted for the data in the left panel of Figure 4. The line of best fit shows an upward trend, indicating that higher terminal rates were associated with higher endurance rates. However, the linear regression did not provide a good fit for the data (r^2 = .074). The right panel of Figure 4 shows the highest timing achieved plotted with endurance rates. These data are

plotted in the same way as the left panel. Again, the regression line in the right panel shows an upward trend, although the linear regression provides a poor fit for the data (r^2 = .06).

Examining endurance using a measure of proportional change, however, shows a consistent relation between the timing condition and endurance probes. Figure 5 shows the log proportion of the response rate per minute during the endurance test divided by the highest rate achieved in the previous condition. For example, Participant 101 achieved a rate of 40 during the one-min timings and an endurance rate of 35 for condition cycle 2. Thirty five was divided by 40, and was logarithmically transformed, yielding a value of -0.058. Participant 101, 102 and113 showed the greatest relative decrease on the endurance probes following the rate condition for every condition cycle. With the exception of condition cycle two, Participant 104's endurance rates decreased the most after rate conditions. Overall, the rate of responding on the endurance probes decreased the most following the rate condition for 18 of the 19 condition cycles.

Figure 6 shows the correct responses per minute during the application probes for each participant. Participant 101 completed application problems at a faster rate following practice conditions than during rate conditions for all four condition cycles. Participants 102's performance during application probes was higher following practice conditions than during probes that followed rate conditions for four of the five condition cycles. Participant 104 achieved the highest application rate following the practice conditions for all of the condition cycles. For Participant 113, the practice condition produced the highest application for only one of the five condition cycles. Overall, the practice condition produced the highest application rate for 14 of 19 condition cycles.

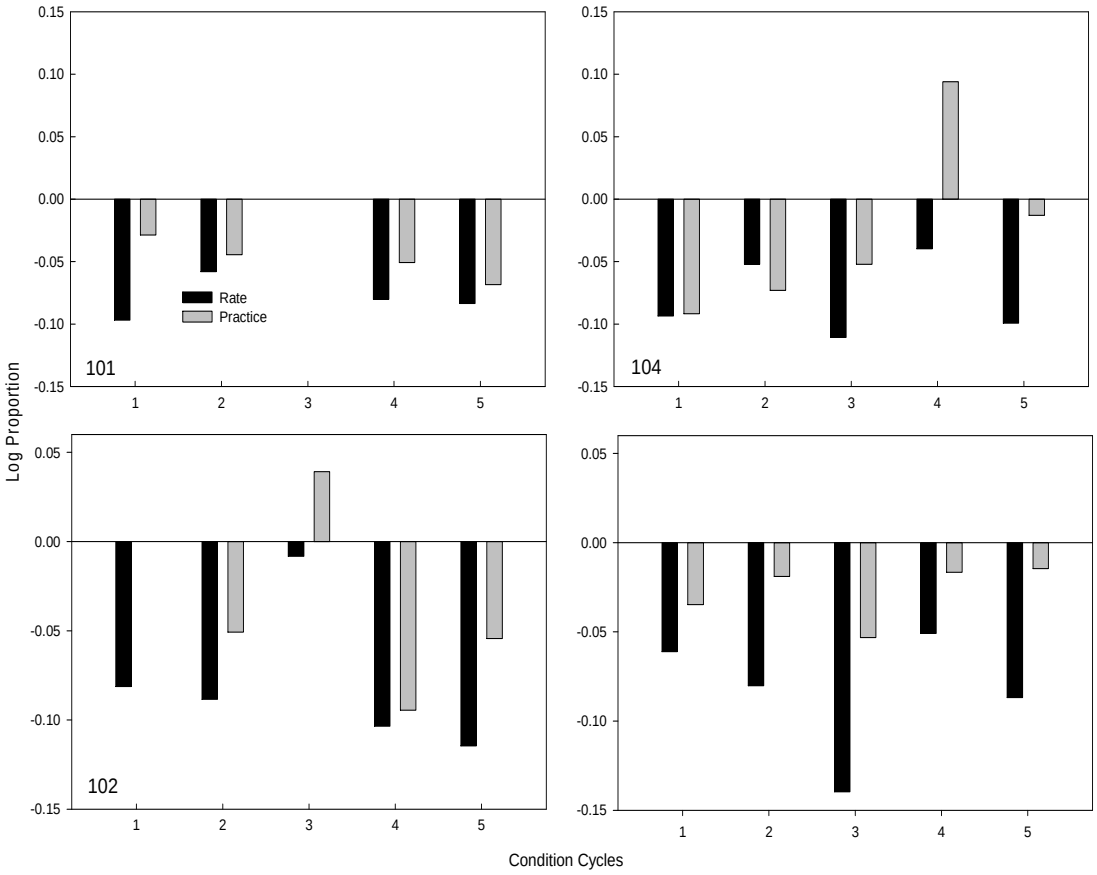

Figure 5. The log correct response rate per minute during the endurance test divided by the correct response rate from the previous condition's highest timing.

The left panel of Figure 7 shows the relation between the mean of the response rate from the last three timings of a condition and the subsequent application rate achieved. Like endurance, superior application performance is stated to be an outcome of rate-building procedures (Johnson & Layng, 1996). Thus, application rates should be correlated to the terminal rate. A linear regression was plotted against the data to determine the relation between terminal rates and application rates in the same manner as endurance rates. The line of best fit for the left panel shows there is no upward trend in the relation between terminal rate and application rate, indicating that high terminal rates do not predict high application rates. The line of best fit was

