Stimulus Fading Versus Error Correction in Math Fact Acquisition by Learning Disabled Students

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Teachers frequently develop their own materials to compensate for learners' unique characteristics, but these teacher-made materials are unlikely to capitalize on established instructional techniques using stimulus manipulation such as systematic stimulus fading or shaping. Although the research on stimulus manipulation for teaching discrete tasks is well documented with children with severe disabilities, the research with students with learning disabilities is limited. The present study compared the effectiveness of stimulus fading to simple error correction in teaching multiplication facts to three students with learning disabilities. The stimulus fading procedures increased the accuracy of multiplication facts of two of the three students over error correction. The third student acquired the facts more quickly under error correction. When asked, two of the three students preferred the method by which they learned best. Implications for using different instructional strategies for establishing initial skill acquisition with different learners is discussed.

Teachers frequently have difficulty locating instructional materials with features appropriate for individualizing instruction. They often develop their own materials to compensate for learners' unique characteristics. These teacher-developed materials are unlikely to capitalize on established instructional techniques using stimulus manipulation such as systematic prompt fading (Koury & Browder, 1988), stimulus shaping (McGee, Kranitz, & McClannahan, 1986), or stimulus fading (Rincover, 1978), because of the great amount of time required for development (Cooper, Heron, & Heward, 1987).

The success of stimulus manipulation for teaching discrete tasks to children with moderate or severe disabilities is well documented (e.g., Browder & Lalli, 1991; Dube, Moniz, & Gomes, 1995; Mosk & Bucher, 1984; Strand & Morris, 1986). Stimulus manipulation has also been used successfully with mildly handicapped children to teach discrete tasks such as sight word discrimination (Browder, Koury, Belfiore, Heller, Wozniak, Lalli, & Lin, 1990), letter discrimination (Bradley-Johnson, Sunderman, & Johnson, 1983), missing minuend (Smeets, Lancioni, & Striefel, 1987), and writing mathematical operations from pictorial representations (Lancioni, Smeets, & Oliva, 1987). Few studies have focused specifically on the effects of stimulus manipulation for teaching discrete tasks to students with learning disabilities (Knowlton, 1980; Shimek, 1983).

Most of the research cited investigated the effects of stimulus shaping alone (Bradley-Johnson, et al., 1983; Lancioni, et al., 1987), in combination with verbal prompting (Mosk & Bucher, 1984), in comparison to collective feedback (Smeets et al., 1987), or to stimulus fading (Smeets, et al., 1987). Others investigated the effects of stimulus fading alone (Knowlton, 1980; Shimek, 1983), or combined with verbal prompts and compared to trial and error learning (Strand & Morris, 1986). In every case, the stimulus manipulation procedures were found to be effective in teaching discrete academic tasks to their subjects. Further, when compared to verbal feedback or trial and error learning, strategies frequently used in instruction, stimulus shaping and stimulus fading were found more successful. Although the stimulus manipulations proved successful, many of the investigators commented on the time required to prepare the materials used in the instructional tasks.

Existing evidence on the effectiveness of stimulus manipulation for teaching discrete academic tasks is compelling; however, the time required to develop the necessary materials remains a concern for many educators. When the issue of interest is not fluency but initial skill acquisition (Binder, 1993, 1996), is stimulus manipulation
The present study was designed to analyze the effectiveness of stimulus fading versus error correction on the initial skill acquisition of basic multiplication facts with students with learning disabilities with a zero baseline. The purpose of the study is threefold: 1) to expand the research base involving stimulus manipulation with children with learning disabilities; 2) to compare the effectiveness of prompt fading to instructional procedures frequently used during instruction for initial skill acquisition; and 3) to determine the preferences of elementary-aged students with learning disabilities for prompt fading or error correction.

Method

Participants and Setting
The participants in the study were three fourth-grade students enrolled in a resource room for students with learning disabilities and/or behavior disorders. Each student had been classified as learning disabled (LD), according to state and local guidelines. All were identified by the resource room teacher as needing assistance with memorizing multiplication facts. Student 1, Jeremy, an 11-year-old boy, had been placed recently in the resource room, after being in a self-contained classroom for LD students. He was highly distractible and had difficulty attending for more than a few seconds at a time. He had scores of 100, 89, and 92 on the Sequential Processing, Simultaneous Processing and Mental Computation subtests of the Kaufmann Assessment Battery for Children. Student 2, Darrica, a 10-year-old girl, had been receiving LD services for only two months. Her WISC-R scores were: Full Scale-81, Verbal-77, and Performance-90. Student 3, Michael, an 11-year-old boy, had been working in an LD resource room for several years. His WISC-R scores were: Full Scale-104, Verbal-95, and Performance-115.

