*THE EFFECTS OF HIGH-PREFERENCE PROBLEMS ON THE
COMPLETION OF NONPREFERRED MATHEMATICS PROBLEMS*

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Failure to initiate and remain engaged in academic tasks can have long-lasting effects for students. In this study, we investigated the effects of high-preference sequences on both digits correct per minute and latency to initiate nonpreferred mathematics problems for 3 students with emotional and behavioral disorders. We found that high-preference sequences had negligible positive effects on rate of problem completion but had larger effects on problem initiation. This study replicates and extends prior work on the effects of high-preference sequences on mathematics problem initiation and completion.

Key words: behavioral momentum, academic responding, compliance

Over the past 25 years, high-probability (high-*p*) sequences have been supported in the research literature as a method to increase compliance with requests across various settings, individuals, and tasks (Lee, 2005; Mace et al., 1988). Based on the theory of behavioral momentum (Nevin, Mandell, & Atak, 1983), high-*p* sequences include a series of tasks or requests with a high probability of completion, and subsequent reinforcement, to increase the overall density of reinforcement for a given response class. This increase in reinforcement level increases compliance with requests to complete tasks that previously had a low probability (low *p*) of evoking compliance (Lee, 2006).

Some experimenters have employed a variant of the high-*p* procedure with students in academic settings to decrease the latency to

initiate individual problems within tasks (Belfiore, Lee, Vargas, & Skinner, 1997) and to increase the rate at which those same tasks are completed (Hutchinson & Belfiore, 1998). In this application, a series of two or three brief, preferred problems (e.g., single-digit math problems) are arranged just prior to a less preferred problem (e.g., a multidigit math problem).

This academic variant differs from the typical implementation of the high-*p* procedure in two important ways. First, the academic application of the procedure uses a format that is almost entirely controlled by the student; in the traditional high-*p* procedure, the distribution of each high-*p* sequence is controlled by the practitioner. Second, programmed reinforcers are usually delivered by the teacher or experimenter (see Zuluaga & Normand, 2008). The academic variant instead relies on problem completion as a conditioned reinforcer (Skinner, 2002). The purpose of the present study was to replicate the effects of high-preference sequences obtained in previous research, as well

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as to assess the generality of the effects of high-preference sequences in an academic setting to an additional dependent variable (i.e., accuracy).

METHOD

Participants and Setting

Three students who demonstrated the skills required to complete multidigit multiplication problems, but who refused to complete assignments, were nominated by their teachers to participate in the study. Participants included Greg, who was 14 years old, Jeff, who was 16 years old, and Tony, who was 18 years old. The students were enrolled at a chartered alternative school for students with emotional and behavioral disorders. A graduate student conducted all sessions in a classroom adjacent to the students' main classroom. Each participant sat in a study carrel that consisted of a desk (0.75 m by 1 m) and a vertical barrier (0.75 m) on three sides. A Web camera was focused on the table and provided a permanent record of student responding.

Design and Response Measurement

The study consisted of two phases. In the first phase, a modified forced-choice stimulus preference assessment based on the procedures described by Belfiore *et al.* (1997) was used to validate the hypothesis that students would prefer single-digit over multidigit multiplication problems, and that these single-digit problems would serve as effective high-preference problems. During the preference assessment phase, the dependent variable was *worksheet selection*, defined as the student pointing to and completing a worksheet.

After establishing preference, we used a multiple baseline design across participants to evaluate the effects of the high-preference sequence. For baseline and intervention phases, latency to initiate subsequent problems, percentage of problems correct, and digits correct per minute (DCPM) served as dependent measures. We collected latency data from the

video recordings of each session. During baseline sessions, we defined *latency* as the time in seconds from the moment the student lifted his pencil after completing one problem to the moment he began to write the answer to the next problem. Similarly, we defined *latency* during high-preference sessions as the time in seconds from the moment the student lifted his pencil after completing the final high-preference problem in a series to the moment he began to write the answer for the subsequent low-preference problem. We calculated percentage of problems correctly completed by dividing the number of problems correct by the total number of problems attempted for each session. We calculated DCPM by counting the total number of digits correctly completed for all problems and dividing by session time in minutes (Hosp, Hosp, & Howell, 2007).

To calculate interobserver agreement for each phase of the study, a second observer recorded the latency to initiate low-preference problems, number of problems correct and incorrect, and DCPM for 32% of baseline and intervention sessions for each participant. For the latency data, the smaller latency was divided by the larger latency and then multiplied by 100% for each interobserver agreement session. We calculated agreement for both the percentage correct and DCPM measures by dividing the smaller obtained value of number correct and digits correct by the larger and multiplying by 100%. The mean agreement for latency was 92% and 96% for baseline and high-preference phases, respectively, across participants. The agreement for both percentage correct and DCPM was 100%.

Procedure

Preference assessment. During the preference assessment, the student was asked to choose between two worksheets that contained either 45 single-digit multiplication problems (e.g., 4×6) or a series of five three-digit multiplication problems (e.g., 658×394). All students selected the single-digit problems for each of the five trials, thus confirming those as

high preference and the multidigit problems as low preference.

In addition to assessing preference, the worksheets also provided information regarding accuracy of fact completion that was used in the development of materials. Facts that involved the numbers 7 and 8 often evoked incorrect responses. Based on this information, we excluded 17 math facts including 7×1 , 7×2 , 7×3 , 7×4 , 7×5 , 8×6 , 8×7 , 8×8 , 8×9 , and their inverse combinations from baseline and high-preference intervention worksheets. We excluded these facts because (a) we did not want students practicing obvious fact errors, and (b) the poor accuracy and fluency of these facts may have had some unknown effect on the high-preference intervention, which is characterized by fast and accurate responding.