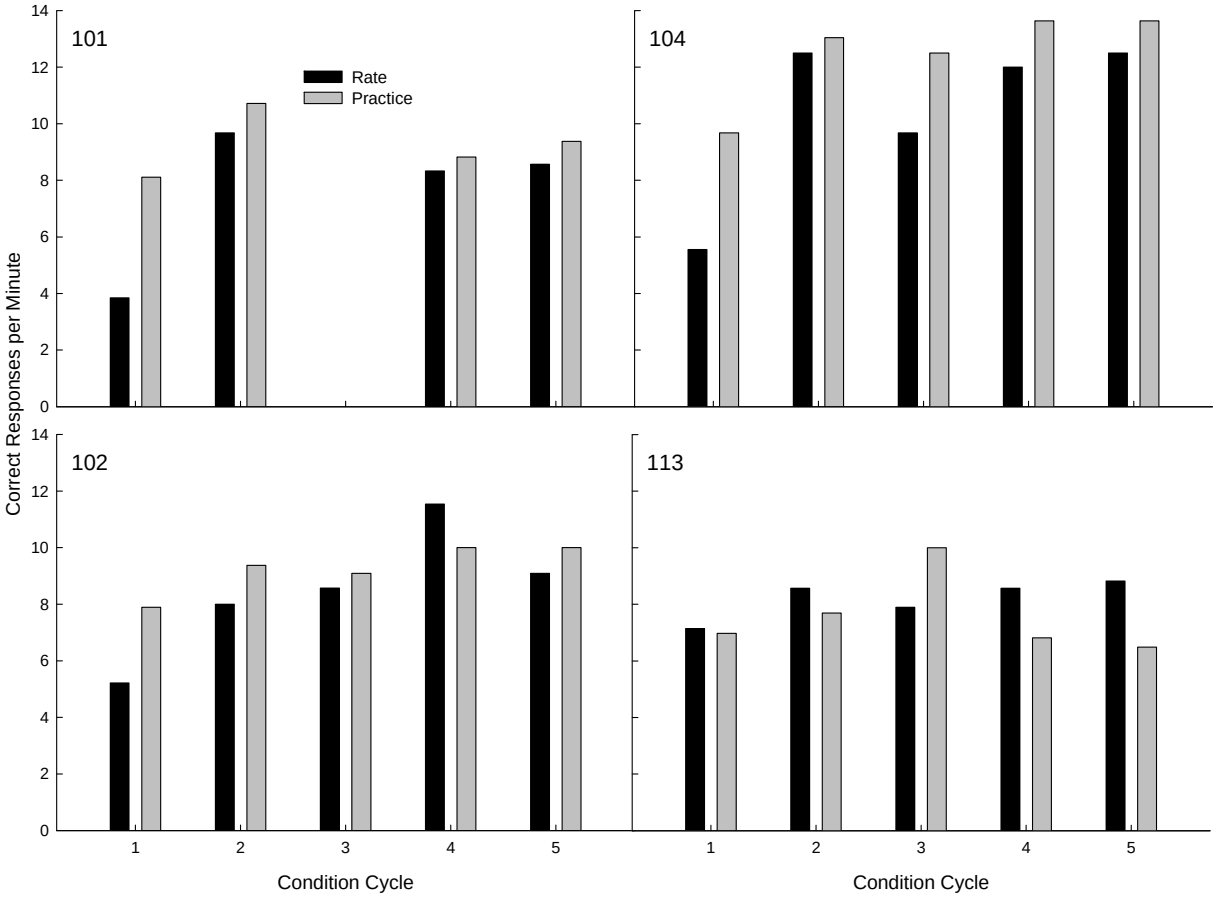

Figure 6. Correct rate of response per minute during application tests for each participant.

also a poor fit for the data (r^2 = .001). The right panel of Figure 7 shows highest rate achieved plotted in the same manner as the terminal rate on the left panel. The line of best fit for the right panel shows a slight downward trend, indicating that the highest rate achieved during a condition was not correlated with high application rates. This line was also a poor fit for the data (r^2 = .008).

The final RESAA outcome analyzed by the current study was retention. Previous literature would predict that the performance produced by rate-building procedures would be less

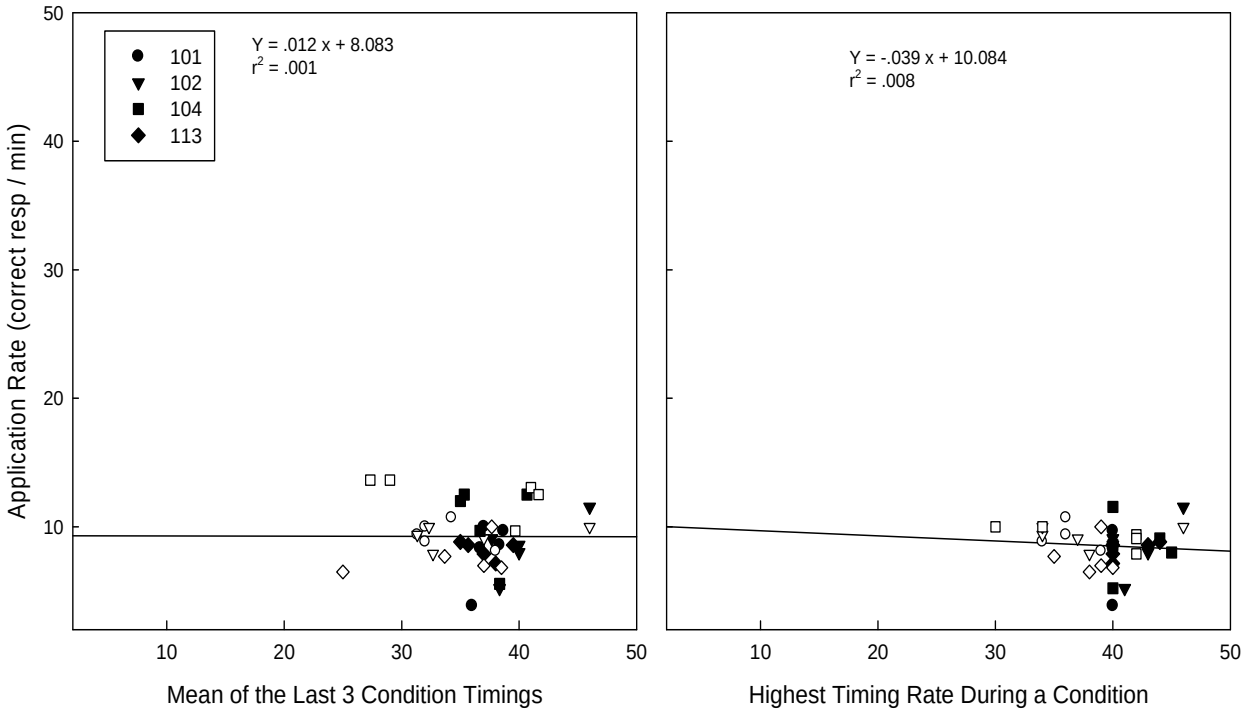

Figure 7. Correct application rate as a function of both the mean correct response rate from the last three timings in each condition and the highest rate achieved during a condition. Closed circles represent rate conditions and open circles represent practice conditions. The solid line represents the line of best fit. The linear equation and Pearson's r^2 are also provided.

disrupted by a break from training than would procedures with no rate criterion (Johnson & Layng, 1996). To evaluate this, a relative measure of performance was used to determine the decrease in performance from normal sessions to the retention test. The top panel of Figure 8 shows the log of the response rate on the endurance portion of the retention test divided by the average response rate on the endurance probes from every condition cycle. Participants 101, 102, and 113's correct response rates from endurance probes following the rate condition showed the greatest decrease from the prior conditions to the retention test. For Participant 104, endurance