All instructional sessions were conducted individually in the resource room. The student sat facing the teacher at a table, with his or her back to the classroom. Four to six other students were working on individual assignments in their seats. Two instructional sessions, one for each method, took place each day, one between 8:00 and 8:30 a.m., and the other between 11:00 and 11:30 a.m. Each session was taught by either the resource teacher or a university research associate who had been a team teacher in the resource room the previous year. In this study, both will be referred to as teachers. The two had 4 and 8 years experience, respectively, working with students with mild disabilities. Both the time of day and the teacher were randomly alternated for each method, each day.

Experimental Design and Procedures
Experimental design. A multielement design was used to assess the effectiveness of error correction and stimulus fading for each of the three students. Each student received both teaching methods each day. Methods were counterbalanced each day.

Screening procedures. Students were administered a written screening test of the 100 multiplication facts comprised of all single digit math families (e.g., x1 to x9) on three consecutive days. The facts were presented randomly in horizontal equations. A different form of the screening test was used each day. The teacher gave each student an answer sheet and said, "Write the answer to each fact you know." The screening sessions were untimed because the teacher was interested in determining only those facts unknown to the student and for use in the pool of facts to be taught by the two instructional methods.

Before scoring, the teacher duplicated each student's answer sheets on a photocopy machine. One copy was scored by the teacher, the other by the university research associate. All responses were checked for interrater reliability, which was 100% for all students.

Students' incorrect responses for each screening session were recorded on a summary chart to determine facts which were unknown each day across the three days. These unknown facts were placed in a pool of potential training facts. If the student knew a fact one day and not the next, the fact would not be used in the pool. A group of twenty facts was selected from this pool of unknown facts. The twenty unknown facts were then divided randomly into two sets, one set for instruction using visual fading of the answers and the other for traditional error correction drill.
Instructional materials. The HyperCard (1992) application for the Macintosh computer was used to design the flash cards. The cards used in the training measured 3 x 5 with horizontally presented multiplication facts. Two probe sheets with 100 multiplication facts were designed for each set of facts. Each set of 10 facts was randomly presented 10 times.

Fading. Initially, answers to the multiplication facts were present on the flash cards used with the visual fading method. The intensity of the answers was then systematically faded using a computer command which lightened the answer (Chart I). Five levels of fading were used.

Error Correction. During the error correction method, identical flash cards were used. During this procedure, however, the flash cards contained no answers.

Instructional Procedures. The instructional procedures for Fading and Error Correction were the same, except for the materials used. At the start of each session, the teacher told the students that they would be working on multiplication facts. The students were instructed to look at the fact and say the answer. If the answer was unknown, they were instructed to say, "I don't know." The teacher would then say the answer and go on to the next fact.

During the fading condition, the teacher, at the start of each session, presented a card displaying the five levels of fading, pointed to the level for that day and said, "Today the answers will look like this." These instructions were modified on Day 5 for Students 1 and 2, because both teachers felt that the students were not attending to the multiplication facts, but were simply reading the answers. On Day 5 and subsequent days, these two students were told to read the fact and then say the answer, during both instructional conditions.

The teacher then set the timer for 5 minutes. Facts were presented one at a time by the teacher. In both Fading and Error Correction, correct responses were followed with brief positive feedback, such as "Good," "Right," or "Correct." When an incorrect response was made, the teacher said, "No, the answer is..." If the student made no response after 3 seconds, the teacher told the student the answer and went on to the next fact. After one trial with each fact, the teacher shuffled the cards and repeated the above procedures until the timer rang, signifying the end of the instructional session. The five minute session was for instruction and no probing took place at that time.