Baseline. Baseline worksheets consisted of five low-preference (multidigit) problems printed in a column along the right margin of the page aligned in five rows. Baseline sessions lasted 10 min. The experimenter gave students a packet with 10 pages of low-preference problems (50 total problems), which was more than they could complete during the 10-min session. After distributing the packet, the experimenter read the following directions: "Here is your assignment [experimenter pointed to packet]. Please complete as many problems as you can until I tell you to stop."

The experimenter activated a stopwatch and walked to a location approximately 3 m behind the participant. After 10 min, the experimenter asked the participant to stop writing, collected all materials, and thanked the participant for working.

High-preference problems. Intervention worksheets were similar to baseline with the exception that three high-preference (single-digit) problems were embedded prior to each low-preference problem. Procedures were identical to those used during baseline except that students were told to complete the problems row by row. The experimenter monitored compliance to this instruction from a position behind the student (approximately 3 m).

RESULTS AND DISCUSSION

During baseline, Greg's mean latency to initiate low-preference problems was 7.0 s (range, 4 s to 10 s; see Figure 1), and he completed 93% of problems correctly (14.4 low-preference DCPM; range, 6.4 to 20). His mean latency to initiate the low-preference problems during intervention was 3.8 s (range, 2.8 s to 5.2 s). He completed 91% of problems correctly, with an average of 14.6 (range, 11.7 to 17) low-preference DCPM (18.6 total DCPM when both the low-preference and high-preference digits were used in the calculation).

Jeff's mean latency to initiate each problem during baseline was 3.9 s (range, 2.8 s to 5.4 s), his accuracy was 57%, and he completed an average of 17.4 low-preference DCPM (range, 16.5 to 18.1). When the high-preference intervention was implemented, his mean latency was 2.6 s (range, 2.1 s to 3.4 s). His accuracy during intervention increased to 63%, and he completed 18.3 (range, 14.9 to 24) low-preference DCPM (23.5 total DCPM).

During baseline, Tony's latency to initiate low-preference problems was 4.8 s (range, 2.4 s to 9.8 s). His accuracy was 63%, and he completed an average of 25.8 (range, 18.3 to 33.6) low-preference DCPM during that same phase. After implementation of the intervention, his mean latency was 2.5 s (range, 2.3 s to 2.9 s). Accuracy increased to 75%, and he completed 26.5 (range, 23.4 to 34.8) low-preference DCPM (33.6 total DCPM).

We examined the effects of high-preference problem sequences on both the latency to initiate low-preference math problems and accuracy of problem completion. Overall, we found that the addition of high-preference problem sequences decreased the latency to initiate less preferred problems and had negligible effects on problem accuracy. This study builds on prior work on high-preference sequences in academic settings in at least two important ways.

First, initial research in this area (Belfiore et al., 1997) used reversal designs to demonstrate the effects of high-preference sequences on

Figure 1. Mean latency to initiate low-preference problems in baseline and high-preference conditions.

latency to initiate low-preference problems. Although procedurally sound in terms of withdrawing the high-preference sequence during baseline, one drawback of a reversal design is irreversibility of some behaviors. Indeed, responding in the second baseline phase in Belfiore et al. (1997) failed to return completely to levels obtained in the first baseline phase. The authors hypothesized that the additional practice gained through the high-preference sequences made the low-preference problems less aversive over time, thus affecting subsequent baseline performance. The current study demonstrates that effects can be adequately evaluated using a multiple baseline design. This demonstration has implications for practitioners who must make decisions regarding the effects of an intervention while maintaining continuity of instruction.

Second, many of the initial studies that examined high-preference sequences in academic settings relied solely on latency as the dependent variable. Although latency is an important measure of compliance and task persistence, information regarding the effects of high-preference sequences on accuracy was lacking. Data from the present study suggest that high-preference sequences can have a slight positive effect on task accuracy, both in terms of percentage correct and DCPM. However, accuracy levels were still below the recommended criterion of 90% to 95% correct for independent assignments (Archer & Hughes, 2011). Given the negligible increases in accuracy across students in the present study, high-preference sequences may be better suited for independent practice of previously acquired skills.

This study is not without limitations. First, the specific mechanism that is responsible for the observed effects is difficult to ascertain. Zuluaga and Normand (2008) found that programmed reinforcement may be necessary to achieve increased compliance using high- p sequences. In the present study, no such programmed reinforcement was used. In the absence of programmed reinforcement, we speculate that task completion may have served as a

conditioned reinforcer. The addition of a series of problems that could be completed quickly (i.e., high preference) increased the density of reinforcement associated with the task, which affected both latency to initiate problems and, to a lesser extent, rate of completion. Future researchers should examine further the potential sources of reinforcement in high- p sequences.

Second, a distinction must be made between high- p and high-preference items or problems. In the current study, we assessed relative preference for worksheets and presented the more preferred of the two alternatives as high-preference problems. We did not, however, assess probability of compliance for completing a given item, so the degree to which the problems are high- p is unknown. In future studies, researchers should add a second component to the preference assessment in which students are asked to complete both types of tasks (those initially identified as preferred and those identified as nonpreferred) and monitor the probability of compliance independent of the preference assessment.

Finally, we did not conduct an assessment to determine the function of noncompliance across students. For this study, *noncompliance* was defined as a failure to initiate and complete tasks in a timely manner. Given the individual nature of behavioral function, future researchers could use information from functional analyses to develop interventions that are packaged with high-preference sequences to maximize effects for individual students. For example, high-preference sequences could be coupled with extinction or differential reinforcement to target behaviors that are often associated with noncompliance.

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