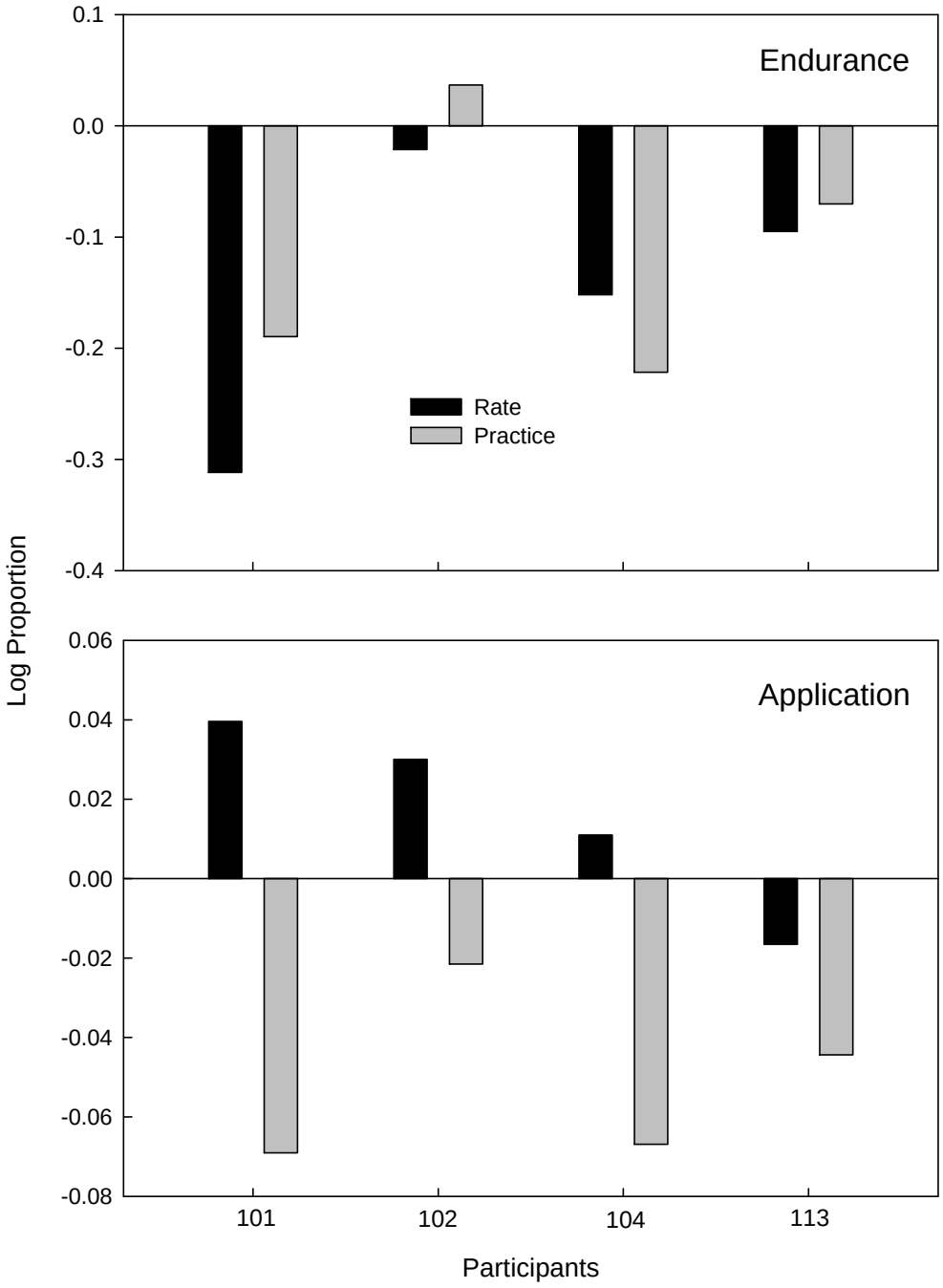

Figure 8. The log correct response rate during the retention test divided by the mean correct response rate per minute during earlier probes for the endurance and application material.

rates for the practice condition during which practice was chosen showed the greatest relative decrease. Overall, the correct response rate during the retention test dropped most relative to earlier rate conditions for three of the four participants.

The bottom panel of Figure 8 shows the log of the response rate on the application portion of the retention test divided by the average response rate on the endurance probes from all condition cycles. During the retention test, all of the participants' application rates exhibited the greatest relative decrease in rates achieved during the practice conditions. For Participants 101, 102, and 104, application rates from the rate conditions improved during the retention test.

Table 3 shows the participants' responses to the survey given after the retention test. To evaluate the accuracy of self report, these survey responses were compared to actual behavioral measurements of preference and performance. Because the first two items of the survey could not be compared with objective data, like actual choices during the preference conditions, they were excluded from the analysis. Participant 101 indicated that she enjoyed both conditions. Furthermore, she correctly indicated that she completed math problems more quickly during the rate condition, yet was more accurate in neither condition. Participant 101 also reported a preference for the practice condition. For Participant 101, the answers given on the survey corresponded with her behavioral data. Participant 102 indicated that she enjoyed the rate condition, but did not enjoy the practice condition. Participant 102 also indicated that she completed problems more quickly in the rate condition and completed problems more accurately in the practice condition. Although there little difference between accuracy achieved in the two conditions, her answers to items three and four were correct when compared to her performance. Participant 102 also indicated she preferred the rate condition, which matches the behavioral

Table 3

Participants' Responses to the Post-Experiment Survey

	Participant			
Survey Item	101	102	104	113
1. Enjoyed Rate	4	5	2	4
2. Enjoyed Practice	4	2	4	5
Which Condition Did You:				
3. Complete More Quickly	R	R	P	P
4. Complete More Accurately	0	P	P	P
5. Prefer	P	R	P	P

For survey items 1-2, (1=Strongly Disagree, 5=Strongly Agree). For survey items 3-5 (R=Rate, 0=Neither, P=Practice).

measure of preference. Participant 104 indicated that she did not enjoy the rate condition, but did enjoy the practice condition. Furthermore, she indicated that she completed problems more quickly and more accurately in the practice condition. Although there was little difference between the two conditions in terms of accuracy or rate, Participant 104's answers are correct. Participant 104 also indicated she preferred the practice condition, which agrees with the study's behavioral measure. Participant 113 indicated that she strongly enjoyed the practice condition and enjoyed the rate condition. Furthermore, Participant 113 indicated that she completed

problems more quickly and more accurately in the practice condition. When compared with the performance data, Participant 113's answers to survey items three and four are inaccurate. However, she indicated a preference for the practice criteria, which corresponds to her choices before preference conditions. With few exceptions, the participants' answers to the survey corresponded with behavioral measures of preference and performance.

Discussion

Overall, 3 of the 4 participants showed a strong preference for the practice condition. Furthermore, the participant who preferred the rate condition did so only on 3 out of 5 choices. In addition, self-reported measures of preference were consistent with choice of condition, with 3 of the 4 participants indicating a preference for the practice condition.

There were consistent, albeit small differences in the performance outcomes produced by the two conditions. Although the rate condition typically produced the highest rate during the one-min timings, it did not consistently produce superior fluency in terms of endurance, application, and retention. For instance, endurance rates following rate conditions showed the largest relative decrease when compared to the preceding one-min timings. In terms of endurance performance, the rate condition did not systematically produce the higher correct response rate. Furthermore, response rates achieved in practice conditions decreased less from one-min timings to the longer endurance test when compared to rate conditions. For 3 of the 4 participants, application rates were generally higher following practice conditions. During the retention test, endurance rates from the rate condition showed the largest relative decrease, whereas the application rates from practice conditions showed the largest relative decrease. In terms of performance outcomes, neither condition consistently produced superior performance outcomes. When systematic differences were observed, these differences were quite small. There was also no systematic relation between the condition that produced the highest rate and the condition that produced superior endurance and application outcomes during a condition cycle.

The findings of this study deviate largely from previous research comparing rate building to self-paced methods. Although Miller et al. (1995) reported a strong preference for rate-

building procedures, the current study found the opposite. Furthermore, most studies on rate-building procedures report superior performance outcomes when compared to self-paced methods. The current study used the endurance, application, and retention as measures of fluency, but found little differences in the outcomes produced by the rate and practice conditions. Although the rate condition typically produced the highest correct responses per minute, the rates in the practice condition were comparable. Furthermore, the correlation between high response rates and superior RESAA outcomes was not observed. This could either be because the rates in the two conditions were not drastically different, or because other factors are more important in producing RESAA outcomes. The findings of this study are similar to those of Shirley and Pennypacker (1994). Specifically, when practice was kept constant across rate-building procedures and self-paced procedures, neither condition produced consistently superior RESAA outcomes.

Methodological differences may explain the discrepancies between the outcomes of this study and prior research. The current study is the only one to date that employed behavioral measure of preference for rate-building procedures. However, it is unlikely that this caused the discrepancy between the current study and Miller et al. (1995). In the current study, all of the participants self-reported their preferences consistently with their earlier choices during the practice condition. A more logical conclusion is that the differences in the two conditions being compared caused the discrepancy. Miller et al. did not control for the amount of practice and reinforcement across conditions. These procedural differences probably influenced the participants' preference towards the practice condition. When practice and reinforcement are equated across conditions, the resulting outcomes do not systematically favor rate building.

Because the current study equated conditions to control for the variables (such as reinforcement density) mentioned by Doughty et al. (2004), other factors must have controlled participants' choices during preference conditions. One possibility is that the participants preferred the most efficient condition, defined as the condition that facilitated the completion of the same amount of correct responses in a shorter amount of time. This conclusion is unlikely, because the rate condition was systematically more efficient than the practice condition. However, the difference between the times necessary to complete the two conditions was not largely different, which could have contributed to preference for the practice condition. If the participants were artificially slowed during the practice condition in order to increase the relative efficiency of the rate condition, this could result in a shift in preference.