Probes. Immediately following interaction with the flash cards, the teacher placed a probe sheet face down in front of the student and said, "Here is a sheet with the facts we just practiced. Write the correct answers as quickly as you can. Skip the problems you don't know. If you spent too much time on a problem, I will tell you to go on. You probably won't finish the page. When the timer rings, put a line under the last problem you worked." The teacher set the timer for one minute and told the student to begin. If the student hesitated for more than three seconds on a problem, the teacher said, "Go on to the next problem." When the timer rang, the student was reminded to put a line under the last problem he or she worked on. The probe sheets were then scored by the teacher. Complete answers to problems were scored either as correct (the student wrote the correct answer), or incorrect (the student wrote an incorrect answer or skipped the problem). The scored probes were not shown to the students.

Procedural Reliability. Procedural reliability was collected twice for each student during each condition, once by a School-Based Special Education Consultant, and once by each teacher. Behaviors measured for reliability included appropriate directions, length of instructional session, teacher feedback, correct, incorrect, and no answer responses, and probe procedures. Procedural reliability was 100% for all sessions.

Social Validity. In order to assess social validity, one probe sheet from each set of facts was given to a fourth-grade teacher whose math class was identified as low average. None of the students were identified as having a disability. The teacher was requested to follow the same probe procedures used in the resource room. For the facts used in the visual fading condition, the fourth graders' corrects ranged from 5 to 29, with a mean of 11. Incorrects ranged from 0 to 91 with a mean of 25. For facts used in the error
correction condition, corrects ranged from 2 to 24 with a mean of 8. Incorrects ranged from 0 to 93 with a mean of 26.

At the conclusion of the study, each student was also asked which of the two procedures he or she liked best. Participant 1 definitely preferred the fading procedure. He was frequently frustrated when he did not know the answer during the error correction condition. Participant 2 was undecided about which procedure she liked the best, although she learned more facts during the fading condition. One possible explanation for her indecision was her recent placement in the resource room. Both procedures were very different from what she had experienced previously in the regular classroom. Participant 3 liked the error correction condition better, because he said it made him think harder. He also knew more multiplication facts at the beginning of the study than the other two and had much experience learning through an error correction method.

Results and Discussion

Although both teaching methods were used and students probled each day, charted data from each method are shown separately, instead of overlaid on each day, for easier interpretation. Chart 2 shows results for Jeremy. His correct answers accelerated greatest under the fading condition (i.e., x 3.0 versus x 1.5). His incorrect answers decelerated more rapidly during fading as well. For Darrica (Chart 3), under fading, correct accelerations were somewhat greater and incorrect answers decelerated much more rapidly (i.e., divide 2.5 versus divide 1.4). For 2 of the 3 participants in this study, prompt fading generated greater correct accelerations and incorrect decelerations during initial acquisition of basic multiplication problems. The other student, Michael, learned considerably faster under the error correction procedure. The effectiveness of error correction for him was sizable. Results point to ever present differences in learners and reemphasized the need to employ varied teaching strategies with students with learning disabilities.

These findings are consistent with the work of others. Browne, Koszy, Belfiore, Heller, Wozniak, Lalli, and Lie (1990) found no single method effective for all students when comparing stimulus shaping, stimulus fading, time delay, and trial and error. Similarly, McComas and her colleagues (McComas, Wacker, Cooper, Asmus, Richman, & Stoner, 1996) compared the effects of various stimulus prompts for teaching reading comprehension and spelling to low performing students. No single strategy was most effective for all students in initial skill acquisition. They suggest evaluating the effectiveness of each strategy in a hierarchical manner (Harding, Wacker, Cooper, Miller, & Jensen Kovalan, 1991).

Because we were interested in establishing an initial skill repertoire and determining the best method by which to do so, we were not interested in addressing issues of fluency building. In contrast to investigations of developing an initial skill repertoire, when the question is one of fluency and skill retention, methods which develop performance to fluency prove most effective (Binder, 1993, 1996).

Although prompt fading was found to be effective, it requires materials preparation with more complexity than those used in error correction. For this study, a Macintosh computer and Hypercard program were employed to produce the specialized materials. Using a computer to produce the materials resulted in materials production in a fraction of the time normally required. Consequently, for those students responding to prompt fading during training, and perhaps for those who did not), the effort to develop specialized materials is worthwhile, especially if computers will assist in the task.

Michael and Jeremy preferred the method by which they learned best. Asking students about how they like to learn appears useful, although direct measures of performance obtained during teaching or periodic review are the most accurate guide for teachers.

References