The second possibility is that the participants preferred the condition that produced superior performance outcomes. This also seems unlikely, because neither condition produced superior endurance, application, and retention outcomes. Although specific outcomes did favor the rate condition or the practice condition, the overall the outcomes produced by the two conditions were not vastly different. Like efficiency, methods that would make one condition superior in terms of performance outcomes could cause a shift in preference.

A final possibility is that the participants preferred the condition that required the least amount of improvement in behavior. The practice condition required the participants to complete a certain number of problems, but did not require any improvement in correct response rates. Although improvement in response rate during the practice condition would allow the participants to earn money more quickly, it was not required. The rate condition, however, required improvement if the participant's arithmetic skills were not already fluent. Evidence of

this is seen in Participant 102's performance. Participant 102 could already complete addition problems quickly, and as a result the rate criterion would be relatively less stringent for her than for the other participants who needed to improve. Consistent with this possible relation, 102 was the only participant who showed a preference for the rate condition. This suggests two possible changes for future research. One would be to recruit participants that are more fluent than the participants in the current study. The other would be to lower the rate criterion to a point where little improvement was needed. Either one of these changes might shift preference.

Discrepancies between the current study and previous studies in terms of performance outcomes can be attributed largely to methodological differences. To date, few studies that evaluated the use of fluency aims also controlled for the amount of practice in a control condition. As mentioned earlier, Shirley and Pennypacker (1994) obtained mixed results when practice was yoked across conditions. The current study also controlled for practice, and was unable to produce largely discrepant performance outcomes. This is a strong indication that the number of problems completed has an effect on performance outcomes. However, it is difficult to determine what role rate plays in this process. Because repeated practice generally leads to higher response rates during successive one-min timings, the two variables are usually confounded.

There was also no clear evidence of a linear relation between correct rates achieved during one-min timings and subsequent performance outcomes. Although there was a weak positive correlation between timing rates and endurance rates, there was no correlation in the analysis of the application data. This indicates that achieving high rates during one-min timings does not necessarily predict that high rates will be achieved in endurance and application tests.

However, this could be due to the sample of data from this study. Both conditions produced comparable results, and thus the rates achieved during the one-min timings might have been too similar to produce differential RESAA outcomes. If correct responding during the practice condition was markedly slower than the rate condition, then statements about RESAA outcomes could be properly evaluated. Overall, the limited data indicate that requiring high rates during timings does not necessarily produce superior RESAA outcomes.

Several procedures used in the current study could have limited the results obtained in general. The participants were always exposed to the conditions in the same order for the first condition cycle, which might have influenced the outcomes observed. This is particularly problematic if the effects of the rate condition carried over to the practice condition. Specifically, once the participants were made to complete problems quickly, they did so regardless of the condition. Furthermore, the rate criterion used was always the same, while the practice criterion changed across condition cycles. Because the rate condition was always static, the participants might have preferred the condition where the criterion changed, not the actual practice condition itself. Another concern was the number of participants that had to be dismissed from the study. All of the participants dismissed could not meet the correct rate requirement, suggesting that the frequency aim might have been too high. It also indicates that people who were less fluent in math skills were being excluded from the study, which limits the generality of the findings.

The findings of the current study differ from those reported by Critchfield and Perone (1990). Specifically, the participants in the current study could accurately self-report both their performance and preference outcomes, whereas the participants' in the study by Critchfield and Perone could not. The amount of feedback given to the participants in the two studies could

explain the discrepant results. Participants in the current study were given feedback, and kept track of this feedback on a standard behavior chart. In contrast, the participants in the Critchfield and Perone study were not given feedback (depending on the experimental condition). If feedback and the behavior chart were not provided in the current experiment, self reports on the survey might have been less accurate.

Further research would need to address these concerns, particularly those that may influence the participants' preference. Both the participants' level of fluency and the stringency of the criterion could play a role in participants' preference for either condition. Recruiting and categorizing participants based on fluency and systematically manipulating the rate criterion would permit an examination of these assumptions. If the participants' preferred the condition with a changing criterion versus a static criterion, then systematically manipulating the rate criterion would eliminate this possible confound. Furthermore, methodology should be developed that directly manipulates rate for the purposes of examining its effects on both preference and performance. The implementation of contingencies that favor high and low rates would accomplish this goal.

The effect of the choice situation itself could also be explored. It has been demonstrated that people's behavior changes when given a choice between two alternatives. Dunlap et al. (1994) exposed children to two conditions, one in which educational tasks were predetermined by the experimenter, and one condition where the child was allowed to choose their educational task. Although the material was roughly equivalent across the two conditions, the participants exhibited more on-task behavior and less disruptive behavior during the choice condition. The findings in this study were replicated by Powell and Nelson (1997) with a participant from a

general education population rather than a student in a special education program. Powell and Nelson also studied choice without another behavioral management program in place, unlike Dunlap et al. who had reinforcement contingencies in both conditions. Although the yoking procedure of the current study did not allow for a comparison of choice and forced-choice conditions, a preference situation might augment the performance outcomes of either a rate or practice condition.

Overall, the findings of this study are largely discrepant from previous rate-building studies. The current study demonstrated that participants generally preferred the practice criterion over the rate criterion. While this is may be a function of the relative stringency of the rate condition, further research is needed to explore this interpretation. The current study also found that neither of the conditions produced superior performance outcomes. At a procedural level, this is probably due to both reinforcement and practice being equated across conditions. However, this does not help explain what produces superior RESAA outcomes. Previous studies have suggested that correct response rate itself is important in performance outcomes. The current study cannot adequately evaluate this claim; the practice condition produced comparable rates to those achieved in the rate condition. While this information would be useful for understanding the mechanics of rate building, it would be impractical in an applied setting to artificially slow down students.

Given the findings of this study, behavioral educators should be wary of implementing a rate criterion when academic training skills. The majority of participants did not prefer the rate condition, and instead preferred a condition which produced comparable RESAA outcomes. In addition, the practice condition was capable of producing high rates during one-min timings and

during test probes. This indicates that a correct-response criterion could be implemented to produce performance outcomes comparable to those produced by rate-building procedures.

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Appendix A

CONSENT AND INFORMATION FORM

An Experimental Analysis of Preference for Rate Building

Principal Investigator: Chase, Philip Department: ARTS & SCIENCES-Psychology Tracking Number: None

Study Title:

An Experimental Analysis of Preference for Rate Building

Co-Investigator(s):

Lightner, Andrew

Sponsor

None.

Contact Persons

If you have any questions, concerns, or complaints about this research, you can contact Andrew Lightner, B.S. at 304/676-5595 or Dr. Philip Chase at 304/293-2001 ext. 31626.

For information regarding your rights as a research subject, you may contact the Office of Research Compliance at 304/293-7073.

Introduction

You, _____, have been asked to participate in this research study, which has been explained to you by Andrew Lightner, B.S. This study is being conducted by Mr. Lightner in order to fulfill the requirements for a master's thesis in the Department of Psychology at West Virginia University, under the supervision of Philip N. Chase, Ph.D.

Purposes of the Study

The purpose of this study is to learn about the effects rate and practice criteria have when applied to arithmetic problems. The information collected in this study might be used in Mr. Lightner´s master's thesis.

Description of Procedures

This study involves completing arithmetic problems during one minute timings, under either a rate condition or a practice condition. The rate condition asks you to meet rate and percent correct criteria before being tested. The practice condition asks you to meet a practice and percent correct criterion before being tested. Periodically you will be asked whether you prefer the rate condition or the practice condition. This study will take approximately 6 hours to complete. Sessions will be an hour long. You will be given the option of a five minute break every fifteen minutes. You are expected to participate in one session per day for approximately six days. You will also be asked to come back for an additional session after two weeks. It is important you come during the agreed upon time every day. If you miss a session, you will be asked to complete a make-up session within a week of the missed session. If you miss two or more sessions, or you do not call in advance of missing a session, you might be dropped from the study. Approximately four female undergraduates enrolled at WVU are expected to participate.

Risks and Discomforts

There are no known or expected risks from participating in this study, except for the mild frustration associated with answering the simple arithmetic problems.

Alternatives

You do not have to participate in this study. If you decline from participating in the study, you will not be exposed to any negative consequences.

Benefits

You may not receive any direct benefit from this study. The knowledge gained from this study may eventually benefit others.

Financial Considerations

You will receive both extra credit and monetary compensation for participating in this study. You will be paid $0.005 for every correct response during a writing speed assessment. You will be paid $1.75 every time you meet a condition´s criteria. Furthermore, you will receive $0.01 for each correct response during endurance probes and $0.28 for each correct response during application probes. You will be paid $1.00 for every day you attend your scheduled session. If you miss an appointment, the

$1.00 will not be given for the rescheduled session. If you become ineligible for the study for missing session, then you will lose the attendance compensation. However, if you are dismissed for failure to acquire the task successfully, you will still be given the attendance bonus. You will be compensated for your participation at the end of the study. The experimenter will keep careful records of your attendance and payment throughout the study. Payment will be given upon completion of the study, or in the event that you stop participating.

Confidentiality

Any information about you that is obtained as a result of your participation in this research will be kept as confidential as legally possible. Your research records and test results, just like hospital records, may be subpoenaed by court order or may be inspected by federal regulatory authorities without your additional consent. Research records do not include any information that can identify you. These records will also be kept in a locked room located inside a research laboratory in the Life Sciences Building. In any publications that result from this research, neither your name nor any information from which you might be identified will be published.

Voluntary Participation

Participation in this study is voluntary. You are free to withdraw your consent to participate in this study at any time. Refusal to participate or withdrawal will not affect your future care, [or your employee status at West Virginia University or your class standing or grades, as appropriate] and will involve no penalty to you. In the event new information becomes available that may affect your willingness to participate in this study, this information will be given to you so that you can make an informed decision about whether or not to continue your participation. You have been given the opportunity to ask questions about the research, and you have received answers concerning areas you did not understand.

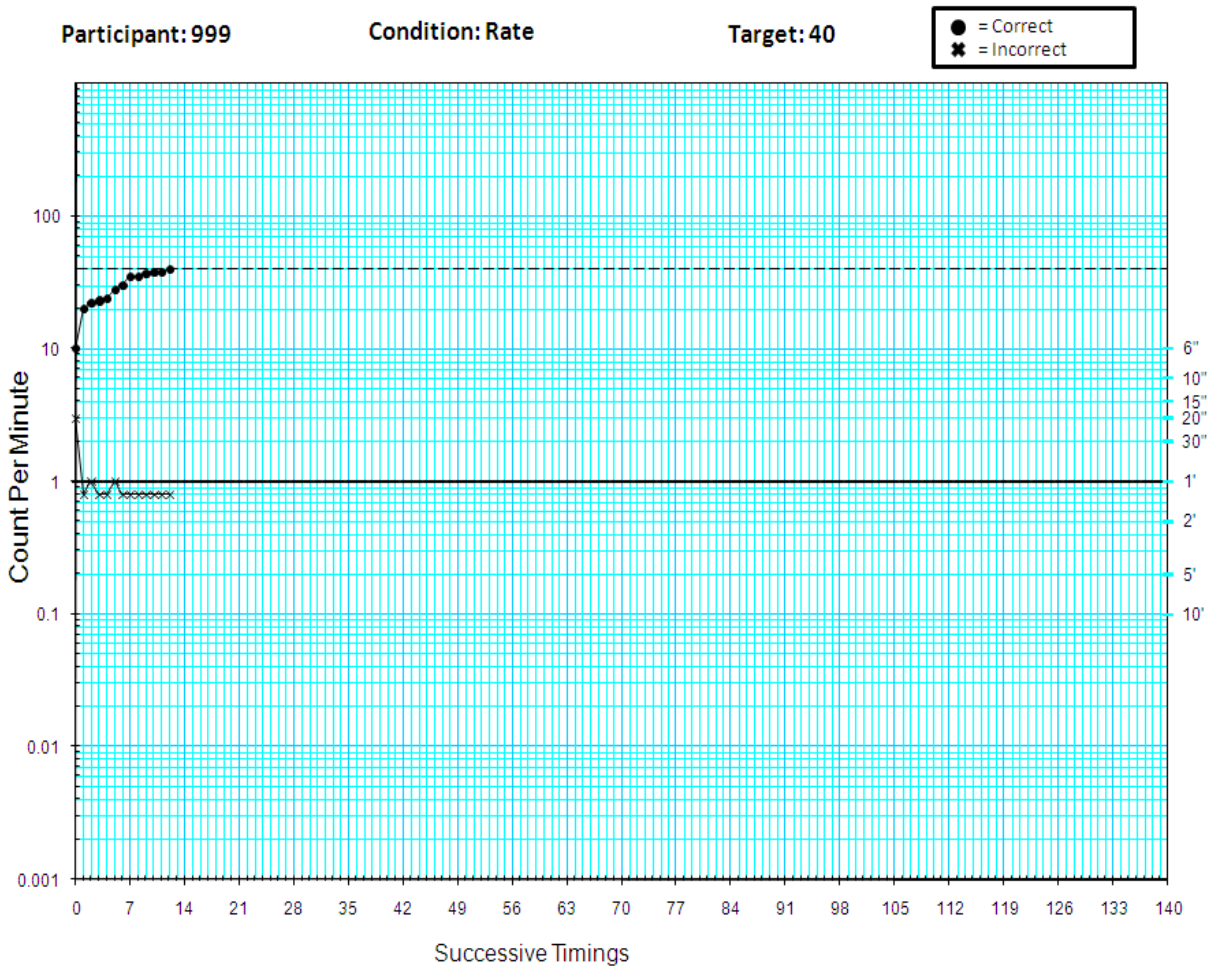
Upon signing this form, you will receive a copy.

I willingly consent to participate in this research.

Signature of Subject or Printed Name Date Time Subjects Legal Representative

The participant has had the opportunity to have questions addressed. The participant willingly agrees to be in the study.

Appendix B


Participant: 999
Condition: Rate
Target: 40
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= Incorrect
Count Per Minute
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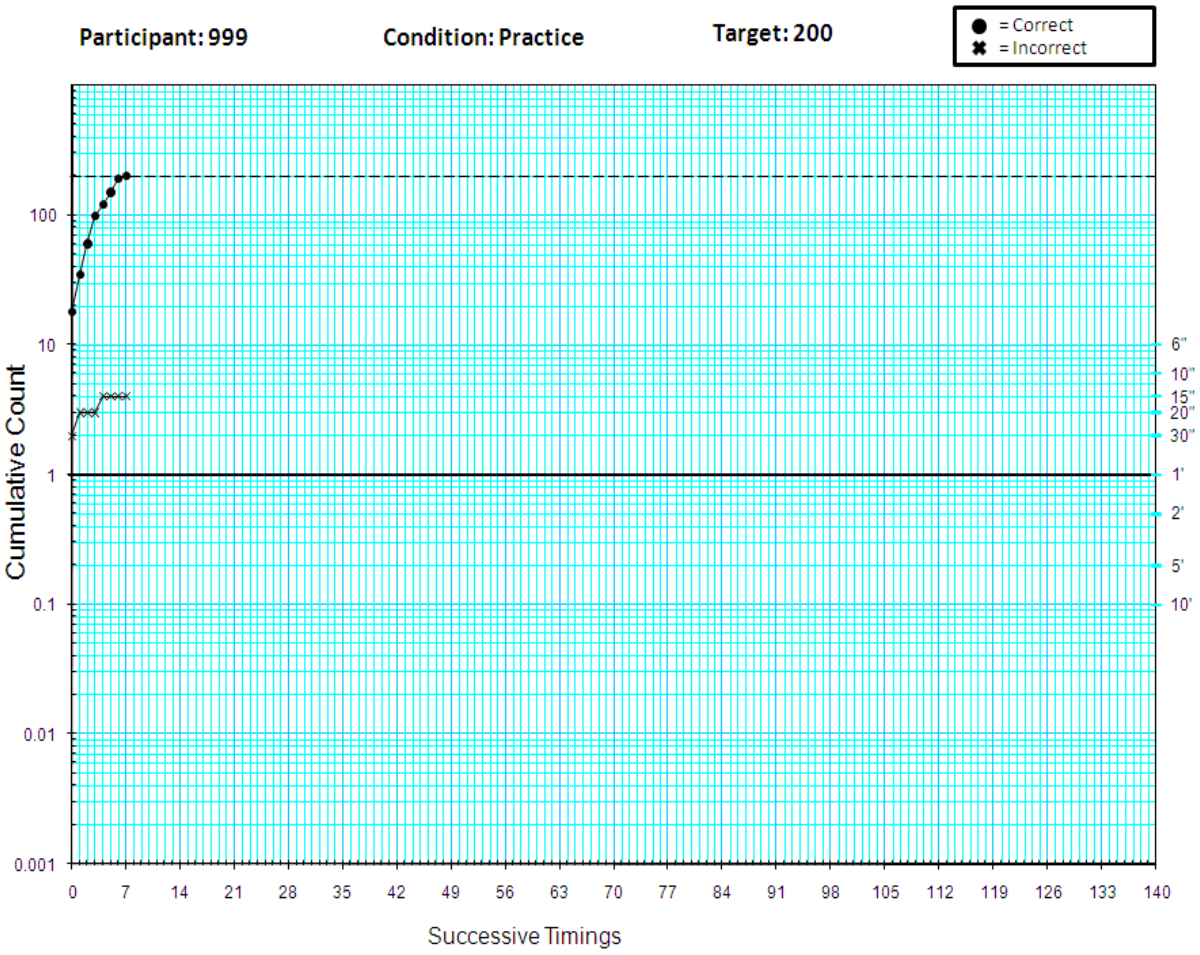
30"
1'
2'
5'
10'
0
7
14
21
28
35
42
49
56
63
70
77
84
91
98
105
112
119
126
133
140
Successive Timings

Appendix C


Participant: 999
Condition: Practice
Target: 200
= Correct
= Incorrect
Cumulative Count
100
10
1
0.1
0.01
0.001
6"
10"
15"
20"
30"
1'
2'
5'
10'
0
7
14
21
28
35
42
49
56
63
70
77
84
91
98
105
112
119
126
133
140
Successive Timings

Appendix D

Rate Assessment Instructions

"In order to begin the study, we need to assess your writing speed. You will be given worksheets with numbers listed horizontally across them. When I tell you to begin, you will copy the number into the blank provided to the right of the target number as fast as you can. Throughout the entire study, please write the numbers in digits, not words. You will receive a few one-minute timings to see how quickly and accurately you can write numbers. Please complete the problems in order, going left to right starting with the first row. Please tell me when you are ready to begin."

Rate Chart Instructions

"In the conditions ahead, you will need to plot some of the feedback I give you on charts. I will give you data and you will need to plot them in the appropriate places on the charts. This chart is used to plot your correct rate of response and incorrect rate of response in the rate condition. The sample data shows some hypothetical performance data presented as the number of correct responses, the number of incorrect responses, and percent correct. Now look at the chart. On this chart we have plotted the correct and incorrect rates of response from the data.

If you examine the chart you will see that the X-axis is marked timings, so after each one minute timing you will be plotting your rates over timings. The Y-axis is simply labeled "count per minute," which allows you to plot both correct rate of response and incorrect rate of response on the same chart. Pay careful attention to the numbers on the Y-axis, it is derived from a semi-log calculation, so make sure you're reading the graph correctly. From 1 to 10 each mark denotes a number from 1-10, from 10 to 100 each mark denotes 10s (10, 20, etc.), and so forth.

Also, you will notice different symbols. First, correct rate of response is plotted using filled circles and incorrect rate of response is plotted using “x”s. This will allow you to see if your speed and accuracy is improving. Also notice the solid red line in the middle. This line is called a record floor. This is the lowest rate of responding you can make during a timing. For example, for a one-minute timing, the record floor is one. This means the least number of responses you can make is one response per minute. If you don’t make any correct responses this would be plotted as a filled circle one line below the record floor for that timing. If you do not make any incorrect responses, which is more likely, you would plot an x one line below the record floor. Also notice dotted line at the top. This represents the criterion you are trying to reach. Do you have any questions?”

Rate Feedback Instructions

“You have reached our criteria for this assessment of your arithmetic skills. Please plot the correct rate and incorrect rate on your chart. When you are done plotting the data, please tell me when you are ready to continue”

Or

“You wrote X number of problems correctly during your one-minute timing. You also wrote Y number of problems incorrectly. Your percent correct was XX%. Both your correct rate of response and accuracy did not meet our criteria. Please plot the correct rate and incorrect rate on your chart. When you are done plotting the data and are ready for another minute timing, please tell me.”

Or

"You wrote X number of problems correctly during your one-minute timing. You also wrote Y number of problems incorrectly. Your percent correct was XX%. You met our accuracy criterion, but your correct rate of response did not meet our criterion. Please plot the correct rate and incorrect rate on your chart. When you are done plotting the data and are ready for another minute timing, please tell me."

Or

"You wrote X number of problems correctly during your one-minute timing. You also wrote Y number of problems incorrectly. Your percent correct was XX%. Your correct rate of response met our criterion, but your accuracy did not meet our criterion. Please plot the correct rate and incorrect rate on your chart. When you are done plotting the data and are ready for another minute timing, please tell me."

Practice Chart Instructions

"This chart is used to plot your correct rate of response and incorrect rate of response in the practice condition. The sample data shows some hypothetical performance data presented as the number of correct responses, the number of incorrect responses, and percent correct. Now look at the chart. In this chart we have plotted the correct and incorrect rates of response from the data.

If you examine the chart you will see that the X-axis is marked successive timings, so like during the rate condition you will be plotting your rates over one-minute timings. The Y-axis for the practice condition though is labeled cumulative count per minute. The Y-axis is again derived from a semi-log calculation, and you will again be plotting correct and incorrect

responses on the same chart. Now, the major difference is that you will be plotting the cumulative number of responses. For example, if you make 20 correct responses and 2 incorrect responses during the first timing, and 25 correct responses and 1 incorrect response during the second timing, you will plot a filled circle at the 20 line and an "x" at the 2 line for the first timing, then a filled circle at the 45 line and an "x" at the 3 line for the second timing. I will give the cumulative correct on your feedback sheet, so you do not need to add them together yourself.

The record floor is still the same as during the rate condition; remember that one is the lowest amount of responding you can make during a timing, and you will be plotting zeros below the record floor. Also notice the same star and dotted line is at the top. In the practice condition you will be trying to meet this criterion with the cumulative number of correct responses. Do you have any questions?"

Practice Feedback Instructions

"You have reached our criteria for this assessment of your arithmetic skills. Please plot the number of cumulative correct responses and incorrect responses on your chart. When you are done plotting the data, please tell me when you're ready to continue.

Or

"You wrote X number of cumulative problems correctly across your one-minute timings. You also wrote Y number of problems incorrectly. Your percent correct for this timing was XX%. Both your total number of problems completed and accuracy did not meet our criteria. Please plot the cumulative correct responses and cumulative incorrect responses on your chart. When you are done plotting the data and are ready for another minute timing, please tell me."

Or

"You wrote X number of cumulative problems correctly across your one-minute timings. You also wrote Y number of problems incorrectly. Your percent correct for this timing was XX%. You met our accuracy criterion, but your total number of problems completed did not meet our practice criterion. Please plot the cumulative correct responses and cumulative incorrect responses on your chart. When you are done plotting the data and are ready for another minute timing, please tell me."

Or

"You wrote X number of cumulative problems correctly across your one-minute timings. You also wrote Y number of problems incorrectly. Your percent correct for this timing was XX%. Your total number of problems completed met our practice criterion, but your accuracy did not meet our criterion. Please plot the cumulative correct responses and cumulative incorrect responses on your chart. When you are done plotting the data and are ready for another minute timing, please tell me."

Appendix E

1) **64** _____ 2) **78** _____ 3) **18** _____ 4) **51** _____ 5) **82** _____

6) **80** _____ 7) **54** _____ 8) **26** _____ 9) **94** _____ 10) **99** _____

11) **93** _____ 12) **22** _____ 13) **96** _____ 14) **74** _____ 15) **22** _____

16) **49** _____ 17) **69** _____ 18) **71** _____ 19) **81** _____ 20) **95** _____

21) **64** _____ 22) **78** _____ 23) **18** _____ 24) **51** _____ 25) **82** _____

26) **66** _____ 27) **44** _____ 28) **98** _____ 29) **88** _____ 30) **35** _____

31) **85** _____ 32) **19** _____ 33) **32** _____ 34) **59** _____ 35) **48** _____

36) **39** _____ 37) **75** _____ 38) **64** _____ 39) **62** _____ 40) **93** _____

41) **46** _____ 42) **17** _____ 43) **26** _____ 44) **14** _____ 45) **31** _____

46) **33** _____ 47) **45** _____ 48) **88** _____ 49) **76** _____ 50) **15** _____

51) **43** _____ 52) **65** _____ 53) **83** _____ 54) **82** _____ 55) **92** _____

56) **13** _____ 57) **67** _____ 58) **99** _____ 59) **87** _____ 60) **85** _____

61) **26** _____ 62) **35** _____ 63) **53** _____ 64) **20** _____ 65) **61** _____

66) **26** _____ 67) **69** _____ 68) **73** _____ 69) **43** _____ 70) **87** _____

Appendix F

Participant:_____
Date:_____
Condition:_____
Cycle:_____
Array:_____

Timing 1	**Timing 2**	**Timing 3**
Correct Rate:_____	Correct Rate: _____	Correct Rate: _____
Incorrect Rate:_____	Incorrect Rate:_____	Incorrect Rate:_____
Accuracy:_____	Accuracy:_____	Accuracy:_____
Timing 4	**Timing 5**	**Timing 6**
Correct Rate:_____	Correct Rate: _____	Correct Rate: _____
Incorrect Rate:_____	Incorrect Rate:_____	Incorrect Rate:_____
Accuracy:_____	Accuracy:_____	Accuracy:_____
Timing 7	**Timing 8**	**Timing 9**
Correct Rate:_____	Correct Rate: _____	Correct Rate: _____
Incorrect Rate:_____	Incorrect Rate:_____	Incorrect Rate:_____
Accuracy:_____	Accuracy:_____	Accuracy:_____
Timing 10	**Timing 11**	**Timing 12**
Correct Rate:_____	Correct Rate: _____	Correct Rate: _____
Incorrect Rate:_____	Incorrect Rate:_____	Incorrect Rate:_____
Accuracy:_____	Accuracy:_____	Accuracy:_____
Timing 13	**Timing 14**	**Timing 15**
Correct Rate:_____	Correct Rate: _____	Correct Rate: _____
Incorrect Rate:_____	Incorrect Rate:_____	Incorrect Rate:_____
Accuracy:_____	Accuracy:_____	Accuracy:_____
Timing 15	**Timing 16**	**Timing 17**
Correct Rate:_____	Correct Rate: _____	Correct Rate: _____
Incorrect Rate:_____	Incorrect Rate:_____	Incorrect Rate:_____
Accuracy:_____	Accuracy:_____	Accuracy:_____
Timing 18	**Timing 19**	**Timing 20**
Correct Rate:_____	Correct Rate: _____	Correct Rate: _____
Incorrect Rate:_____	Incorrect Rate:_____	Incorrect Rate:_____
Accuracy:_____	Accuracy:_____	Accuracy:_____
Timing 21	**Timing 22**	**Timing 23**
Correct Rate:_____	Correct Rate: _____	Correct Rate: _____
Incorrect Rate:_____	Incorrect Rate:_____	Incorrect Rate:_____
Accuracy:_____	Accuracy:_____	Accuracy:_____

Appendix G

1)	36 + 23	**2)**	23 + 36	**3)**	10 + 10	**4)**	47 + 36	**5)**	36 + 36	**6)**	10 + 23	**7)**	36 + 36
8)	10 + 23	**9)**	47 + 47	**10)**	23 + 36	**11)**	36 + 23	**12)**	36 + 36	**13)**	10 + 23	**14)**	23 + 10
15)	36 + 47	**16)**	10 + 23	**17)**	47 + 47	**18)**	10 + 10	**19)**	36 + 36	**20)**	36 + 36	**21)**	23 + 23
22)	23 + 23	**23)**	36 + 23	**24)**	47 + 47	**25)**	47 + 47	**26)**	36 + 36	**27)**	23 + 23	**28)**	47 + 36
29)	10 + 10	**30)**	36 + 36	**31)**	36 + 36	**32)**	47 + 47	**33)**	36 + 23	**34)**	23 + 36	**35)**	23 + 23
36)	36 + 23	**37)**	47 + 47	**38)**	36 + 36	**39)**	23 + 23	**40)**	47 + 47	**41)**	36 + 36	**42)**	10 + 10
43)	23 + 36	**44)**	10 + 23	**45)**	10 + 10	**46)**	23 + 36	**47)**	36 + 47	**48)**	23 + 10	**49)**	23 + 23
50)	20 + 20	**51)**	10 + 10	**52)**	10 + 10	**53)**	23 + 23	**54)**	23 + 23	**55)**	36 + 47	**56)**	47 + 36
57)	23 + 23	**58)**	47 + 47	**59)**	23 + 23	**60)**	10 + 10	**61)**	47 + 36	**62)**	23 + 10	**63)**	36 + 47
64)	10 + 23	**65)**	47 + 47	**66)**	10 + 10	**67)**	10 + 10	**68)**	20 + 16	**69)**	47 + 36	**70)**	47 + 47

Appendix H

Array 1: 10, 23, 36, 47

Array 2: 11, 20, 32, 48

Array 3: 13, 28, 30, 41

Array 4: 12, 26, 31, 40

Array 5: 15, 22, 38, 42

Array 6: 16, 25, 39, 49

Array 7: 18, 27, 35, 43

Array 8: 19, 29, 33, 45

Array 9: 17, 21, 34, 40

Array 10: 14, 24, 30, 44

Array 11: 12, 20, 36, 46

Array 12: 10, 24, 37, 42

Array 13: 17, 25, 32, 47

Array 14: 13, 22, 35, 49

Array 15: 18, 23, 37, 45

Appendix I

Participant:_____
Date:_____
Condition:_____
Cycle:_____
Array:_____

Timing 1	**Timing 2**	**Timing 3**
Cum. Correct:_____	Cum. Correct: _____	Cum. Correct: _____
Cum. Incorrect:_____	Cum. Incorrect:_____	Cum. Incorrect:_____
Accuracy:_____	Accuracy:_____	Accuracy:_____
Timing 4	**Timing 5**	**Timing 6**
Cum. Correct:_____	Cum. Correct: _____	Cum. Correct: _____
Cum. Incorrect:_____	Cum. Incorrect:_____	Cum. Incorrect:_____
Accuracy:_____	Accuracy:_____	Accuracy:_____
Timing 7	**Timing 8**	**Timing 9**
Cum. Correct:_____	Cum. Correct: _____	Cum. Correct: _____
Cum. Incorrect:_____	Cum. Incorrect:_____	Cum. Incorrect:_____
Accuracy:_____	Accuracy:_____	Accuracy:_____
Timing 10	**Timing 11**	**Timing 12**
Cum. Correct:_____	Cum. Correct: _____	Cum. Correct: _____
Cum. Incorrect:_____	Cum. Incorrect:_____	Cum. Incorrect:_____
Accuracy:_____	Accuracy:_____	Accuracy:_____
Timing 13	**Timing 14**	**Timing 15**
Cum. Correct:_____	Cum. Correct: _____	Cum. Correct: _____
Cum. Incorrect:_____	Cum. Incorrect:_____	Cum. Incorrect:_____
Accuracy:_____	Accuracy:_____	Accuracy:_____
Timing 15	**Timing 16**	**Timing 17**
Cum. Correct:_____	Cum. Correct: _____	Cum. Correct: _____
Cum. Incorrect:_____	Cum. Incorrect:_____	Cum. Incorrect:_____
Accuracy:_____	Accuracy:_____	Accuracy:_____
Timing 18	**Timing 19**	**Timing 20**
Cum. Correct:_____	Cum. Correct: _____	Cum. Correct: _____
Cum. Incorrect:_____	Cum. Incorrect:_____	Cum. Incorrect:_____
Accuracy:_____	Accuracy:_____	Accuracy:_____
Timing 21	**Timing 22**	**Timing 23**
Cum. Correct:_____	Cum. Correct: _____	Cum. Correct: _____
Cum. Incorrect:_____	Cum. Incorrect:_____	Cum. Incorrect:_____
Accuracy:_____	Accuracy:_____	Accuracy:_____

Appendix J

1. Jim has thirty-six apples. He goes to the market and buys forty-seven more apples. How many apples does Jim have?

_____

2. Amanda has forty-seven dollars. She borrows forty-seven more dollars from her sister. How many dollars does Amanda have?

_____

3. Kent has ten baseball cards. He borrows ten more baseball cards from his brother. How many cards does Billy have?

_____

4. Sheila has twenty-three eggs. She goes to the grocery store and buys twenty-three more. How many eggs does Sheila have?

_____

5. Skip has ten lollipops. He goes trick-or-treating and is given twenty-three more. How many lollipops does Skip have?

_____

Appendix K

Participant: _____ Date: _____

The five questions in this survey will help us know what you think of **the conditions you completed two weeks ago.** Answer each item by circling the number that best represents your opinion.

1. I enjoyed completing arithmetic problems when a rate criterion was present.

1	2	3	4	5
Strongly Disagree	Disagree	No opinion	Agree	Strongly Agree

2. I enjoyed completing arithmetic problems when a practice criterion was present.

1	2	3	4	5
Strongly Disagree	Disagree	No opinion	Agree	Strongly Agree

3. In which condition did you complete math problems more quickly?

1	3	5
Rate	Neither	Practice

4. In which condition did you complete math problems more accurately?

1	3	5
Rate	Neither	Practice

5. Which condition did you prefer?

1	3	5
Rate	Neither	Practice

Thank you for your help!

Andrew Lightner
April, 2009

PERSONAL DATA

Date of Birth: February 17th, 1983
Address: 53 Campus Drive, Life Sciences Building, Office # 2130
Morgantown, WV 26505-6040
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Electronic Mail: Andrew.Lightner@mail.wvu.edu

EDUCATION

Fall 2008 to Present **Master of Arts** in Psychology, Behavior Analysis
West Virginia University, Morgantown, WV, U.S.A.
Thesis in progress: An experimental analysis of preference for rate building
Adviser: Philip N. Chase, Ph.D.
Expected completion: March 2009

2006 **Bachelors of Science** in Psychology
West Virginia University, Morgantown, WV, U.S.A.

RESEARCH EXPERIENCE

Spring 2008-present, Research in Progress
Applied Behavior Analysis and Human Operant Laboratory, Department of Psychology, West Virginia University, Morgantown, WV, U.S.A.

Supervisor: Claire St. Peter Pipkin, Ph.D.
Activities: Acting as a therapist in applied treatment, teaching functional communication skills, collecting data during treatment sessions, conducting human operant sessions
Topics:
- Using children's choice to identify reinforcers
- Resurgence of responding in a human operant preparation

Spring 2008-present, Research in Progress
Operant Conditioning Laboratory, Department of Psychology, West Virginia University, Morgantown, WV, U.S.A.

Supervisor: Kennon A. Lattal, Ph.D.
Activities: Designing experiments, programming experimental contingencies in MED-PC, conducting sessions, analyzing data
Topics:

- Effects of response feedback on keypecking and on a spatially defined operant in variable-interval schedules of reinforcement
- A comparison of resurgence and spontaneous recovery

Fall 2008-present, Research in progress

Human Operant Laboratory, Department of Psychology, West Virginia University, Morgantown, WV, U.S.A.

Supervisor: Philip N. Chase, Ph.D.
Activities: Conducting experiments, collecting, analyzing, presenting data, aiding in the evaluation of an education program.
Topics:

- Effects of rate building on preference and performance
- Methods of inquiry for computer-based mathematics curricula

Conference Presentations

Lightner, A. R. & Chase, P. N. (2008, October). *An experimental analysis of preference for rate building*. Poster presented at the Annual Meeting of the Southeastern Association for Behavior Analysis, Atlanta, GA.

Chase, P. N., Dickson, C. A., Walker, V. L., Lobo, H. E., & **Lightner, A. R.** (2008, May). *Methods of inquiry for computer-based mathematics curricula.* Paper presented at the 34th Annual Convention of the Association for Behavior Analysis, Chicago, IL.

TEACHING EXPERIENCE

Fall 08 - Present Behavior Principles Lab (PSYC 302, undergraduate course)
Department of Psychology, West Virginia University
Supervisors: Megan Maxwell, Ph.D.
Position: Lab Proctor, Lecturer
Activities: Managing students' conduct in a lab setting, preparing and delivering occasional lectures

Spring 08 - Summer 08 Intro to Developmental Psychology (PSYC 241, undergraduate course)
Department of Psychology, West Virginia University
Supervisor: Julie Patrick, Ph.D.
Position: Lecturer
Activities: Preparing and delivering lectures, supervising an undergraduate assistant, evaluating students' performance.

Fall 08 Intro to Psychology (PSYC 101, undergraduate course)
Department of Psychology, West Virginia University

Supervisors: Claire St. Peter-Pipkin, Ph.D., Hawley Montgomery-Downs, Ph.D.
Position: Lecturer, Learning Center Proctor
Activities: Preparing and delivering lectures, monitoring students in the Learning Center

AFFILIATIONS

Association for Behavior Analysis (ABA) Student Member
Southeastern Association for Behavior Analysis (SEABA) Student Member

Professional References

Available upon request